TEKTUS CONSULTANTS LIMITED
A • 10 MADDEN ST
AUCKLAND CBD 1010
E • KIAORA@TEKTUS.NZ
W • TEKTUS.NZ

STEVENSON AGGREGATES LTD

Clevedon Quarry Fast Track Substantive Application

Surface Water Management Report

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1 Introduction

Tektus has been engaged by STEVENSON AGGREGATES LTD (SAL) to develop a surface water management strategy to support a Resource Consent application for the staged expansion of Clevedon Quarry under the Fast-Track Approvals Act (FTAA) 2024.

This report outlines the proposed surface water or stormwater management for the site including treatment of sediment laden runoff from the quarry establishment and operations. The management strategy has been developed in general accordance with *Auckland Council's Guidance Document 005: Erosion and Sediment Control (GD05, 2016/2025)* and *Auckland Council's Guidance Document 001: Stormwater Management Devices in the Auckland Region (GD01, 2017).*

The stormwater management approach has been informed by a hydrological assessment of the site and includes the following processes:

1. Capture and treatment of sediment laden runoff to address primary water quality impacts and outcomes;
2. Attenuation of peak flows, responding to hydrological changes; and
3. Polish of runoff post sedimentation processes via a constructed water quality wetland, reinforcing the targeted outcomes.

The proposed quarry, from a surface water perspective, is split into two main areas; the lower quarry floor (Front of House area (FoH)) and the upper main quarry extraction area. Refer to Figure 1 below. These areas have different constraints and different surface water management approaches accordingly.

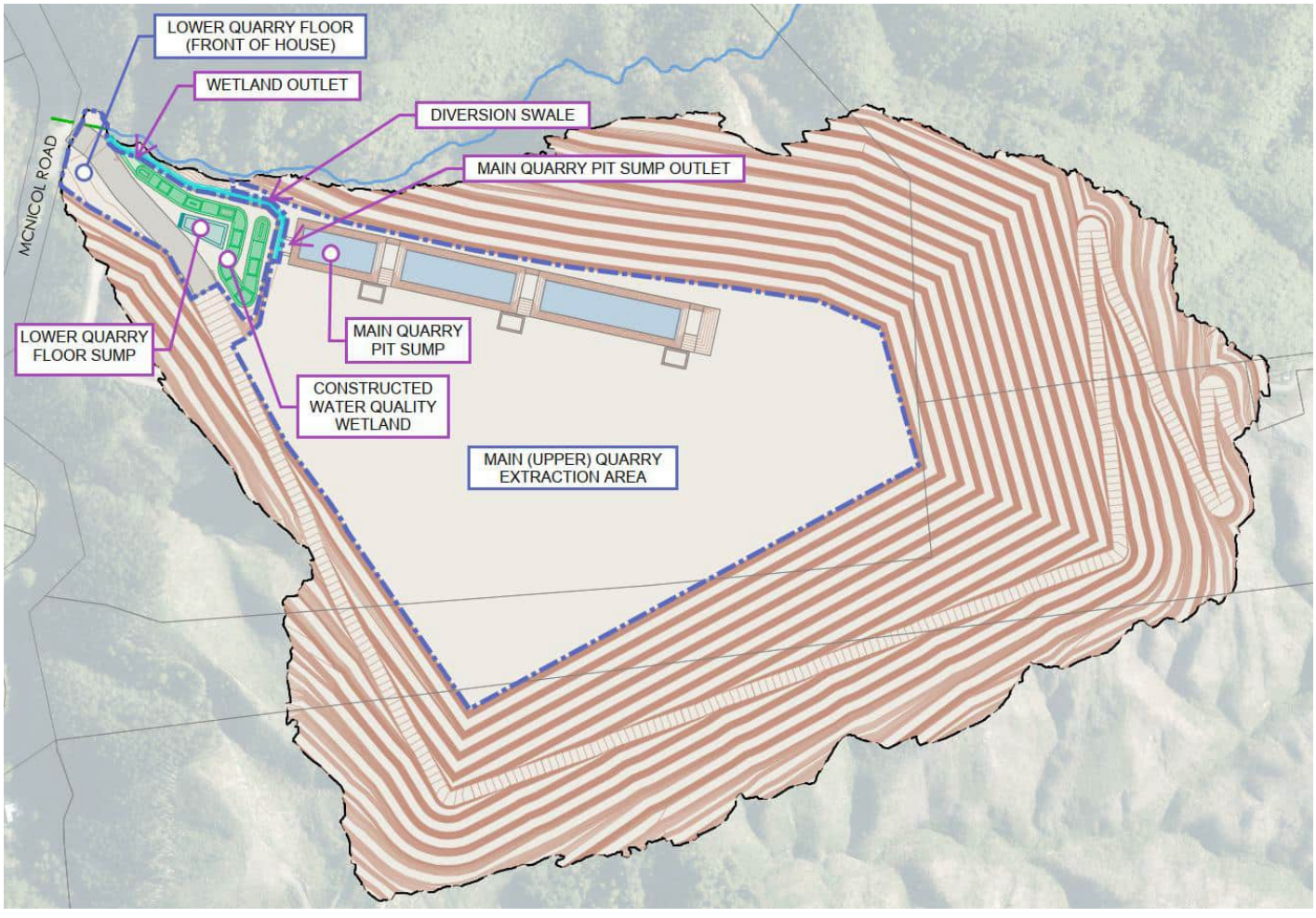


Figure 1: Overall indicative quarry floor extent

2 Site Description

2.1 Proposed Works

The Clevedon Quarry is located at 546 McNicol Road, Clevedon (Lot 1 DP 169491). It is a greywacke hard rock quarry that has been operational since the 1970s supplying aggregate to the Auckland market. It currently extracts approximately 200,000 – 300,000 tonnes per year.

SAL hold an existing consent (granted in 2018) allowing expansion of the current quarry to enable the extraction of approximately 60 million tonnes (MT) of aggregate and overburden over 35 years, across six stages at an annual extraction rate of 3 MT per year. This Fast-track application seeks to expand beyond the existing consent to a life of quarry footprint of approximately 74 ha and a 4.6 ha overburden disposal area. This expansion would occur entirely within SAL wider landholdings (totalling 544 ha) over an approximately 50-year period split across five indicative stages. It would provide approximately 150 MT of aggregate. Figure 2 below shows the extent of the proposed life of quarry footprint.



Figure 2: Indicative staged Clevedon Quarry expansion

The proposed expansion area is primarily within the Special Purpose Quarry Zone (SPQZ) (59.2 ha; 80% of expansion area) with the remaining 14.8 ha in the Rural Production Zone (RPZ). As part of Stage 4, the proposed quarry would extend into SEA_T_5588.

Activities on site generally include: construction of haul roads; overburden removal (including establishment of the overburden disposal area); and day to day operations including rock crushing and processing and truck movements.

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2.2 Existing Hydrology

The Clevedon Quarry is located within the Hunua Stream catchment (156km²) above the Wairoa River. The Wairoa River is the second largest river in Auckland with a total catchment area of 258km² where it outlets to the Tāmaki Straight. The catchment generally comprises steep terrain to the east in the Hunua Ranges Regional Park with flatter agricultural land around the Wairoa River. The catchment includes two reservoirs/dams; Cosseys Reservoir and the Wairoa Dam/Reservoir. Flows within the Wairoa River at the quarry site are estimated at 413m³/s in the existing 100-year event and are anticipated to reach 680m^3/s in the 3.8°C climate change scenario (based on Auckland Council GeoMaps information). Within the quarry, runoff is currently captured and treated via two sediment ponds that discharge to Stream 1 – being one of four tributaries of the Wairoa River across the quarry site extents, and which are described further as follows.

Four permanent and intermittent stream tributaries of the Wairoa River surround the quarry – referred to as streams 1, 2, 2a, and 3 in the supporting T+T technical reports – and all of which would be impacted to varying degrees by the proposed quarry expansion. Descriptions of the streams are included below:

- Stream 1 (catchment area 1.10km²): runs to the north of the quarry area and discharges under McNicol Road via an existing 60m long 1200mm diameter (Ø) culvert. The tributary has a relatively steep gradient (average of 8% alongside the quarry) with a small waterfall/hydraulic jump 70m upstream of the culvert entrance. The typical stream depth is 1.5m upstream of the waterfall and increases to 3-4m downstream (*Rileys Flood Assessment Clevedon Quarry, 2020*). Landcover in the catchment is primarily native forest/bush. The stream is separated from the lower extent of the quarry by an approximately 100m long bund. An existing runoff treatment pond discharges to the lower extents of this stream via a piped outlet and spillway. Overall, the stream is identified to have high ecological value and very high species values.
- Stream 2 (catchment area 0.35km²): runs through the centre of the proposed quarry expansion. The catchment is relatively steep with landcover consisting of cleared forest. The stream is identified to have moderate to high ecological value and high species values.
- Stream 2a (catchment area 0.07km²): runs through the southernmost portion of the quarry expansion. The upper limits of the catchment are cleared forest whilst the lower portion is still intact forest landcover. The stream is identified to have moderate to high ecological value and low species values.
- Stream 3 (catchment area 1.16km²): runs to the south of the proposed quarry expansion. The catchment area comprises steep, cleared forestry landcover. The stream is identified to have moderate ecological value and high to very high species values.

Figure 3 below shows the existing stream network in relation to the proposed quarry expansion. Tektus has undertaken a hydrological assessment to understand the potential impacts of the proposed quarry expansion. This accounts for and addresses the principal changes to existing hydrology in terms of the alteration of stream catchments.

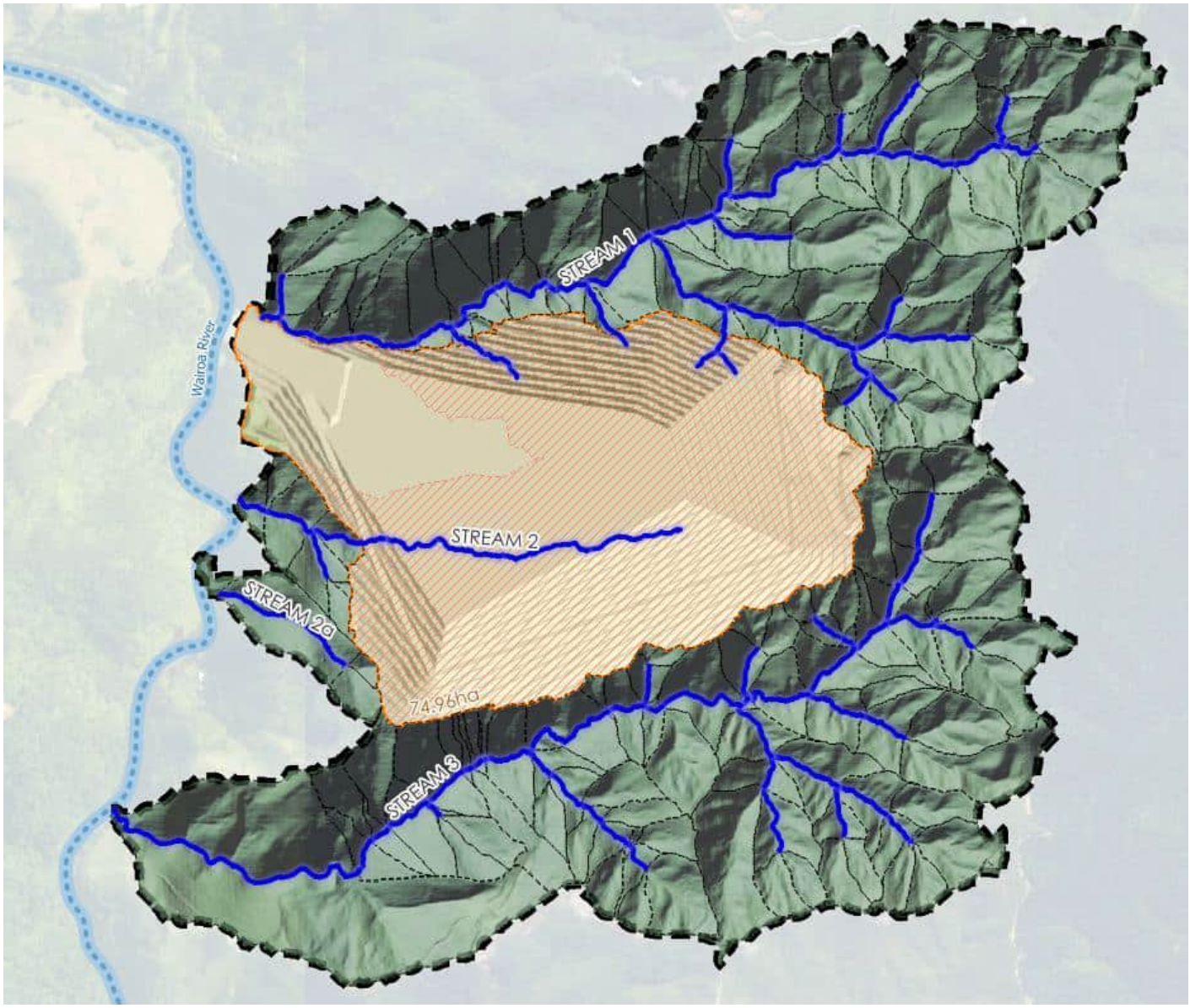


Figure 3: Existing stream network (reproduced from Tonkin + Taylor Clevedon Quarry Expansion Fast-Track Referral Application: Ecology Memo)

2.3 Existing Flooding

Flooding impacts are predicted in the lower portion of the existing quarry. These impacts are caused by: the limited capacity of the existing Ø1200mm culvert under McNicol Road causing flows to overtop Stream 1; and the Wairoa River flooding over McNicol Road.

SAL commissioned Riley Consultants to carry out a Flood Assessment in 2020 (*Rileys Flood Assessment Clevedon Quarry, 2020*) to identify any overtopping into the quarry from Stream 1 and the flood levels associated with the blockage of the Ø1200mm culvert through the carpark and across McNicol Road. We note that best practice climate change factors have changed since this analysis was carried out. The analysis highlighted that flood levels have two peaks; one associated with the culvert overtopping, and the other with the Wairoa River overtopping McNicol Road. Through the car park, flood levels reach RL 21.58m (AVD1946) in the blocked culvert 1% AEP scenario due to flows from Stream 1. Flood levels then reach RL 20.87m (AVD1946) due to overtopping from the Wairoa River.

Anecdotal information from SAL highlight that these flooding effects have little impact on the operation of the quarry aside from limiting access to the site along McNicol Road.

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The Rileys reporting also highlighted a point in Stream 1, approximately 70m upstream of the culvert entrance (above the waterfall), where flows may overtop the stream bank and spill into the quarry. The magnitude of the inflow is not explored, but based on the levels, we would expect the flows to be minimal.

3 Hydrology Assessment

The proposed quarry extension will impact the hydrology of the streams surrounding the quarry. GIS analysis was undertaken to understand the extent of the catchment changes for each stream. Catchments were delineated for the pre and post quarry expansion scenarios and the changes assessed to identify the most severely impacted reaches. This comparison is summarised in Figure 4 below. The scaling from red to green represents the biggest reductions in catchment area to smallest. It should be noted that this analysis does not include the final leg of Stream 1 where the quarry will discharge – this was investigated through the subsequent hydrology modelling.

