BIOME
WATER AND ENVIRONMENTAL CONSULTING

Bioretention Basin and Drainage Reserve Design Report

Altitude Aspire,

Terranora

for

Newland Developers Pty Ltd

Version 3

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Executive Summary

This Bioretention Basin and Drainage Reserve Design Report (Version 3), has been prepared on behalf of Newland Developers Pty Ltd to support revised designs of the bioretention basins and central drainage channel conveyance within the Altitude Aspire residential development at 37 Fraser Drive, Terranora (the subject site).

Versions 1 and 2 of this report were submitted to Council for consideration and whilst the revised designs presented for the bioretention basins and central drainage channel conveyance were conceptually supported, additional detail has been requested. This version of the report includes the requested additional detail.

It is noted that two (2) reports, including a *Stormwater Assessment & Management Plan* and *Hydrologic & Hydraulic Assessment Report*, by Gilbert and Sutherland (dated April 2013) have been previously completed and approved by Council. These reports detail designs and sizing of the stormwater treatment measures (bioretention basins) and also provide a hydraulic assessment of the previous central drainage channel conveyance channel.

The purpose of this report is to:

- provide revised (up to date) *MUSICv6* modelling and a greater level of detail for the bio-retention basin to be located within the central drainage area; and
- to detail an alternative configuration for the central drainage reserve and conveyance channel, aimed at limiting peak velocities and depths so as to improve safety and ongoing maintenance requirements.

It has been demonstrated via *MUSICv6* modelling, that the proposed revised bioretention basin configurations and stormwater treatment train will achieve pollutant removal efficiencies of 80%, 60%, 45% and 90% for TSS, TP, TN and gross pollutants respectively.

In addition it has been demonstrated that peak water depths and velocities within the central drainage reserve can be greatly reduced, from the previous design, whilst maintaining the overall capacity of the flowpath to convey upstream flows. Maximum d.V product has been reduced from over 6 m^2/s to below 3.5 m^2/s.

Whilst this represents an improvement in safety, urban waterways and stormwater drainage systems with d.V products of greater than 0.6 m^2/s remain a safety risk (Table 12.1.12 of QUDM). It will therefore be necessary to restrict access and discourage a person/child from entering areas with an expected d.V product of greater than 0.6 m^2/s with the provision of fencing and dense planting to restrict/limit public/pedestrian access.

Where flows are concentrated and flow velocities are expected to be higher, appropriate scour protection has been incorporated into the revised design to protect against scour.

This report has been reviewed by a Registered Professional Engineer of Queensland (RPEQ), and certification has been provided that if the design parameters set out in this report are included within the development, stormwater pollutant load reductions in accordance with best practice should be achieved and the safety (peak flow, depths and d.V product) characteristics of the central drainage reserve improved from the previous design solution.

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1 Introduction

This *Bioretention Basin and Drainage Reserve Design Report* (Version 3), has been prepared on behalf of Newland Developers Pty Ltd to support revised designs of the bioretention basins and central drainage conveyance channel within the Altitude Aspire residential development at 37 Fraser Drive, Terranora (the subject site).

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- to detail an alternative configuration for the central drainage reserve and conveyance channel, aimed at limiting peak velocities and depths so as to improve safety and ongoing maintenance requirements.

1.1 Objectives

The objective of this report is to present an optimised design of the stormwater treatment measures and central drainage channel, supported by current modelling software and industry best practice management measures.

1.1.1 Operational Phase Objectives

The overarching objective for stormwater quality management during the operational phase of the development is to ensure that development does not cause an unacceptable impact or nuisance which could result in actionable damage to downstream properties and receiving environments. The following objectives are to be achieved.

Operational Phase Objective (Quality)	Stormwater discharged from the site achieves the specified load based reduction targets in accordance with the Tweed Shire Council Water Quality Objectives (as described in Table D7.07-WQO of the Development Design Specification D7 – Stormwater Quality). For the development site relevant targets are TSS 80%, TP 60%, and TN 45%.
Operational Phase Objective (Quantity)	Central drainage conveyance capacity is not compromised and peak velocities and depths are maintained so as to limit safety risks and minimise ongoing maintenance requirements.

2 Site Location

The site is located to the west of Fraser Drive, Terranora and covers an area of approximately 36 ha. The site location is displayed in Figure 2.1.

Figure 2.1 Site Location

2.1 Rainfall

Based on rainfall data obtained from the Bureau of Meteorology (BOM) from the Tweed Heads Golf Club rainfall station 58056, the mean annual rainfall expected for the site is 1,693 mm (Figure 2.2).

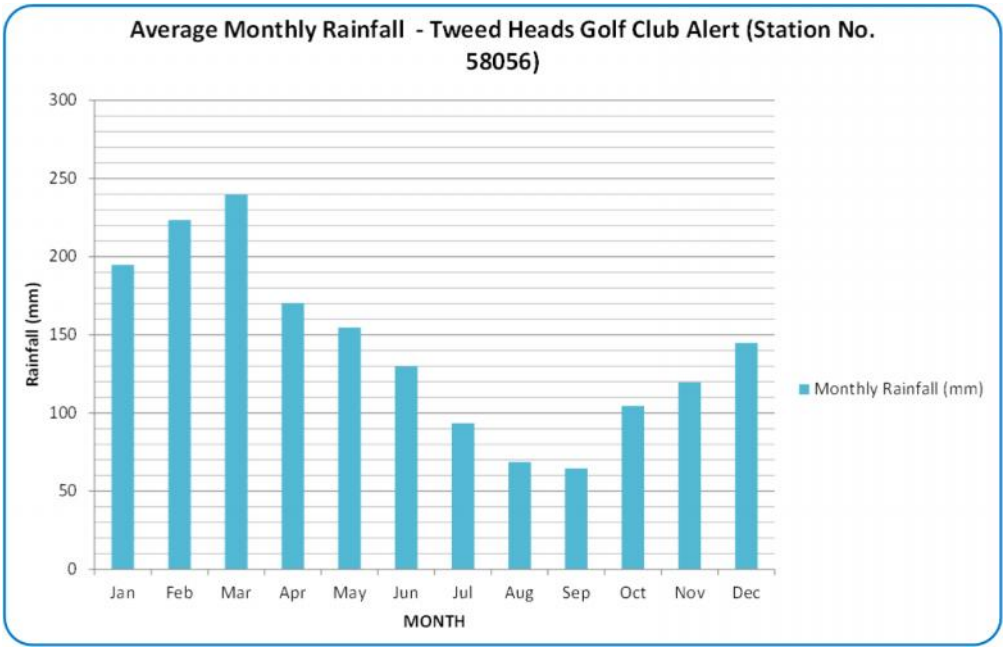


Figure 2.2 Monthly Rainfall Data

3 Previous Central Drainage Reserve Configuration

The site is being development as a 251 lot residential subdivision over several stages (Figure 3.1). As part of the approved development layout, a central drainage reserve has been included for the conveyance and treatment of stormwater from both the upstream and internal catchments.

The previous design of the central drainage corridor accommodates stormwater management features comprising of four (4) bioretention treatment basins and a constructed trapezoidal drainage channel to convey catchment flows through the site to the discharge point north of Broadwater Parkway. Stormwater detention is provided on the northern side of Broadwater Parkway via a low bund with hydraulic outlet controls.

This stormwater management concept was developed by Gilbert & Sutherland and detailed with their approved *Stormwater Assessment & Management Plan* (April 2013) and the *Hydrologic and Hydraulic Assessment* (April 2013).

The proposed stormwater management measures included;

- Rainwater tanks, with a 5kL storage capacity installed to capture roof runoff within each residential allotment;
- Four (4) Bioretention Basins;
- A central drainage channel for the conveyance of upstream and internal catchment flows; and
- A low bund on the downstream side of Broadwater Parkway for mitigation of peak discharge.

The previous central drainage configuration is presented within Figure 3.2 below.

Figure 3.1 Development Layout

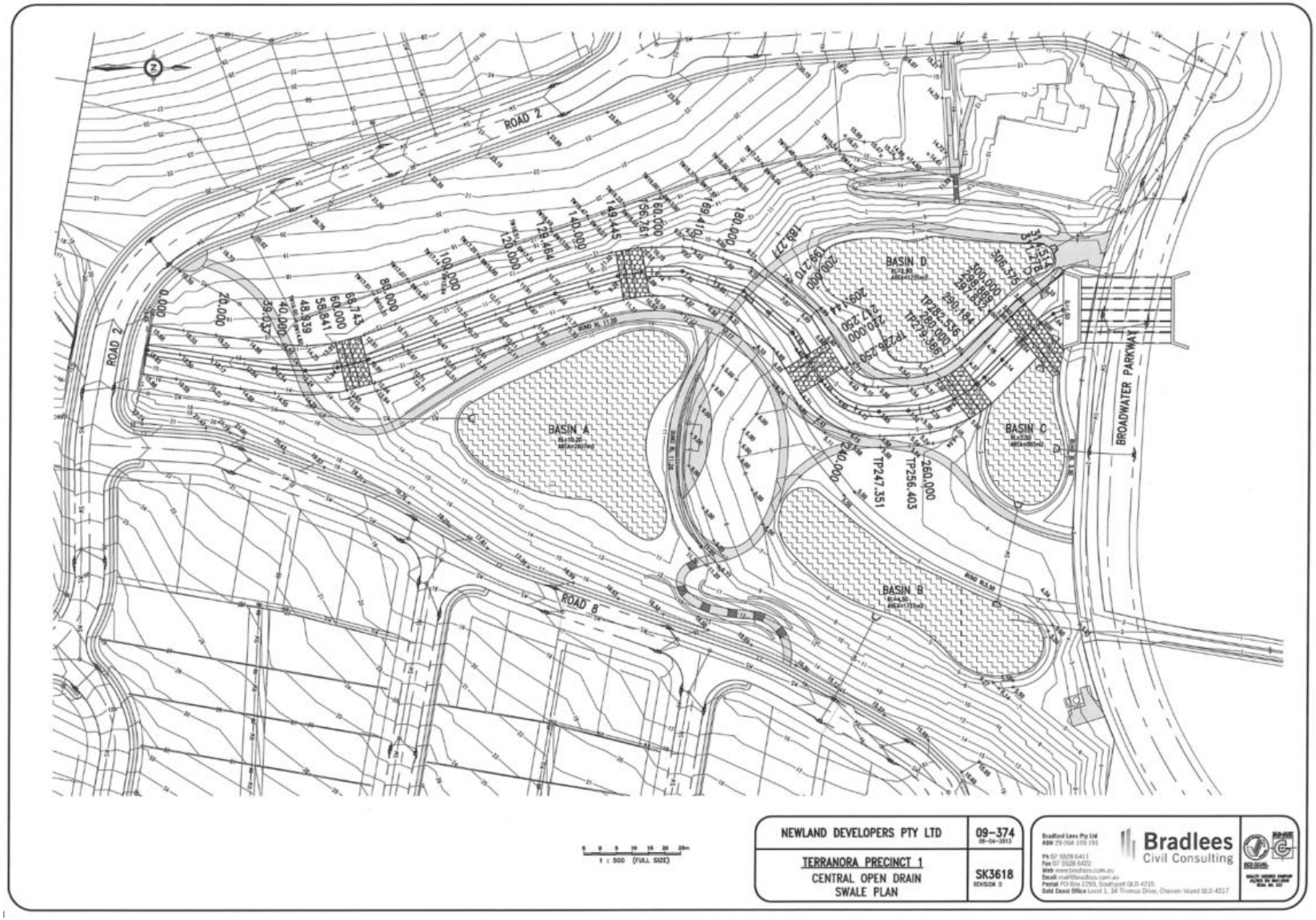


Figure 3.2 Previous Central Reserve Configuration

Since the original stormwater concept was prepared by Gilbert and Sutherland, there have been several MUSIC software updates and a number of parameter amendments. In general, these changes have resulted in smaller bioretention filter area requirements.

Undertaking revised *MUSICv6* modelling therefore provides the opportunity to optimise bioretention filter area requirements within the central drainage reserve and decrease construction and ongoing maintenance costs.

Hydraulic analysis of the previous central drainage channel design by Bradlees (Appendix A) was undertaken to assess the design requirements for the proposed constructed trapezoidal drainage channel. Whilst upstream and internal catchment conveyance through the central drainage reserve can be achieved, the resulting d.V product expected during the 0.01 AEP flood event are expected to be over 6 m^2/s. Modelling suggests that this d.V product would extend along the entire length of the channel and therefore in order to address safety concerns, fencing and appropriate warning signage would be required to restrict public access.

4 Revised Central Drainage Reserve Configuration

Given the opportunity to update and optimise the bioretention configurations and in an effort reduce the extent and scale of the current d.V product within central drainage reserve a revised central drainage reserve configuration has been proposed.

The following sections outline the design parameters for the alternative design solution.

4.1 Schematic Design Plan

Figure 4.1 presents a schematic design plan of the proposed alternative drainage and treatment system to be incorporated within the development. The Operational Control Plan Drawing Set within Appendix B contains design drawings which illustrate the layout and design requirements of each mitigation measures. Figures 4.2 to 4.4 provide a civil design drawing of the revised concept.

Whilst the alternative stormwater treatment train proposed within this report remains similar in principle to those stated within the approved Gilbert & Sutherland report, the following modifications have been proposed;

- Four (4) bioretention basins will be retained but reconfigured for the treatment of allotment and road surfaces;
- The central drainage channel will be replaced in part by a wide vegetated flow path to increase the width of flow, and therefore reduce flow depth and velocity;
- The upper 100 m of the new drainage path will be rock lined as the topography in this areas dictates that a relatively narrow flowpath will be required;
- This upper rocked channel will open out into a wide vegetated area of low flow depths and velocities;
- Approximately half way down the drainage channel, a pipe and weir arrangement will divert low flows into a low flow rock lined channel;
- The flow through these culverts during the 1 year ARI will be 6.50 m^3/s (approximately to the Q1 peak discharge) and 12.61 m^3/s during the 100 year ARI.
- High flows will discharge over two (2) central weirs into a wide (40 m) vegetated channel during storm events greater than Q1;
- Flows over the 40 m wide vegetated channel with have low depths and velocities; and
- The combined high and low flow channels discharge into the culverts under Broadwater Parkway.

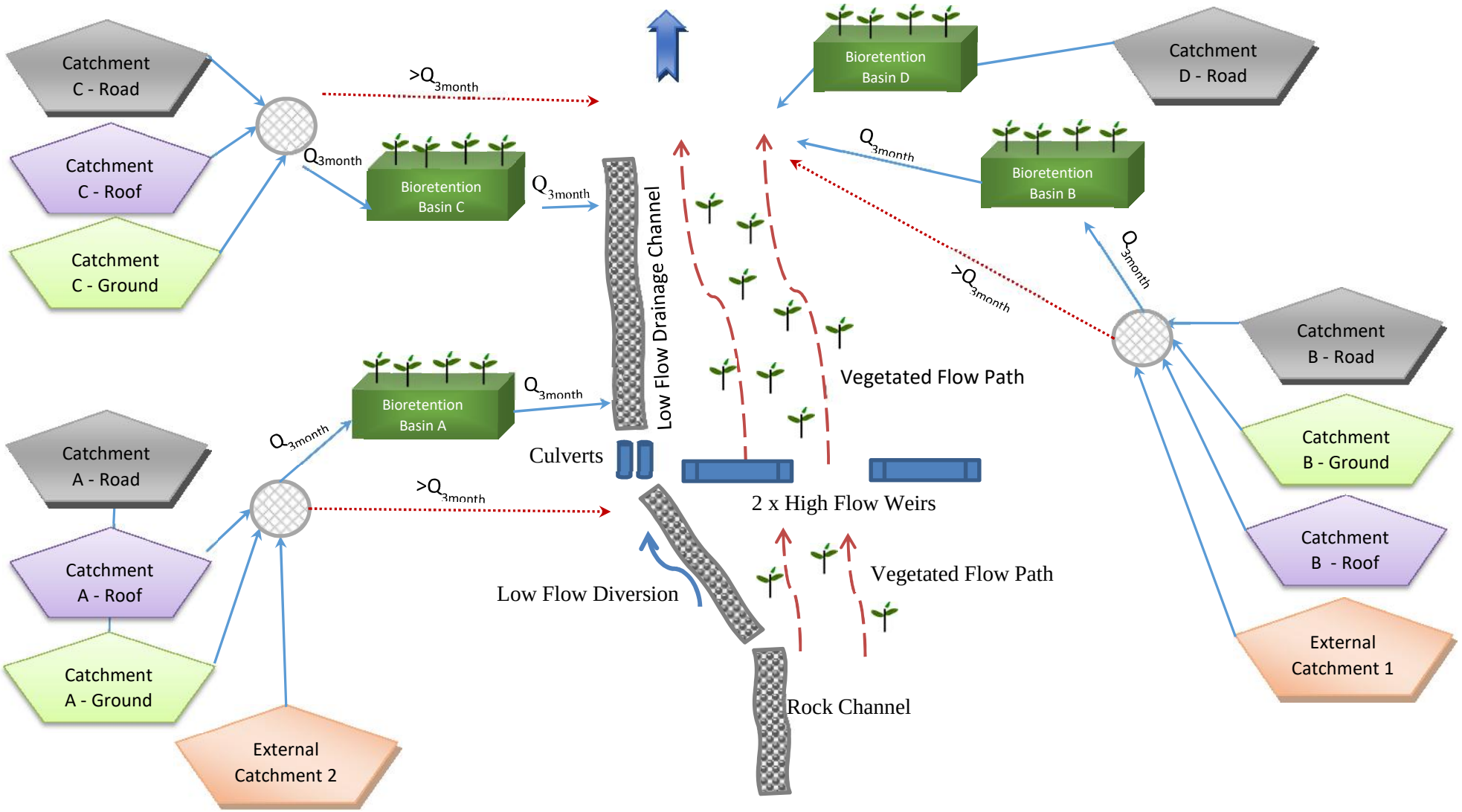


Figure 4.1 Schematic Stormwater Drainage and Treatment Concept

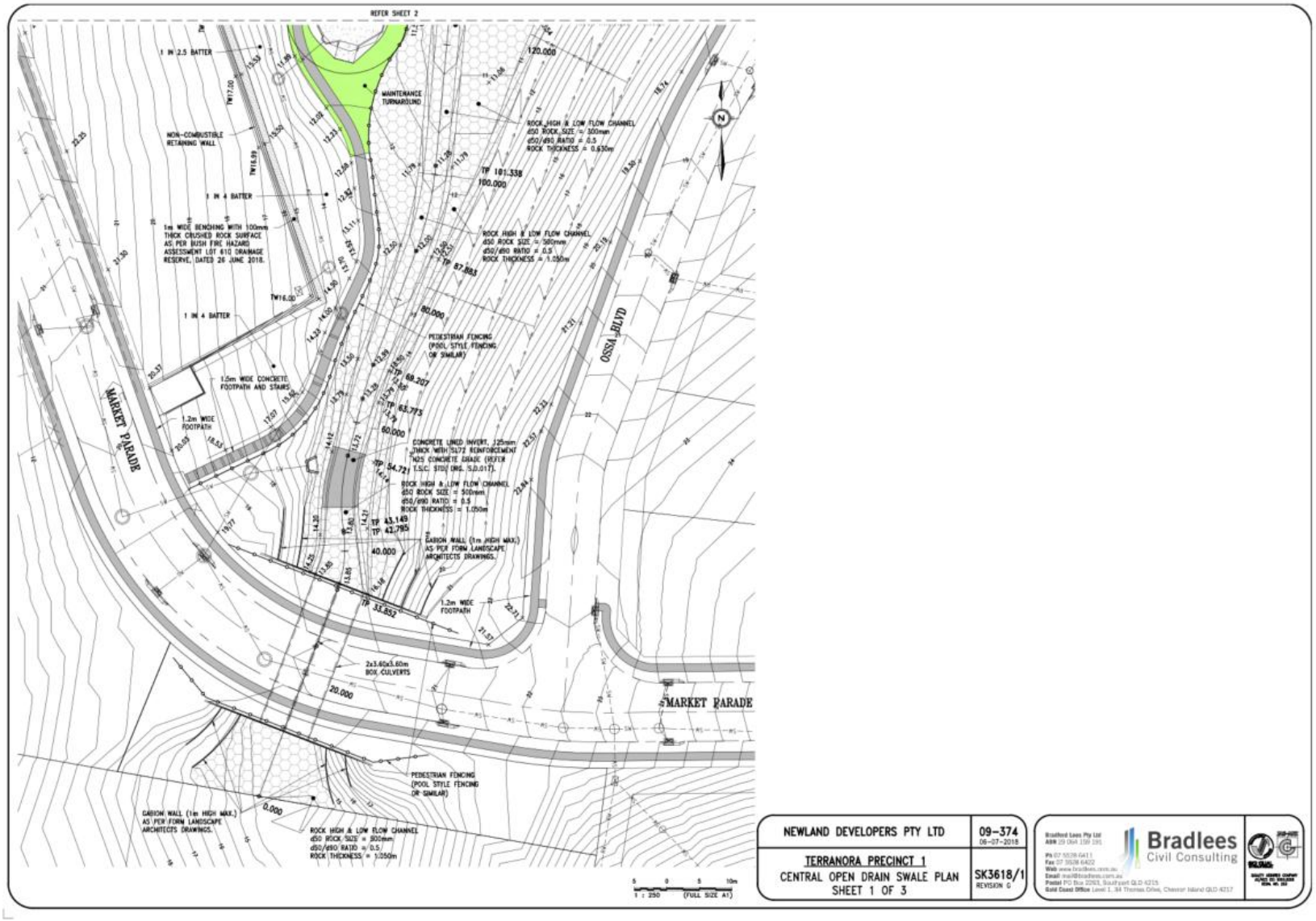


Figure 4.2 Revised Central Drainage Reserve Configuration (Bradlees) Sheet 1 of 3

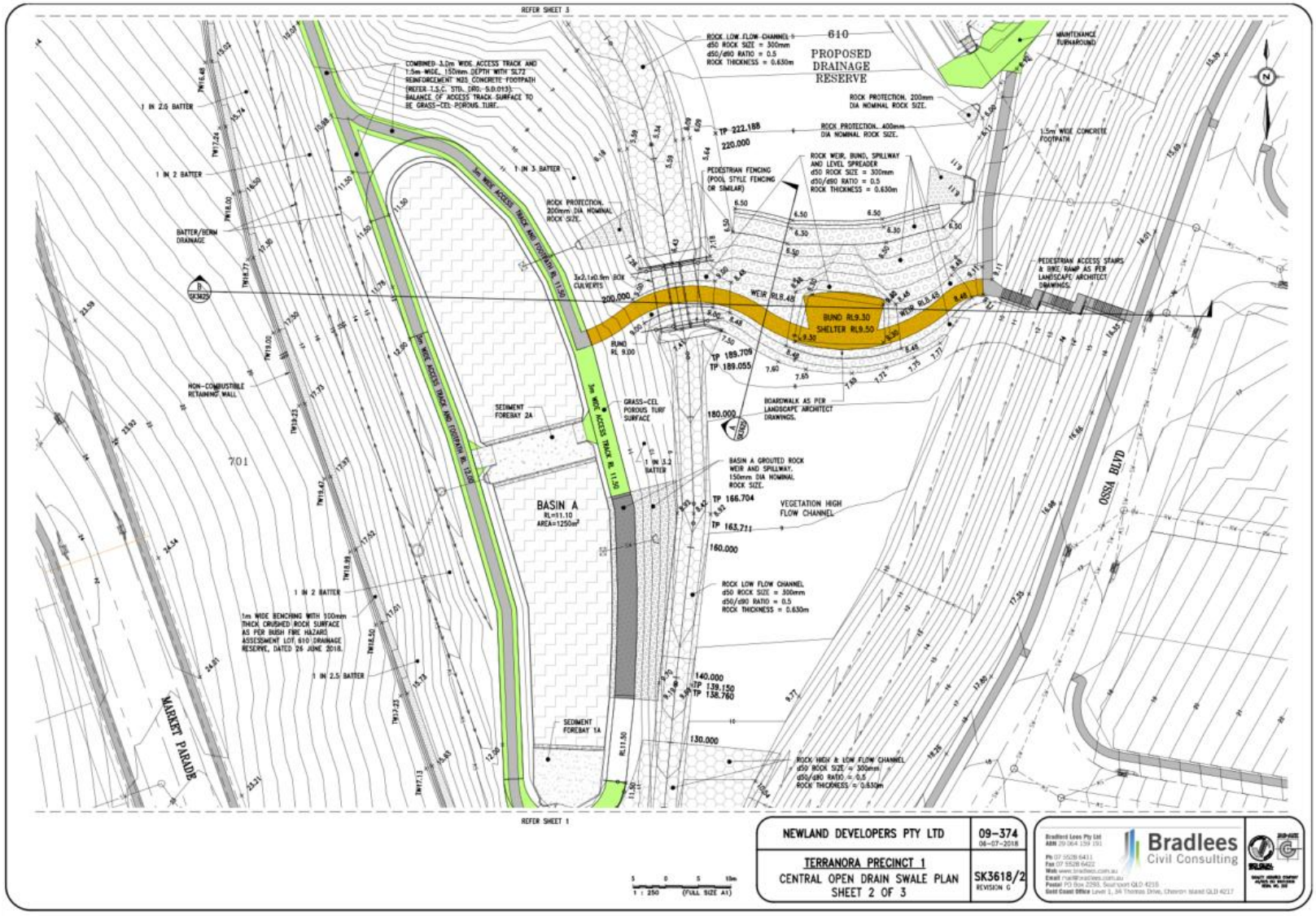


Figure 4.3 Revised Central Drainage Reserve Configuration (Bradlees) Sheet 2 of 3