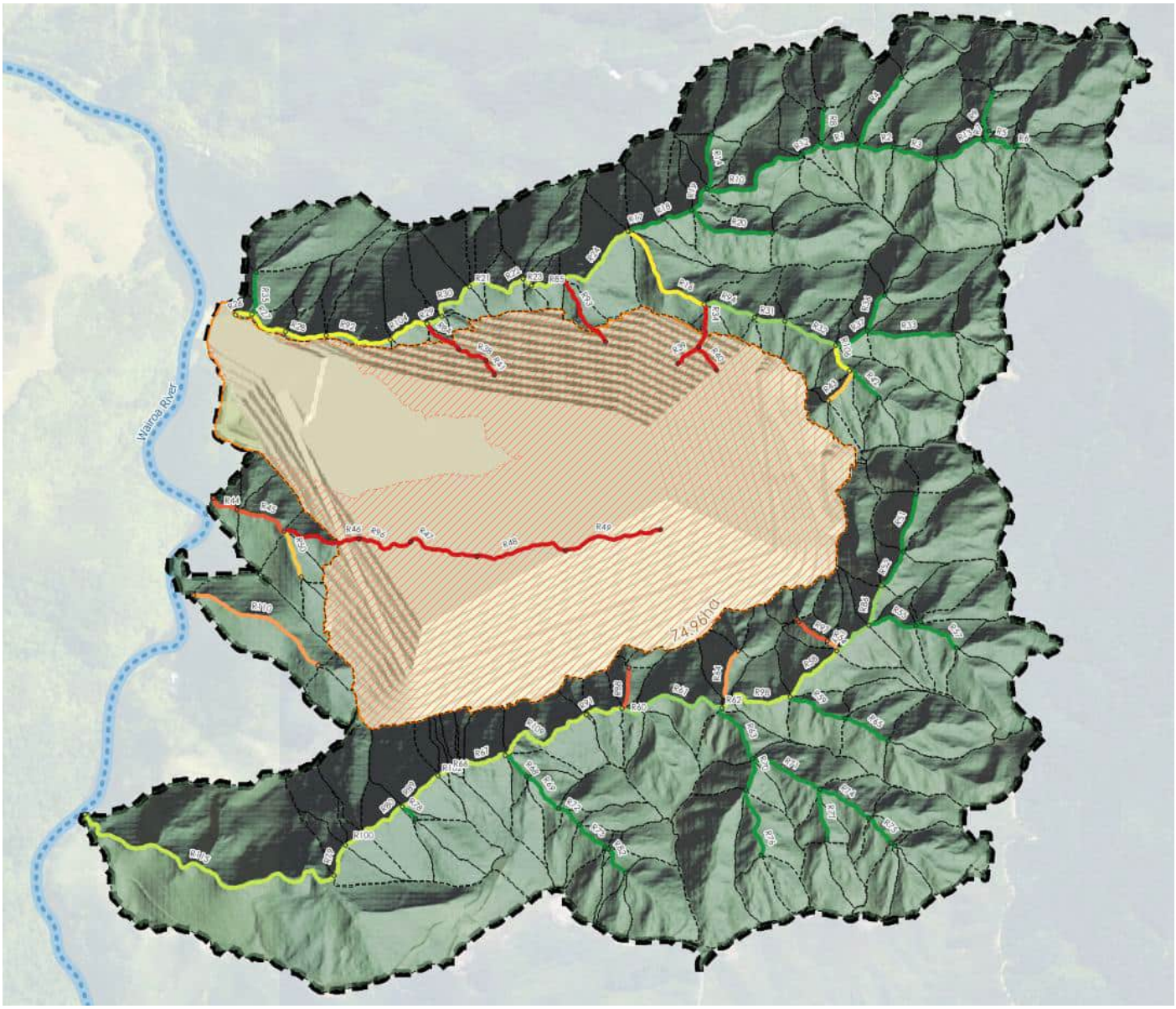


Figure 4: Summary of stream catchment changes for the post quarry expansion scenario

The catchment analysis highlighted the redirection of a large portion of the Stream 2 catchment to Stream 1. Hydrological modelling was used to assess these impacts and inform the necessary mitigation.

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3.1 Model Build

HEC-HMS (version 4.13) was used to construct a detailed hydrological model to assess the changes to the four impacted streams. The model covers an area of 2.66 km². To ensure an accurate representation of pre and post development hydrology, and to enable a detailed assessment of stream affects, the catchment was subsampled into stream networks based on a minimum catchment area of 1.5 ha. The resulting catchments and stream reaches are shown in Figure 5.

The kinematic wave equation was utilised to provide an appropriate estimation of travel time within the hydraulic links that makeup the stream network. Lengths and slopes were extracted from the existing Digital Elevation Model (DEM) with an approximate stream geometry based on a 5.0 wide base with 1:5 side slopes. These parameters were estimated from typical DEM samples for the 100-year event.

Reducing the assumed stream geometry would lower the time of concentration and increase peak flow estimates in the stream. From a flooding perspective, this would highlight the worst-case scenario considering the impacts on the Ø1200 culvert, but it would significantly increase any attenuation targets for the site (meaning less mitigation required on site). Given the minimal impacts from flooding on the quarry, the undersized nature of the existing culvert, the high value of the receiving environment, and the intended approach to attenuate events up to the 100-year ARI event; adopting a more conservative approach to the hydrology attenuation was favoured in this case.

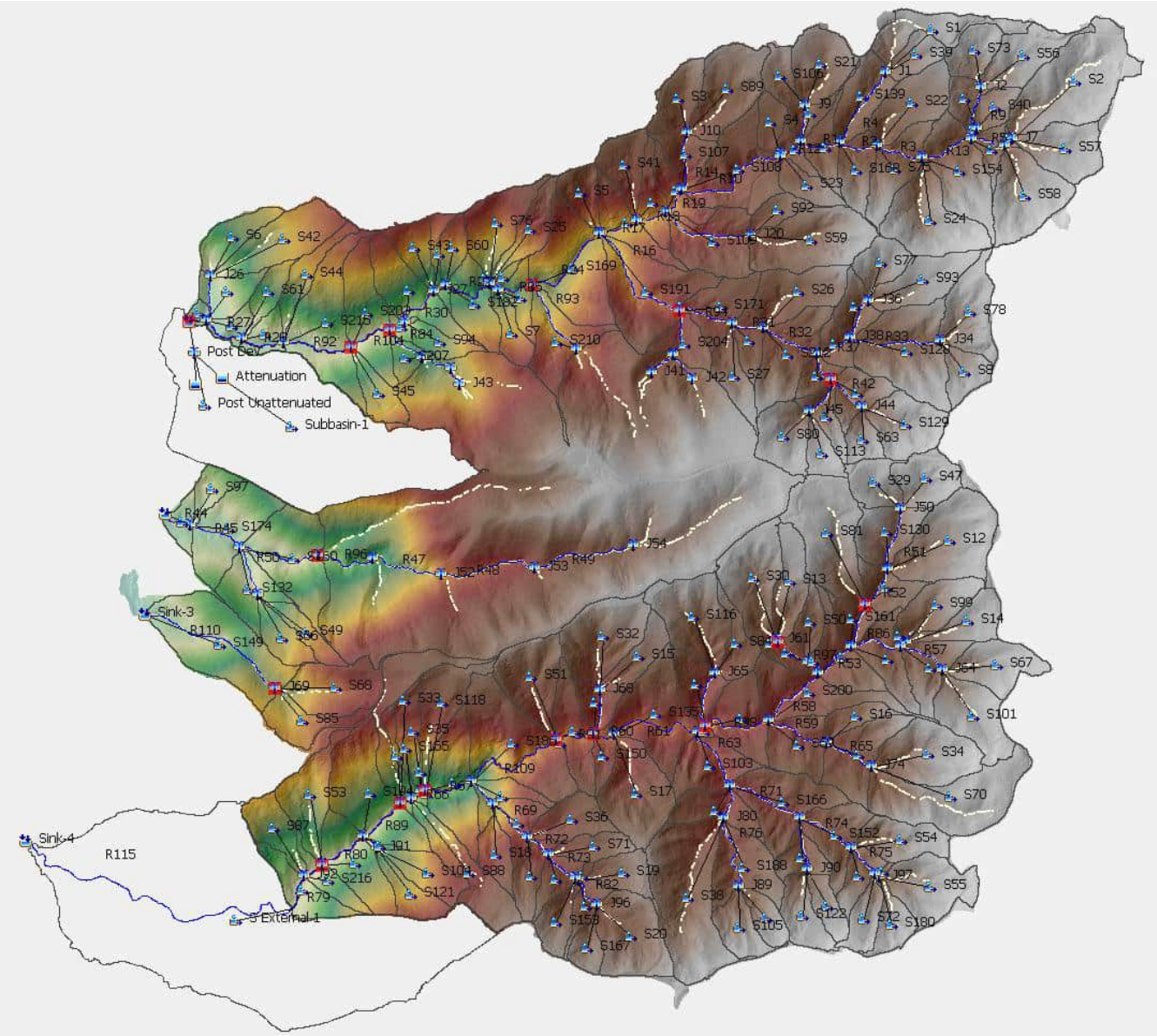


Figure 5: HEC-HMS model schematic

Existing catchment parameters including rainfall and CN values were derived from the Auckland Council Over Land Flow Path (OLFP) layer within its GeoMaps datasets. Post development CN values were interpreted from TP108 and conservatively classified as 'newly graded pervious area with no vegetation' (91) to represent the developed and active quarry land use footprint. Future climate rainfall depths and distributions were derived from SWCOP V4. Table 1 below shows a summary of the landcover, and rainfall parameters used.

Table 1: Summary of catchment hydrology parameters

Landcover	Soil Class	CN
Existing Vegetation	B	61
Quarry Works	C	91
Event	**24 Hour Depth (mm)**	**Climate Factors**
90th	29.4	Current
95th	38.9	Current
2Y	92.0	2.1
5Y	151.3	2.1
10Y	186.6	2.1
20Y	186.6	2.1
100Y	325.2	3.8

When analysing the impacts of the overburden disposal site on stream hydrology, consideration was given to increasing CN values to align with the quarry area to assess the impacts of temporary works prior to revegetation and stabilisation of the site. However, as this overburden area is in the upper reaches of the catchment and is outside of the main quarry catchment, the increase in CN value would result in an increase in runoff volume and peak flows which would mask the impacts of the stream diversion and catchment reduction that the quarry has on Stream 3. Therefore, the stabilised, post rehabilitation condition of the overburden area is considered a more accurate representation of the true, full-picture quarry impacts, and as such the CN values for these areas were retained at 61.

3.2 Model Calibration

Our model results were compared to the peak flows from the Auckland Council OLFP layer to calibrate and verify the accuracy and relevance of the HEC-HMS model – with particular focus on the northern stream (Stream 1). Flooding information was also received from the Healthy Waters Regionwide Rural Rapid Flood Model. This includes 3.8°C climate change. Unfortunately, some of the values presented were significantly different from the Auckland Council OLFP data and Rileys' reporting (e.g. flows in the Wairoa River were over 1000m³/s compared to 680m³/s on the OLFP layer). These results have been queried with Healthy Waters, and a response has not yet been received at the time of writing. This information from the Rapid Flood Model was therefore disregarded for the purposes of calibration.

Peak flows and lag time associated with the northern stream prior to the quarry outfall at Stream 1 are comparable in smaller events (2- to 10-year). However, in larger events, the peak flow results from the HEC-HMS model are greater than the corresponding reaches in the Auckland Council OLFP layer. This is attributed to a higher velocity in the stream and a corresponding reduction in time of concentration, which in turn results in increased peak flows. The velocities from the HEC-HMS model are in line with what would be expected in steeper topographic areas with heavily channelised valleys. The Rileys report, carried out in 2020 using 2.1°C climate change factors and an older hydrograph, had a peak flow for Stream 1 of 31m³/s (24-hour rainfall depth of 286mm). A linear scaling comparison of the rainfall to the 3.8°C climate change data would equate to a 35m³/s peak. This is comparable to the 37.6m³/s output from the model built for this assessment. A comparison of the HEC-HMS model and Auckland Council OLFP information is included in Table 2 below.

Table 2: HEC-HMS model and Auckland Council OLFP results comparison

Event	Result	AC OLFP	HEC HMS Results
2Y	Lag Time (mins)	30.67	28
	Peak Flow (m^3/s)	4.44	4.23
10Y	Lag Time (mins)	30.67	22
	Peak Flow (m^3/s)	13.49	15.37
100Y	Lag Time (mins)	30.67	20
	Peak Flow (m^3/s)	29.52	37.62

As the main concern with respect to in-stream hydrology is framed by smaller higher-frequency events, and larger lower-frequency events govern sizing of conveyance and flood impacts, the proposed model is considered appropriate for both ensuring accurate representation of stream hydrology, and conservative sizing of infrastructure. It should be noted that the model is being used for a comparative analysis, so differences in peak flows between the models should not change the trends of the conclusions drawn.

4 Hydrology Mitigation

The management of runoff from a hydrological-impacts perspective associated with the proposed quarry works are explored below.

There is a significant increase in peak flow from the quarry expansion to Stream 1 due to the diversion of runoff from Stream 2 and resulting increase in catchment area from 11.86 ha to 71.40 ha. Refer to Table 3 below for a summary of the pre- and post-development flows leaving the proposed quarry. Unmitigated, this would have erosive impacts on Stream 1 and would impact the hydraulics of the existing Ø1200mm culvert under McNicol Road. To avoid downstream impacts, the proposed overall design intent is to attenuate peak flows in rainfall events from the 95th percentile event up to and including the 100-year ARI.

The attenuation shall be achieved entirely by utilising the proposed sediment drop-out sump within the quarry pit to provide storage and the controlled release of runoff. The sump is designed to capture and store runoff from events up to the 20-year ARI and pump them out below the 95th percentile pre-development rate. This release rate was determined based on a combination of hydrology mitigation and sediment drop-out rates in the sump. The stored volume is only released once sediment drop-out has occurred circa 3.5 days post rainfall event. This means the release occurs outside of flood conditions in the stream.

A 20m wide spillway weir is proposed to control outflows from the sump, providing controlled flow release coupled with additional storage volumes above the spillway crest level, thereby achieving attenuation of events in excess of the 20-year ARI. This will direct flows to a diversion channel that would discharge to Stream 1 at the existing outlet location. The sump in the main quarry floor has enough storage for approximately 70% of the runoff in the 100-year ARI event. This not only means that peak flows would be attenuated significantly, but that the peaks would not align (hence the total runoff is less than the sum of the two peak flows). The combined impact of this means the post-development peak discharge is 4.3m^3/s in the 100-year ARI. This is 60% of the pre-development peak flow rate.

Runoff from the lower quarry floor is unattenuated. The storage in the main sump means that the runoff from the lower quarry floor reaches Stream 1 outside of the peak flows from the main quarry floor. In events up to the 20-year ARI, the lower quarry floor can therefore be considered hydrologically separate from the main quarry floor. Flows from the lower quarry floor, due to the small catchment area (2.9 ha vs the 11.9 ha existing quarry catchment), are below pre-development and therefore do not require attenuation. In larger events up to the 100-year ARI, there is some release from the main floor during the 24-hour rainfall event. Combined flows are still effectively insulated from each other due to the offset in peaks. Refer to the total flows vs individual element flows in Table 3 below for context. It should be noted that the hydrological analysis was carried out with all elements in a single model to ensure all effects were captured. The upper and lower quarry floors were not considered individually in the assessment.

Table 3: Summary of HEC-HMS model results for the quarry catchment

Rainfall Scenario	Parameters	Existing	Stage 1			Stage 5		
			Total	Upper Floor*	Lower Floor	Total	Upper Floor*	Lower Floor
	Catchment Area (ha)	11.9 ha	20.5 ha	17.6 ha	2.9 ha	74.9 ha	72.0 ha	2.9 ha
	CN	91	91	85	91	91	91	91
	Soil Loss (mm)	25 mm	25 mm	44 mm	25 mm	25 mm	25 mm	25 mm
95th	Rainfall (mm)	38.85	38.85	38.85	38.85	38.85	38.85	38.85
	Peak Runoff (m³/s)	0.50	0.11	0.45 (0.0)	0.11	0.11	2.38 (0.0)	0.11
	Runoff Volume (m³)	2,305	3,976	2,573	563	14,551	13,988	563
2Y	Rainfall (mm)	92.00	92.00	92.00	92.00	92.00	92.00	92.00
	Peak Runoff (m³/s)	1.70	0.38	1.73 (0.0)	0.38	0.38	7.70 (0.0)	0.38
	Runoff Volume (m³)	8,008	13,813	10,118	1,958	50,555	48,597	1,958
5Y	Rainfall (mm)	151.30	151.30	151.30	151.30	151.30	151.30	151.30
	Peak Runoff (m³/s)	3.00	0.68	3.33 (0.0)	0.68	0.68	13.84 (0.0)	0.68
	Runoff Volume (m³)	14,812	25,548	19,714	3,621	93,506	89,885	3,621
10Y	Rainfall (mm)	186.60	186.60	186.60	186.60	186.60	186.60	186.60
	Peak Runoff (m³/s)	3.84	0.87	4.60 (0.0)	0.87	0.87	18.69 (0.0)	0.87
	Runoff Volume (m³)	18,925	32,642	25,629	4,626	119,470	114,844	4,626
20Y	Rainfall (mm)	222.30	222.30	222.30	222.30	222.30	222.30	222.30
	Peak Runoff (m³/s)	3.84	1.04	5.62 (0.0)	1.04	1.04	22.53 (0.0)	1.04
	Runoff Volume (m³)	23,107	39,855	31,690	5,649	145,869	140,220	5,649
100Y	Rainfall (mm)	325.20	325.20	325.20	325.20	325.20	325.20	325.20
	Peak Runoff (m³/s)	7.22	1.63	9.01 (1.044)	1.63	4.29	35.24 (4.13)	1.63
	Runoff Volume (m³)	35,222	60,750	49,387	8,610	222,348	213,738	8,610

**Runoff during the 24-hour storm event is shown in brackets. For events up to the 20-year; runoff will be discharged at 0.464m³/s via the water quality wetland ~3 days after the rain event.*

4.1 Events up to the 20-year ARI

As outlined in Section 4 above, peak flow attenuation for all events up to and including the 100-year ARI (including 3.8°C climate change) is proposed to be achieved via the sediment treatment sump in the main quarry pit. For events smaller than the 20-year ARI, the release rate will be less than the 95th percentile pre-development peak flow for the quarry catchment. Flows are retained for 3 days (for sediment settling) before being discharged to the water quality wetland. The magnitude of the attenuation and delay for release is such that there will be no adverse effects downstream.

4.2 Events up to the 100-year ARI

In events up to the 100-year ARI event, peak flows from the quarry bypass the wetland and discharge via a diversion channel to Stream 1 just above the Ø1200 culvert under McNicol Road. The peak flows are reduced to 60% of the pre-development 100-year, so the function of the Ø1200 culvert under McNicol Road is expected to be unchanged. Accordingly, flood depths and hazards are also anticipated to be unchanged across McNicol Road.