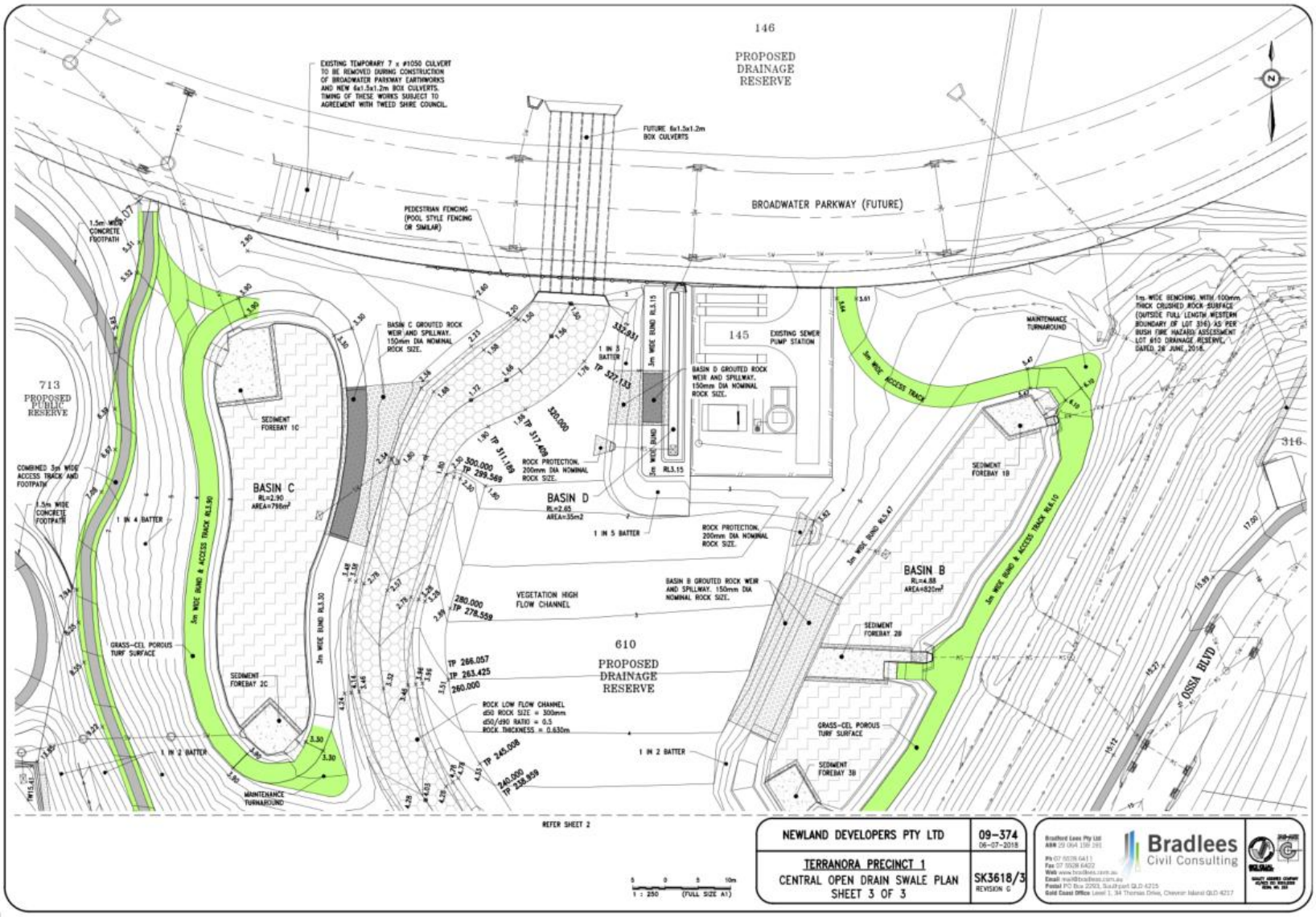


Figure 4.4 Revised Central Drainage Reserve Configuration (Bradlees) Sheet 3 of 3

4.2 Quality Control – Pollutant Reduction

In accordance with Tweed Shire Council Design Specifications, the site is required to meet minimum mean annual load based reductions of 80% for Suspended Sediment; 60% for Total Phosphorus, 45% for Total Nitrogen; and 90% for Gross Pollutants.

The Model for Urban Stormwater Improvement Conceptualisation (*MUSIC v6*) has been used to estimate the potential pollutant loads generated by the development and to re-size the proposed treatment measures. The following sections outline the parameters relied upon within the *MUSIC v6* modelling.

4.2.1 Rainfall and Evapotranspiration Data

The Tweed Standard Rainfall Dataset has been obtained from the Tweed Shire Council website and utilised for modelling purposes as required within DDS-D7 section D7.13. A summary of the Meteorological data utilised is included within Table 4.1 below.

Table 4.1 Meteorological and Rainfall Runoff Data Reporting

BOM Station No.	Murwillumbah (Bray Park) – Station No. 058158
Period	16/10/1973 to 30/06/1984 (10.5 years)
Time step	6 minute
Mean annual rainfall (mm)	1,697
Evapotranspiration	1,363

4.2.2 Developed Case - Catchment Parameters

The developed site has been considered as four (4) internal catchments based on the proposed layout and the developed earthworks. It is noted that there are two (2) external catchments which contribute flows to two (2) of the internal catchments and therefore need to be considered within the proposed stormwater treatment train. Each of the catchments has been modelled as an Urban Residential land use according to proposed land uses within the developed site. Each internal catchment has been split into roof, road and ground level source nodes in accordance with the proposed layout. It is noted that the larger unit allotments and external catchments have been modelled as 'lumped' residential catchments. Table 4.2 summarises the sub-catchment areas and Drawing DWG 210 – Appendix B presents the sub-catchment delineation. The pollutant export and runoff parameters for each sub catchment adopted is based on the data from the Water by Design *MUSIC v6* Modelling Guidelines (2010), as summarised in Table 4.3 and 4.4.

Table 4.2 *MUSIC v6* Sub-Catchment Areas

Catchment ID	Land Use	Area (ha)	Total Impervious (%)
Catchment A	Urban Residential - Road	2.481	60
	Urban Residential - Roof	3.763	100
	Urban Residential - Ground Level	4.584	20
	Urban Residential - Lumped	0.737	55
Catchment B	Urban Residential - Road	1.727	60
	Urban Residential - Roof	3.285	100

	Urban Residential - Ground Level	3.286	20
Catchment C	Urban Residential - Road	2.621	60
	Urban Residential - Roof	1.606	100
	Urban Residential - Ground Level	2.244	20
	Urban Residential - Lumped	2.151	55
Catchment D	Urban Residential - Road	0.863	60
External Catchment 1	Urban Residential - Lumped	1.189	55
External Catchment 2	Urban Residential - Lumped	1.048	55
Total (ha)	-	**31.6**	-

Table 4.3 Rainfall Runoff Parameters

Parameter	All Nodes
Landuse	Residential
Rainfall threshold (mm)	1
Soil storage capacity (mm)	500
Initial storage (% capacity)	10
Field capacity (mm)	200
Infiltration capacity coefficient a	211
Infiltration capacity exponent b	5.0
Initial depth (mm)	50
Daily recharge rate (%)	28
Daily baseflow rate (%)	27
Daily deep seepage rate (%)	0

Table 4.4 Pollutant Export Parameters

Flow Type	Surface Type	Total Suspended Solids (log mg/L)		Total Phosphorous (log mg/L)		Total Nitrogen (log mg/L)	
		Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
	Urban Residential						
Base Flow	Roof	N/A	N/A	N/A	N/A	N/A	N/A
	Road	1.00	0.34	-0.97	0.31	0.20	0.20
	Ground	1.00	0.34	-0.97	0.31	0.20	0.20
	LUMPED	1.00	0.34	-0.97	0.31	0.20	0.20
Storm Flow	Roof	1.30	0.39	-0.89	0.31	0.26	0.23
	Road	2.43	0.39	-0.30	0.31	0.26	0.23
	Ground	2.18	0.39	-0.47	0.31	0.26	0.23
	LUMPED	2.18	0.39	-0.47	0.32	0.26	0.23

4.2.3 Treatment Measures

In order to determine the design requirements for the necessary stormwater treatment measures, key “Treatment Nodes” were added to the *MUSICv6* model. The following sections outline the modelling parameters relied upon for each “Treatment Node”.

Bioretention

It is proposed that bioretention measures be incorporated into the development layout to provide the necessary load based reductions. Bioretention systems operate by capturing water and retaining water in an extended ponding area (no more than 400 mm deep for a maximum of four (4) days to prevent anaerobic conditions, plant death and insect breeding), before filtering through a soil media. The devices remove pollutants via the following physical processes:

- Sedimentation in the extended detention storage;
- Filtration by filter media;
- Nutrient uptake by biofilms;
- Nutrient adsorption and pollutant decomposition by soil bacteria; and
- Adsorption of metals and nutrients by filter particles (Somes & Crosby, 2007).

In accordance with Water by Design Guidelines, Table 4.5 summarises the treatment node parameters used in the *MUSIC v6* modelling whilst Figure 4.5 provides typical design parameters for the proposed bioretention devices. A bioretention Design Checklist in accordance with the Water by Design Bioretention Technical Design Guidelines has been completed and is included within Appendix C.

Table 4.5 Bioretention Parameters

Catchment ID	Bioretention A	Bioretention B	Bioretention C	Bioretention D
Surface area (m^2)	1,500	1,014	880	40
Has the filter area been calculated appropriately?	Yes	Yes	Yes	Yes
Extended detention depth (m)	0.3	0.3	0.3	0.3
Filter area (m^2)	1,250	820	798	35
Unlined filter media perimeter (m)	0.01	0.01	0.01	0.01
Saturated hydraulic conductivity (mm/hour).	200	200	200	200
Filter depth (m)	0.5	0.4	0.5	0.5
TN content of filter media (mg/kg)	400*	400*	400*	400*
Proportion of organic material in filter (%)	< 5	< 5	< 5	< 5
Orthophosphate content of filter media (mg/kg)	30*	30*	30*	30*
Is the base lined? (Y/N)	Yes	Yes	Yes	Yes
Effectiveness of plant TN removal	Effective	Effective	Effective	Effective
Overflow weir width (m)	Surface Area/10	Surface Area/10	Surface Area/10	Surface Area/10
Exfiltration rate (mm/hr)	0.00	0.00	0.00	0.00
If an exfiltration rate has been used, have node water balance losses been used in calculation of treatment train effectiveness?	N/A	N/A	N/A	N/A
If exfiltration rate has been used, is the exfiltration rate justified?	N/A	N/A	N/A	N/A
Underdrain present?	Yes	Yes	Yes	Yes
Submerged zone with carbon present?	No	No	No	No
Depth of submerged zone (m)	N/A	N/A	N/A	N/A
Confirmation that K and C* remain default?	Yes	Yes	Yes	Yes

*As per Healthy Land and Water Recommendations for MUSICv6 modelling

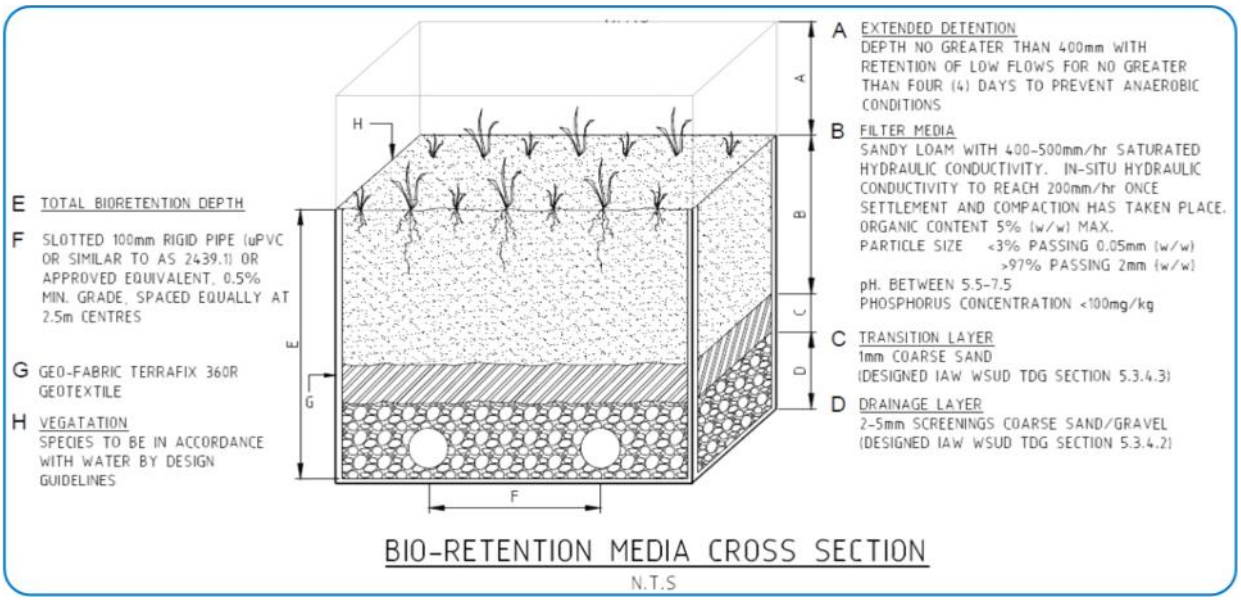


Figure 4.5 Bioretention specifications

Coarse Sediment Forebay

For the contributing catchments to the bioretention measures with and area greater than 2 ha, a coarse sediment forebay will be installed at each piped discharge point into the bioretention basins. Each forebay will limit sediment accumulation over the bioretention filter surface and reduce the potential for clogging. This will also help to reduce the frequency of maintenance required for the bioretention systems. For the larger basins, Basins A and B, the forebays have been shaped so as to allow formation of two (2) smaller filter cells. This will assist in constructability, limit the length of underdrainage, and in addition reduce the risk of uneven distribution of stormwater over the filter surface. Table 4.6 provides a summary of the sediment forebay calculations and requirements. The sediment forebays have been excluded from the *MUSIC v6* modelling.

Table 4.6 Sediment Forebay Parameters

Basin ID	Forebay I.D	Contributing Catchment Area (ha)	Q_{3month} Inflow Rate (m^3s)	Settling Velocity (m/s)	Area (m^2)	Depth (m)	Capture Efficiency (%)
Basin A	1A	5.78	0.718	0.1	82.5	0.2	80
	2A	5.78	0.718	0.1	82.5	0.2	80
Basin B	1B	0.6	0.281	0.1	33	0.2	80
	2B	2.4	0.397	0.1	46	0.2	80
	3B	6.0	0.34	0.1	39	0.2	80
Basin C	1C	6.3	0.72	0.1	83	0.2	80
	2C	2.6	0.325	0.1	38	0.2	80

4.2.4 Bioretention Basin Staged Construction and Establishment

In accordance with the Water by Design Construction and Establishment Guidelines: Swales Bioretention Systems and Wetlands (C & E Guidelines), inflow of sediment-laden runoff during the building stage is a major risk to the successful and long-term functioning of bioretention systems.

During the building phase of developments, sediment can seal the surface of the filter media, move into and clog the filter media and accumulate in the under-drainage. Within the C & E Guidelines, there are four (4) options recommended to overcome the challenges associated with delivering bioretention systems. These generally include the following options:

- Option 1: Surface Protection
- Option 2: Bypass flows and early establishment of vegetation;
- Option 3: Sediment basin and bioretention function; and
- Option 4: Leave as sediment basin.

It is recommended that Option 4 method to leave the basin as a sediment basin during the construction phase of the proposed development be implemented. This method will generally include the following:

- Earthworks and bulking out of basin;
- Install the hydraulic structures;
- Allow system to operate as a sediment basin (Type D as determined in Section 5.3.4) during the building phase; and
- When 80-90% of building in the catchment is complete, the bioretention system can be cleaned and profiled, the under-drainage and bioretention media installed, and the vegetation planted and established.

For details of the procedure and order of construction for Option 4 method please refer to Section 3.10 (Steps 1-41) of the C& E Guidelines.

When 80% of building within the treatment catchment has been completed, the bioretention system can be cleaned out and profiled, before the under-drainage and bioretention media installed, and the vegetation planted and established.

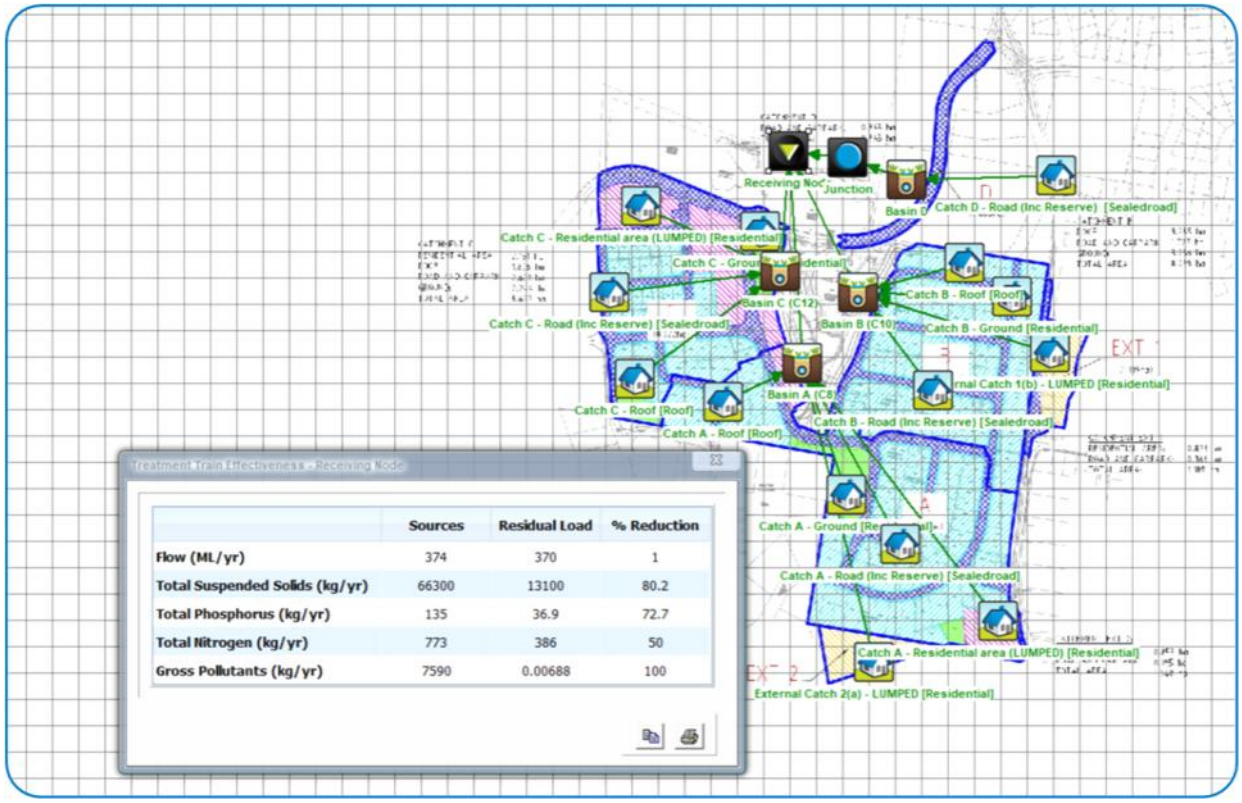
4.2.5 Modelling Results

Results of the *MUSICv6* modelling for the treatment train effectiveness are summarised in Table 4.7. The results indicate the 80%, 60%, 45% and 90% reduction target for TSS, TP, TN and gross pollutants respectively are achieved for the rainfall data set simulated. A screen capture of the *MUSICv6* modelling results is included as Figure 4.6.

Table 4.7 Treatment Train Effectiveness

Catchment ID	Pollutant	Inflows (kg/yr)	Outflows (kg/yr)	Reduction (kg/yr)	Reduction Achieved (%)	Water Quality Objective (%)
TOTAL (A, B, C, D)	TSS	66,300	13,100	53,200	**80.2**	80.0
	TP	135	36.9	98.1	**72.7**	60.0
	TN	773	386	387	**50.0**	45.0

NOTE: All simulations have been run with pollutant export estimation set to “stochastic generation”.



	Sources	Residual Load	% Reduction
Flow (ML/yr)	374	370	1
Total Suspended Solids (kg/yr)	66300	13100	80.2
Total Phosphorus (kg/yr)	135	36.9	72.7
Total Nitrogen (kg/yr)	773	386	50
Gross Pollutants (kg/yr)	7590	0.00688	100

Figure 4.6 Screen Capture of MUSIC Modelling Results

5 Hydraulic Assessment - *TUFLOW*

The 1D - 2D hydrodynamic flood model *TUFLOW* has been utilised to route stormwater through the central drainage channel of the site in an effort to;

- confirm the capacity of the drainage path;
- determine post-development depths within the drainage path; and
- quantify post-development velocities to ensure adequate surface scour protection.

5.1.1 Modelling Procedure

To simulate the peak flow behaviour within the catchment and quantify peak flood depths, discharges, and flow velocities, hydraulic modelling using the 1D/2D hydrodynamic model TUFLOW was undertaken. This involved the insertion of inflow hydrographs into the model upstream of the site. The hydrographs were taken from the previously approved *Hydrologic and Hydraulic Assessment (April 2013)* by Gilbert & Sutherland. Table 5.1 presents the peak inflow at each location for the full range of AEP's and the locations are depicted in Figure 5.1.

Table 5.1 Peak Model Inflows

Inflow Location	0.632 (1 yr ARI) (m^3/s)	0.393 (2 yr ARI) (m^3/s)	0.181 (5 yr ARI) (m^3/s)	0.095 (10 yr ARI) (m^3/s)	0.049 (20 yr ARI) (m^3/s)	0.02 (50 yr ARI) (m^3/s)	0.01 (100 yr ARI) (m^3/s)
A	4	5.5	7.7	9	11	12.4	14.1
B	1.8	2.4	3.1	3.6	4.2	4.4	4.9
C	0.7	0.9	1.2	1.3	1.5	1.5	1.6
D	0.03	0.1	0.2	0.2	0.3	0.4	0.5
E	0.03	0.1	0.2	0.2	0.3	0.3	0.3
F	0.04	0.1	0.1	0.2	0.2	0.2	0.2
G	2.2	2.4	3.1	3.5	4.2	4.4	4.9
H	1.5	2.1	2.9	3.4	4	4.4	4.9

5.1.2 Digital Terrain Model (DTM)

The modelling scenario has relied upon the civil design DTM provided by Bradlees. The upper section of the channel is rock lined, which spreads to a rock lined low flow channel which winds down to the diversion weir. Approximately half way down the channel there is a diversion weir and a set of central culverts which direct flows below the 1 year ARI into a low flow rock lined channel along the western side of the lower flowpath. The culverts have been sized to ensure that the main weir does not engage on any storm events less than 1 year ARI. This is to ensure that the large vegetated area downstream of the weir is not inundated in frequent flow events. 2D modelling indicates that flows over the central weir will only occur on events of greater than the 1 year ARI.

The low flow culverts consist of 3 x 2100 x 900 RCBC and a grade of 9.5%. The flow through the culverts during the 1 year ARI is predicted to be 6.50 m^3/s and 12.61 m^3/s during the 100 year ARI. Modelling indicates that these culverts will have a peak velocity of 3.7 m/s during the 100 year ARI event. QUDM allows for a peak velocity of 5 to 6 m/s.

In addition to the DTM, drainage culverts under Broadwater Parkway were added as 1D elements into the *TUFLOW* model. These culverts are modelled as 6 x 1500 x 1200 RCBC in accordance with the *Hydrologic and Hydraulic Assessment (April 2013)* by Gilbert & Sutherland.

5.1.3 Downstream Boundary Condition

The downstream boundary of the model has been applied downstream of Broadwater Parkway as a free draining outlet. This arrangement is considered appropriate as the culverts under Broadwater Parkway act as a flow restriction.

An additionally scenario with a regional Q100 tailwater has been analysed as part of a sensitivity analysis to test the immunity of Broadwater Parkway. The model was modified to include a tailwater level of RL 2.90 m downstream of Broadwater Parkway.

5.1.4 Manning's Coefficient

Based on recommendations from; *Chow. V. T, (1959) Open Channel Hydraulics*, *Tweed Shire Council Development Design Specification D5 (V1.4),* the following Manning Coefficients were applied:

- Lower rock lined channel: 0.080
- Vegetated channel: 0.060
- Upper rock lined channel: 0.090
- Mid rock lined channel 0.080
- High Flow Weir (top): 0.090
- High Flow Weir (downstream face): 0.140

Figure 5.2 below presents the extent of each surface type.

The manning's n value for the vegetated portion of the drain has been selected to represent a dense cover of grass species with limited canopy trees. This will provide Council with a low maintenance asset and restrict uncontrolled pedestrian access. The landscape intent prepared by Form Landscape Architects envisages endemic grass and sedge species such *Lomandra spp*. A minimum cover of approximately 70% with a typical vegetation height of 1.0 m has been relied upon.

As per Chow (1959) a manning's value of 0.06 has therefore been appropriate for floodplains with light brush and trees, with upper and lower limits of 0.08 and 0.04 respectively. The results presented within further sections of this report rely on a typical manning's n value 0.06.

5.1.5 Hydraulic Model Simulation

Simulation of the adopted design storm events was undertaken based on:

- Applying the inflow hydrographs within the *TUFLOW* model; and
- Applying the appropriate downstream boundary condition to the hydraulic model.

Key model outputs describing flood behaviour include peak water levels, flows and velocities. Results of the hydraulic analysis have been presented in the following sections for the design scenarios.

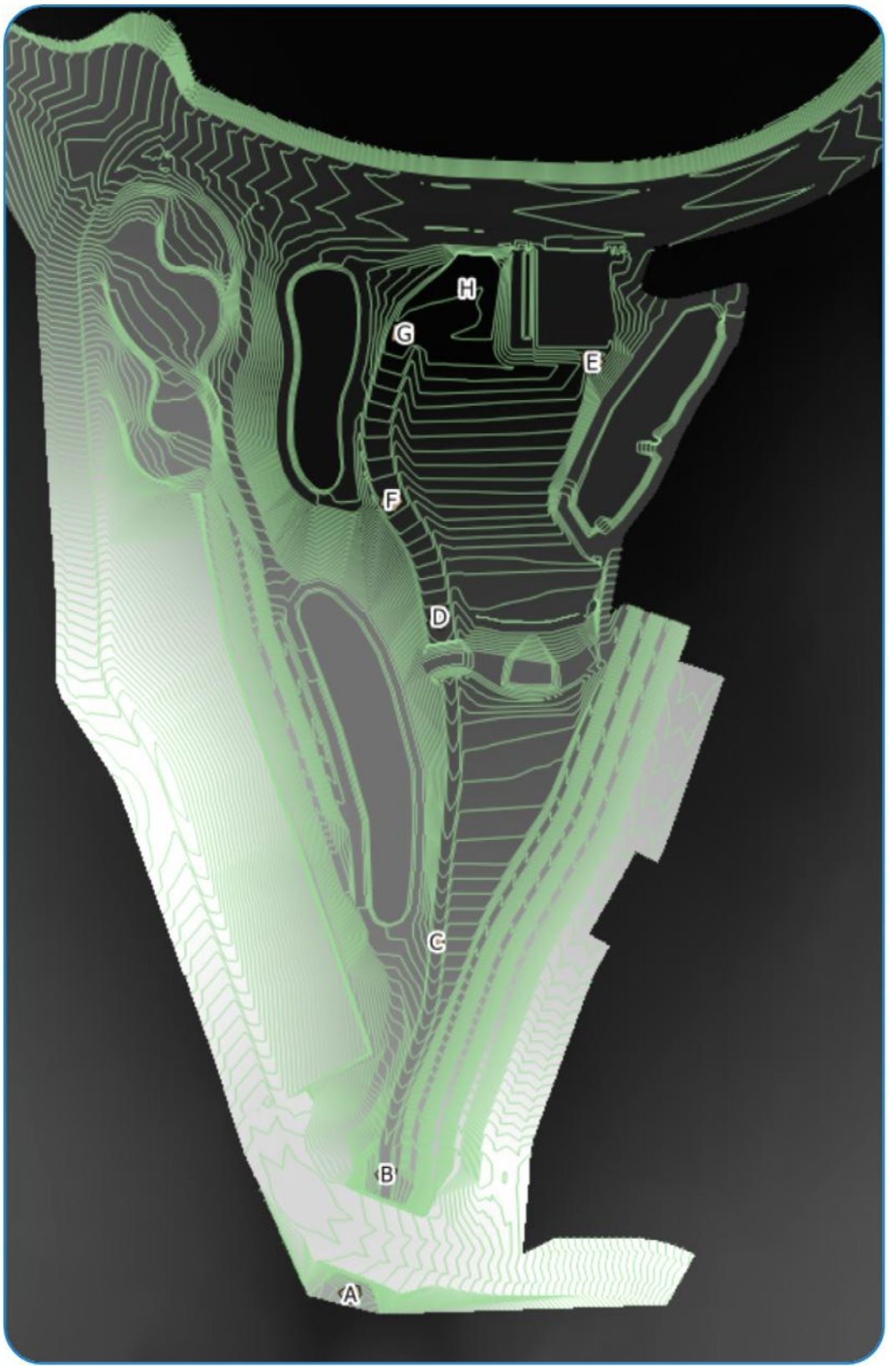


Figure 5.1 TUFLOW Model Inflow Locations

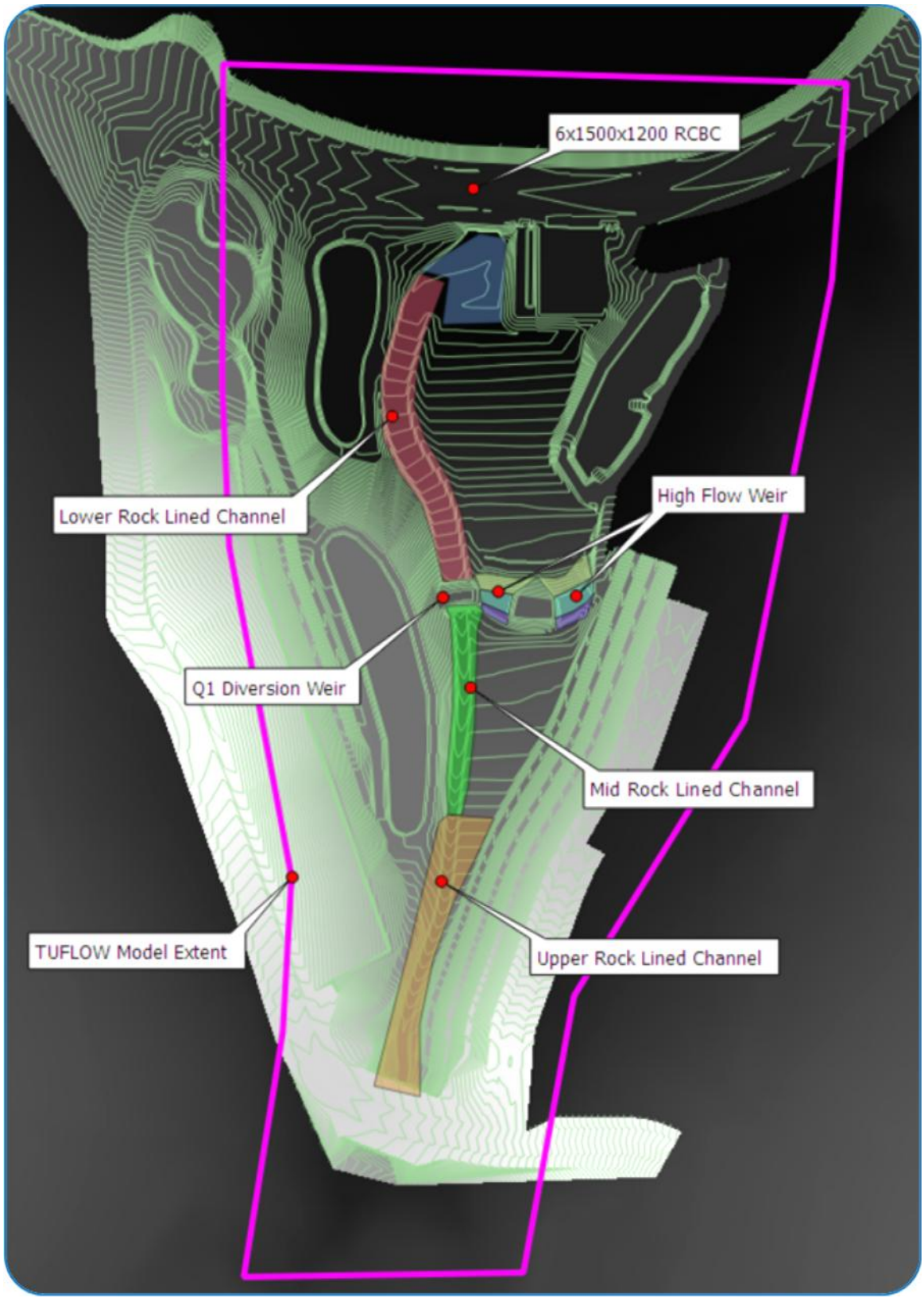


Figure 5.2 TUFLOW Model Layout

5.2 Modelling Results

The following sections provide a summary of the 2D modelling results for modified drainage channel. Result plots for all modelling events have been included within Appendix D.

5.2.1 Peak Flood Depths

Flood depths estimated by TUFLOW for the 100 year ARI (Figure 5.3) and 1 year ARI (Figure 5.4) storms are presented below. Peak water depths occur at the following locations during the 100 year ARI:

- Outlet of Market Parade culverts - 1.72 m deep;
- Behind the central culverts - 1.55 m deep; and
- Upstream of Broadwater Parkway - 1.66 m.

Depths within the vegetated flow areas are below 0.60 m in a for the 100 year storm.

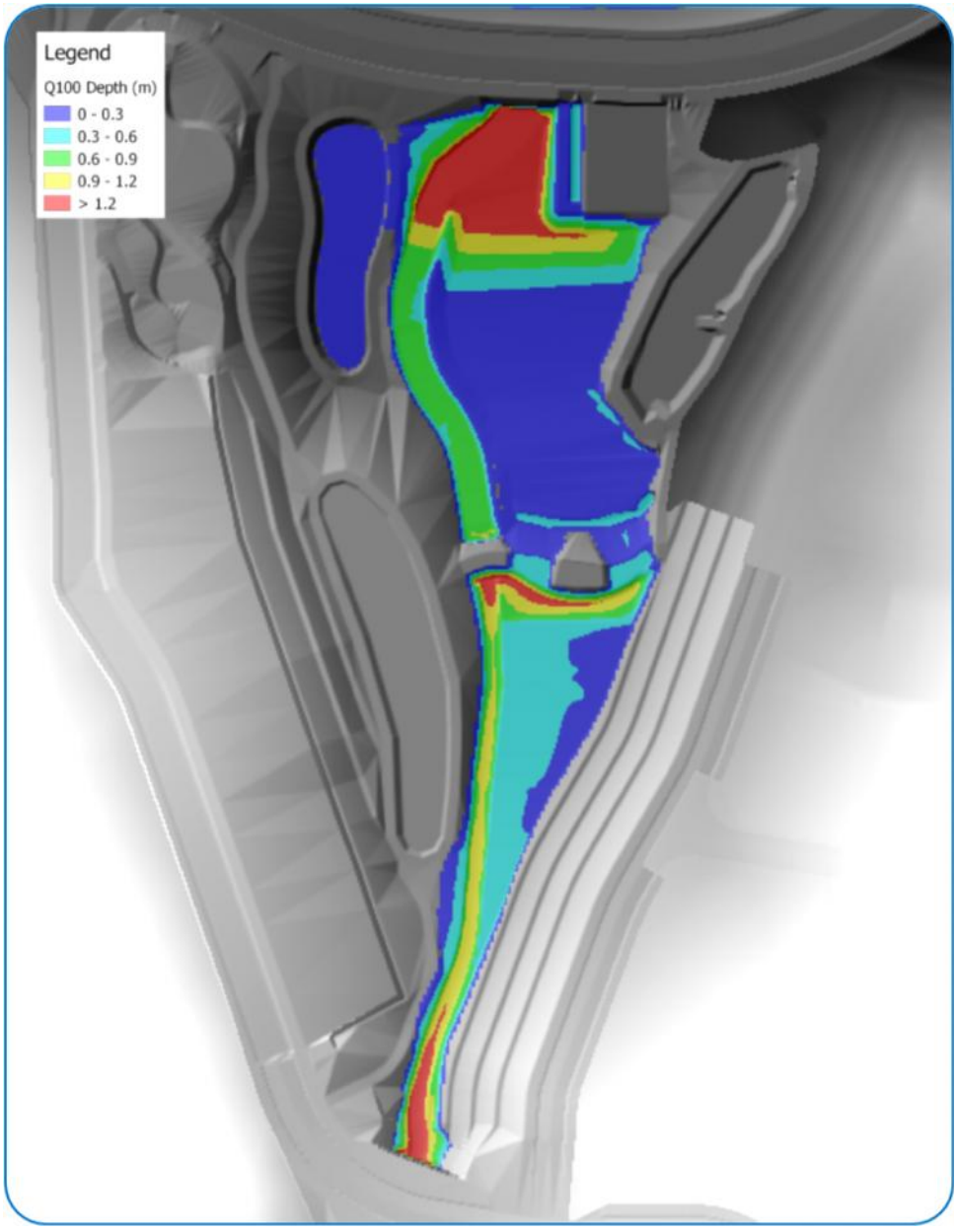


Figure 5.3 100 year ARI Peak Flood Depth

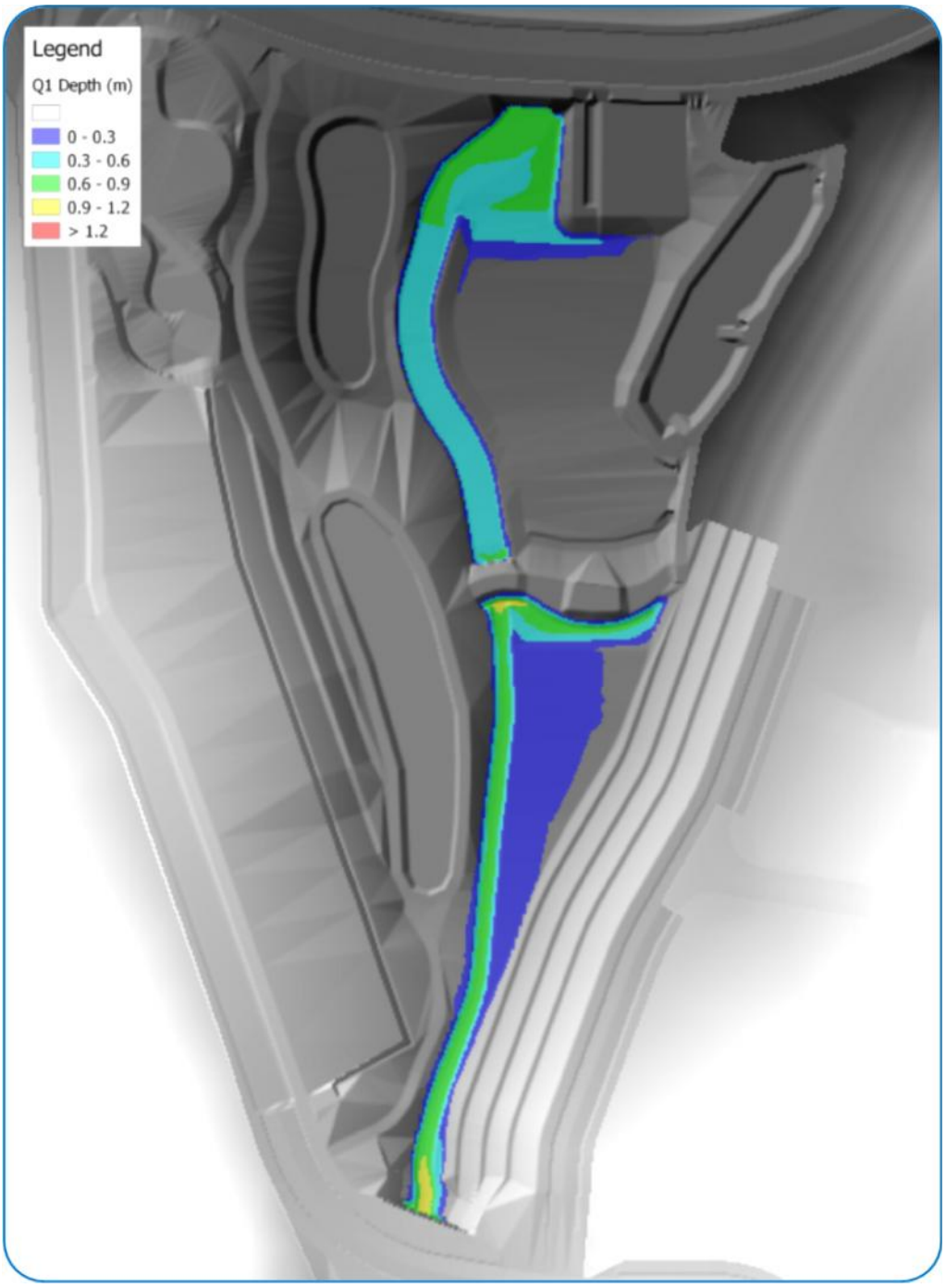


Figure 5.4 1 year ARI Peak Flood Depth

5.2.3 Peak Velocity

The expected peak discharge through the drainage channel, based on the 100 year ARI TUFLOW modelling, are shown below in Figure 5.5. Velocities within the upper rock lined channel are approximately 2.9 m/s, while the lower rock lined channel is approximately 2.3 m/s. Velocity over the high flow weir peaks at 1.9 m/s on the downstream slope, with 0.85 m/s expected over the crest.

Velocities within the upper vegetated channel are expected to peak at 1.7 m/s, with velocities in the lower vegetated section generally around 1.4 m/s. In accordance with Table 9.5.2 of QUDM and the design slope for these areas (upper vegetated channel 2.9% and lower vegetated channel 6%), these velocities are not expected to cause scour, provided 70% vegetation cover is maintained.

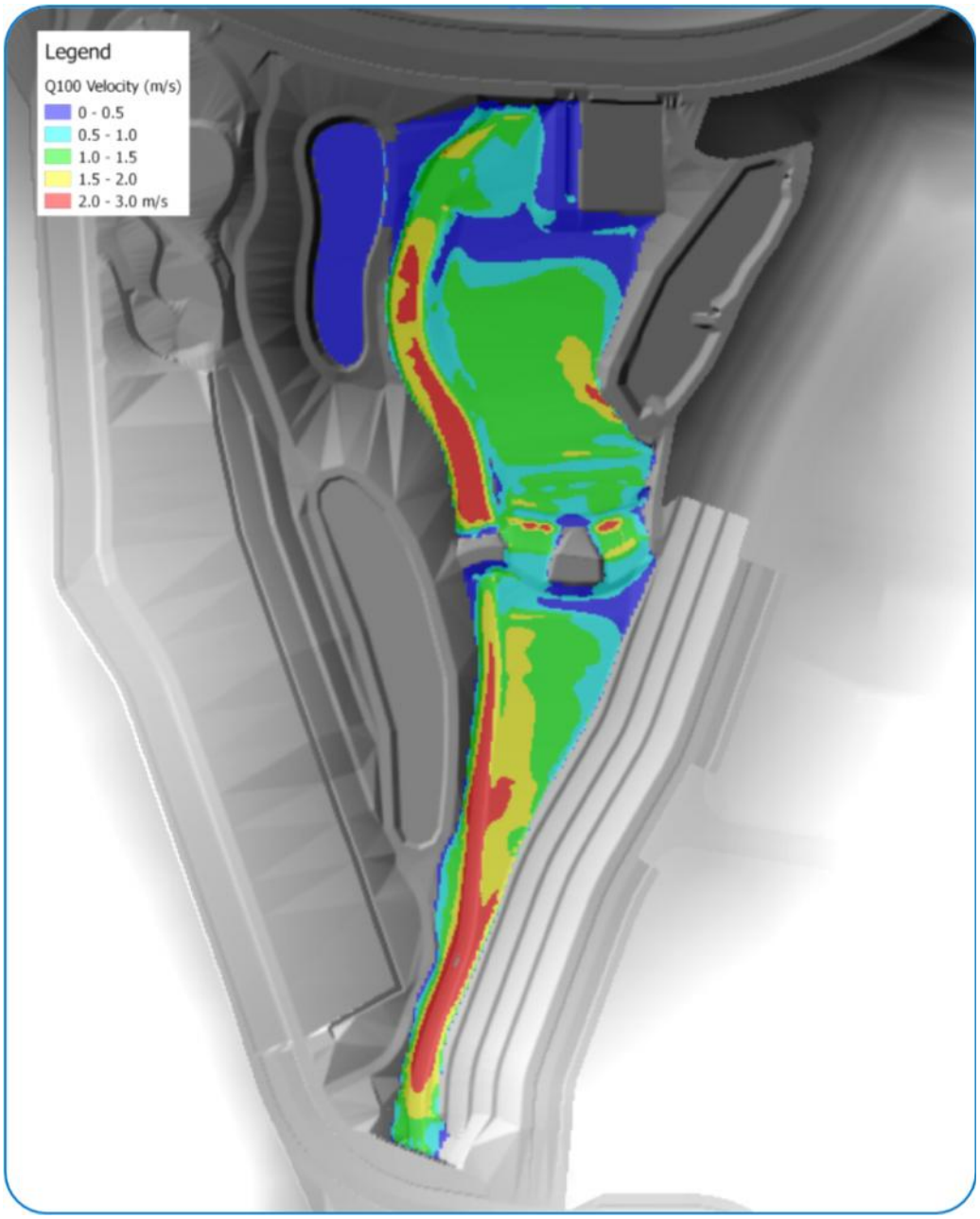


Figure 5.5 100 year ARI Velocity Plot

5.2.4 Depth x Velocity

The d.V product is generally below 0.4 m^2/s over the majority of the vegetated area downstream of the weir. Flow over the crest of the weir is also below 0.4 m^2/s. Areas where the d.V product is predicted to be above 0.6 m^2/s is generally restricted to rock lined high flow areas within defined conveyance channels. The maximum d.V product during the 100 year ARI is expected to be below 3.5 m^2/s and will occur directly downstream of Market Parade.

The magnitude of the predicted d.V product within the high flow channel has been substantially reduced from that previously reported for central drainage reserve configuration. Maximum d.V produced has been reduced from over 6 m^2/s to below 3.5 m^2/s.

Whilst this represents an improvement in safety, urban waterways and stormwater drainage systems with d.V products of greater than 0.6 m^2/s remain a safety risk (Table 12.1.12 of QUDM). It will therefore be necessary to restrict access and discourage a person/child from entering areas with an expected d.V product of greater than 0.6 m^2/s with the provision of fencing and dense planting to restrict/limit public/pedestrian access in the locations indicated on Figure 5.6.

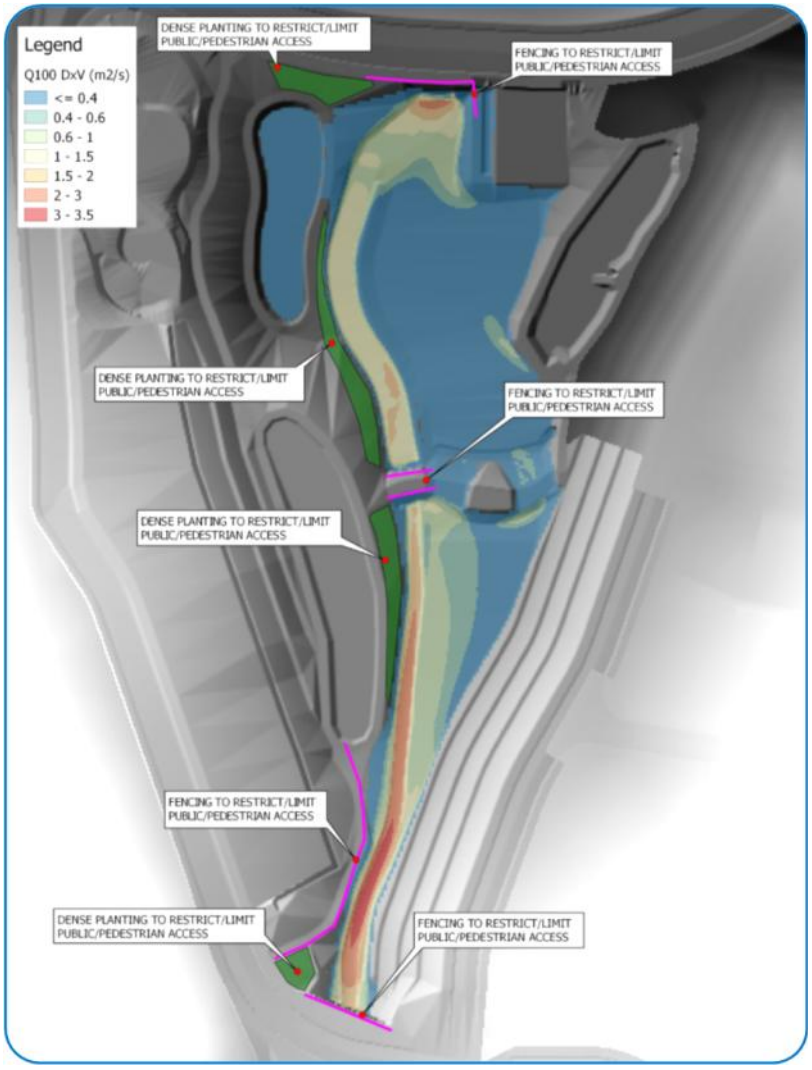


Figure 5.6 100 year ARI d.V Product Plot

5.2.5 Sensitivity Analysis

A sensitivity analysis has been undertaken to analyse:

- potential changes in the Manning's n values within the central conveyance channel; and
- the impacts of a regional 100 year ARI tailwater.

Manning's Variations

As a sensitivity analysis, the upper and lower Manning's n values of 0.04 and 0.08 have been tested within the main conveyance channels to simulate either poor grass establishment or a denser outcome. This sensitivity analysis predicted an increase in typical velocities by 20–30% when the lower manning's n value of 0.04 was applied, with peaks in the order of 1.9 m/s. Based on the design slope of 6% and in accordance with QUDM, a velocity of this magnitude could result in scour. The sensitivity analysis suggests that this would only occur on ARI events greater than that 20 year event. Maintenance of a minimum vegetation cover of 70% will be required within the open conveyance areas.

When the upper manning's n value of 0.08 is used, velocities reduce to below 1.2 m/s and flow depth increases by approximately 40 mm. This increased depth is contained within the design of the conveyance areas.

Regional Tailwater

Additionally a scenario with a regional Q100 tailwater has been analysed to test the immunity of Broadwater Parkway. The model was modified to include a tailwater level of RL 2.90 m downstream of Broadwater Parkway. This high tailwater level increases the peak Q100 flood level upstream of Broadwater Parkway to approximately RL 3.60 m AHD. The proposed sag level on Broadwater Parkway is 3.75 m AHD, therefore the road surface is still flood free during the regional Q100 tailwater scenario.

6 Conclusions

This *Bioretention Basin and Drainage Reserve Design Report* (Version 3), has been prepared on behalf of Newland Developers Pty Ltd to support revised designs of the bioretention basins and central drainage channel conveyance within the Altitude Aspire residential development at 37 Fraser Drive, Terranora (the subject site).