Section 2.3 above outlined the findings of a Rileys report commissioned in 2020 relating to the operation of the Stream 1 culvert and flooding within the quarry carpark. Flood attenuation means that the peak flows do not change in the post-development scenario, but measures have been adopted to minimise flooding within the proposed quarry extents.

The quarry floor has been raised to RL 22.5m (NZVD 2016) to ensure floodwaters from the blocked culvert scenario do not spill into the quarry. Flood levels are estimated at ~RL 22.2m immediately upstream of the culvert in the Rileys reporting (AUK1946), which is equivalent to RL 21.9m in NZVD 2016. This therefore provides for over 500mm freeboard to the lower operating quarry floor. This is also above the flood level associated with the Wairoa River when it spills over McNicol Road (RL 20.57 NZVD2016). The flood storage provided in the entrance to the existing quarry has little to no impact on the function of the Wairoa River (approximately 350m³ in the existing scenario); however, it is intended to maintain as much of this storage as possible.

The Rileys report also outlined a section of the stream above the existing waterfall (Refer to Figure 6 below) that may spill into the existing quarry in the 100-year scenario. These flows appear to be minimal but, as part of the expansion, the ground level at this location is proposed to be raised to prevent flows entering the quarry. In the existing scenario, these flows that entered the quarry are likely diverted back into the stream through the existing sediment ponds, so keeping these flows in the stream is not expected to change the hydrology of the stream and culvert.



Figure 6: Existing 100-year ARI spill location into quarry from Stream 1

It is noted that the Rileys report was commissioned in 2020 and uses 2.1°C climate change factors and hydrographs. We have based our 100-year ARI analysis on the 3.8°C climate change data to ensure volumes and flow capacities are future proofed but believe the Rileys report is still relevant given the quarry is a temporary activity with a lifespan estimated at 50-years. The 2.1°C climate change is likely more representative of the climate change horizon at 50-years for the 100-year 3.8°C climate scenario. We are therefore comfortable with utilising the outputs of the Rileys report given the adopted freeboard limits applied.

4.3 Events greater than the 100-year ARI

The attenuation in the sump has not been specifically designed to attenuate rainfall events greater than the 100-year ARI. We do however note the volume of storage available would provide some measure of attenuation based on storage alone.

Flows would be directed to the sump and then discharge to the diversion swale. The swale has been designed to convey the 100-year ARI event with 150mm freeboard. When this is overwhelmed, flows would enter the constructed water quality wetland and discharge at the main outlet.

4.4 Pump Failure

Draining the sump is reliant on pumping and is therefore subject to risk if the pumps fail. In this case, the sump arrangement (including lateral and vertical dimensions, and overall volumetric parameters) has been designed to fully capture and retain rainfall events up to the 20-year ARI. The pump operates on a turbidity sensor that will only activate once sediment has settled (estimated at three days based on sedimentation drop-out rates). This allows a three-day window to repair or replace the pump if it fails following a rainfall event (although it is noted the only risk if this is timeframe is extended is if another runoff-generating rainfall event occurs before the drain down).

Attenuation for the 100-year event is controlled via a broad crested weir – so is not at risk if the pump fails. It is a matter of repairing the pump prior to the next rainfall event to ensure storage is available to capture runoff for subsequent events.

Appropriate operation and maintenance inspections would greatly reduce the risk of pump failure occurring during a runoff generating rainfall event. Pumps are also likely utilised throughout day-to-day quarry operation for water recycling so issues should be identified very quickly if they do occur.

5 Water Quality Impacts

Given the scale of the proposed quarry extension and the sensitivity of the receiving environment, the management of water quality impacts, and principally, sediment laden runoff is a key part of the overall stormwater management approach. Other forms of water quality contaminants may occur within a quarry operation of this nature; including oil and particulate residues from plant and machinery operating on site. However, sediment is the overwhelming contaminant of concern in a quarry context and remains as an appropriate singular focus and proxy for overall water quality outcomes.

A detailed review of local, national, and international documentation was undertaken to help guide the management of sediment laden runoff within the proposed quarry extension. Ultimately, an approach based on the principles of Auckland Council Guidance Document 05 (GD05, 2016/2025) was adopted incorporating additional storage volumes in line with overseas best practise and to account for the duration of works.

In general, the site runoff shall be managed via the following:

1. Capture sediment laden runoff (sump)
2. Store the runoff to allow for sediment drop out
3. Pump out in a controlled manner based on turbidity of the captured runoff post sediment drop out

The key parameters of the sediment removal process are explored below.

5.1 Sediment Laden Runoff Mitigation Design

In Auckland, GD05 outlines best practise for treatment of sediment laden runoff for temporary earthworks and ground disturbing activities and includes a chapter focussing on quarrying activities (G6.0). In this context, sediment removal ponds (devices generally used to treat catchments over 3000m² up to 5 ha) have a specified storage volume of 3% of the contributing catchment area. For the full proposed quarry expansion (74 ha) this would result in a storage volume of 22,200m³. This is equivalent to approximately 50% of the 2-year rainfall event volume from this overall catchment area, with no account for climate change.

The proposed quarry expansion is expected to be carried out over an approximate 50-year timeframe, drawing into question the relevance of guidance for temporary earthworks activities considering such a large contributing catchment and prolonged works duration. We do note that Section G6.0 relates specifically to quarry activities and does not have any additional requirements above the 3% catchment area. However, international documents were reviewed to investigate whether a recurrence event approach would be more suitable. Key extracts are summarised below:

- TG7 Assessing the Design, Size, and Operation of Sediment Ponds Used in Mining V1.0 2015 (BC, Canada) :
    - "The minimum design flow for removal of suspended solids in sediment ponds should correspond to the 10-year, 24-hour runoff flow. All sources of runoff, including rainfall, snow melt, and combined rainfall-snow melt events should be considered in determining the design flow".
- Best Practice Erosion & Sediment Control 2025 – International Erosion Control Association (Australasia)
    - The recommended design storm varies with the type of soil disturbance. It should be noted that nominating a particular design storm does not necessarily guarantee that the sediment basin will achieve the desirable performance outcomes during all storms up to that recurrence interval. The design event is used as a 'nominal' design variable, not a performance standard. Recommended design storms are provided in Table B7.

Table B7 – Recommended design storm for Type A basins

Design storm	Type of soil disturbance
1 EY	• Short-term soil disturbances, such as civil construction and urban development.
0.2 EY	• Long-term soil disturbances, such as landfill sites, quarries and mine sites.

We ultimately resolved that a storage volume approach based on runoff from the 20-year annual recurrence event would be more appropriate than the 3% catchment area approach specified in GD05 given the duration of exposure and a desire from our client to deliver a resilient and robust stormwater management solution.

5.2 Sediment Control Implementation

The proposed quarry design comprises two distinct operating areas: the main quarry extraction area, and the lower quarry floor (FoH). These are shown in Figure 7. Different sediment treatment was proposed for each area based on the size of contributing catchments and anticipated sediment yields from each area.

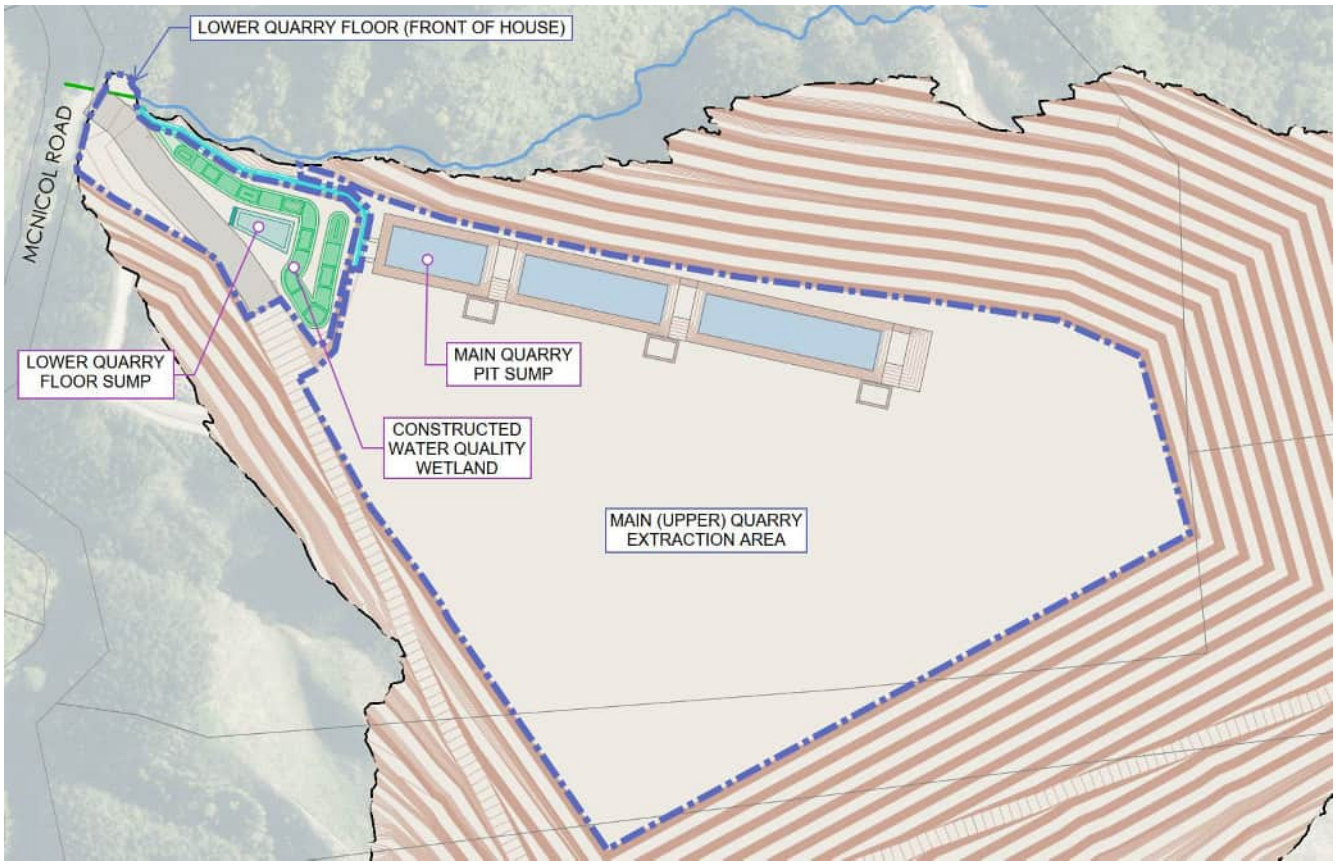


Figure 7: Proposed quarry sediment control layout

5.2.1 Main Quarry Extraction Area Sump

5.2.1.1 Volumetric Design

The main quarry extraction area has the largest contributing catchment area (72 ha) and is where extraction activities will be carried out. This area generates a significant volume of sediment laden runoff in large events and the highest potential for contamination to the receiving environment. Therefore, storage volumes for the sump in the main quarry pit are proposed to be based on the runoff volume from the 20-year ARI event including 2.1°C climate change (2.1°C was selected based on the expected 50-year duration of works).

The 20-year ARI event was selected based on the duration of works, design events in GD05 (GD05 specifies a 20-year ARI design event for diversions), and hydrology mitigation considerations. For the overall quarry expansion, this equates to a minimum live storage volume of 140,000m³. This is exclusive of dead storage and an allowance for groundwater seepage/infiltration.

Dead storage would be included in the base of the sump based on GD05 guidance for 30% of 3% of the contributing catchment area. This equates to 5% of the proposed treatment volume and will be 0.6m deep.

5.2.1.2 Groundwater Inflow

Wallbridge Gilbert Aztec (WGA) completed a hydrogeological assessment for the proposed quarry expansion. The report outlined the pit dewatering requirements based on groundwater inflows. It is predicted that the dewatering requirements for the main extraction area will range from 1.9 l/s (stage 1) to 6.3 l/s (stage 5). Given the design of the quarry, most of this groundwater inflow will end up in the main floor sump. An allowance has therefore been made for additional 'dead storage' to manage this volume.

To avoid the necessity of the pump activating constantly, a three-day infiltration volume was adopted. This corresponds to a total volume of 1,633m³ in stage 5. This will be pumped out to the water quality wetland at the same maximum release rate as outlined in Section 5.2.1.3 or recycled for use in the quarry.

5.2.1.3 Settling Velocities

Following capture of sediment laden runoff, sediment will be contained within the sump and removed from subsequent discharges via sedimentation and drop out processes. Based on the magnitude of the storage, chemically dosed flocculation will be challenging. Drop-out rates are therefore conservatively based on unmodified settling velocities alone.

TP10 in accordance with Stokes Law, has been reviewed to establish the minimum practical particle size (0.01mm) that can passively settle within retention ponds (without chemically enhanced coagulation or flocculation) and forms the basis of the pond's sizing requirements. Figure 8 below, extracted from *TR2010/006 -Particle Size and settling velocity distributions for the design of stormwater treatment devices in the Auckland region*, provides the settling velocities for varying particles sizes. Based on this, a settling velocity of 0.1m/hr has been adopted in accordance with the 10um (0.01mm) target particle size.

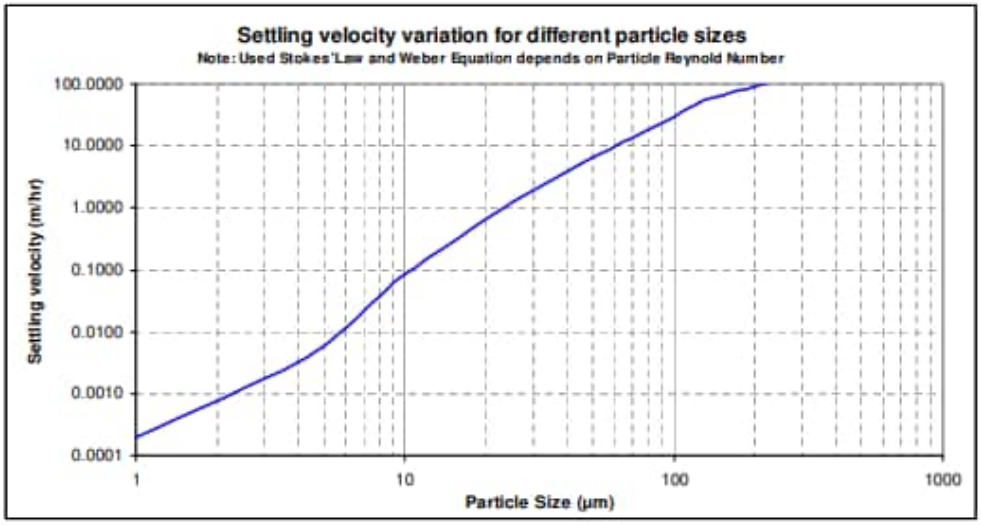


Figure 8: Settling velocity excerpt from TR2010/006

To ensure particles in suspension are not discharged before they are able to settle in the dead storage of the pond the below equation has been utilised and provides a guideline of the maximum release rate.

$$Release\ Rate < Pvolume / \frac{Pdepth}{Svelocity}$$

An assumed sump depth of 8.4m yields a release rate of 464l/s. This is very similar to the peak 95th percentile pre-development site flows (499 l/s). At this release rate, the live storage would be drained in ~3.5 days. A lower release rate can be adopted; it just means that the sump will drain over a longer period. Reuse of this water within the quarry extents can be undertaken prior to the full drop out occurring in areas that drain back to the main pit sump.

Resuspension of sediment is not anticipated during the pump-controlled release, but the pumps would be linked to turbidity sensors that will only activate once turbidity is below 100g/m³ to avoid discharging to the constructed water quality wetland when resuspended sediments may be an issue. As such, the aspect of the sediment storage sump is not critical to the sediment drop out effectiveness i.e. there are no length to width ratios that need to be met.

5.2.1.4 Sump Design

The sump is designed in cells to allow for staged quarry expansion and to facilitate regular maintenance. The cells are proposed to be separated by aggregate 'plugs' that ramp down from the main pit at 1:3 grade to allow for excavator access. The plugs are proposed to be constructed such that the lower 0.6m is in-situ material with limited permeability to contain the dead storage. Material above (a further 2.4m) shall be constructed out of aggregate to allow water to flow between the cells. Refer to Figure 9 below for more information. The total volume contained behind each cell is equivalent to the GD05 prescribed 30% of the 3% contributing catchment area volume.

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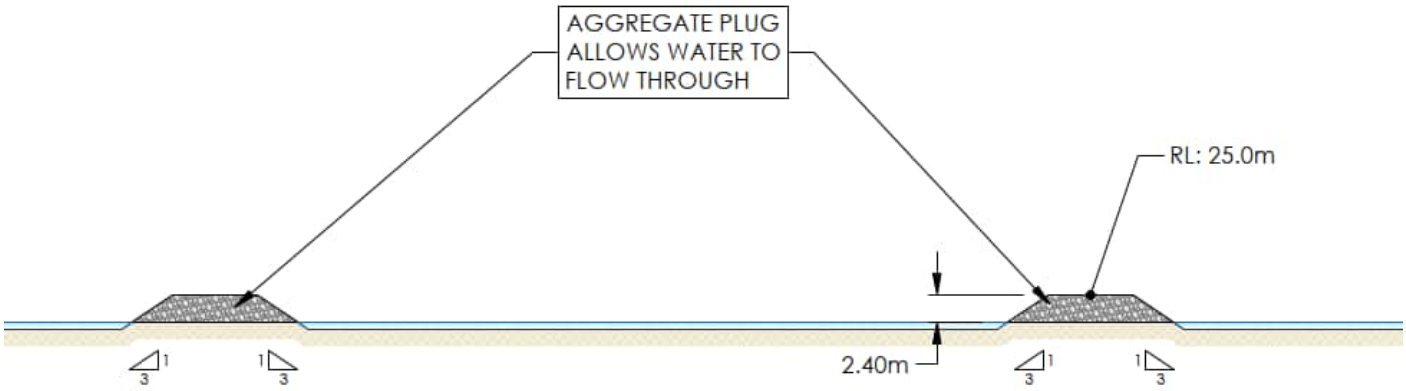


Figure 9: Main quarry pit sump 'plug' schematic

Forebays are proposed for each cell. The main quarry floor will be graded to ensure that runoff is directed to the forebays prior to entering the main sump. The forebays are sized for 10% volume of the 3% contributing catchment area based on the WRC standards.

A summary table for the main sump pit requirements is included below.

Table 4: Main quarry pit sump requirements

Main Quarry Pit Sump Requirements	
Catchment Area (ha)	71.99
3% Catchment Area Volume (m³)	21,596
Treatment Volume (m³)	140,400
GW Infiltration Rate (l/s)	6.30
3-Day Infiltration Volume (m³)	1,633
Dead Storage Volume	6,479
Dead Storage Depth	0.60
Dead Storage %	5%
Additional Attenuation Volume	1109264%
Total Volume (m³)	148,512
Forebay Volume (m³)	2,160

5.2.2 Lower Sump

For the lower level, a more standard GD05 approach sizing the sump for 3% of the contributing catchment area was proposed. This is based on the catchment area being mostly stabilised (road and parking etc), and so the sediment yield will be much less. The contributing catchment is also significantly smaller (2.90 ha) and well-within the recommended design limits for sediment ponds in GD05.

5.2.2.1 Groundwater Inflow

The main quarry floor will intercept most of the groundwater inflow from the benches and base of the quarry. Therefore, no allowance for groundwater inflow has been made for the lower sump.

5.2.2.2 Sump Design

The lower quarry sump has a much simpler design compared to the main quarry pit sump. Sediment drop out is based on a length to width ratio of 3:1. This sump will also be pumped out to the water quality wetland based on turbidity sensors. Water re-use on site from the sump is acceptable if the water will recirculate back to the sump. The forebay is 3m long as per GD05 requirements. Refer to Table 5 below for more information.

Table 5: Lower quarry sump requirements summary

Lower Quarry Sump Requirements	
Catchment Area (ha)	2.90
3% Catchment Area Volume (m³)	870
GW Infiltration Rate (l/s)	N/A
3-Day Infiltration Volume (m³)	N/A
Dead Storage Volume	261.00
Dead Storage Depth	0.40
Dead Storage %	30%
Total Volume (m³)	870
L:W Ratio	3:1

5.3 Overall Site Water Quality Mitigation Design

It is proposed to discharge treated water from the sumps, in events up to the 20-year ARI, through a constructed water quality wetland to remove any remaining suspended solids and other contaminants. The treatment wetland is designed in accordance with GD01 and utilises a treatment train approach from Waikato Regional Council Technical Report TR20/07. A total suspended solids (TSS) removal rate target of 90% has been set for the quarry given the high sensitivity of the receiving environment. This is in excess of the 80% TSS removal target in GD01.

The treatment train removal of contaminants for devices in series is outlined in the equation below:

$$R = A + B - (\frac{A \times B}{100})$$

Where:

R = total removal rate
A = removal rate of the first practice
B = removal rate of the second practice

According to the WRC guidance, wet ponds (with extended detention) have a TSS removal of 75% and wetlands have a TSS removal of 80%. To achieve the 90% target, the wetland would need to operate at a 60% removal rate. Based on *Auckland Regional Council Stormwater Management Devices: Design Guidelines Manual, May 2003 (TP10)*; 50% of the WQV is required to achieve 60% removal. This results in a required wetland area of 4,488m². We have conservatively proposed that the forebay and outlet pool are excluded from the area.

GD01 wetlands are typically designed for the water quality event flow rate; however, the release rates of the sediment removal sump are less than the 95th percentile event, avoiding discharging large flows through the wetland. In addition, flows from rainfall events greater than the 20-year ARI shall be diverted to a channel alongside that wetland. This shall be sized to convey the 100-year ARI rainfall event (accounting for 3.8°C climate change) to avoid resuspension and erosion within the wetland. The full proposed quarry expansion wetland and diversion channel are shown in Figure 10 below.

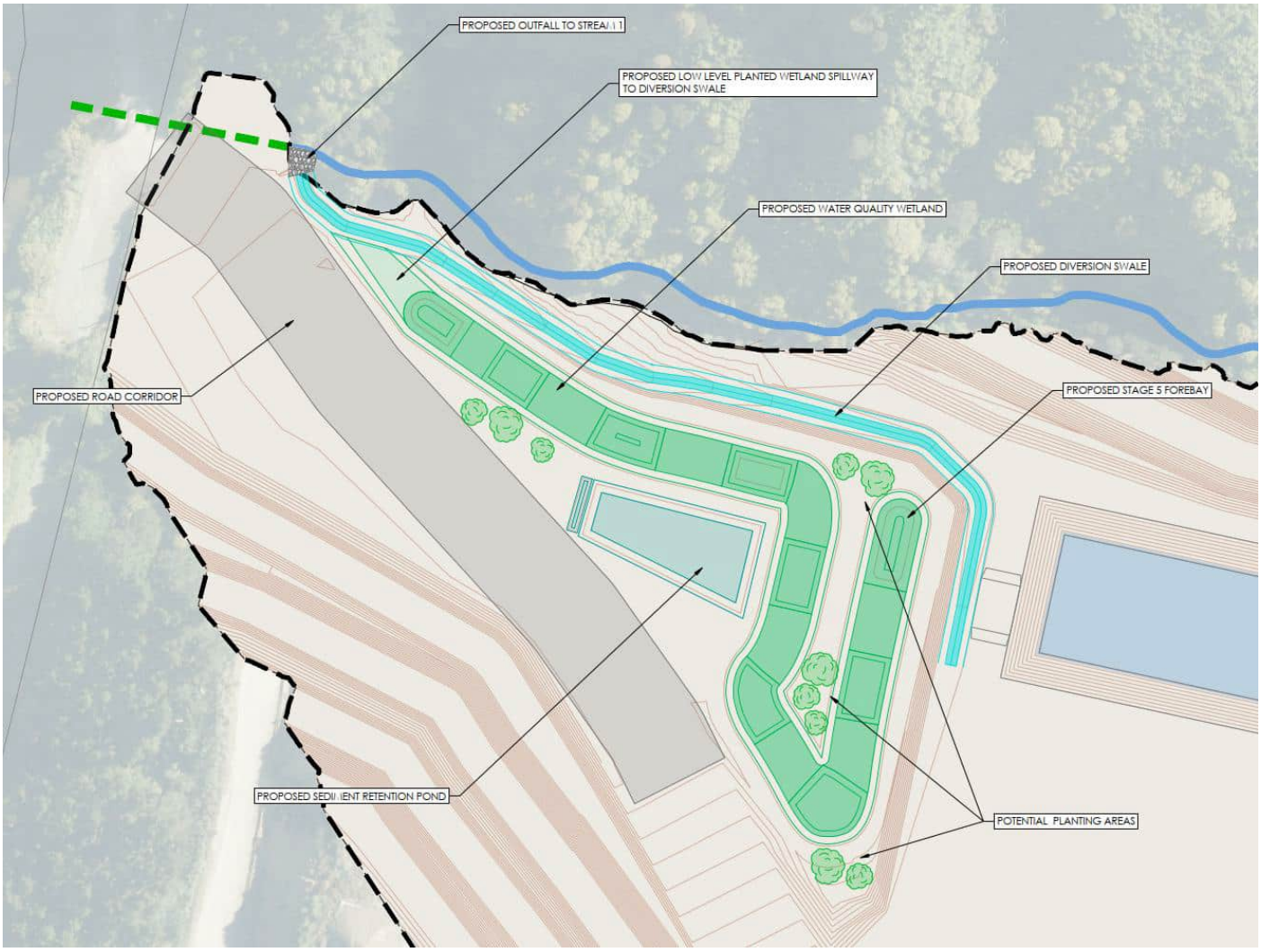


Figure 10: Stage 5 full quarry expansion stormwater management layout

The proposed wetland is designed to maximise travel length whilst maintaining velocities below the limits set out in GD01. Several deep pools are located along the length of the wetland with a secondary forebay to receive pumped flows from the lower quarry floor sump. Specimen trees shall be planted alongside the wetland to provide shading and amenity.

6 Staged Implementation

As the proposed quarry expansion takes place, stormwater management measures can be implemented in a staged manner based on the size of the quarry. Following enabling works, stage 1 should include the construction of the diversion channel, the lower quarry sump, and the main quarry pit sump and wetland sized to treat the proposed open operating area. An indicative stage 1 layout is shown in Figure 11 below.

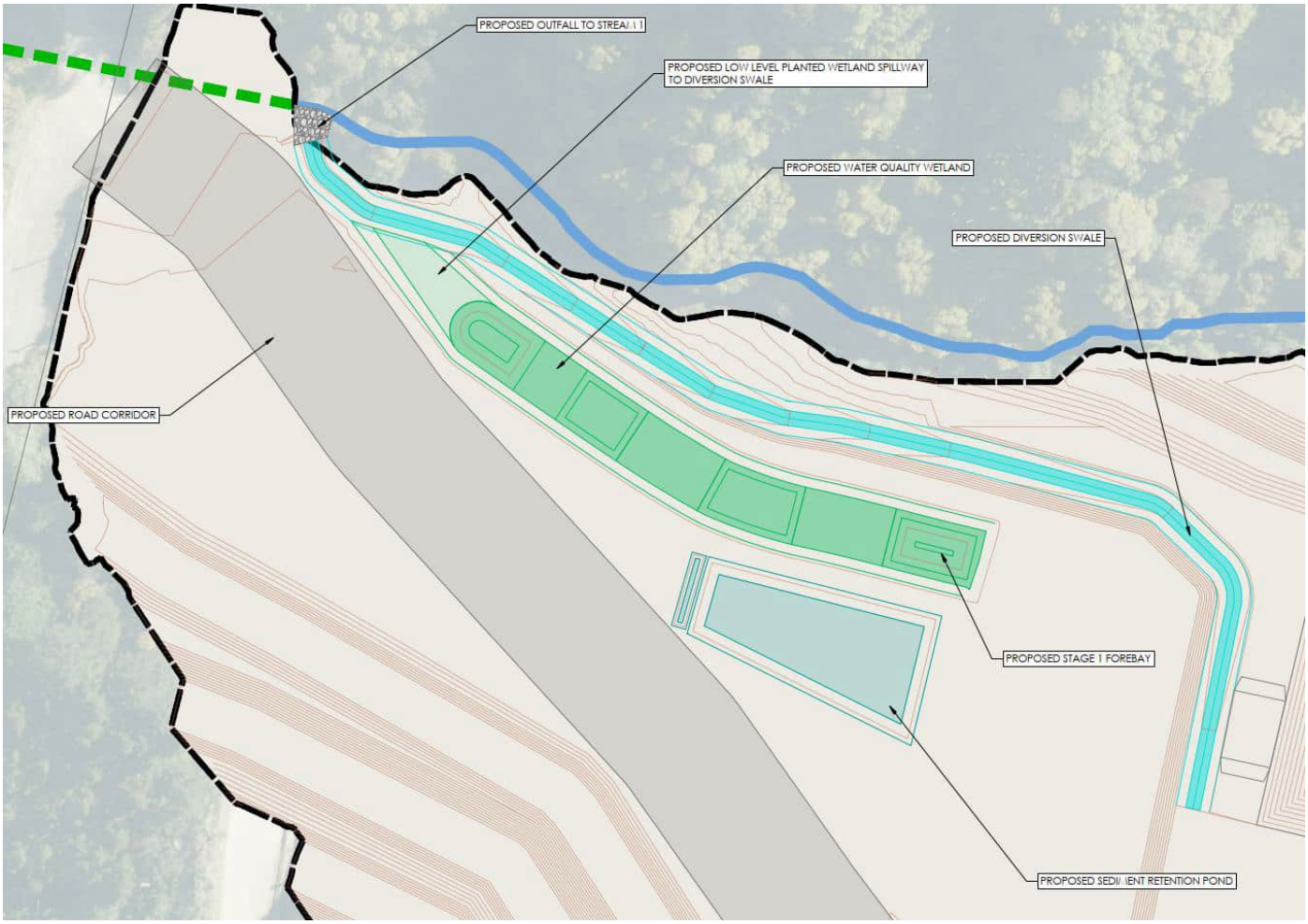


Figure 11: Stage 1 stormwater management layout

The lower quarry sump is sized to capture and treat the whole lower area, so this will not need to be expanded to facilitate expansion. The main quarry pit sump can be extended via cells as the quarry opens more operating area. The sumps should be constructed in a manner that ensures the sump is operational as soon as increased runoff is realised. The proposed main quarry pit cell arrangement in Figure 10 allows for stages 2 and 3 in the second cell and stages 4 and 5 in the third.

The wetland can also be expanded incrementally. The forebay in the stage 1 wetland is included in the stage 5 layout as a deep pool. As with the sumps, the wetland expansion should precede the quarry expansion to ensure the water quality is maintained.

7 Summary

Stormwater management for the proposed expansion of the Clevedon Quarry is proposed to be carried out by a two-stage system, targeting both hydrological and water quality impacts:

1. Sediment laden runoff shall be captured in sumps to remove sediment
2. Captured runoff from the sumps shall be pumped to a water quality treatment wetland

The main quarry pit sediment sump is sized to capture the runoff volume in a 20-year ARI rainfall event (including 2.1°C climate change). This level of service exceeds the minimum requirements of GD05, acknowledging the scale and operational duration of the quarry. Captured volumes are proposed to be pumped out of the sump once sediment drop out has occurred and would discharge via the treatment wetland. This approach achieves a targeted 90% TSS removal.

It is proposed to attenuate peak flows in all events up to the 100-year ARI (including 3.8°C climate change), predominantly via calibration and utilisation of the main quarry pit sediment removal sump. Pump out rates in events up to the 20-year ARI will be limited at less than the pre-development 95th percentile flows. Larger events would be attenuated in the main sump before discharging via the diversion channel. This approach achieves attenuation to approximately 60% of the pre-development peak flow for the quarry catchment (i.e. 60% below pre-development rates) in the 100-year ARI rainfall event, effectively mitigating any adverse effects on the stream, culvert, or downstream environment.

Overall, the proposed stormwater mitigation measures have been appropriately calibrated and designed in accordance international best practice to manage and mitigate hydrological and water quality impacts from the proposed quarry extension and anticipated 50-year operational duration. Residual impacts and downstream effects from the site and the proposed mitigation measures are expected to be negligible beyond the site boundary.