The revised stormwater treatment *MUSICv6* modelling has been undertaken on the proposed revised bioretention basin configurations and stormwater treatment train and it has been shown that it will achieve pollutant removal efficiencies of 80%, 60%, 45% and 90% for TSS, TP, TN and gross pollutants respectively.

This report also demonstrates that peak water depths and velocities within the central drainage reserve can be greatly reduced from the previous design, whilst maintaining the overall capacity of the flowpath to convey upstream flows. Maximum d.V product has been reduced from over 6 m^2/s to below 3.5 m^2/s.

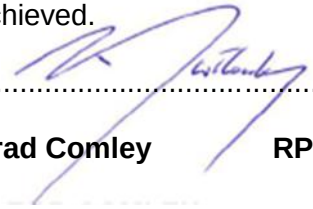
Whilst this represents an improvement in safety, urban waterways and stormwater drainage systems with d.V products of greater than 0.6 m^2/s remain a safety risk (Table 12.1.12 of QUDM). It will therefore be necessary to restrict access and discourage a person/child from entering areas with an expected d.V product of greater than 0.6 m^2/s with the provision of fencing and dense planting to restrict/limit public/pedestrian access.

This report has been reviewed by a Registered Professional Engineer of Queensland (RPEQ), and certification has been provided that if the design parameters set out in this report are included within the development, stormwater pollutant load reductions in accordance with best practice should be achieved and the safety (peak flow, depths and d.V product) characteristics of the central drainage reserve improved from the previous design solution.

7 RPEQ Certification

I am aware that Council may rely upon the contents and findings of this assessment for the purposes of development assessment. In my opinion, the Council can rely upon the information contained within the report and there are no reservations or qualifications in respect to the information other than set out in the report.

I confirm that if the design parameters set out in this report are included within the development stormwater pollutant load reductions in accordance with best practice should be achieved.



..... 23.07.18

Brad Comley **RPEQ 17706** **DATE**

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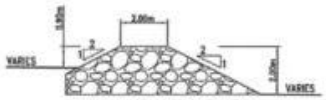
Appendix A

Bradlees Channel Design

(Based on previous concept)



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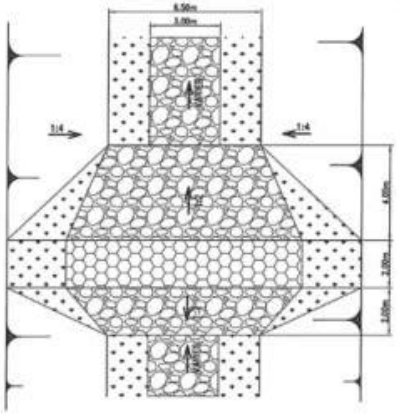

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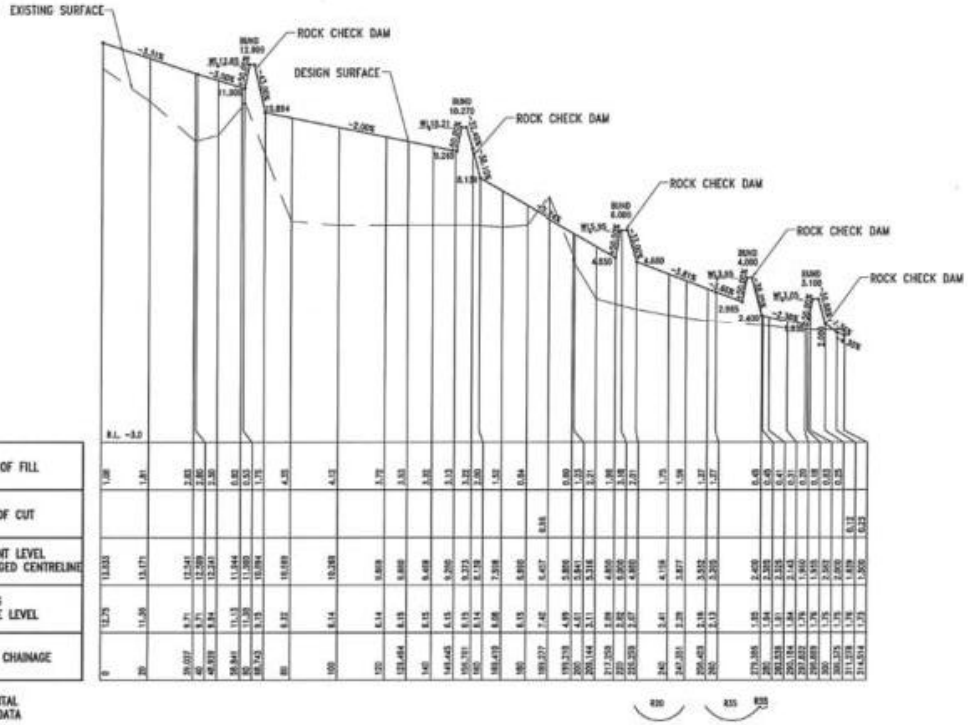

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(FULL SIZE)

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TERRANORA PRECINCT 1 CENTRAL OPEN DRAIN SWALE LONG SECTION	SK3619 REVISION B

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Web www.bradlees.com.au
Email mail@bradlees.com.au
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Gold Coast Office Level 1, 34 Thomas Drive, Chevron Island QLD 4217

Bradlees
Civil Consulting

Appendix B

Operational Control Plan Drawing Set

VERSION: D
DATE : 23.07.18

OPERATIONAL CONTROL PLAN DRAWING SET

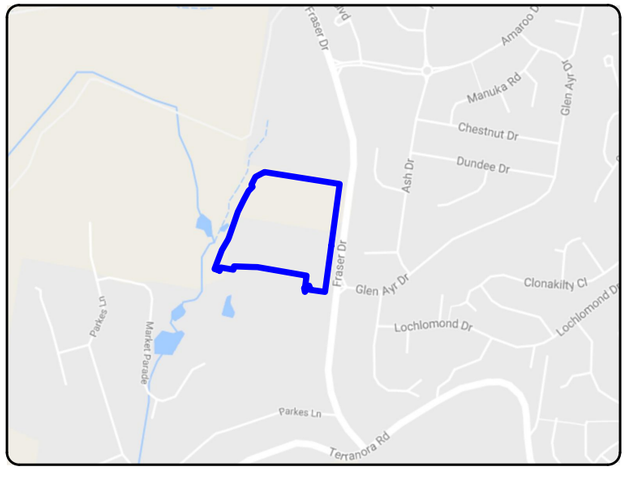
Altitude Aspire Terranora
Terranora Road, Terranora

for

Newland Developers Pty Ltd

Project No: BC-16099

July 2018



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DWG 000	LOCALITY AND DRAWING INDEX PLAN
DWG 200	BIORETENTION CATCHMENT PLAN
DWG 210	MUSIC CATCHMENT PLAN
DWG 300	OPERATIONAL CONTROL PLAN - OVERALL
DWG 301	OPERATIONAL CONTROL PLAN - CENTRAL CONVEYANCE - LONG SECTION
DWG 302	OPERATIONAL CONTROL PLAN - CENTRAL CONVEYANCE - CROSS SECTION SHEET 1 OF 2
DWG 303	OPERATIONAL CONTROL PLAN - CENTRAL CONVEYANCE - CROSS SECTION SHEET 2 OF 2
DWG 304	OPERATIONAL CONTROL PLAN - BASIN A - LAYOUT AND DETAILS
DWG 305	OPERATIONAL CONTROL PLAN - BASIN A - SEDIMENT FOREBAY DETAILS
DWG 306	OPERATIONAL CONTROL PLAN - BASIN B - LAYOUT AND DETAILS
DWG 307	OPERATIONAL CONTROL PLAN - BASIN B - SEDIMENT FOREBAY DETAILS
DWG 308	OPERATIONAL CONTROL PLAN - BASIN C - LAYOUT AND DETAILS
DWG 309	OPERATIONAL CONTROL PLAN - BASIN C - SEDIMENT FOREBAY DETAILS
DWG 310	OPERATIONAL CONTROL PLAN - BASIN D - LAYOUT AND DETAILS
DWG 311	OPERATIONAL CONTROL PLAN - STANDARD DETAILS

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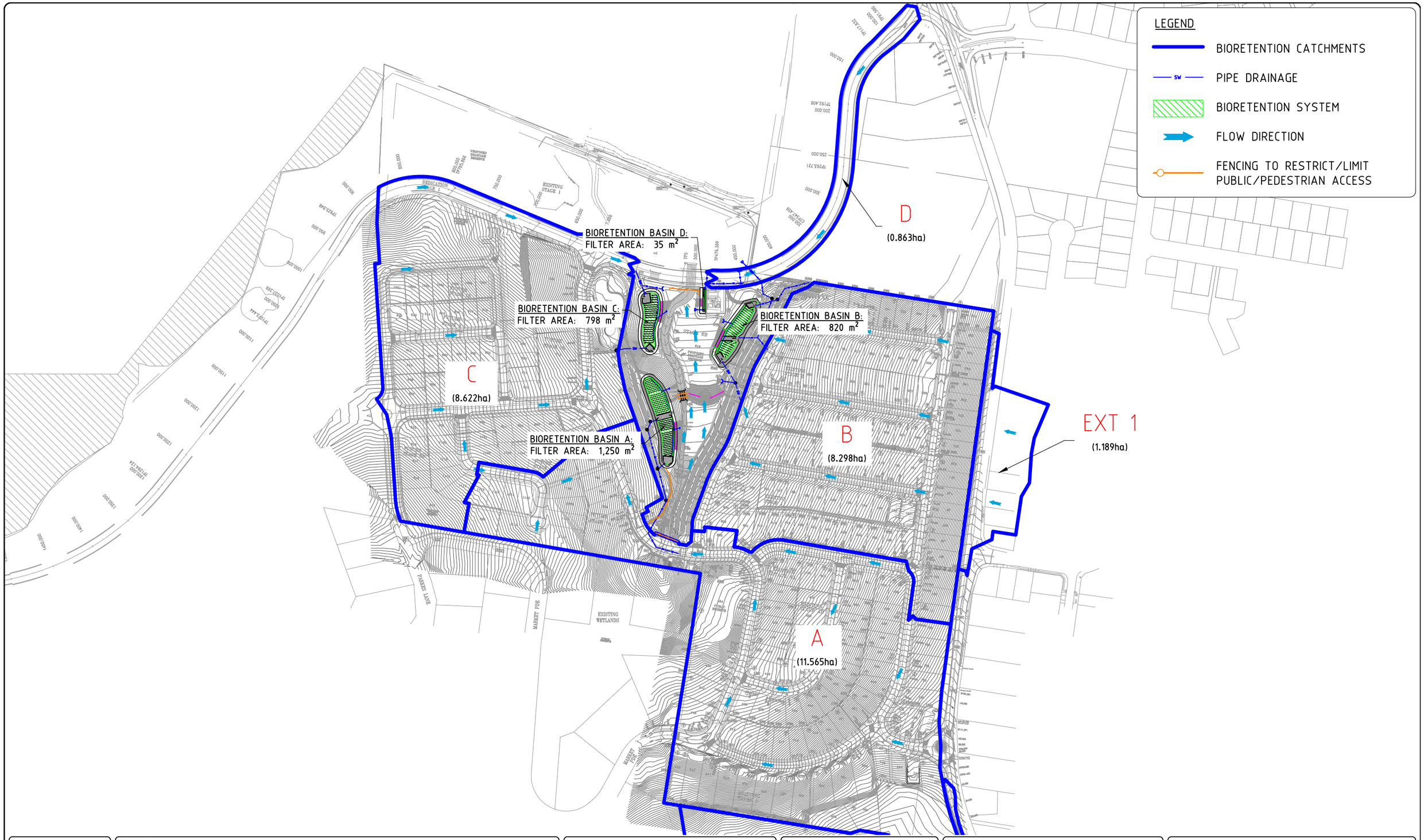
ABN 86 166 087 476



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PROJECT No. :
BC16099

DRAWING No. :
DWG 200

REVISION No. :
D

PROJECT
ALTITUDE ASPIRE TERRANORA

DRAWING TITLE
BIORETENTION CATCHMENT PLAN

CLIENT
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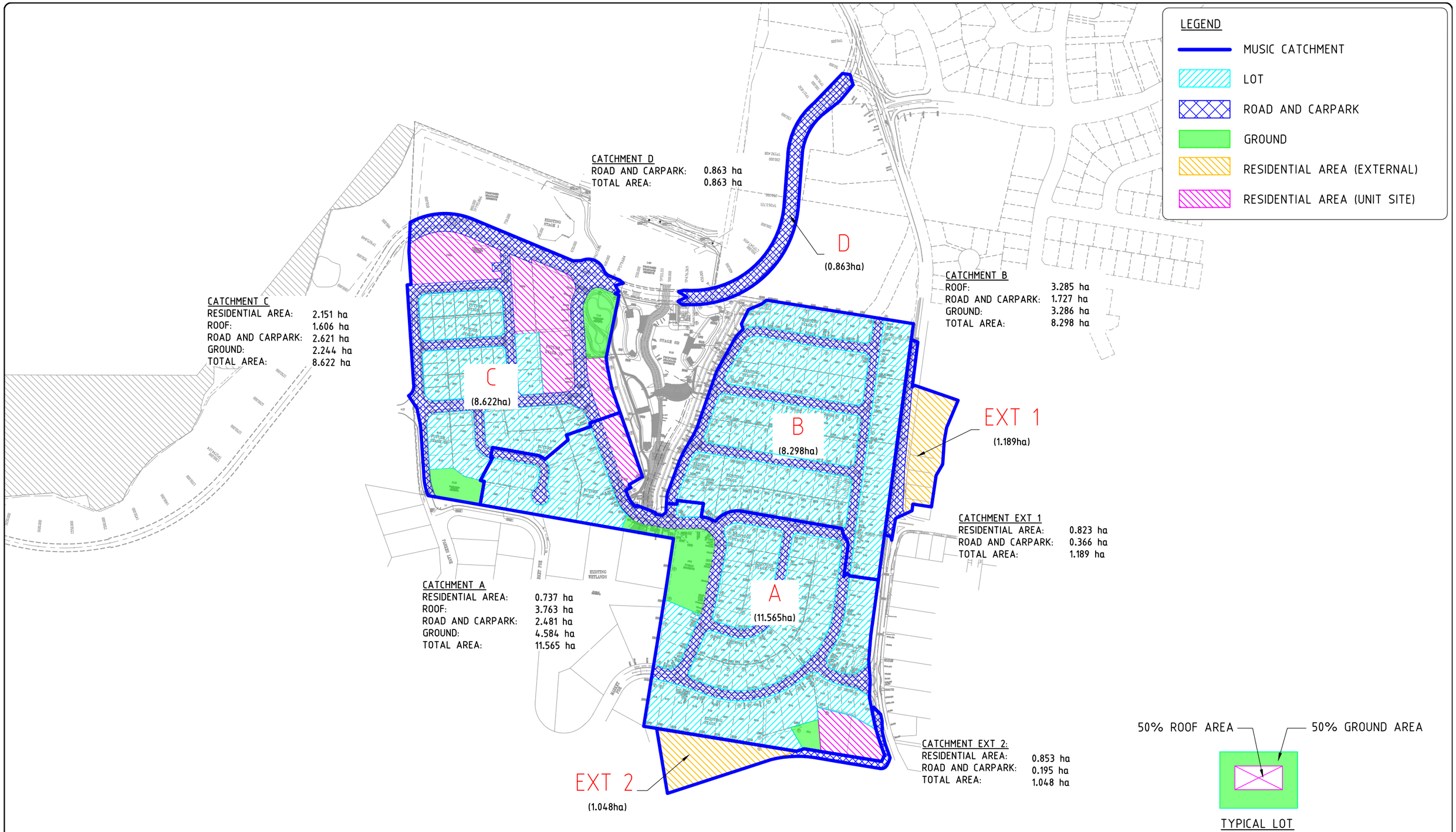

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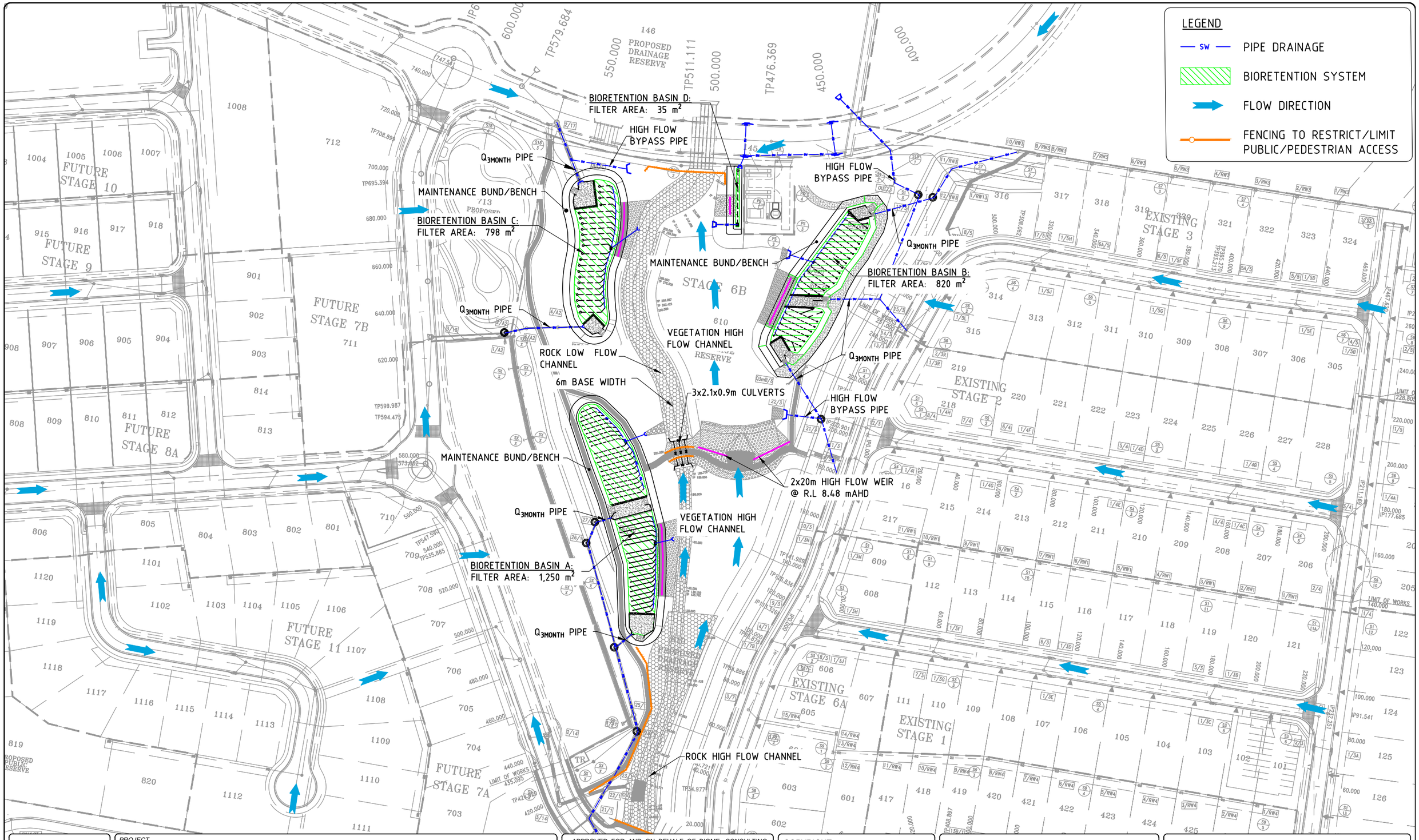

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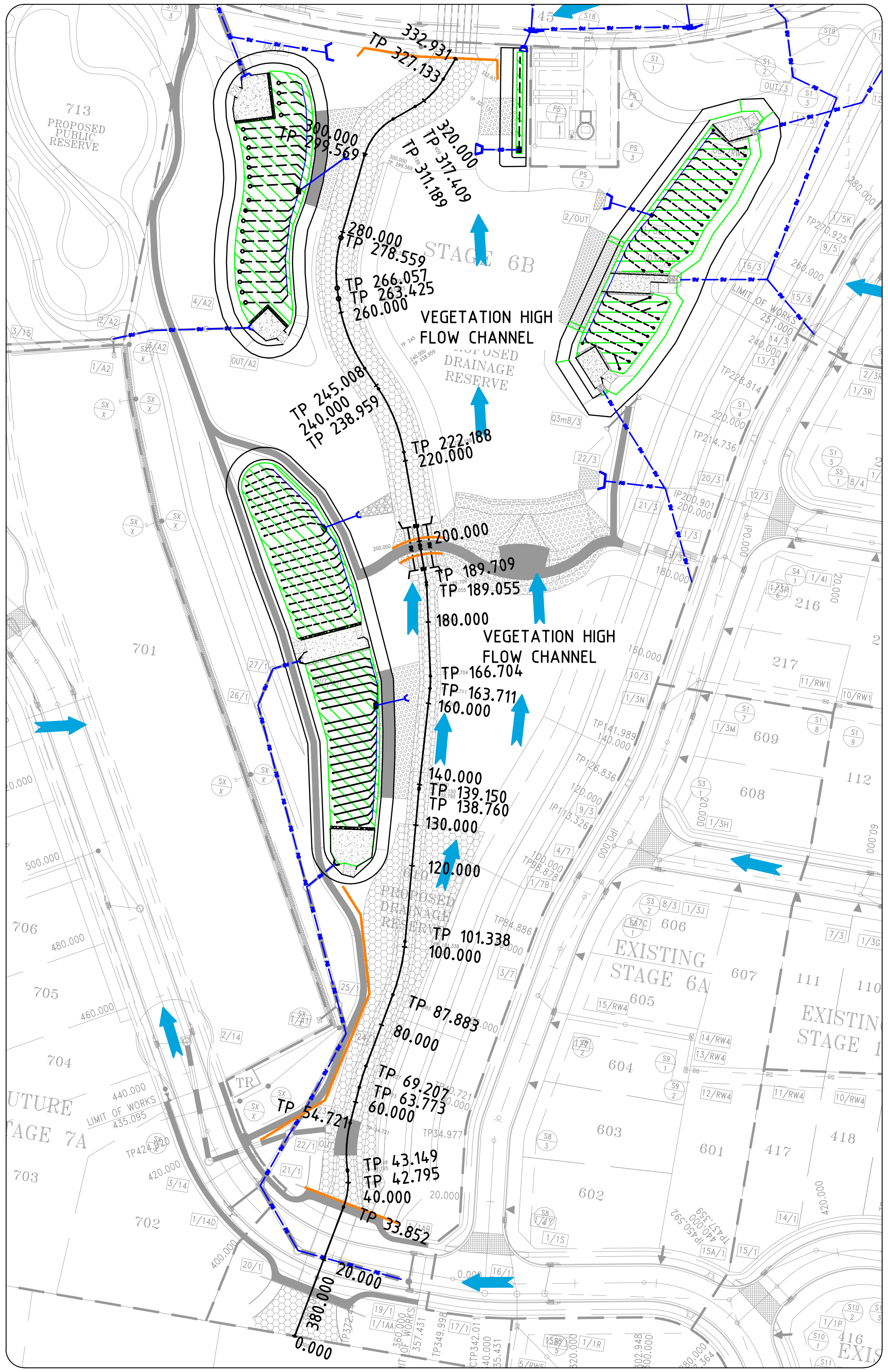

PLAN VIEW

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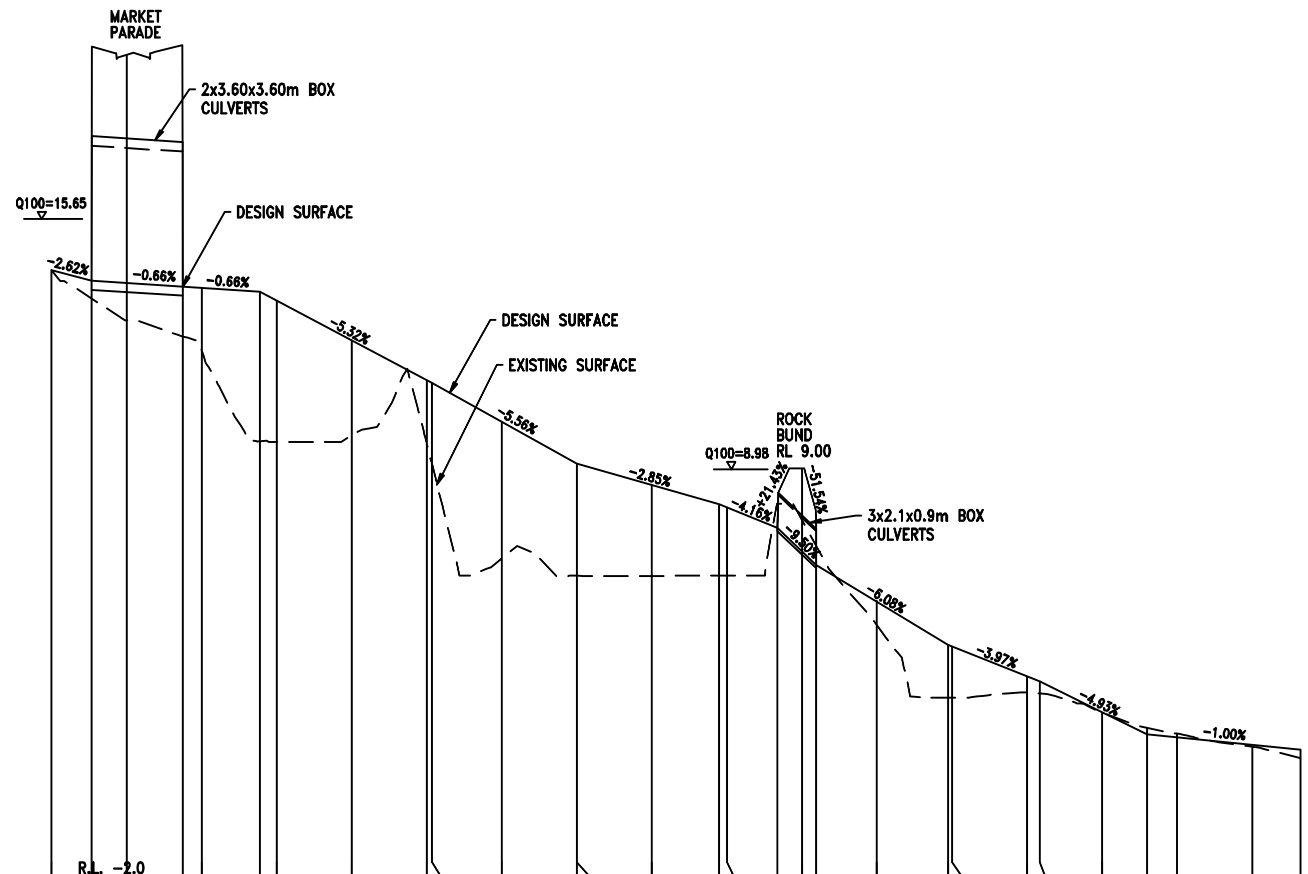