APPENDIX A

Concept Design Drawings

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MCNICOL ROAD

402

401

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LEGEND

- EXISTING PARCELS
- EXISTING STREAM
- EXISTING CULVERT
- PROPOSED MAJOR CONTOURS
- PROPOSED NEW ACCESS CORRIDOR
- PROPOSED DIVERSION SWALE
- PROPOSED WATER QUALITY WETLAND
- PROPOSED SEDIMENT POND
- PROPOSED QUARRY PIT SUMP

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SITE: MCNICOL ROAD, CLEVEDON

TITLE: CLEVEDON QUARRY

SUBTITLE: STORMWATER MANAGEMENT STAGE 1 - OVERVIEW

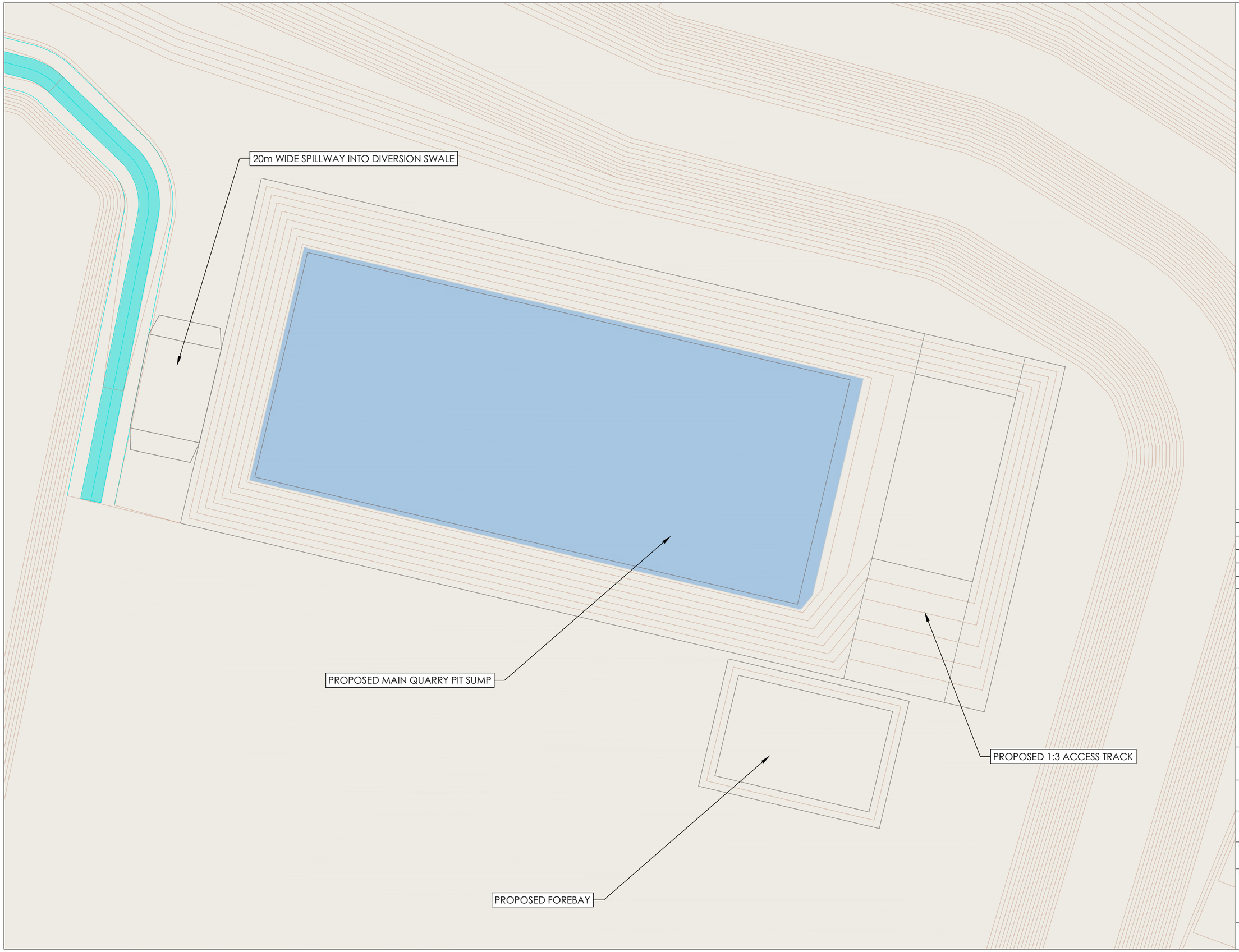
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STORMWATER MANAGEMENT
STAGE 1 - PIT SUMP

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PROPOSED OUTFALL TO STREAM 1

PROPOSED LOW LEVEL PLANTED WETLAND SPILLWAY TO DIVERSION SWALE

PROPOSED WATER QUALITY WETLAND

PROPOSED DIVERSION SWALE

PROPOSED ROAD CORRIDOR

PROPOSED STAGE 1 FOREBAY

PROPOSED SEDIMENT RETENTION POND

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LEGEND

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- EXISTING CULVERT
- PROPOSED MAJOR CONTOURS
- PROPOSED NEW ACCESS CORRIDOR
- PROPOSED DIVERSION SWALE
- PROPOSED WATER QUALITY WETLAND
- PROPOSED SEDIMENT POND
- PROPOSED QUARRY PIT SUMP

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STORMWATER MANAGEMENT STAGE 1 - LOWER QUARRY

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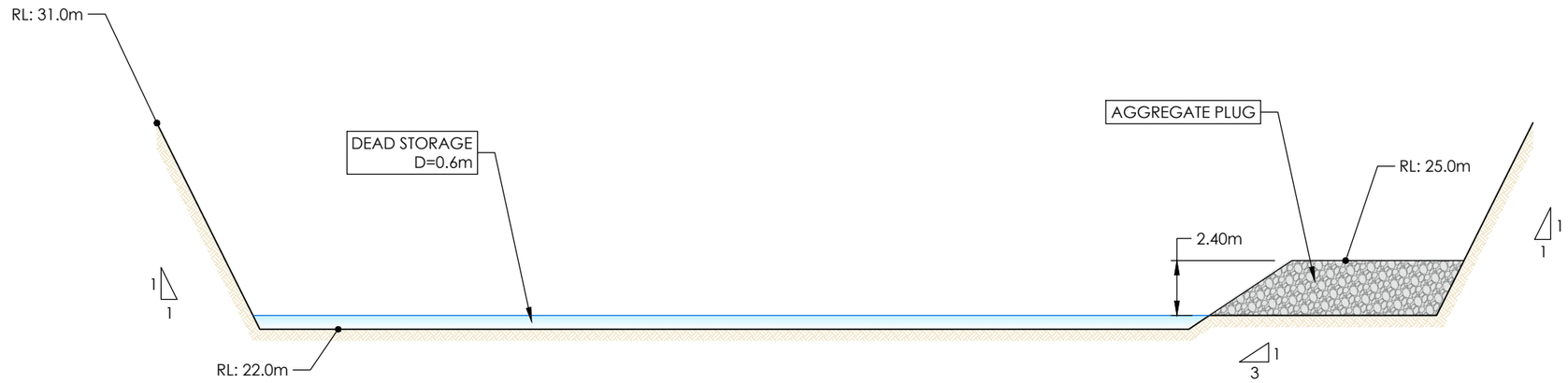
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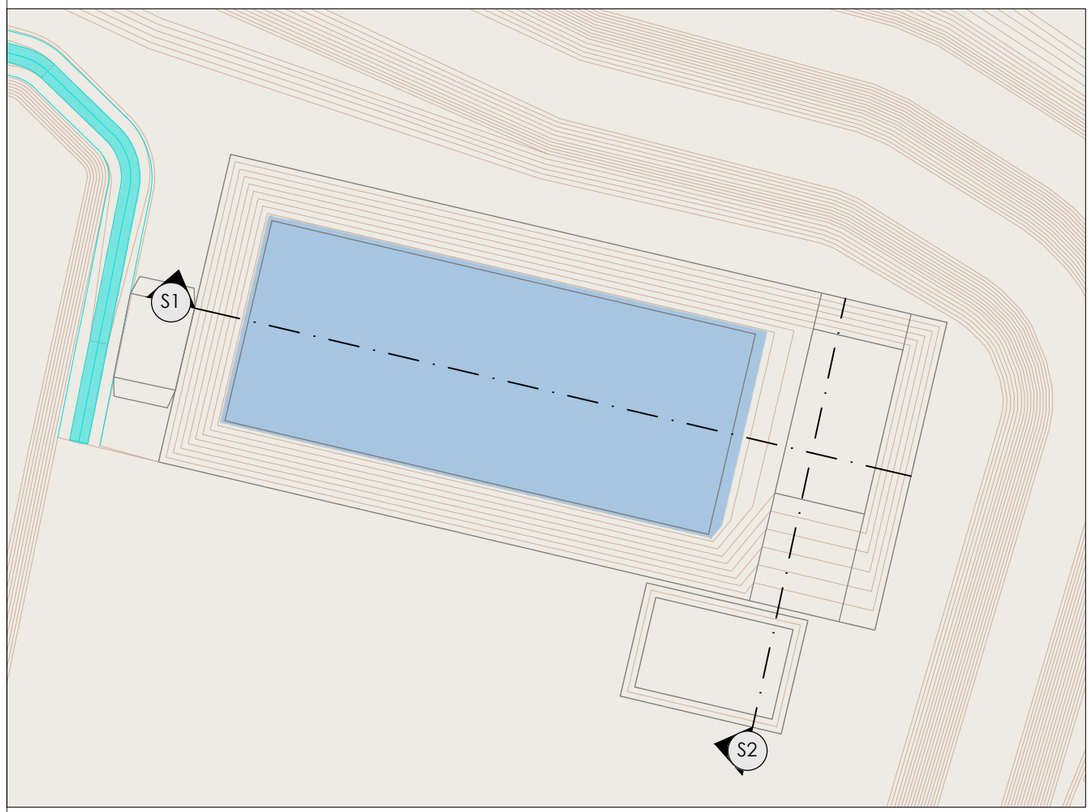
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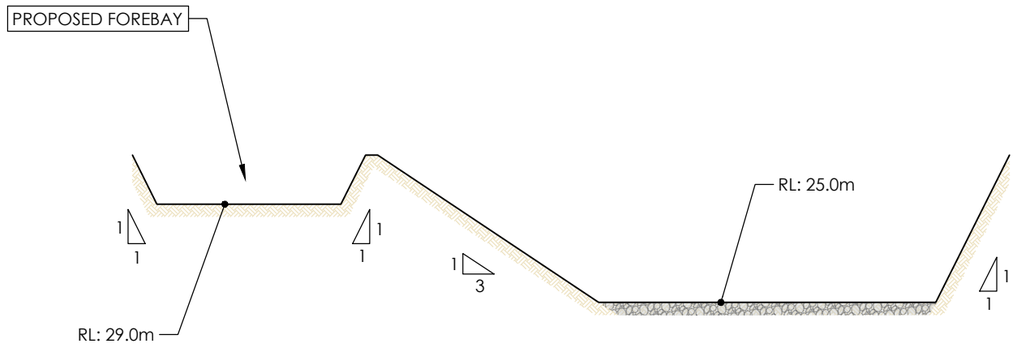


S1 PROPOSED MAIN QUARRY PIT SUMP - STAGE 1 LONGSECTION

SCALE: 1:500H, 1:250V(A3)



SCALE: 1:1000



S2 PROPOSED MAIN QUARRY PIT SUMP FOREBAY - STAGE 1 CROSS SECTION

SCALE: 1:500H, 1:250V(A3)

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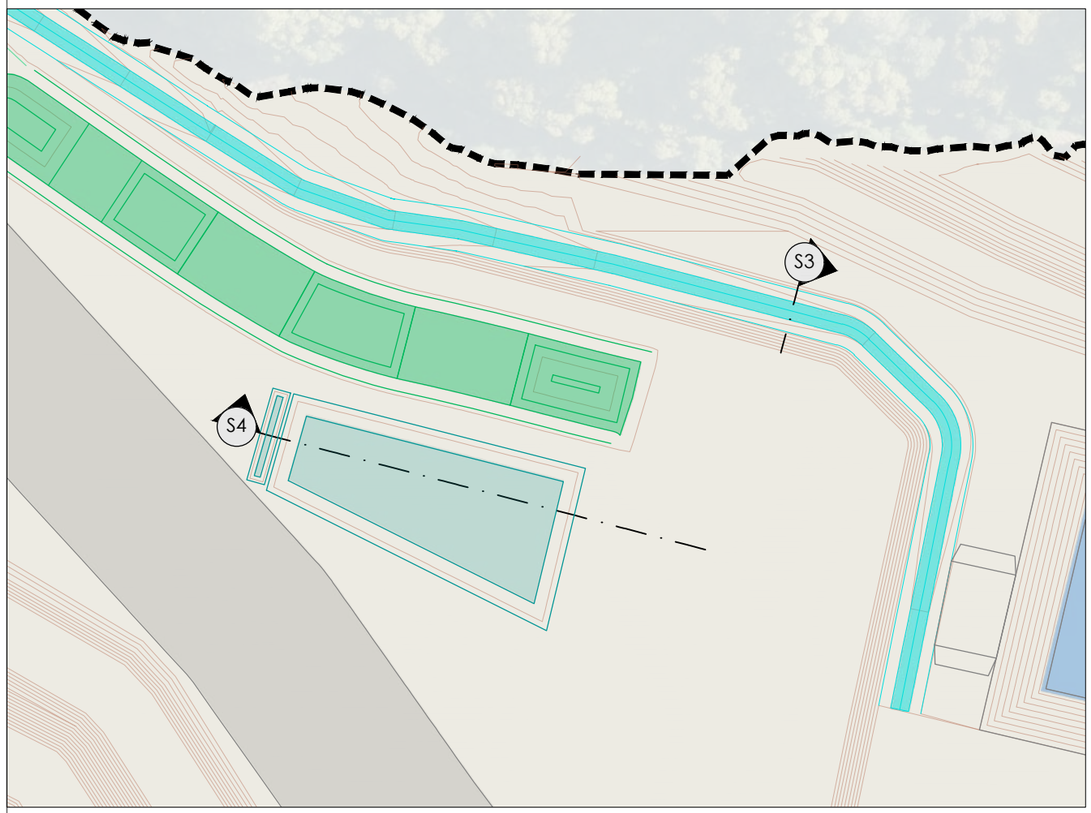
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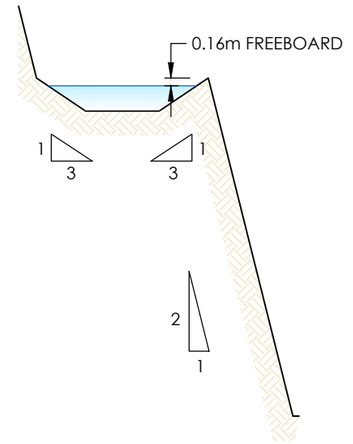
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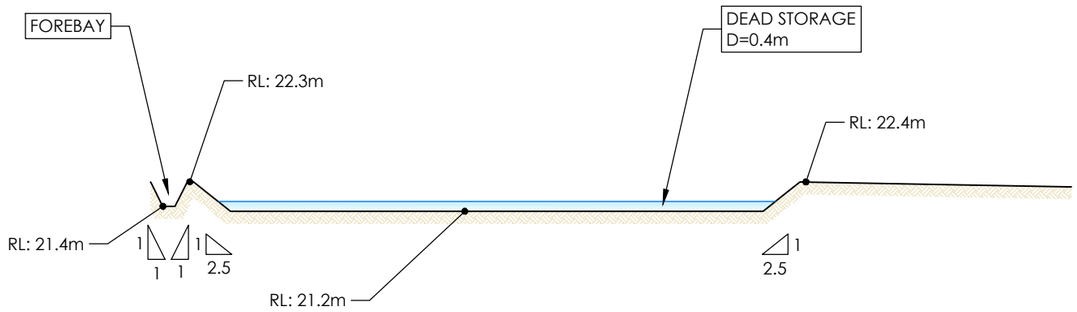


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S3 PROPOSED STAGE 1 DIVERSION SWALE CROSS SECTION

SCALE: 1:250H, 1:125V(A3)



S4 PROPOSED STAGE 1 SEDIMENT POND LONGSECTION

SCALE: 1:500H, 1:250V(A3)

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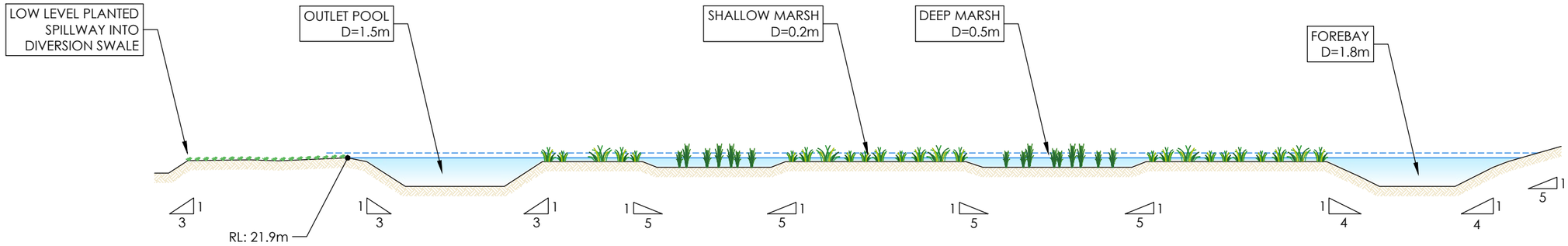
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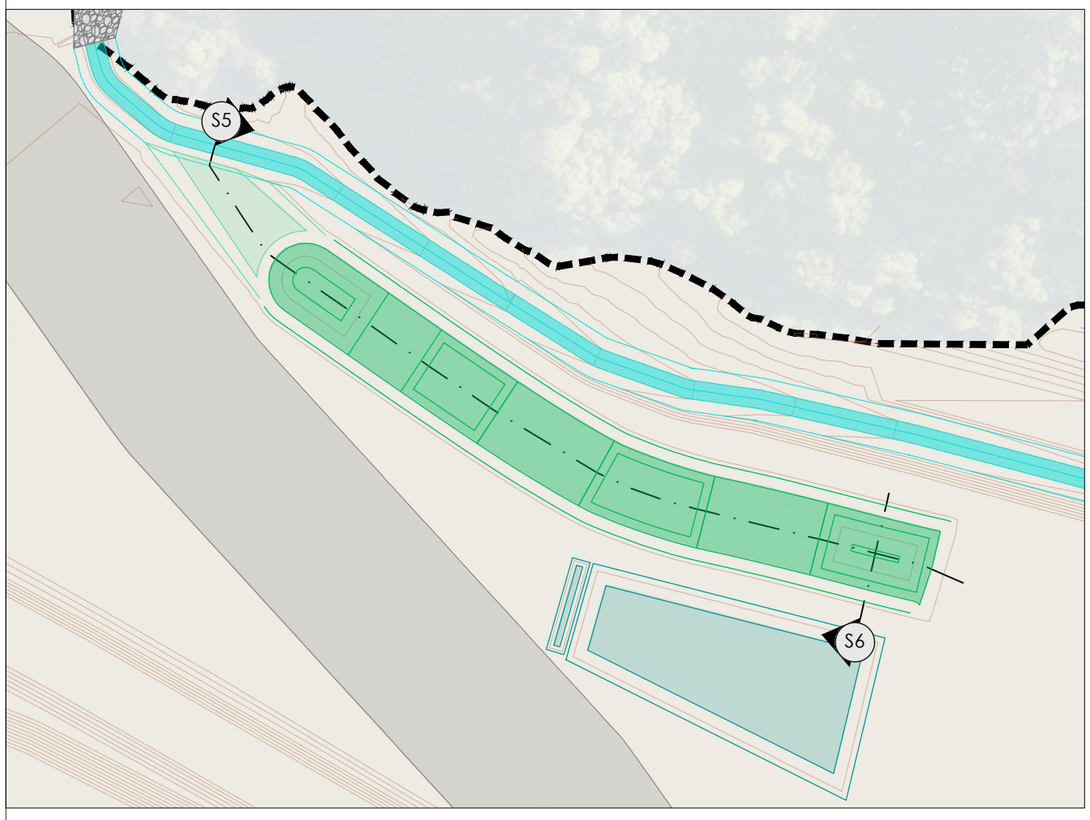
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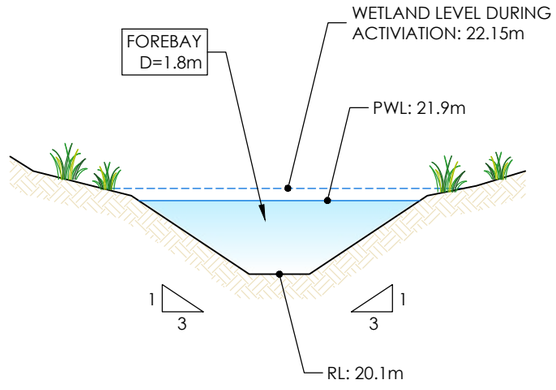


S5 PROPOSED STAGE 1 WATER QUALITY WETLAND LONGSECTION

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SCALE: 1:1000



S6 PROPOSED STAGE 1 WATER QUALITY WETLAND FOREBAY CROSS SECTION

SCALE: 1:250H, 1:125V(A3)

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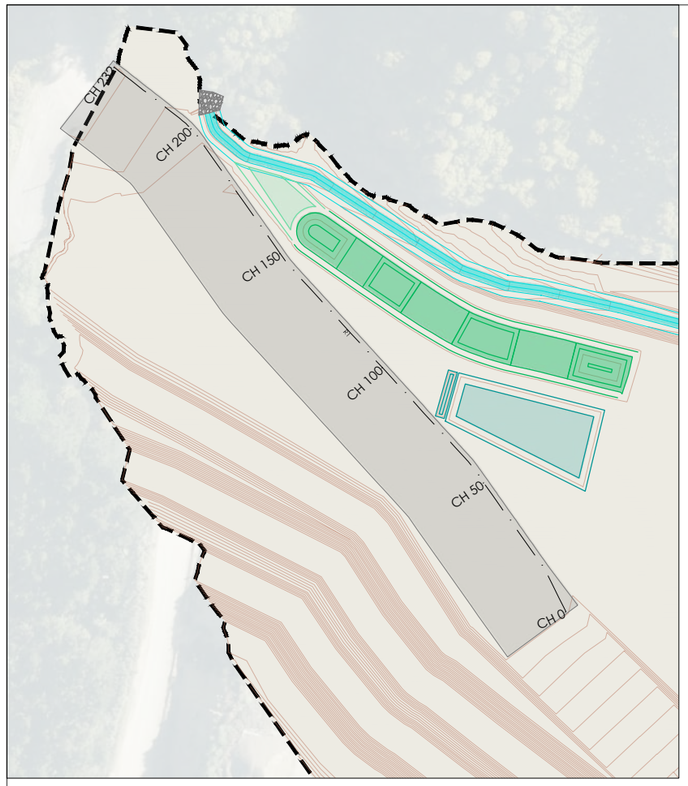
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SUBTITLE: STORMWATER MANAGEMENT STAGE 1 - SECTIONS 3 OF 3

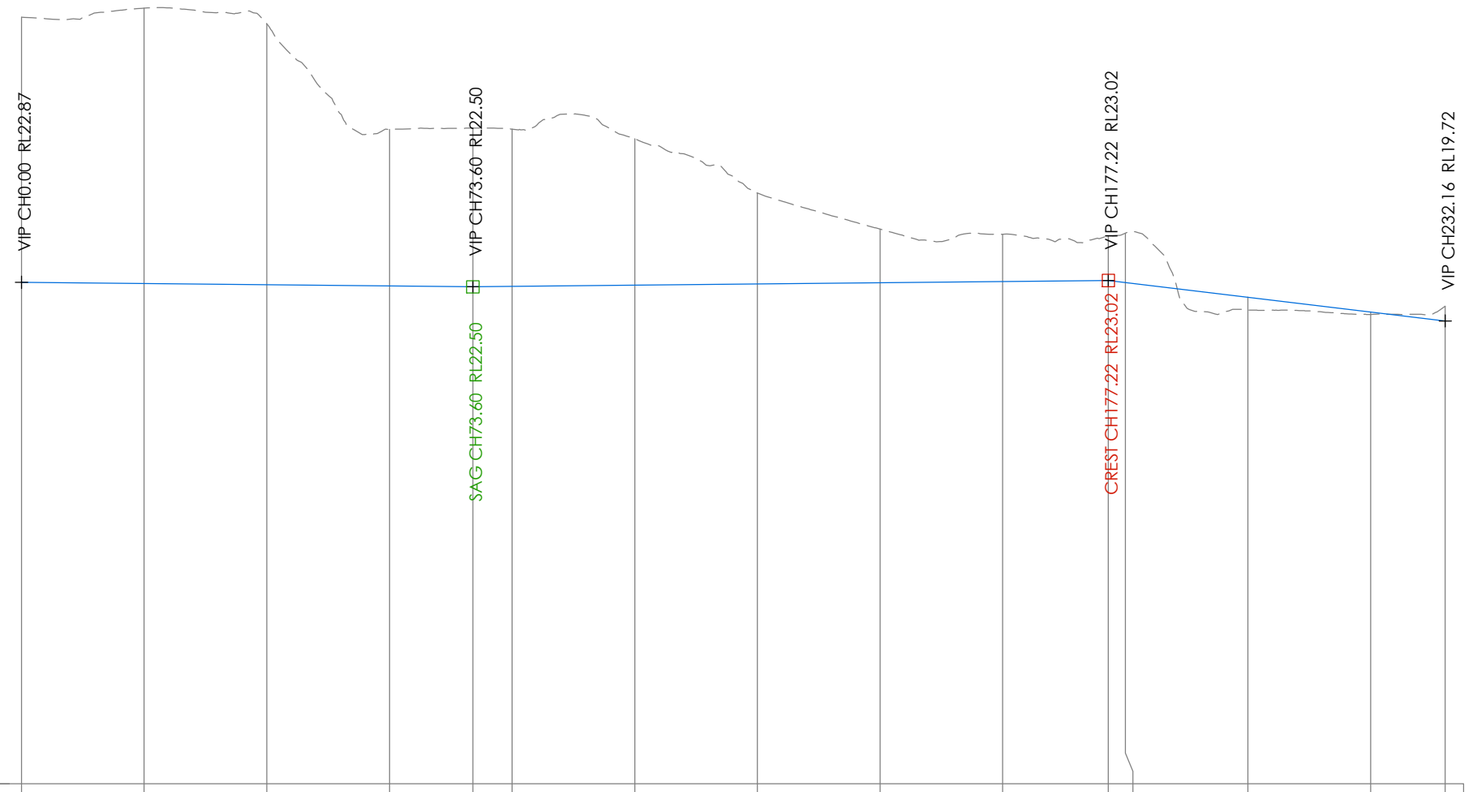
DRAWN:	REVIEWED:	APPROVED:
LT	MW	JT

NORTH:	SCALE AT A3:	DATE:
	AS SHOWN	18.06.2026
	STATUS: PC SUBMISSION	

PROJECT NO:	DRAWING NO:	REVISION:
T25175	405	A



SCALE: 1:2000



DATUM RL = -18.00

HORZ. CURVE LENGTH															
ROAD VERT. GEOMETRY			-0.5%					0.5%				-6%			
GRADE / LENGTH			73.6m L					103.62m L				54.94m L			
ROAD VERT. CURVES LENGTH / K VALUE															
DESIGN LEVELS	22.87	22.77	22.67	22.57	22.50	22.53	22.63	22.73	22.83	22.93	23.02	22.85	21.65	20.45	19.72
EXISTING LEVELS	44.48	45.21	43.94	35.33	35.44	35.35	34.58	30.15	27.21	26.79	26.59	26.87	20.61	20.25	20.93
CUT / FILL DEPTH	-21.61	-22.45	-21.27	-12.76	-12.94	-12.82	-11.95	-7.41	-4.37	-3.86	-3.57	-4.02	1.04	0.20	-1.21
CHAINAGE	0.00	20.00	40.00	60.00	73.60	80.00	100.00	120.00	140.00	160.00	177.22	180.00	200.00	220.00	232.16

R1 PROPOSED ACCESS ROAD CORRIDOR LONGSECTION
SCALE: 1:1000H, 1:500V(A3)

NOTES:

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4. ALL LEVELS IN TERMS OF NZVD-2016.

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REVISION DETAILS:		BY:	DATE:

TEKTUS CONSULTANTS

CLIENT:
STEVENSON AGGREGATES LIMITED

SITE: MCNICOL ROAD, CLEVEDON

TITLE: CLEVEDON QUARRY

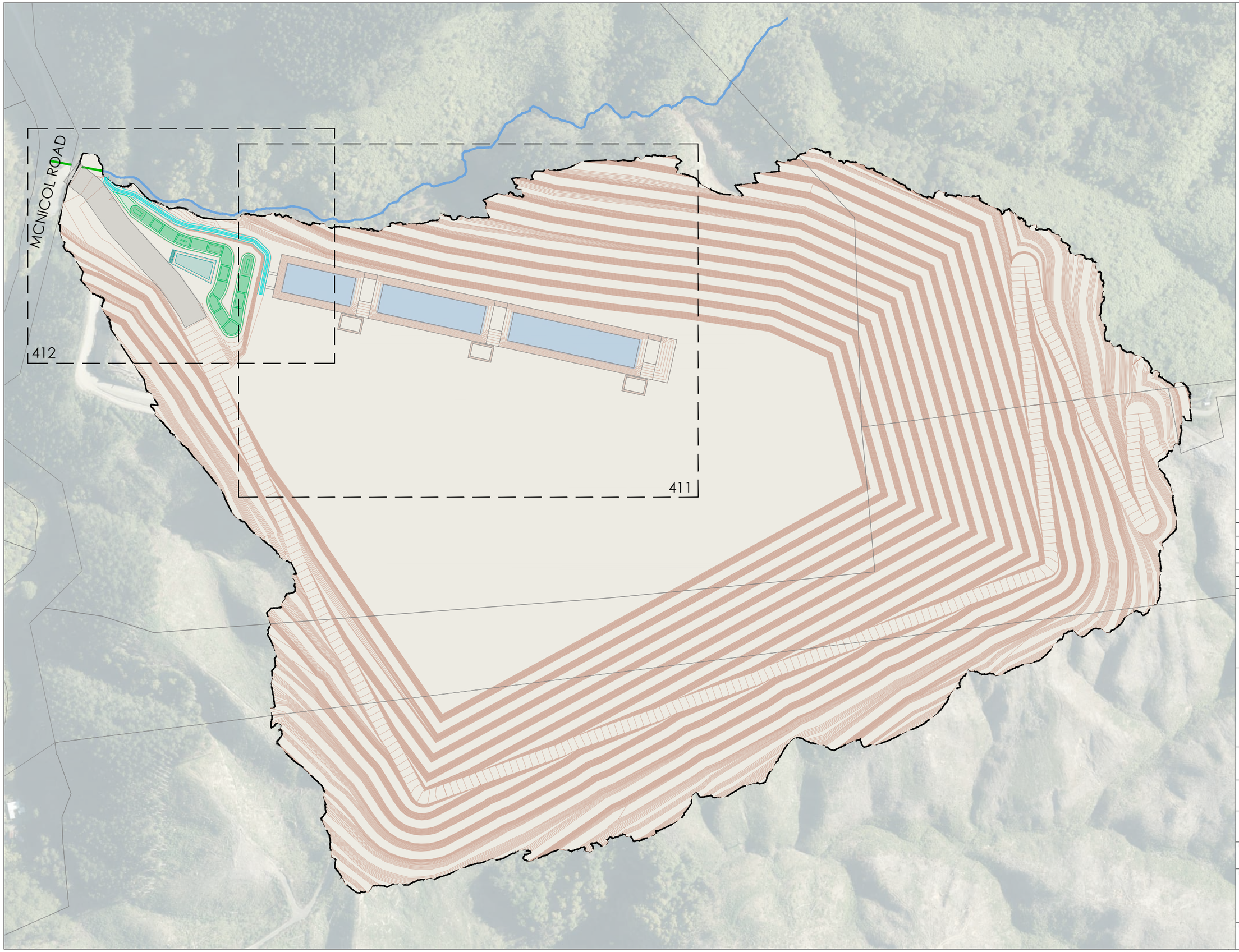
SUBTITLE: PROPOSED ACCESS ROAD CORRIDOR LONGSECTION

DRAWN:	REVIEWED:	APPROVED:
LT	MW	JT

NORTH:	SCALE AT A3:	DATE:
	AS SHOWN	18.06.2026
	STATUS: PC SUBMISSION	

PROJECT NO:	DRAWING NO:	REVISION:
T25175	406	A

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4. ALL LEVELS IN TERMS OF NZVD-2016.

LEGEND

- EXISTING PARCELS
- EXISTING STREAM
- EXISTING CULVERT
- PROPOSED MAJOR CONTOURS
- PROPOSED NEW ACCESS CORRIDOR
- PROPOSED DIVERSION SWALE
- PROPOSED WATER QUALITY WETLAND
- PROPOSED SEDIMENT POND
- PROPOSED QUARRY PIT SUMP

A	FOR PLAN CHANGE SUBMISSION	LT	18.06.2026
REVISION DETAILS:		BY:	DATE:

TEKTUS CONSULTANTS

CLIENT:

STEVENSON AGGREGATES LIMITED

SITE: MCNICOL ROAD, CLEVEDON

TITLE: CLEVEDON QUARRY

SUBTITLE: STORMWATER MANAGEMENT STAGE 5 - OVERVIEW

DRAWN:	REVIEWED:	APPROVED:
LT	MW	JT

NORTH:

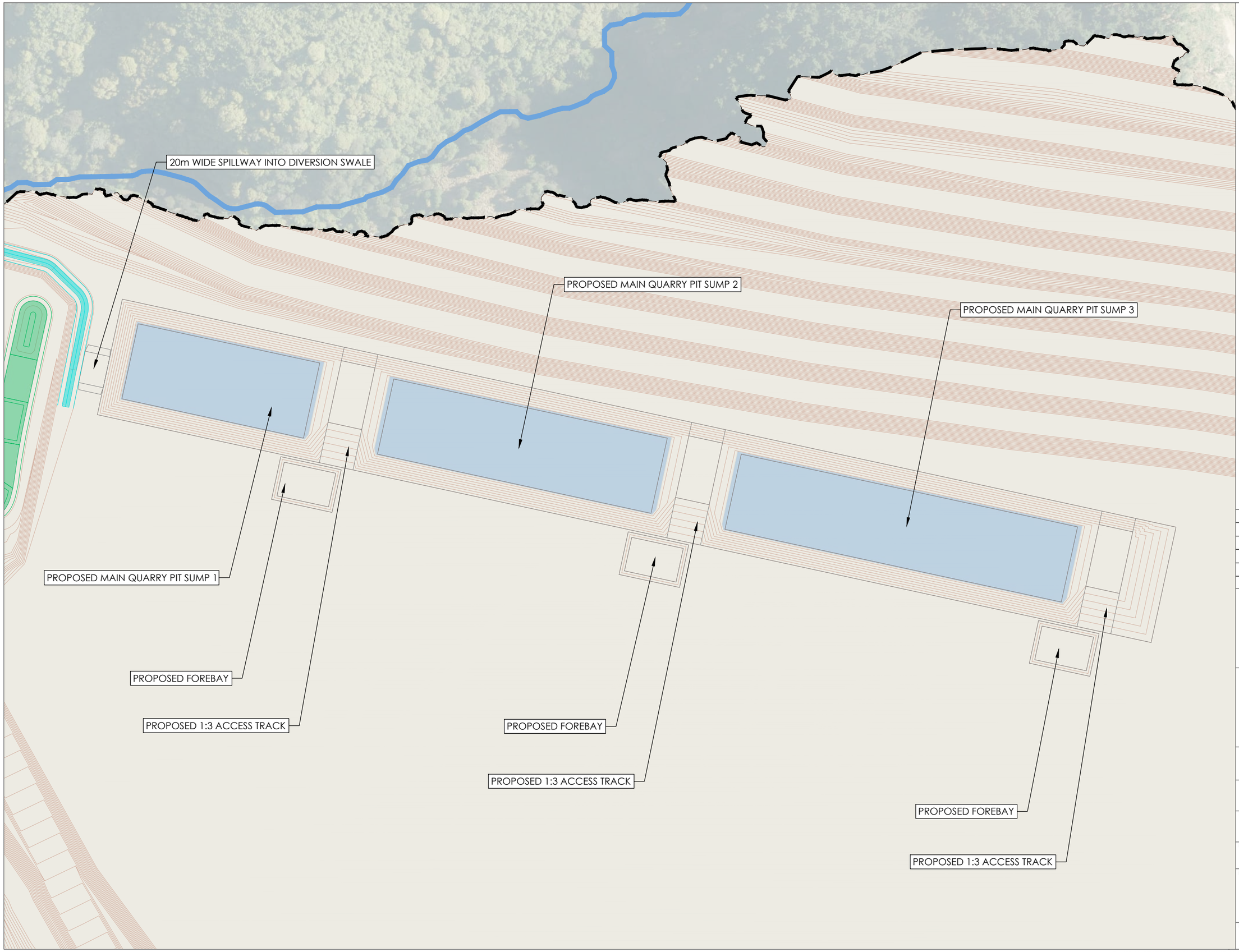
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1:4000	18.06.2026

STATUS: PC SUBMISSION

PROJECT NO:	DRAWING NO:	REVISION:
T25175	410	A

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4. ALL LEVELS IN TERMS OF NZVD-2016.