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60.000	9.708	13.482		3.77
80.000	9.878	12.419		2.54
100.000	9.659	11.355		1.70
101.369	9.119	11.282		2.16
120.000	6.602	10.246		3.64
139.963	6.135	9.135		3.00
140.000	6.135	9.134		3.00
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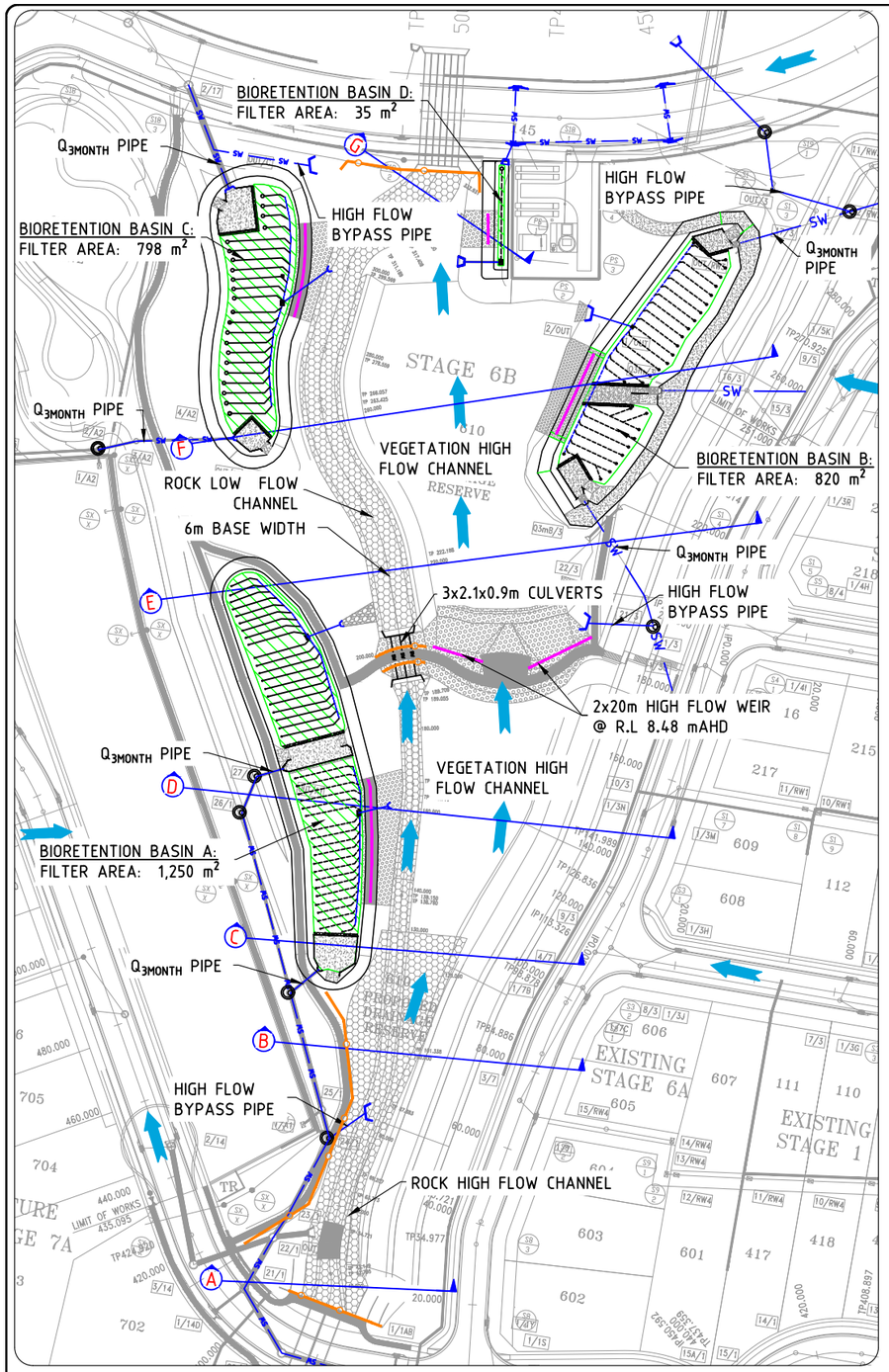

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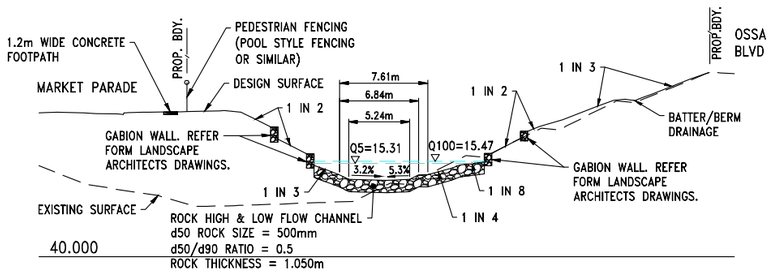

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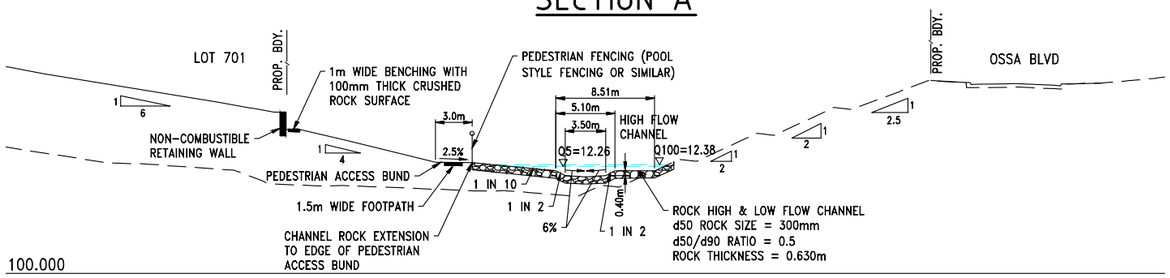

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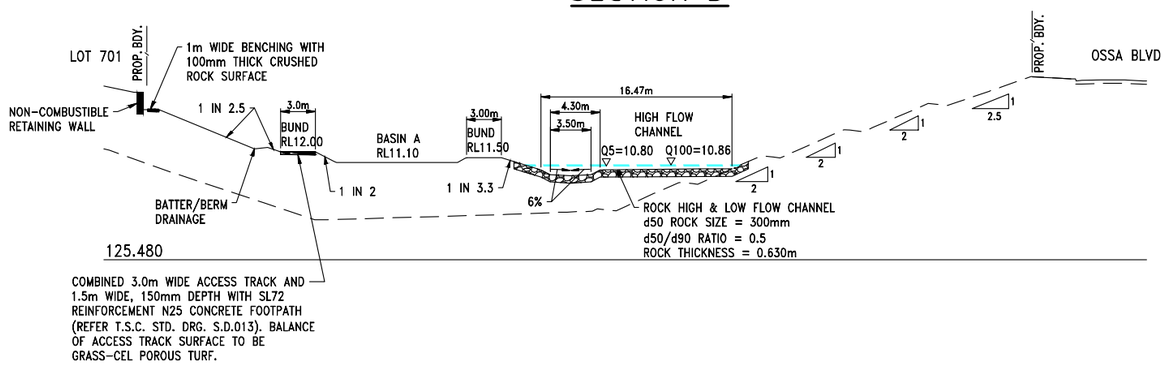

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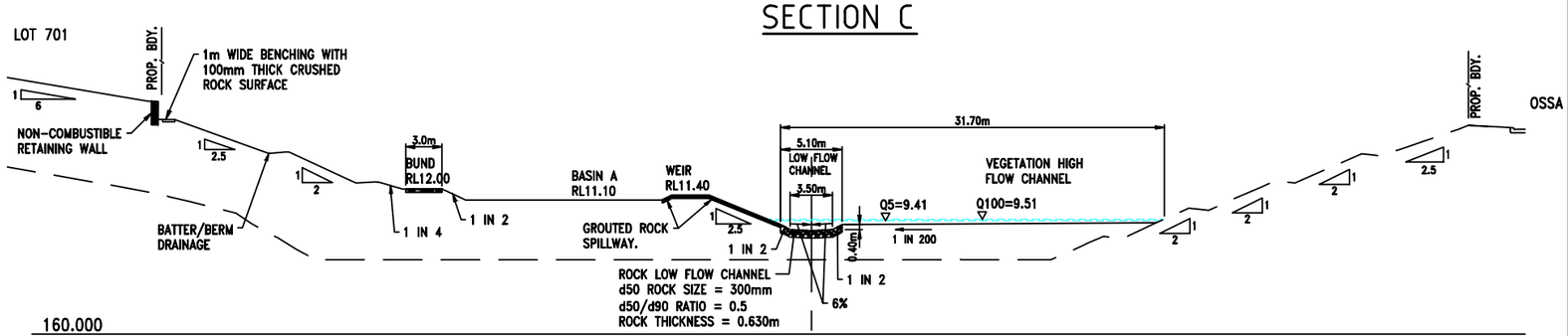

SECTION D

DATE	23.07.18
PROJECT No. :	BC16099
DRAWING No. :	DWG 302
REVISION No. :	D

PROJECT: ALTITUDE ASPIRE TERRANORA

DRAWING TITLE: OPERATIONAL CONTROL PLAN - CENTRAL CONVEYANCE
CROSS SECTION SHEET 1 OF 2

CLIENT: NEWLAND DEVELOPERS PTY LTD

ADDRESS: TERRANORA ROAD, TERRANORA

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TP / HN	BC	BC	A3	1:1500

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ACN 166 087 476
RPEQ No. :

VER.	DESCRIPTION	APPR.	DATE
A	ORIGINAL ISSUE		01.11.17
B	COUNCIL COMMENTS		18.05.18
C	MOD 3 AMENDMENTS		02.07.18
D	COUNCIL MOD3 COMMENTS		23.07.18

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ABN 86 166 087 476

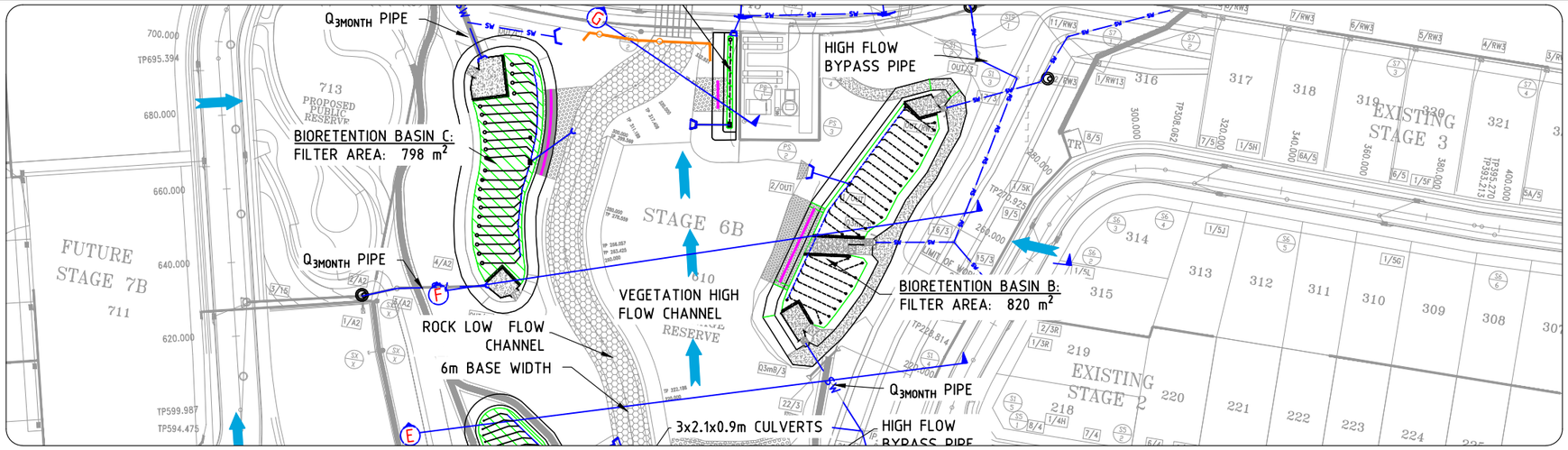
ORIGINAL SCALE BEFORE REDUCTION

15 0 15 30 45 60 75

1 : 1500 (FULL SIZE) (metres)

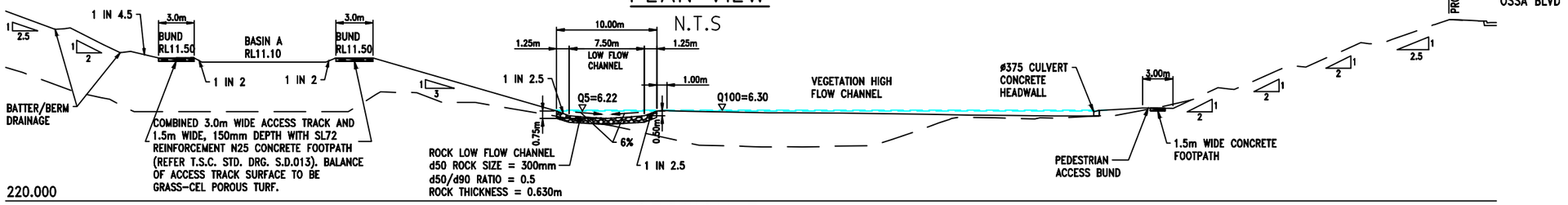
CERTIFIED BY

N

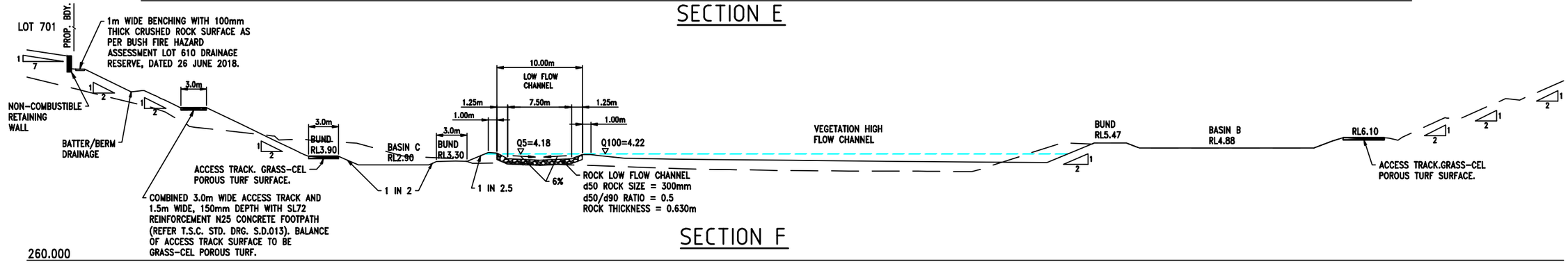


PLAN VIEW

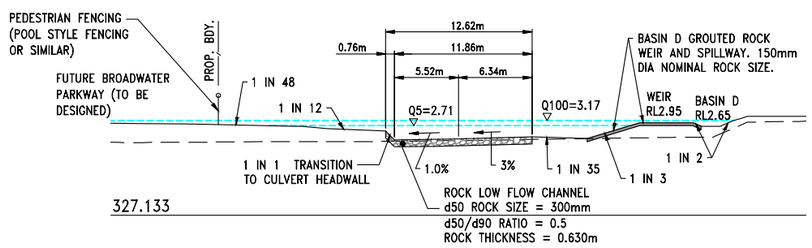
N.T.S



SECTION E



SECTION F



SECTION G

DATE	23.07.18		
PROJECT No. :	BC16099		
DRAWING No. :	DWG 303		
REVISION No. :	D		

PROJECT: ALTITUDE ASPIRE TERRANORA

DRAWING TITLE: OPERATIONAL CONTROL PLAN - CENTRAL CONVEYANCE
CROSS SECTION SHEET 2 OF 2

CLIENT: NEWLAND DEVELOPERS PTY LTD

ADDRESS: TERRANORA ROAD, TERRANORA

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TP / HN	BC	BC	A3	1:1200

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VER.	DESCRIPTION	APPR.	DATE
A	ORIGINAL ISSUE		01.11.17
B	COUNCIL COMMENTS		18.05.18
C	MOD 3 AMENDMENTS		02.07.18
D	COUNCIL MOD3 COMMENTS		23.07.18

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ABN 86 166 087 476

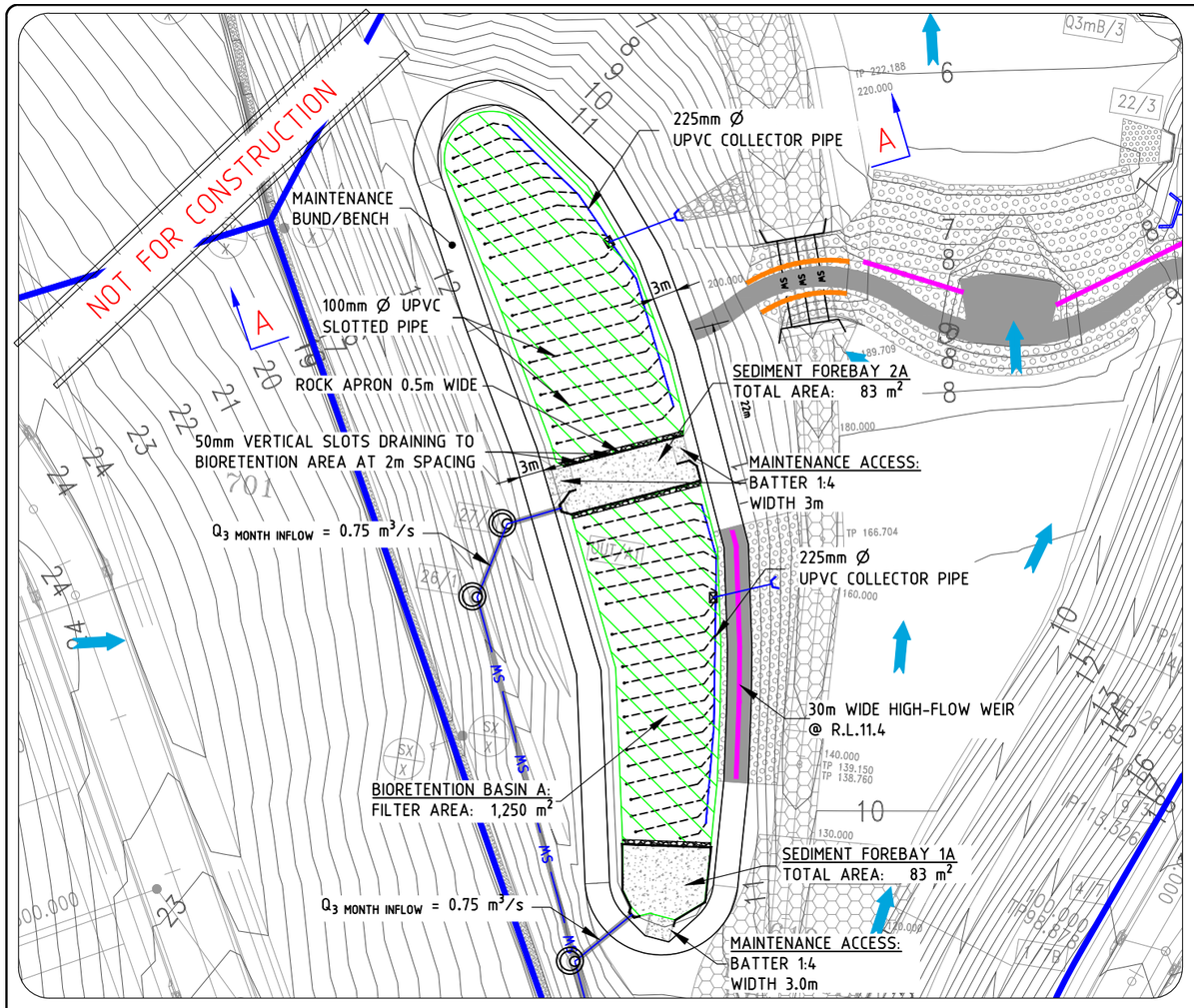
ORIGINAL SCALE BEFORE REDUCTION

12 0 12 24 36 48 60

1 : 1200 (FULL SIZE) (metres)

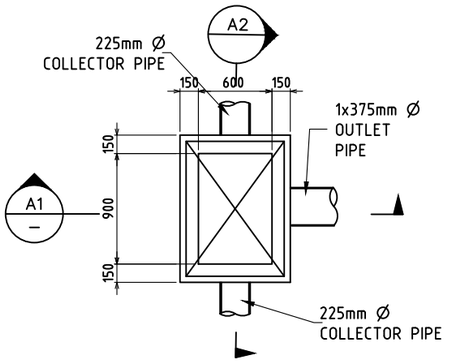
CERTIFIED BY

N



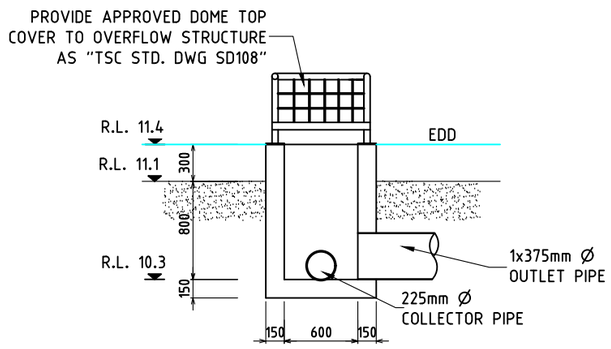
BIO BASIN A PLAN VIEW

N.T.S



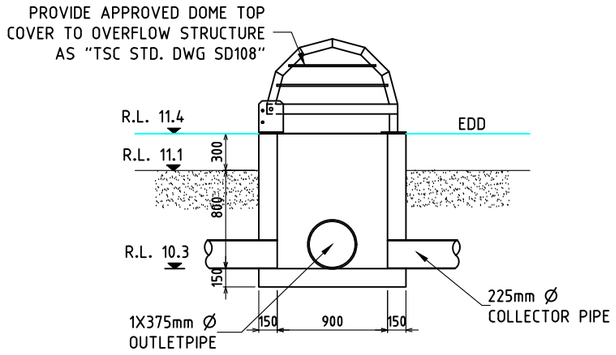
BASIN A OVERFLOW STRUCTURE PLAN

N.T.S



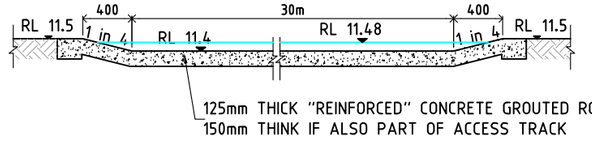
SECTION A1 - A1

N.T.S



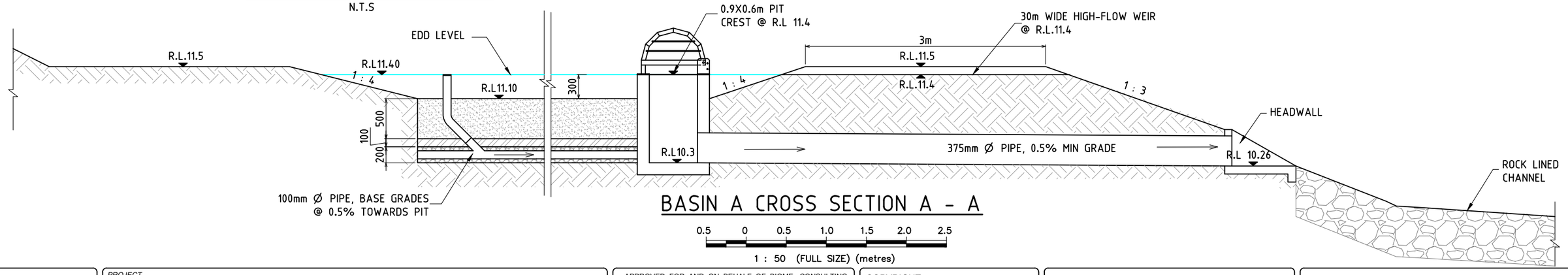
SECTION A2 - A2

N.T.S



WEIR DETAILS

N.T.S



BASIN A CROSS SECTION A - A

0.5 0 0.5 1.0 1.5 2.0 2.5

1 : 50 (FULL SIZE) (metres)

DATE
23.07.18

PROJECT No. :
BC16099

DRAWING No. :
DWG 304

REVISION No. :
D

PROJECT
ALTITUDE ASPIRE TERRANORA

DRAWING TITLE
OPERATIONAL CONTROL PLAN – BASIN A – LAYOUT AND DETAILS

CLIENT
NEWLAND DEVELOPERS PTY LTD

ADDRESS:
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ORIGINAL SCALE BEFORE REDUCTION

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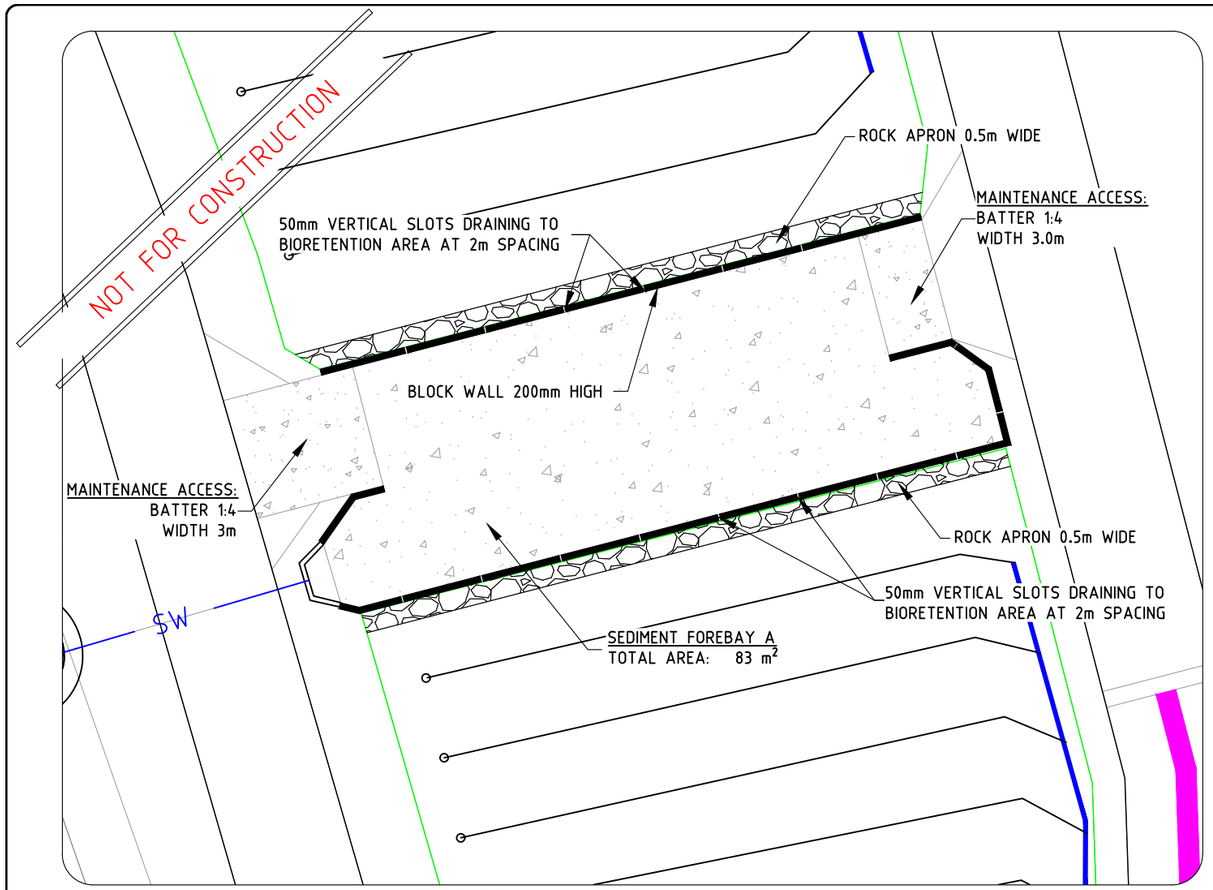
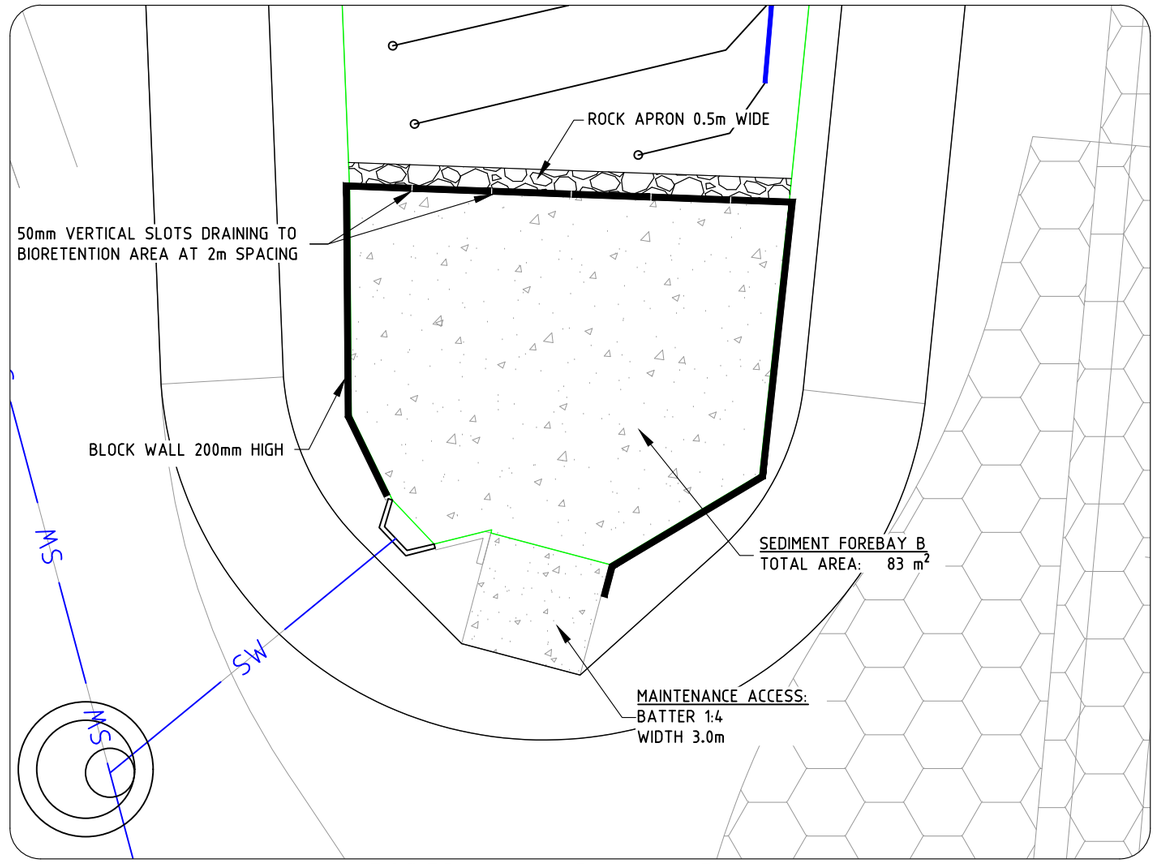
N



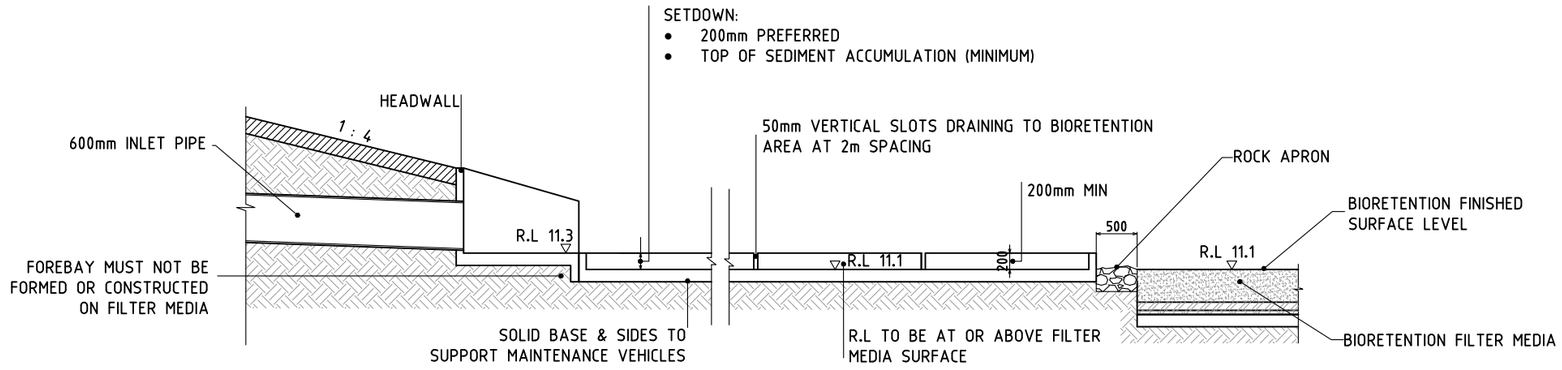
FOREBAY 2A PLAN VIEW

N.T.S



FOREBAY 1A PLAN VIEW

N.T.S



FOREBAY DETAILS

1 0.5 0 0.5 1 1.5 2 2.5 3 3.5 4

1 : 75 (FULL SIZE) (metres)

DATE
23.07.18

PROJECT No. :
BC16099

DRAWING No. :
DWG 305

REVISION No. :
D

PROJECT
ALTITUDE ASPIRE TERRANORA

DRAWING TITLE
OPERATIONAL CONTROL PLAN – BASIN A – SEDIMENT FOREBAY DETAILS

CLIENT
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ORIGINAL SCALE BEFORE REDUCTION

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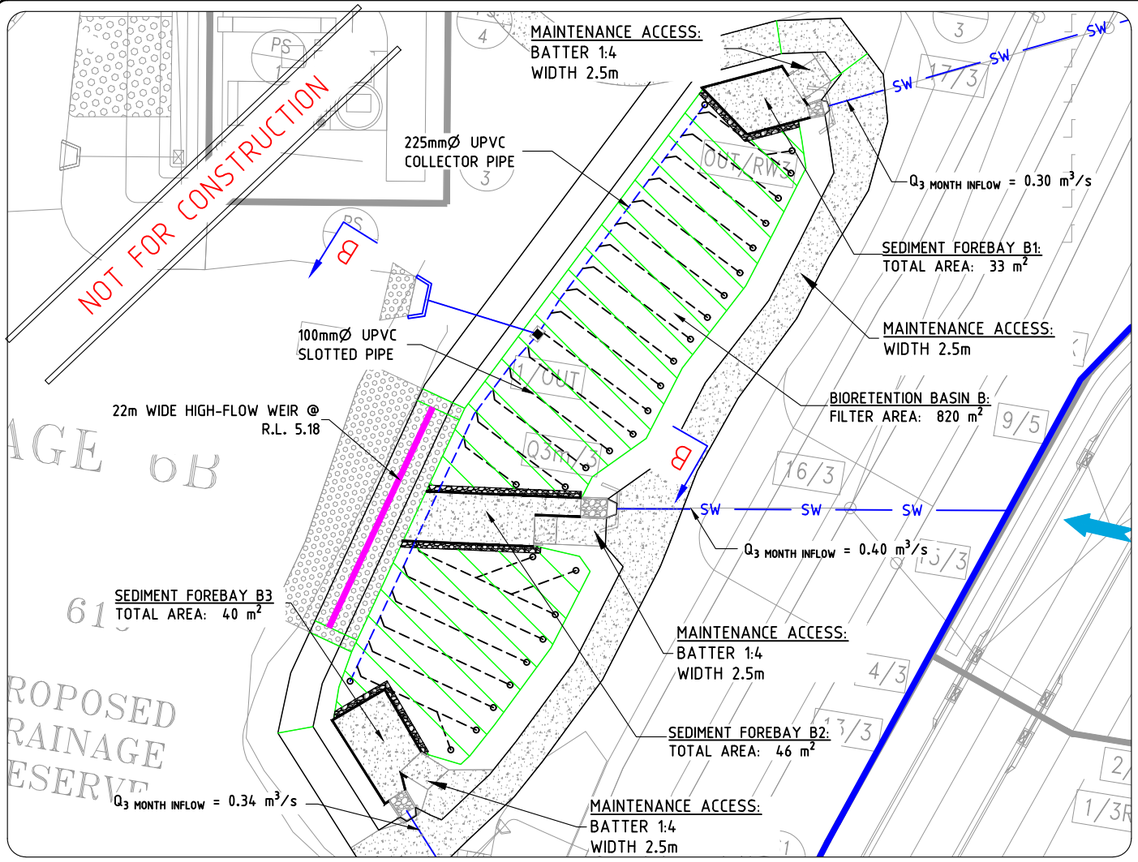
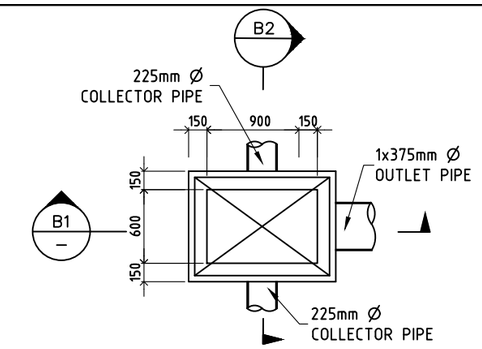
N



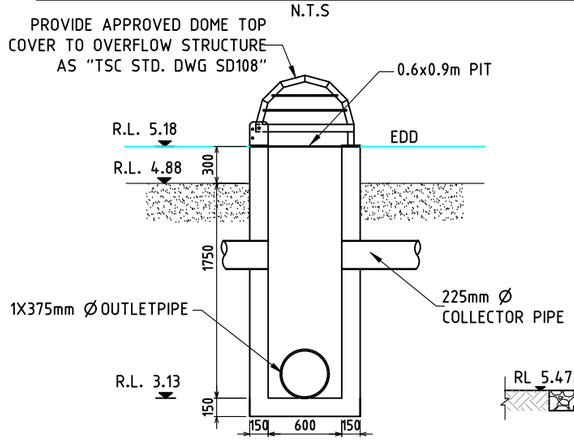
BIO BASIN B PLAN VIEW

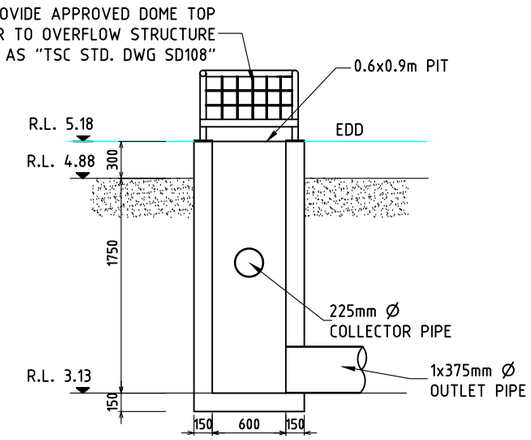
N.T.S



BASIN B OVERFLOW STRUCTURE PLAN

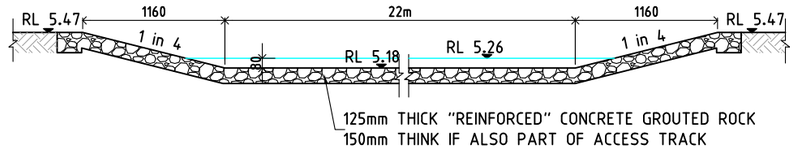
N.T.S





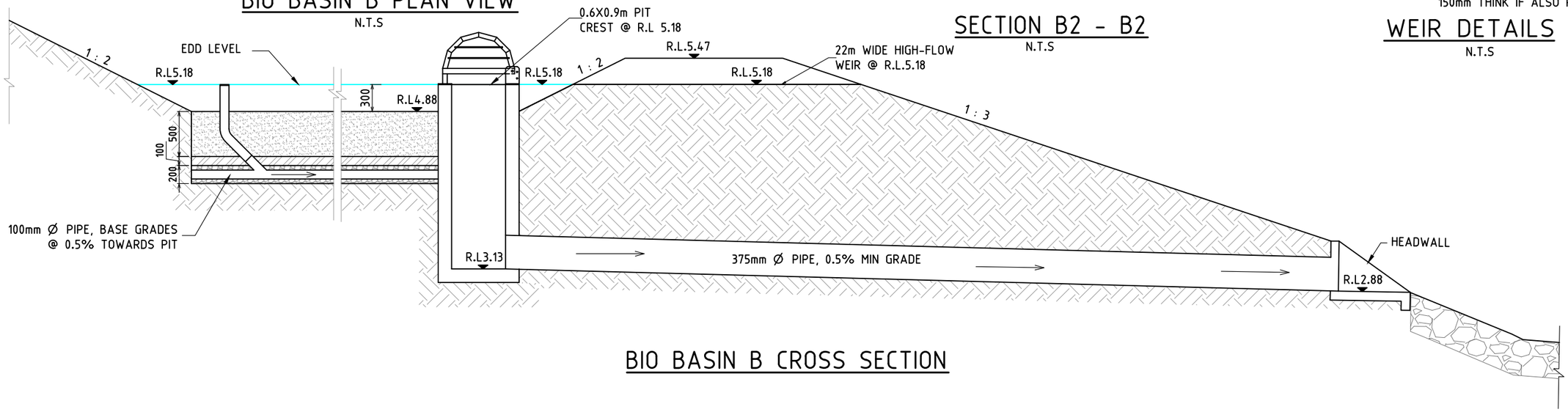
SECTION B1 - B1

N.T.S



WEIR DETAILS

N.T.S



SECTION B2 - B2

N.T.S

BIO BASIN B CROSS SECTION

DATE
23.07.18

PROJECT No. :
BC16099

DRAWING No. :
DWG 306

REVISION No. :
D

PROJECT
ALTITUDE ASPIRE TERRANORA

DRAWING TITLE
OPERATIONAL CONTROL PLAN – BASIN B – LAYOUT AND DETAILS

CLIENT
NEWLAND DEVELOPERS PTY LTD

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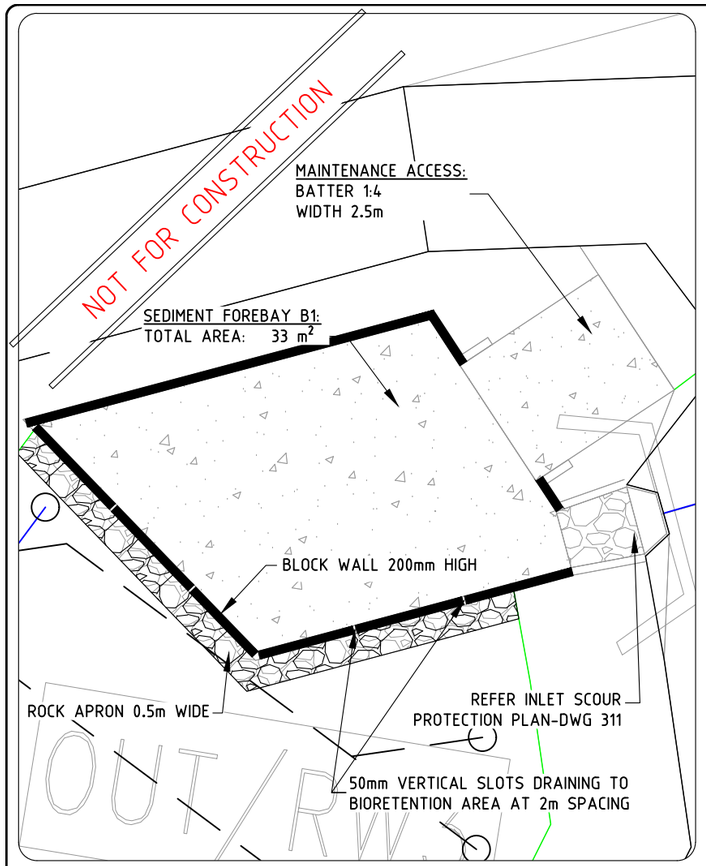
ORIGINAL SCALE BEFORE REDUCTION

0.5 0 0.5 1.0 1.5 2.0 2.5

1 : 50 (FULL SIZE) (metres)

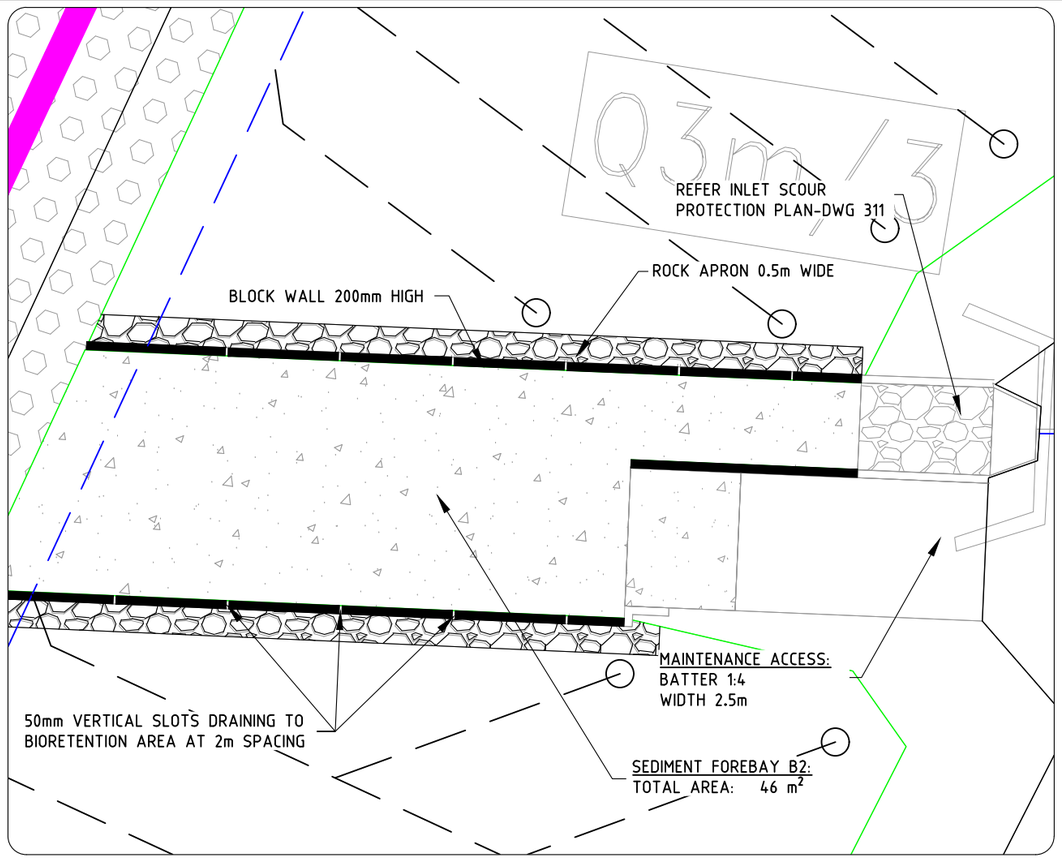
CERTIFIED BY

N



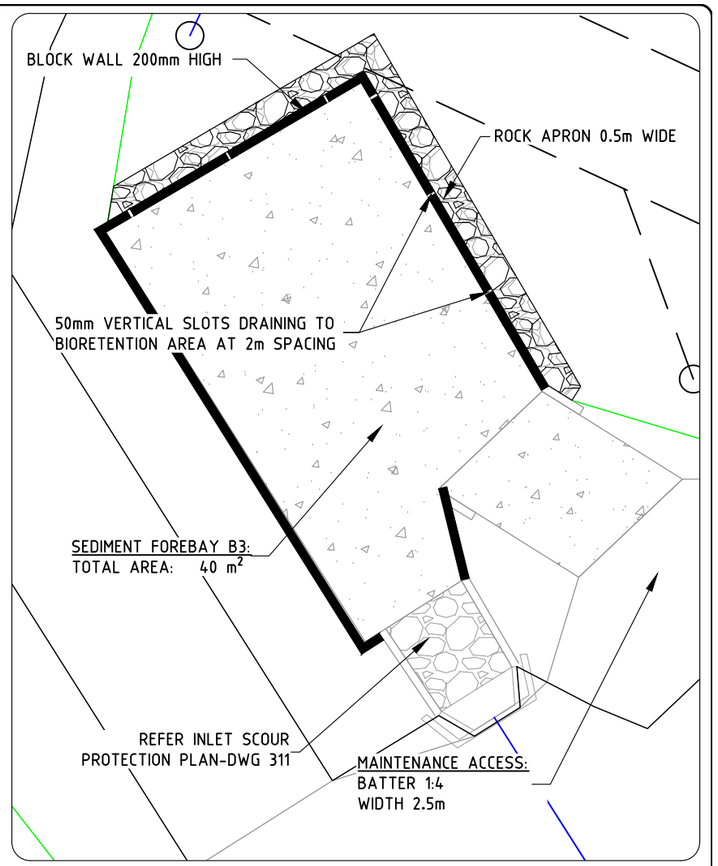
FOREBAY B1 PLAN VIEW

N.T.S



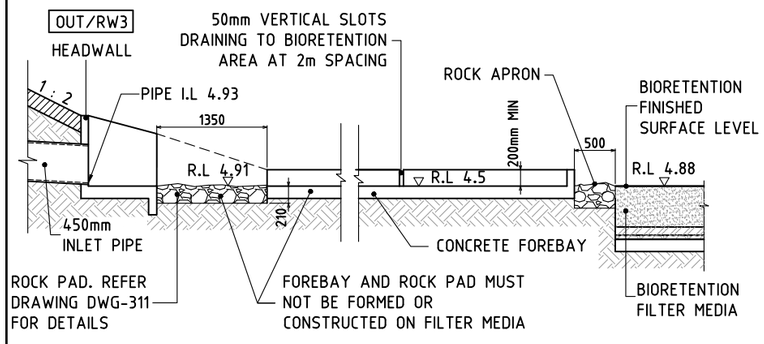
FOREBAY B2 PLAN VIEW

N.T.S



FOREBAY B3 PLAN VIEW

N.T.S



FOREBAY B1 DETAILS

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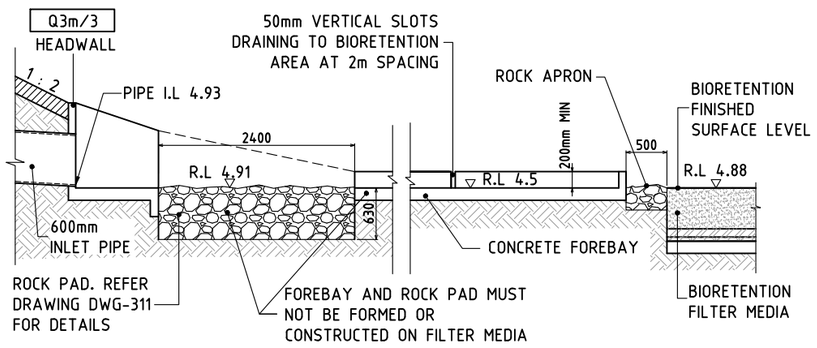
1 : 75 (FULL SIZE) (metres)