LEGEND

- EXISTING PARCELS
- EXISTING STREAM
- EXISTING CULVERT
- PROPOSED MAJOR CONTOURS
- PROPOSED NEW ACCESS CORRIDOR
- PROPOSED DIVERSION SWALE
- PROPOSED WATER QUALITY WETLAND
- PROPOSED SEDIMENT POND
- PROPOSED QUARRY PIT SUMP

A	FOR PLAN CHANGE SUBMISSION	LT	18.06.2026
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TEKTUS CONSULTANTS

CLIENT:
STEVENSON AGGREGATES LIMITED

SITE:
MCNICOL ROAD, CLEVEDON

TITLE:
CLEVEDON QUARRY

SUBTITLE:
STORMWATER MANAGEMENT
STAGE 5 - PIT SUMP

DRAWN:	REVIEWED:	APPROVED:
LT	MW	JT

NORTH:	SCALE AT A3:	DATE:
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	STATUS: PC SUBMISSION	

PROJECT NO:	DRAWING NO:	REVISION:
T25175	411	A

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3. HORIZONTAL DATUM IS NZGD2000. ORIGIN IS MT EDEN.
4. ALL LEVELS IN TERMS OF NZVD-2016.

LEGEND

- EXISTING PARCELS
- EXISTING STREAM
- EXISTING CULVERT
- PROPOSED MAJOR CONTOURS
- PROPOSED NEW ACCESS CORRIDOR
- PROPOSED DIVERSION SWALE
- PROPOSED WATER QUALITY WETLAND
- PROPOSED SEDIMENT POND
- PROPOSED QUARRY PIT SUMP

A	FOR PLAN CHANGE SUBMISSION	LT	18.06.2026
REVISION DETAILS:		BY:	DATE:

TEKTUS CONSULTANTS

CLIENT:

STEVENSON AGGREGATES LIMITED

SITE: MCNICOL ROAD, CLEVEDON

TITLE: CLEVEDON QUARRY

SUBTITLE: STORMWATER MANAGEMENT STAGE 5 - LOWER QUARRY

DRAWN:	REVIEWED:	APPROVED:
LT	MW	JT

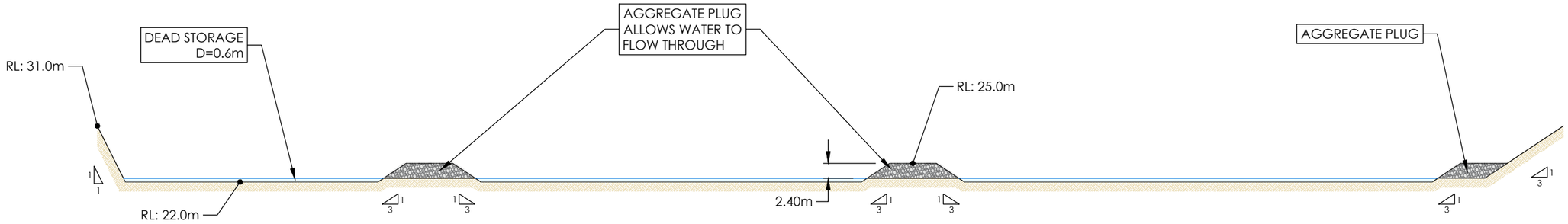
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STATUS: PC SUBMISSION

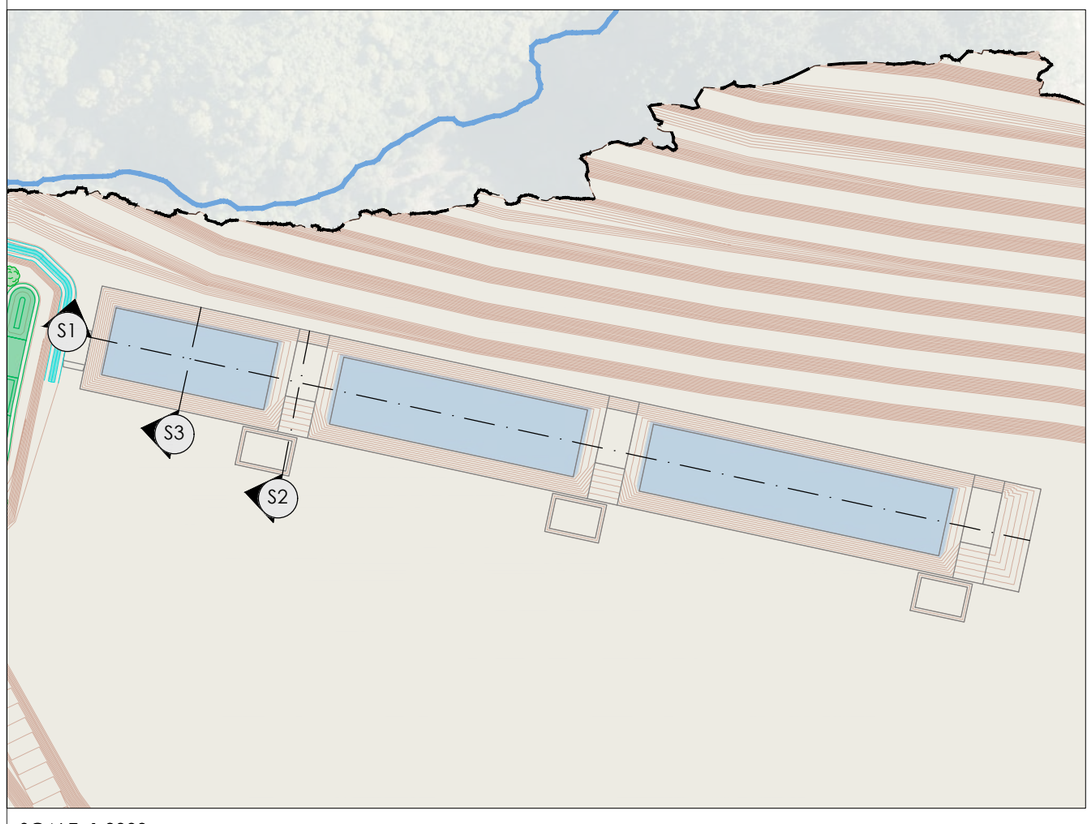
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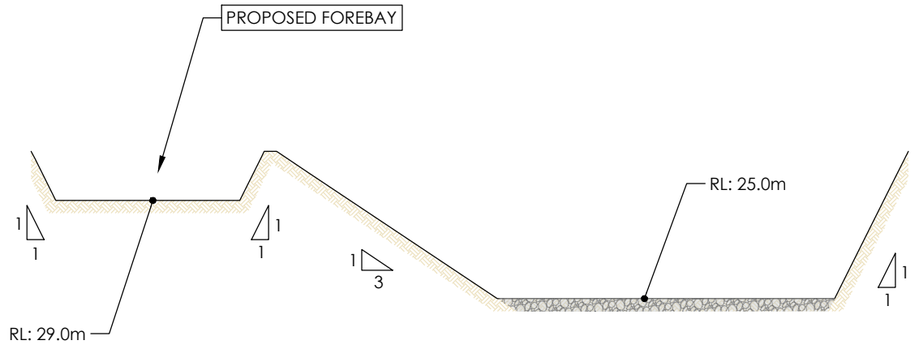


S1 PROPOSED MAIN QUARRY PIT SUMP - STAGE 5 LONGSECTION

SCALE: 1:1500H, 1:750V(A3)

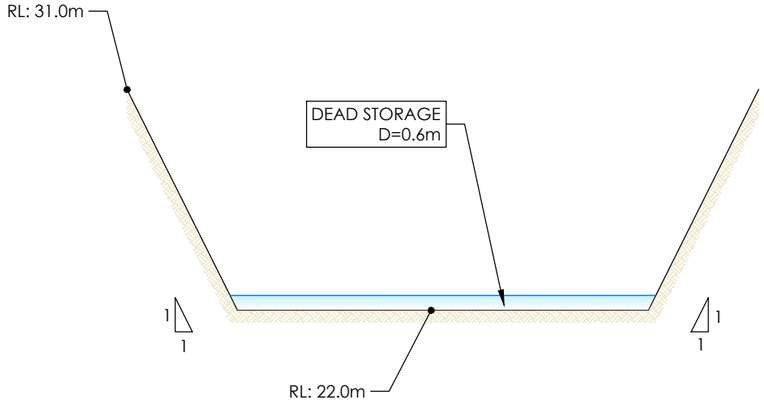


SCALE: 1:3000



S2 PROPOSED MAIN QUARRY PIT SUMP FOREBAY - STAGE 5 CROSS SECTION

SCALE: 1:500H, 1:250V(A3)



S3 PROPOSED MAIN QUARRY PIT SUMP - STAGE 5 CROSS SECTION

SCALE: 1:500H, 1:250V(A3)

NOTES:

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A	FOR PLAN CHANGE SUBMISSION	LT	18.06.2026
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CLIENT:

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SITE: MCNICOL ROAD, CLEVEDON

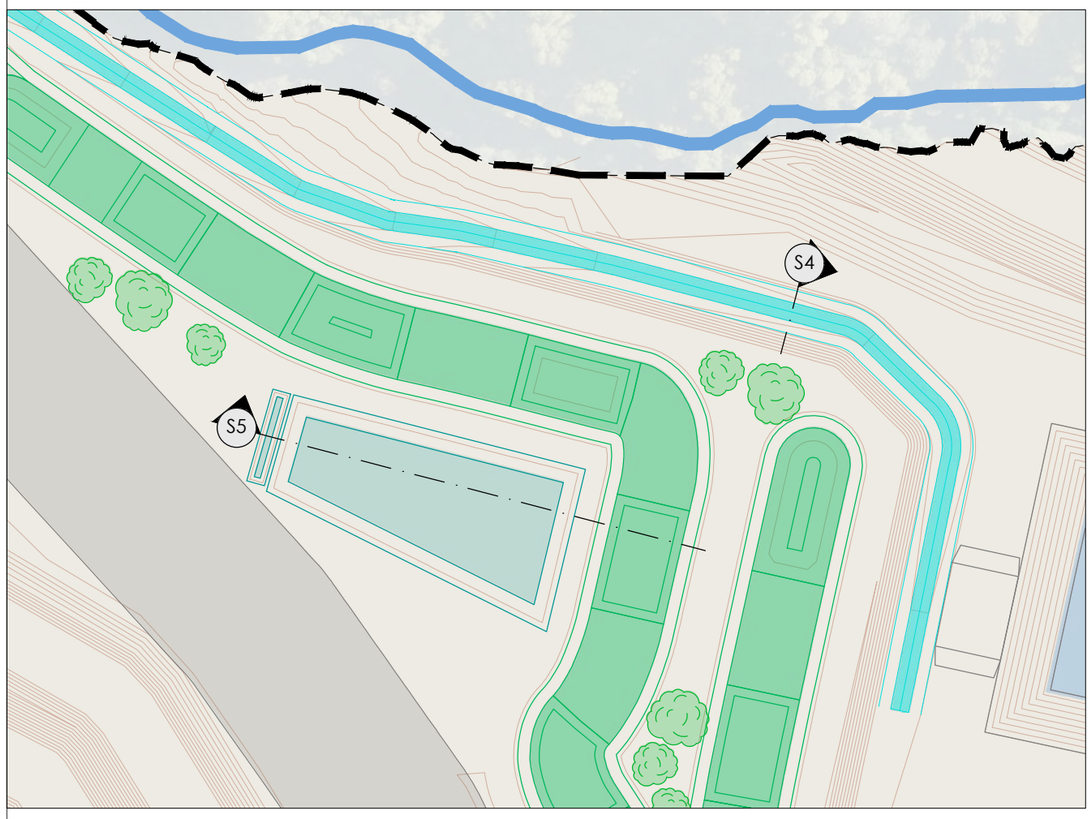
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SUBTITLE: STORMWATER MANAGEMENT STAGE 5 - SECTIONS 1 OF 3

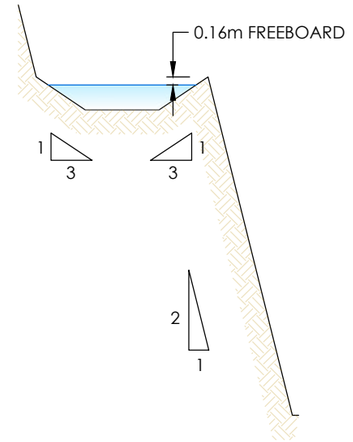
DRAWN:	REVIEWED:	APPROVED:
LT	MW	JT

NORTH:	SCALE AT A3:	DATE:
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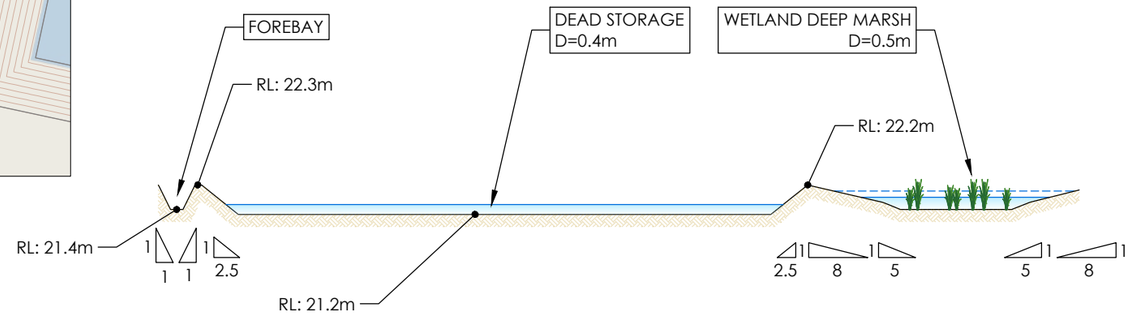


SCALE: 1:1000



S4 PROPOSED STAGE 5 DIVERSION SWALE CROSS SECTION

SCALE: 1:250H, 1:125V(A3)



S5 PROPOSED STAGE 5 SEDIMENT POND LONGSECTION

SCALE: 1:500H, 1:250V(A3)

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REVISION DETAILS:		BY:	DATE:

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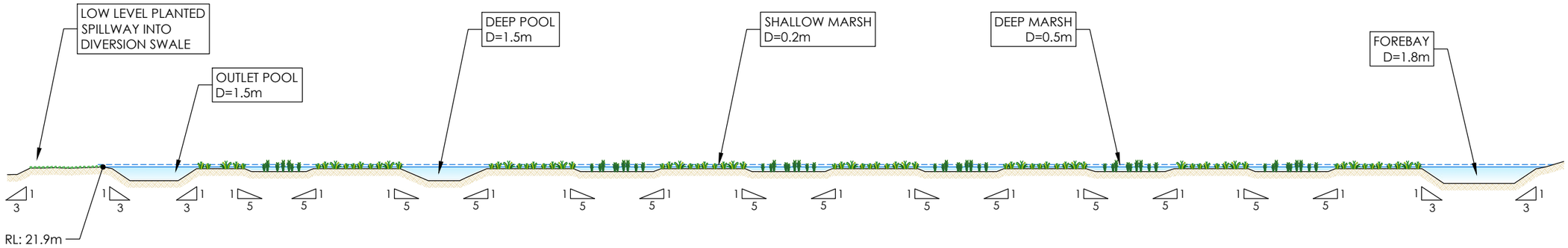
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SUBTITLE: STORMWATER MANAGEMENT STAGE 5 - SECTIONS 2 OF 3