FOREBAY B2 DETAILS

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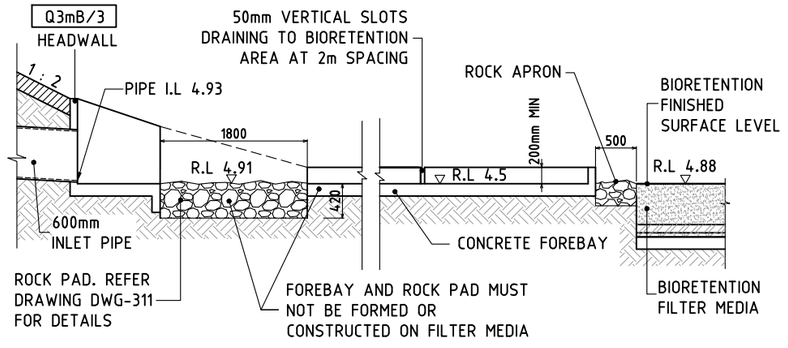

FOREBAY B3 DETAILS

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1 : 75 (FULL SIZE) (metres)

DATE
23.07.18

PROJECT No. :
BC16099

DRAWING No. :
DWG 307

REVISION No. :
D

PROJECT
ALTITUDE ASPIRE TERRANORA

DRAWING TITLE
OPERATIONAL CONTROL PLAN – BASIN B – SEDIMENT FOREBAY DETAILS

CLIENT
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ABN 86 166 087 476

ORIGINAL SCALE BEFORE REDUCTION

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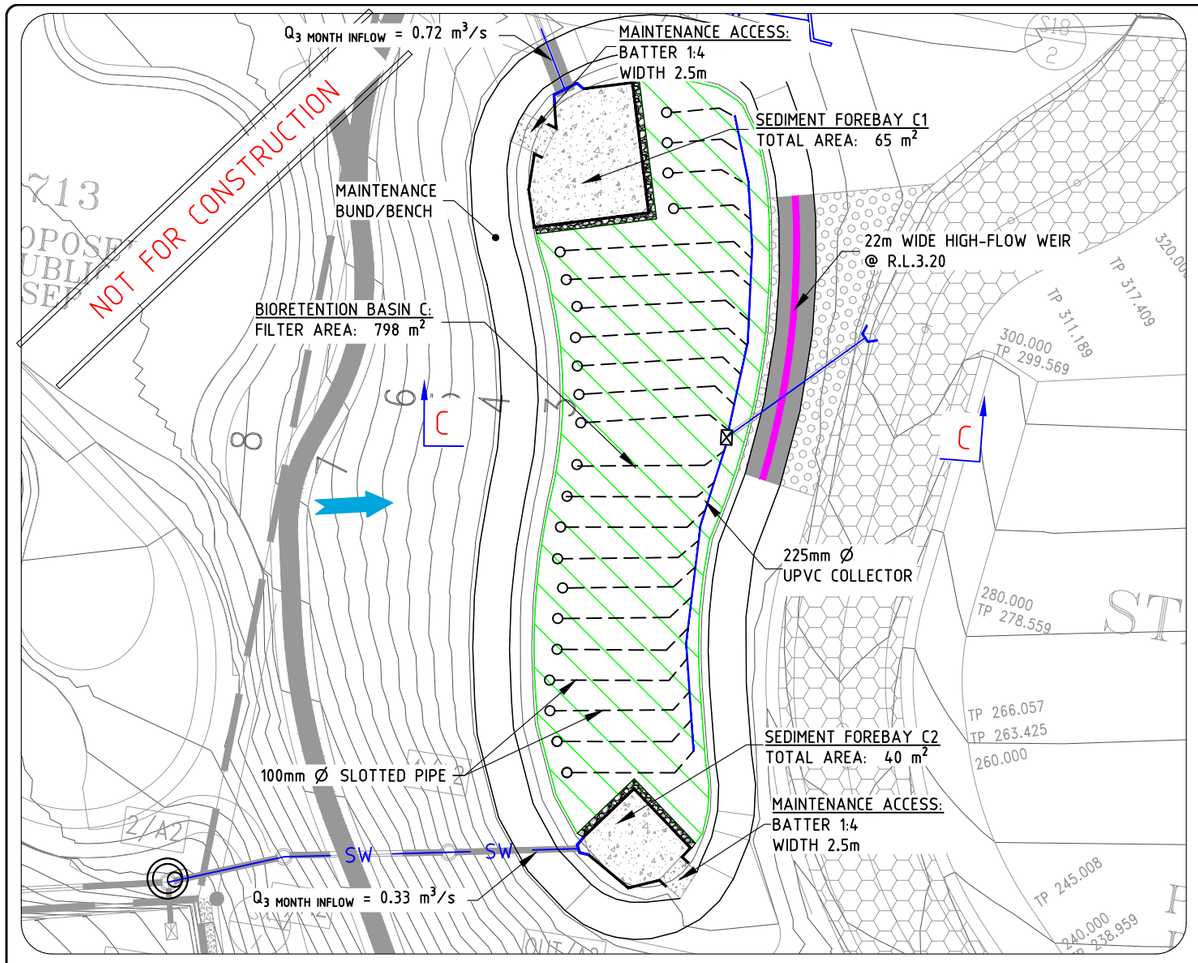
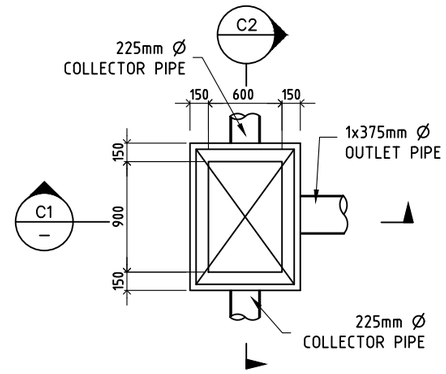


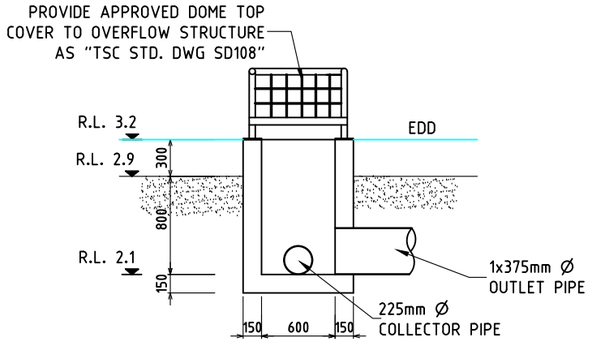
BIO BASIN C PLAN VIEW

N.T.S



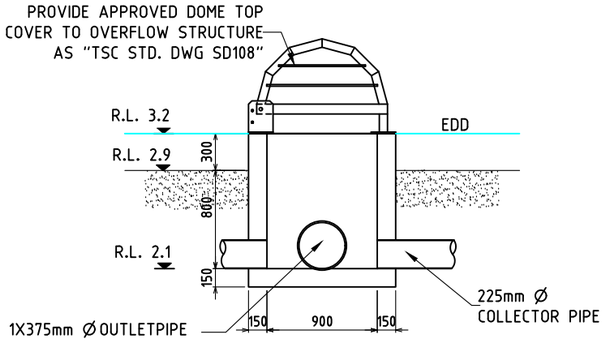
BASIN C OVERFLOW STRUCTURE PLAN

N.T.S



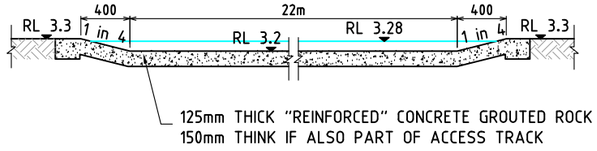
SECTION C1 - C1

N.T.S



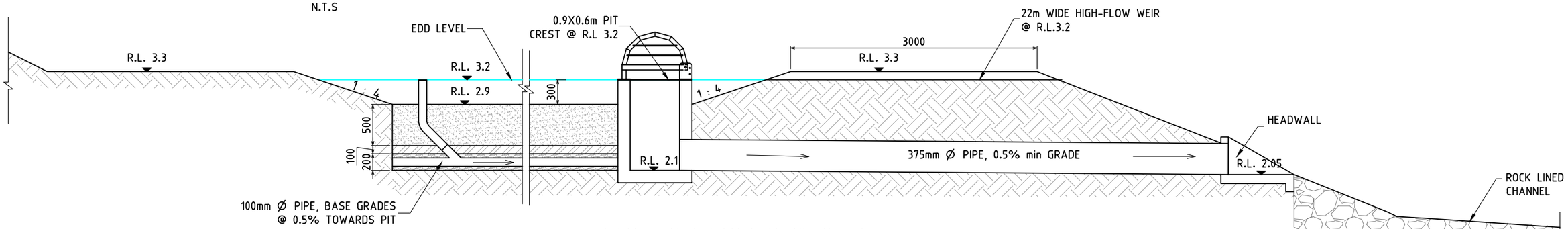
SECTION C2 - C2

N.T.S



WEIR DETAILS

N.T.S



BASIN C CROSS SECTION C - C

0.5 0 0.5 1.0 1.5 2.0 2.5

1 : 50 (FULL SIZE) (metres)

DATE
23.07.18

PROJECT No. :
BC16099

DRAWING No. :
DWG 308

REVISION No. :
D

PROJECT
ALTITUDE ASPIRE TERRANORA

DRAWING TITLE
OPERATIONAL CONTROL PLAN – BASIN C – LAYOUT AND DETAILS

CLIENT
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ADDRESS:
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ABN 86 166 087 476

ORIGINAL SCALE BEFORE REDUCTION

CERTIFIED BY

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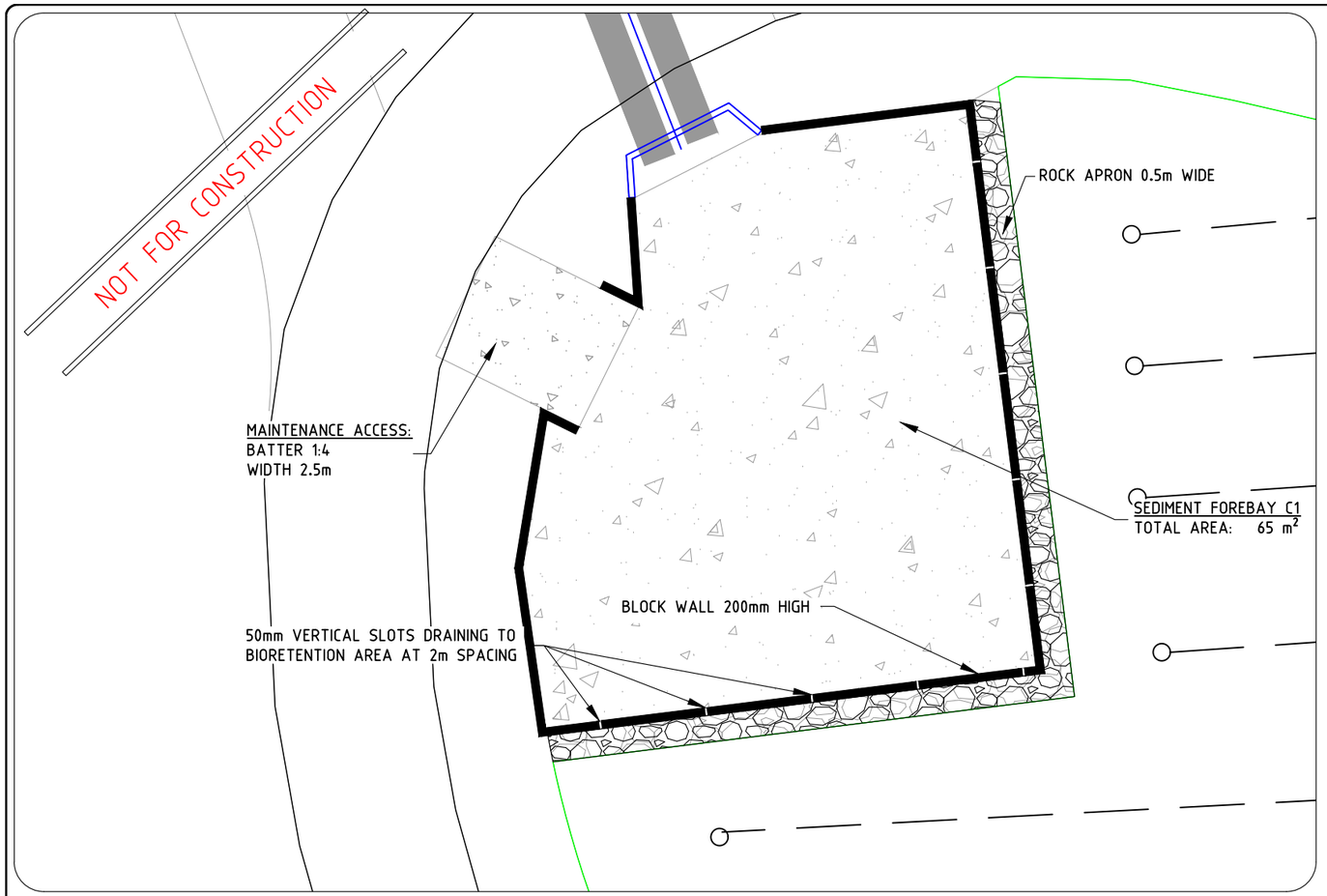
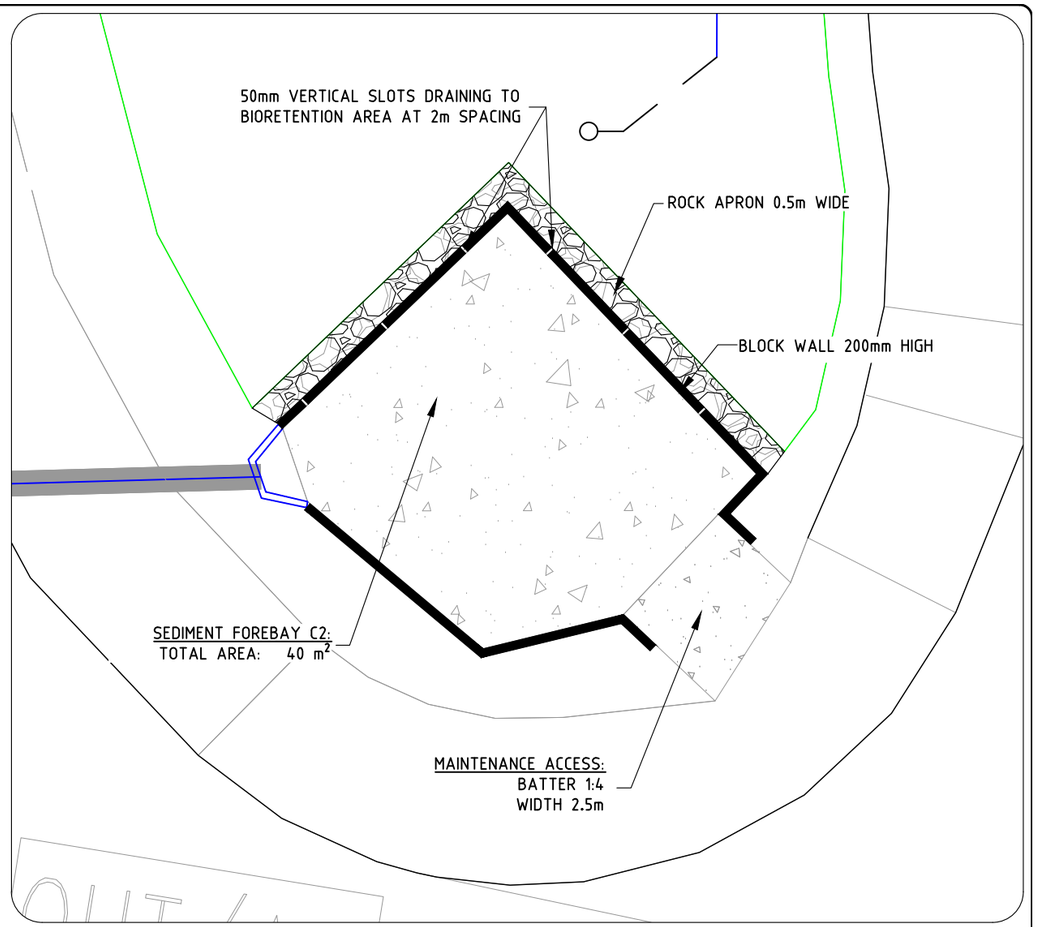


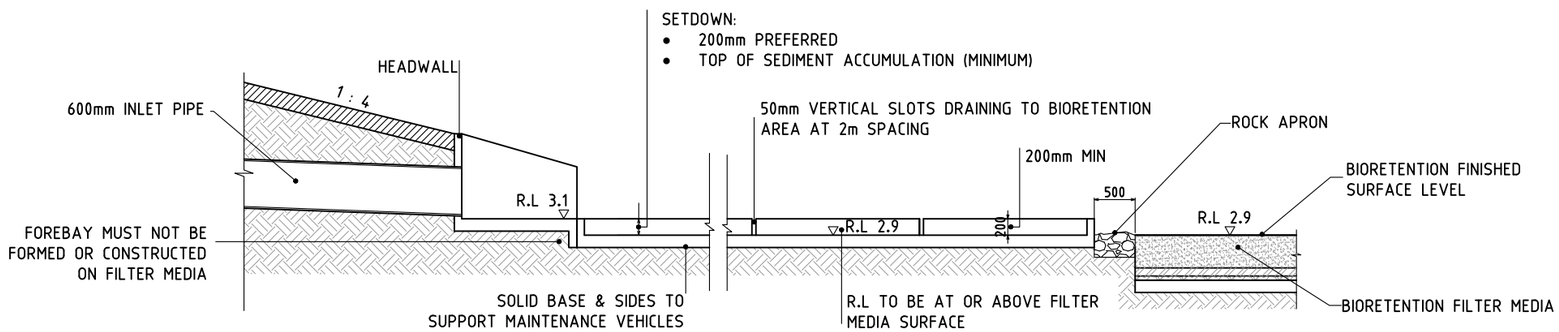
FOREBAY C1 PLAN VIEW

N.T.S



FOREBAY C2 PLAN VIEW

N.T.S



FOREBAY DETAILS

1 0.5 0 0.5 1 1.5 2 2.5 3 3.5 4

1 : 75 (FULL SIZE) (metres)

DATE
23.07.18

PROJECT No. :
BC16099

DRAWING No. :
SMP 309

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PROJECT
ALTITUDE ASPIRE TERRANORA

DRAWING TITLE
OPERATIONAL CONTROL PLAN – BASIN C – SEDIMENT FOREBAY DETAILS

CLIENT
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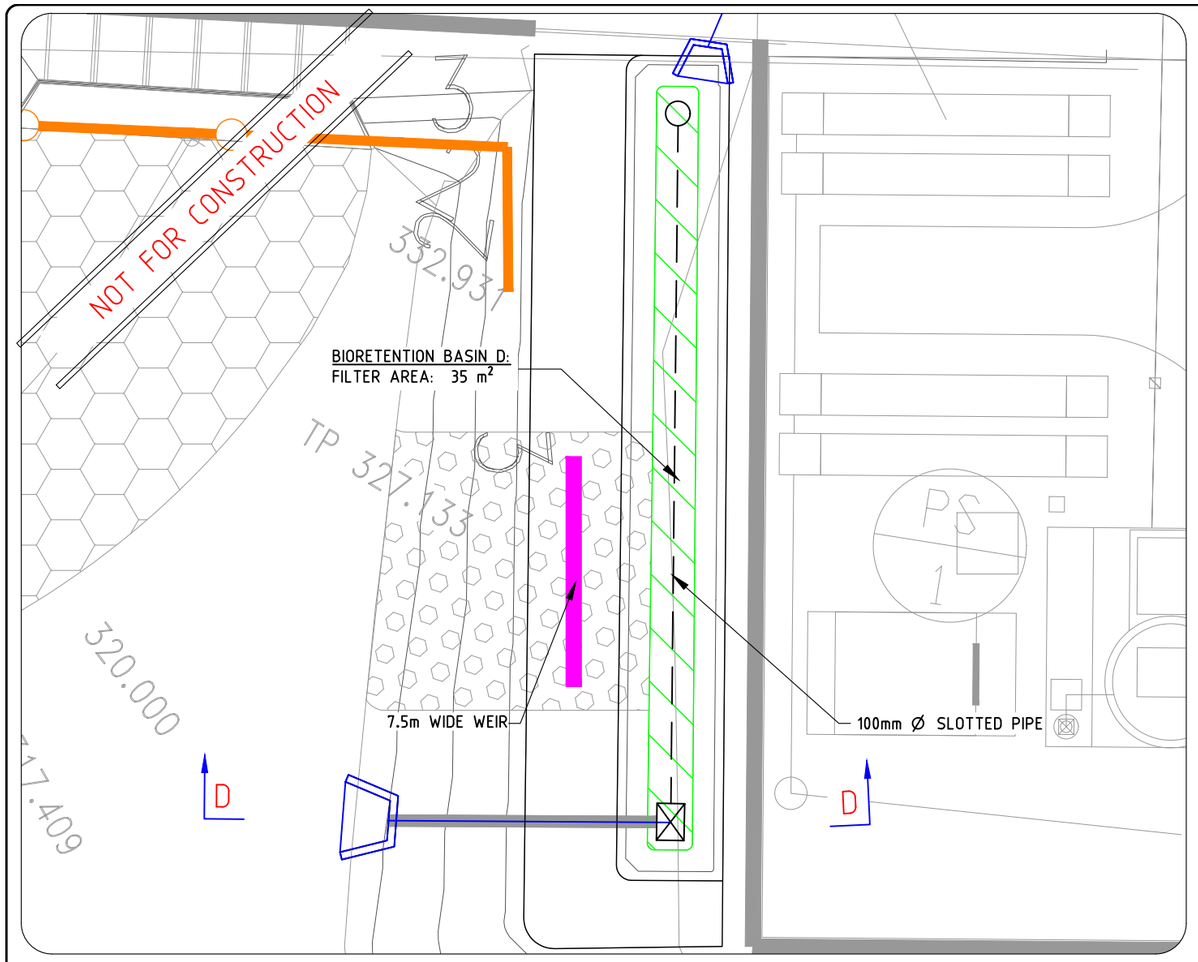

BIO BASIN D PLAN VIEW

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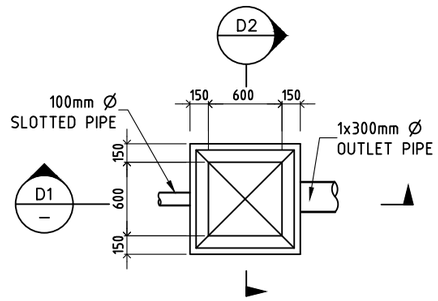

BASIN D OVERFLOW STRUCTURE PLAN

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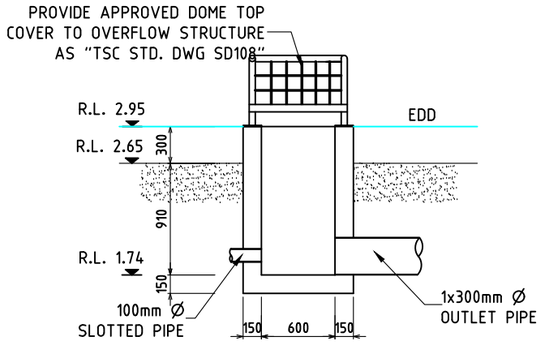

SECTION D1 - D1

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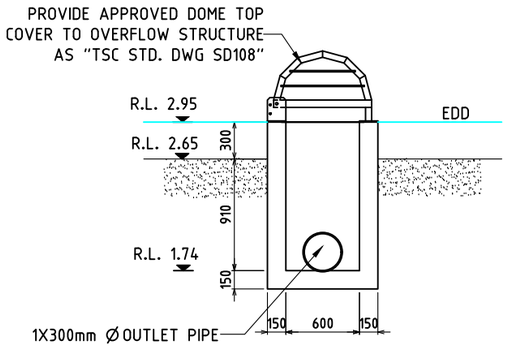