DRAWN:	REVIEWED:	APPROVED:
LT	MW	JT

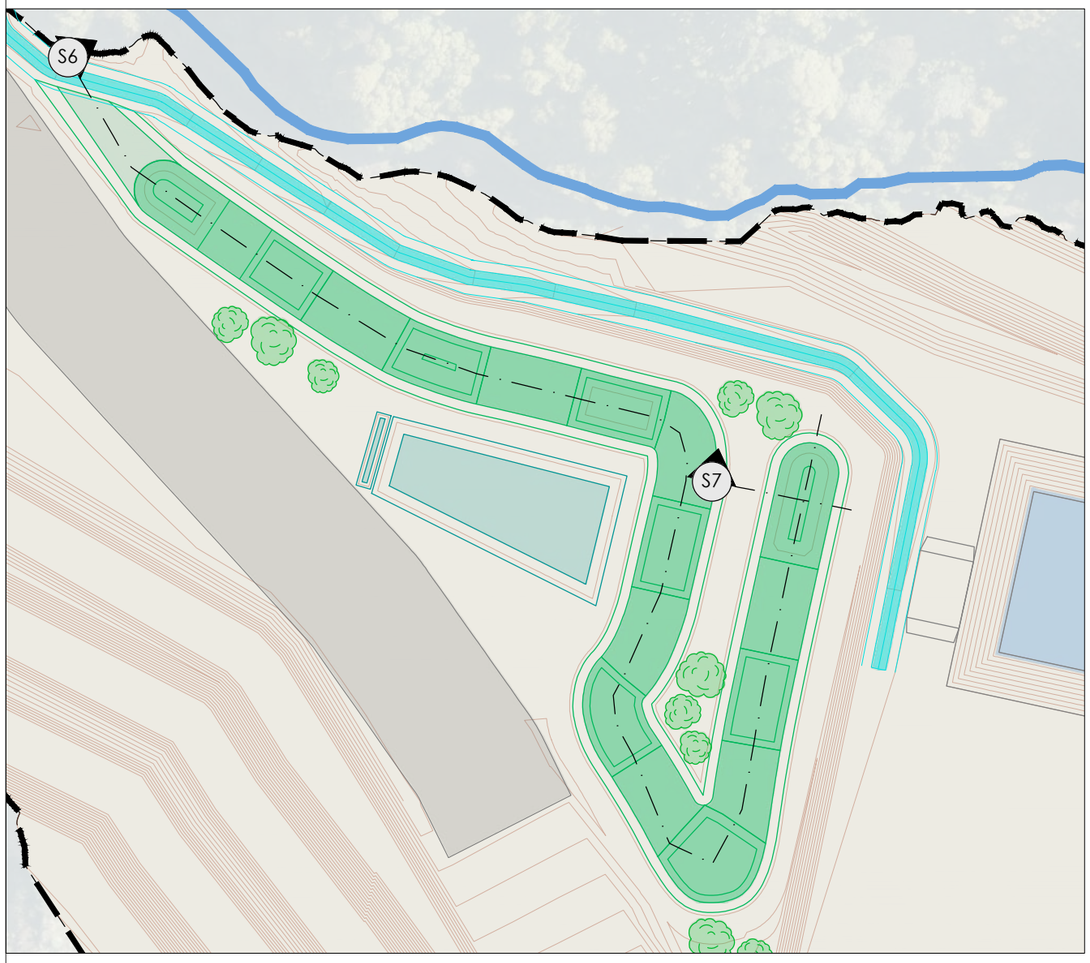
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	AS SHOWN	18.06.2026
	STATUS: PC SUBMISSION	

PROJECT NO:	DRAWING NO:	REVISION:
T25175	414	A

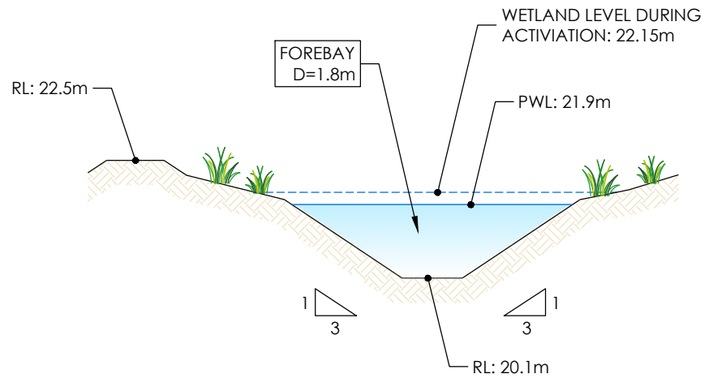


S6 PROPOSED STAGE 5 WATER QUALITY WETLAND LONGSECTION

SCALE: 1:1000H, 1:500V(A3)



SCALE: 1:1250



S7 PROPOSED STAGE 5 WATER QUALITY WETLAND FOREBAY CROSS SECTION

SCALE: 1:250H, 1:250V(A3)

NOTES:

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3. HORIZONTAL DATUM IS NZGD2000. ORIGIN IS MT EDEN.
4. ALL LEVELS IN TERMS OF NZVD-2016.

A	FOR PLAN CHANGE SUBMISSION	LT	18.06.2026
REVISION DETAILS:		BY:	DATE:

TEKTUS CONSULTANTS

CLIENT: STEVENSON AGGREGATES LIMITED

SITE: MCNICOL ROAD, CLEVEDON

TITLE: CLEVEDON QUARRY

SUBTITLE: STORMWATER MANAGEMENT STAGE 5 - SECTIONS 3 OF 3

DRAWN:	REVIEWED:	APPROVED:
LT	MW	JT

NORTH:	SCALE AT A3:	DATE:
	AS SHOWN	18.06.2026
	STATUS: PC SUBMISSION	

PROJECT NO:	DRAWING NO:	REVISION:
T25175	415	A

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TITLE: CLEVEDON QUARRY

SUBTITLE: STORMWATER MANAGEMENT STAGE 5 - SPILLWAY & OUTFALL

DRAWN:	REVIEWED:	APPROVED:
LT	MW	JT
NORTH:	SCALE AT A3: 1:300	DATE: 18.06.2026
	STATUS: PC SUBMISSION	
PROJECT NO: T25175	DRAWING NO: 420	REVISION: A

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APPENDIX B

Calculations

Hydrology Parameters

			Stage 1			Stage 5		
Rainfall Scenario	Parameters	Existing	Total	Upper Bench*	Lower Bench	Total	Upper Bench*	Lower Bench
	Catchment Area (m^2)	118,629 m^2	204,611 m^2	175,611 m^2	29,000 m^2	748,882 m^2	719,882 m^2	29,000 m^2
	CN	91	91	85	91	91	91	91
	Soil Loss (mm)	25 mm	25 mm	44 mm	25 mm	25 mm	25 mm	25 mm
95th	Rainfall (mm)	39 mm	39 mm	39 mm	39 mm	39 mm	39 mm	39 mm
	Peak Runoff (m^3/s)	0.499	0.112	0.454 (0.0)	0.112	0.112	2.38 (0.0)	0.112
	Runoff Volume (m^3)	2,305 m^3	3,976 m^3	2,573 m^3	563 m^3	14,551 m^3	13,988 m^3	563 m^3
2Y	Rainfall (mm)	92 mm	92 mm	92 mm	92 mm	92 mm	92 mm	92 mm
	Peak Runoff (m^3/s)	1.695	0.381	1.731 (0.0)	0.381	0.381	7.7 (0.0)	0.381
	Runoff Volume (m^3)	8,008 m^3	13,813 m^3	10,118 m^3	1,958 m^3	50,555 m^3	48,597 m^3	1,958 m^3
5Y	Rainfall (mm)	151 mm	151 mm	151 mm	151 mm	151 mm	151 mm	151 mm
	Peak Runoff (m^3/s)	2.998	0.683	3.333 (0.0)	0.683	0.683	13.844 (0.0)	0.683
	Runoff Volume (m^3)	14,812 m^3	25,548 m^3	19,714 m^3	3,621 m^3	93,506 m^3	89,885 m^3	3,621 m^3
10Y	Rainfall (mm)	187 mm	187 mm	187 mm	187 mm	187 mm	187 mm	187 mm
	Peak Runoff (m^3/s)	3.836	0.866	4.595 (0.0)	0.866	0.866	18.687 (0.0)	0.866
	Runoff Volume (m^3)	18,925 m^3	32,642 m^3	25,629 m^3	4,626 m^3	119,470 m^3	114,844 m^3	4,626 m^3
20Y	Rainfall (mm)	222 mm	222 mm	222 mm	222 mm	222 mm	222 mm	222 mm
	Peak Runoff (m^3/s)	3.836	1.043	5.623 (0.0)	1.043	1.043	22.531 (0.0)	1.043
	Runoff Volume (m^3)	23,107 m^3	39,855 m^3	31,690 m^3	5,649 m^3	145,869 m^3	140,220 m^3	5,649 m^3
100Y	Rainfall (mm)	325 mm	325 mm	325 mm	325 mm	325 mm	325 mm	325 mm
	Peak Runoff (m^3/s)	7.224	1.631	9.009 (1.044)	1.632	4.287	35.244 (4.13)	1.632
	Runoff Volume (m^3)	35,222 m^3	60,750 m^3	49,387 m^3	8,610 m^3	222,348 m^3	213,738 m^3	8,610 m^3

*Runoff during the 24-hour storm event is shown in brackets. For events up to the 20-year; runoff will be discharged at 0.464m^3/s via the water quality wetland ~3 days after the rain event.

Minimum Hydrology Mitigation Requierments

	Parameters	Stage 1 Upper Bench	Stage 1 lower Bench	Stage 5 Upper Bench	Stage 5 lower Bench
	GW Infiltration Rate	1.9	na	4.5	na
	3-Day Infiltration Volume	492.5	na	1166.4	na
SRP sizing	Treatment Volume	31800.0	870.0	140400.0	870.0
SRP sizing	Primary Release Rate (Pump)	0.105	NA	0.464	NA
SRP sizing	Draindown Time	84.0		84.0	
SRP sizing	Base Area	2391		10663	
SRP sizing	Top Area	5552		22566	
SRP sizing	Depth	9		9	
SRP sizing	Assumed Particle Size	0.01		0.01	
SRP sizing	Settling Velocity	0.1		0.1	
SRP sizing	Settling Time	90.0		90.0	
SRP sizing	Dead Storage Depth	0.6	0.4	0.6	0.4
SRP sizing	Dead Storage Volume	1580	261	6479	261
SRP sizing	Dead Storage %	5%	30%	5%	30%
Attenuation	Secondary Release Rate (weir)	1.00	1.63	4.13	1.63
Attenuation	Weir Width	30.00	NA	30.00	NA
Attenuation	Weir Depth	0.07		0.23	
Attenuation	Additional Attenuation Volume	2848.43		11092.64	
Attenuation	Total Volume	36721.41	1131.00	159137.98	1131.00

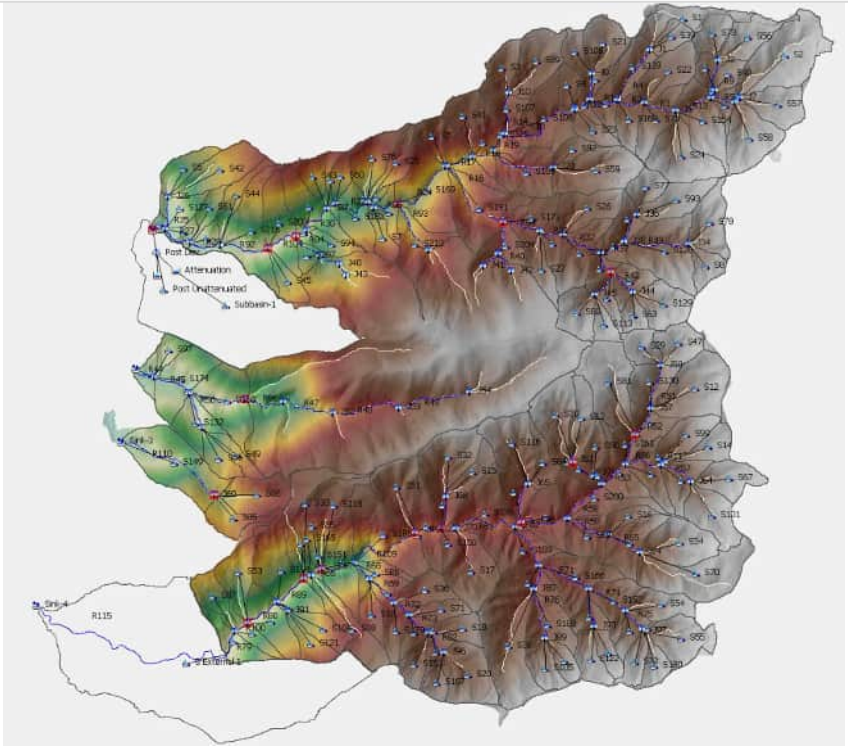
Proposed Storage Volumes

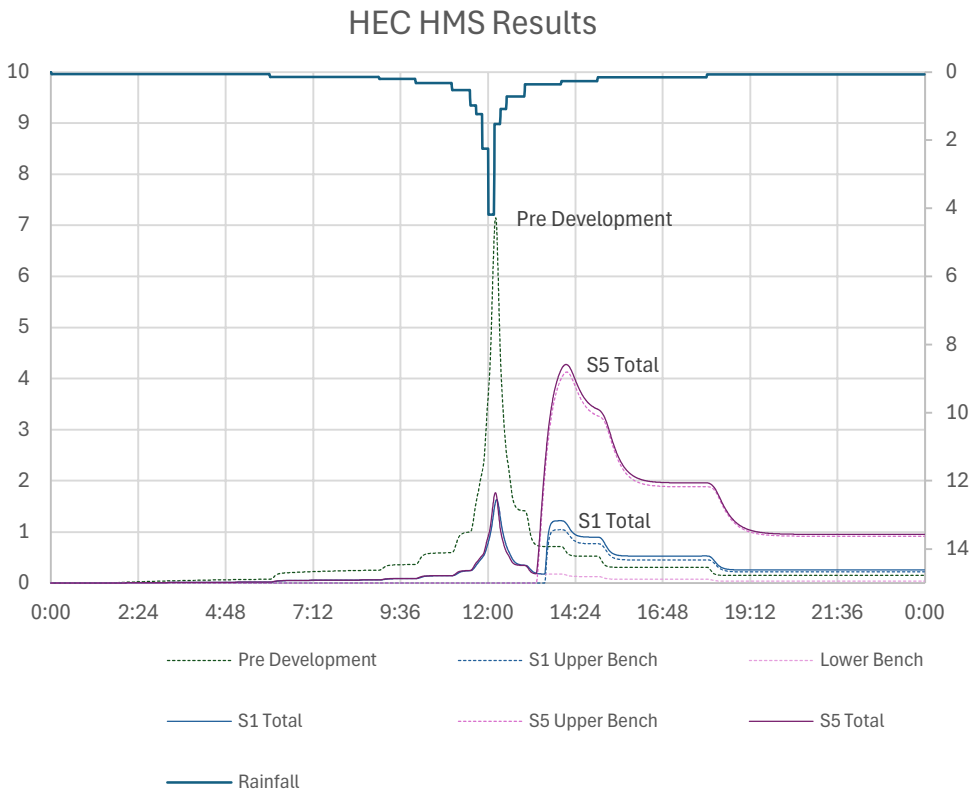
	Eleavtion	Stage 1 Upper	Stage 5 Upper
	22.0-22.6m (SRP Dead Storage)	1681.0	7319.0
	22.6-25.0m (SRP Regular Function	7838.0	33851.0
	22.0-31.0m (Top of SRP)	39583.0	163857.0

Elevation	Lower SRP
21.2- 21.6 (Dead Storage	297.0
21.2- 22.4 (Dead Storage	1046.0

Water Quality Parameters

		Stage 1	Stage 5
Wetland Sizing	Total WQV (m^3)	2452	8976
	Assumed SRP TSS Removal	75%	75%
	SRP Blockage Factor	30%	30%
	Required Wetland TSS Removal Efficiency	60%	60%
	TP10 WQV equivalent Volume Factor	0.5	0.5
	Total TSS Removal No Blockage	90.0%	90.0%
	Total TSS Removal With Blockage	81.0%	81.0%
	Required WQV (m^3)	1226	4488




HEC HMS Results
10
9
8
7
6
5
4
3
2
1
0
0
2
4
6
8
10
12
14
0:00
2:24
4:48
7:12
9:36
12:00
14:24
16:48
19:12
21:36
0:00
Pre Development
S5 Total
S1 Total
Pre Development
S1 Upper Bench
Lower Bench
S1 Total
S5 Upper Bench
S5 Total
Rainfall