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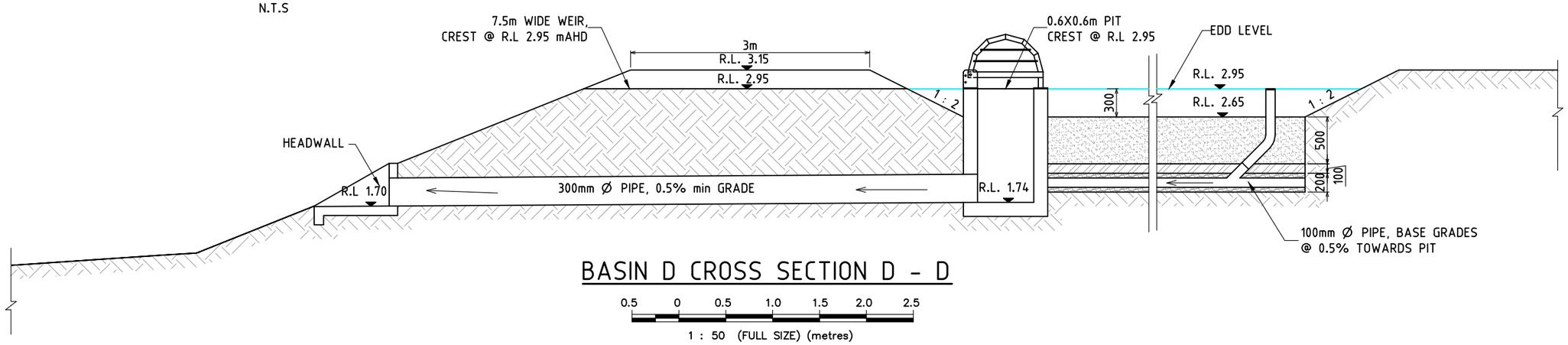

BASIN D CROSS SECTION D - D

0.5 0 0.5 1.0 1.5 2.0 2.5

1 : 50 (FULL SIZE) (metres)

DATE
23.07.18

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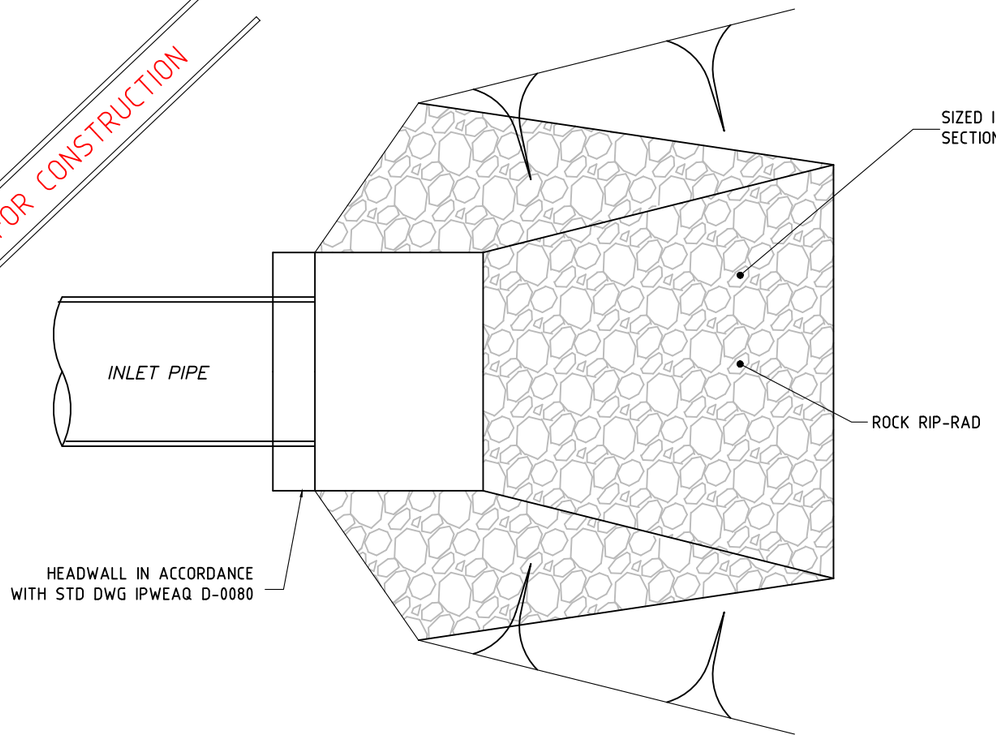

INLET SCOUR PROTECTION PLAN

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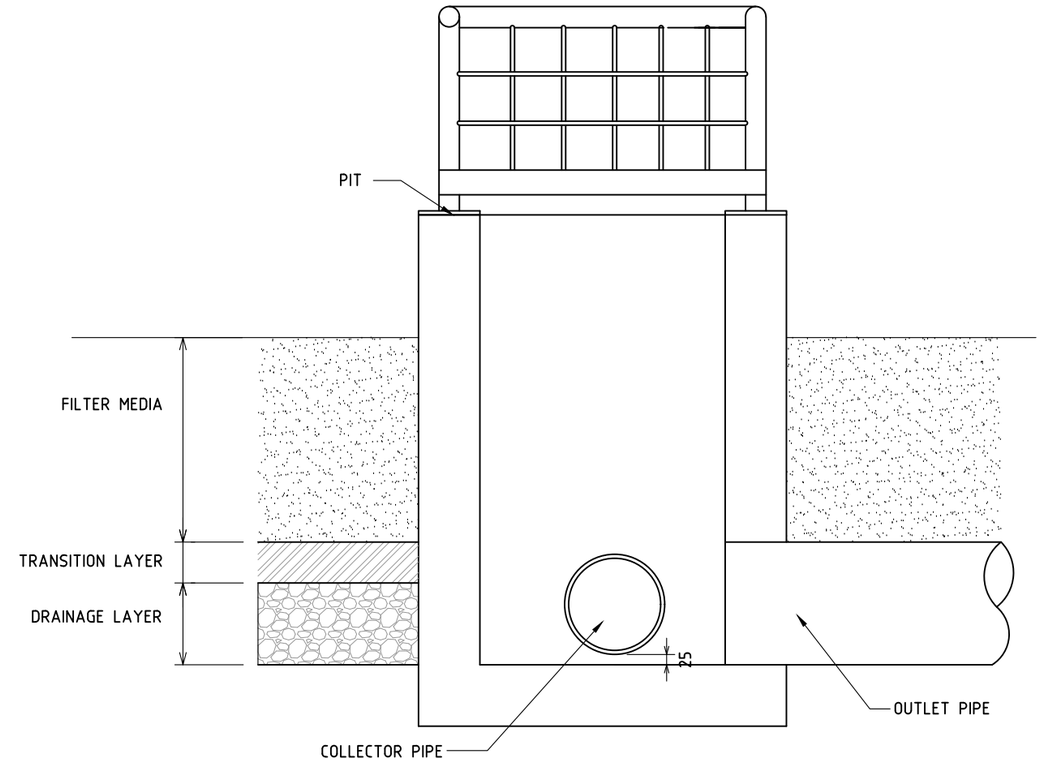

UNDERDRAINAGE PIPE CONNECTION DETAILS

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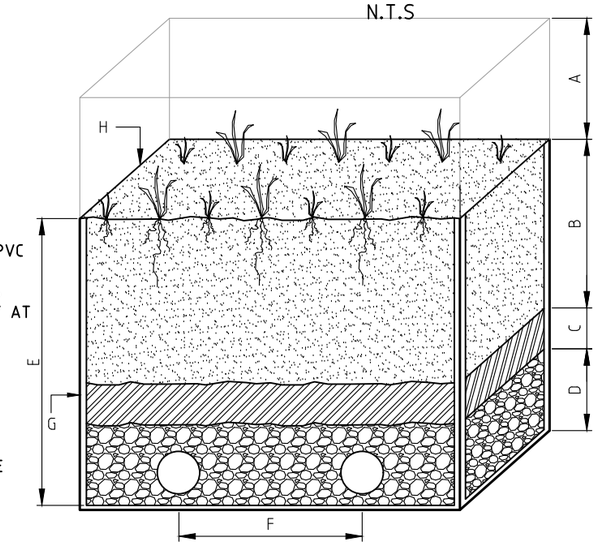

A EXTENDED DETENTION
DEPTH NO GREATER THAN 400mm WITH RETENTION OF LOW FLOWS FOR NO GREATER THAN FOUR (4) DAYS TO PREVENT ANAEROBIC CONDITIONS

B FILTER MEDIA
SANDY LOAM WITH 400-500mm/hr SATURATED HYDRAULIC CONDUCTIVITY. IN-SITU HYDRAULIC CONDUCTIVITY TO REACH 200mm/hr ONCE SETTLEMENT AND COMPACTION HAS TAKEN PLACE.
ORGANIC CONTENT 5% (w/w) MAX.
PARTICLE SIZE <3% PASSING 0.05mm (w/w)
>97% PASSING 2mm (w/w)
pH. BETWEEN 5.5-7.5
PHOSPHORUS CONCENTRATION <100mg/kg

C TRANSITION LAYER
1mm COARSE SAND
(DESIGNED IAW WSUD TDG SECTION 5.3.4.3)

D DRAINAGE LAYER
2-5mm SCREENINGS COARSE SAND/GRAVEL
(DESIGNED IAW WSUD TDG SECTION 5.3.4.2)

E TOTAL BIORETENTION DEPTH

F SLOTTED 100mm RIGID PIPE (uPVC OR SIMILAR TO AS 2439.1) OR APPROVED EQUIVALENT, 0.5% MIN. GRADE, SPACED EQUALLY AT 2.5m CENTRES

G GEO-FABRIC TERRAFIX 360R GEOTEXTILE

H VEGATATION
SPECIES TO BE IN ACCORDANCE WITH WATER BY DESIGN GUIDELINES

BIO-RETENTION MEDIA CROSS SECTION

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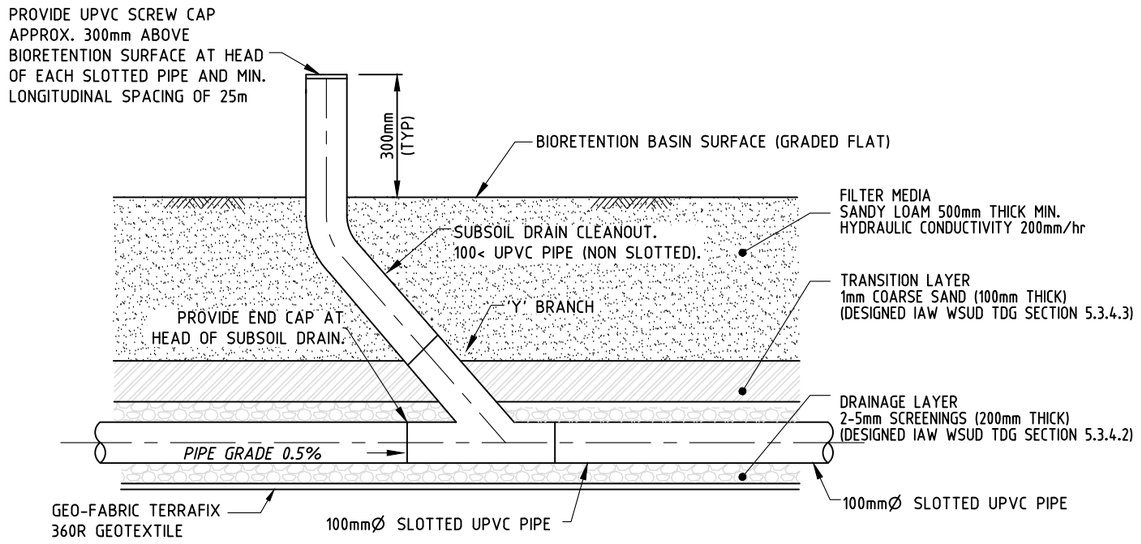

BIORETENTION BASIN SUBSOIL DRAIN CLEANOUT

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Appendix C

Bioretention Design Checklist

BIORETENTION DESIGN CHECKLIST

Item	Description	Detail			
		Basin A	Basin B	Basin C	Basin D
1.Treatment					
a)	Catchment Area	11.57 ha	8.30 ha	8.62 ha	0.86 ha
b)	Filter media area (excluding batters)	1,250 m^2	820 m^2	798 m^2	35m^2
c)	Confirm water quality performance meets the design objectives	Yes			
d)	Confirm hydrological performance meets relevant frequent flow objectives	Yes	Yes	Yes	Yes
2. Design Inflows					
a)	Minor design storm entering system (ARI event)	Q_{3month}	Q_{3month}	Q_{3month}	Q_{3month}
b)	Minor storm peak flow rate – Total (m^3/s)	1.494	1.035	1.045	0.09
c)	Major design storm entering system (ARI event)	Major is Bypassed	Major is Bypassed	Major is Bypassed	1 in 5
d)	Major storm peak flow rate (m^3/s)	-	-	-	0.379
a)	Bioretention drainage profile type	Type 3	Type 3	Type 3	Type 3
b)	Minimum drainage layer depth (mm)	200	200	200	200
c)	Maximum drainage layer depth (mm)	200	200	200	200
d)	Transition layer depth (mm)	100	100	100	100
e)	Saturated zone depth for Type 1 bioretention systems	N/A	N/A	N/A	N/A
f)	Filter media layer depth (mm)	500	500	500	500
g)	Extended detention depth (mm)	300	300	300	300
h)	Freeboard to top of embankment (mm)	100	100	100	100
i)	Maximum water level depth above extended detention for major storm event (mm)	100	100	100	100
j)	Total system profile depth (mm) [3(c)+3(d)+3(f)+3(g)+A3(i)	1200	1200	1200	1200
k)	Layer type (i)Permeable (ii)Impermeable (iii)None to base	Permeable	Permeable	Permeable	Permeable
l)	AASS/PASS assessed and appropriately managed	N/A	N/A	N/A	N/A
m)	Presence of dispersive soils and appropriately managed	N/A	N/A	N/A	N/A
4. Design Levels					
a)	Outlet invert level (m AHD)	10.26	2.88	2.05	1.70
b)	Overflow pit invert level (m AHD)	10.3	3.13	2.1	1.74
c)	Minimum drainage layer level (m AHD)	10.3	4.08	2.1	1.85
d)	Filter media surface level (m AHD)	11.1	4.88	2.9	2.65
e)	Overflow pit crest level (m AHD)	11.4	5.18	3.2	2.95
f)	Overflow weir level (m AHD)	11.4	5.18	3.2	2.95
g)	Maximum design water level (m AHD)	11.5	5.47	3.3	3.15
h)	Top of embankment/batter level (m AHD)	11.5	5.47	3.3	3.15
i)	Inlet/inflow invert level (m AHD)	11.3	4.91	3.1	2.85
j)	Total level difference [4(h)-(4(c)]	1.2 m	1.39 m	1.2 m	1.3 m
k)	Highest astronomical tide level	N/A	N/A	N/A	N/A
l)	Ground water level	N/A	N/A	N/A	N/A

BIORETENTION DESIGN CHECKLIST

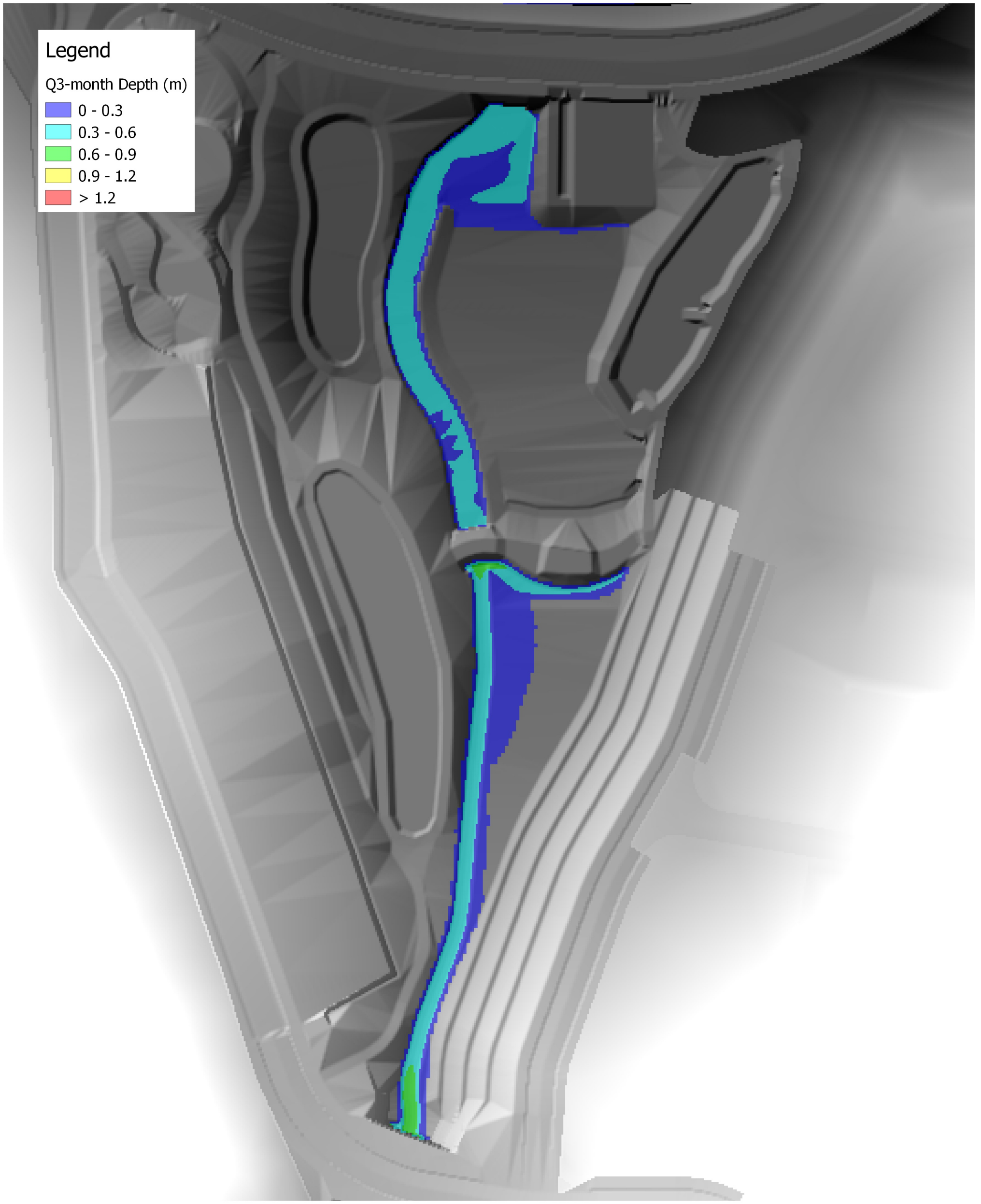
5. Layout					
a)	Maximum filter media length (m)	20	15	16	24
b)	Maximum filter media width (m)	33.5	38.5	30	1.5
c)	Maximum batter slope (V:H)	1:4	1:2	1:4	1:2
d)	Maximum wall height (m)	N/A	N/A	N/A	N/A
e)	Provision for services	N/A - Greenfield	N/A - Greenfield	N/A - Greenfield	N/A - Greenfield
f)	Maintenance access provided(Yes/No)	Yes	Yes	Yes	Yes
g)	Flood storage volume above extended detention (m^3)	N/A	N/A	N/A	N/A
6. Inlet Design					
a)	Inlet/inflow type (i)pipe (ii)channel (iii) sheet flow (iv)other	pipe	pipe	pipe	pipe
b)	Diversion/surcharge type	N/A	N/A	N/A	N/A
c)	Coarse sediment removal (i)forebay (ii)inlet pond (iii)swale (iv) other	2x Forebays	3x Forebays	2x Forebays	N/A
d)	Coarse sediment removal area - Total (m^2)	165	118	121	-
e)	Coarse sediment removal depth (m)	0.2	0.2	0.2	-
f)	Coarse sediment clean-out frequency (/year)	1	1	1	-
g)	Flow distribution	Yes	Yes	Yes	N/A
h)	Confirm scour protection at inflow locations	Yes	Yes	Yes	Yes
i)	Minor storm flow velocity over filter (m/s)	0.374	0.185	0.187	0.15
j)	Major storm flow velocity over filter (m/s)	0.374	0.185	0.187	0.632
7. Underdrainage (outlet design)					
a)	Filer media saturated hydraulic conductivity (mm/hr)	200	200	200	200
b)	Maximum filter infiltration capacity (m^3/s) – Cell 1	0.0215	0.0276	0.0316	0.0028
	Cell 2	0.0235	0.0373	0.0317	
	Cell 3	0.0297			
	Cell 4	0.0242			
c)	Underdrain capacity - Collector (m3/s) Cell 1	0.0375	0.0375	0.0375	0.0043
	Cell 2	0.0375	0.0375	0.0375	
	Cell 3	0.0375			
	Cell 4	0.0375			
8. Overflow design (outlet design)					
a)	Overflow pit type	Rectangular	Rectangular	Rectangular	Rectangular
b)	Overflow pit dimensions	2 x 900x600	900x600	900x600	900x600
c)	Overflow weir length (m)	30	22	22	7.5
d)	Overflow pit capacity (taking into account blockage factor) (m^3/s)	0.314	0.157	0.157	0.157
e)	Overflow pit plus overflow weir capacity (taking into account blockage factor) (m^3/s)	1.889	1.312	1.312	0.394
f)	Outlet pipe size (mm)	2x375	375	375	375
g)	Appropriate outlet scour protection provided	Yes	Yes	Yes	Yes

BIORETENTION DESIGN CHECKLIST

9. Vegetation Design					
a)	Planting style (i)small scale urban (ii)med-large scale urban (iii) bushland	med-large scale urban	med-large scale urban	med-large scale urban	med-large scale urban
b)	Trees and shrubs to be included (yes/no)	Shrubs	Shrubs	Shrubs	Shrubs
c)	Species diversity (number of species)	Six	Six	Six	Six
d)	Species selection	Table 19 WUSD	Table 19 WUSD	Table 19 WUSD	Table 19 WUSD
e)	Planting density	Ground Covers 6 – 8 /m^2 Shrubs 1/ 2-20 m^2	Ground Covers 6 – 8 /m^2 Shrubs 1/ 2-20 m^2	Ground Covers 6 – 8 /m^2 Shrubs 1/ 2-20 m^2	Ground Covers 6 – 8 /m^2
f)	Mulch type and depth	Organic Friable 50-75 mm	Organic Friable 50-75 mm	Organic Friable 50-75 mm	Organic Friable 50-75 mm

Appendix D

Central Drainage Assessment Plots



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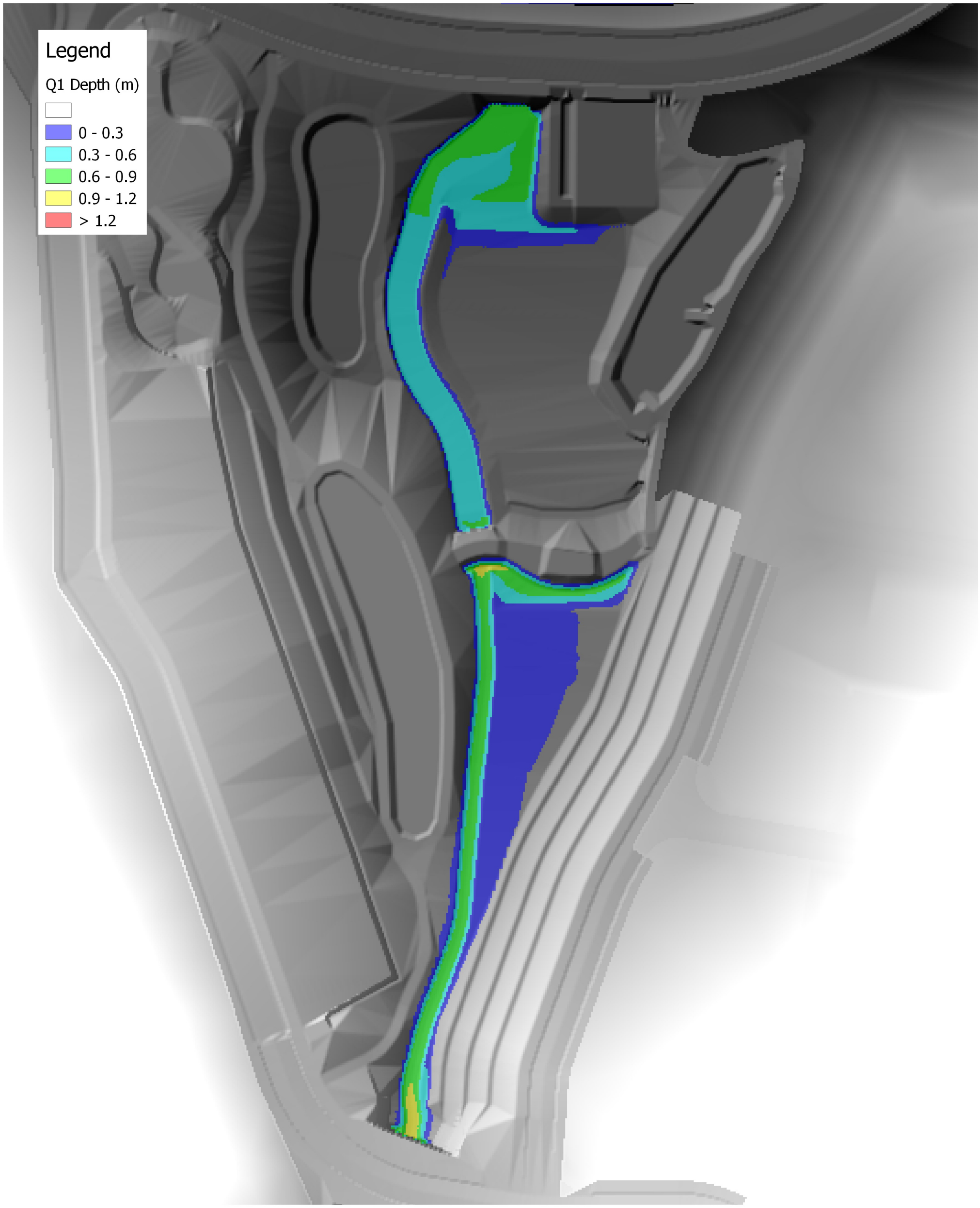

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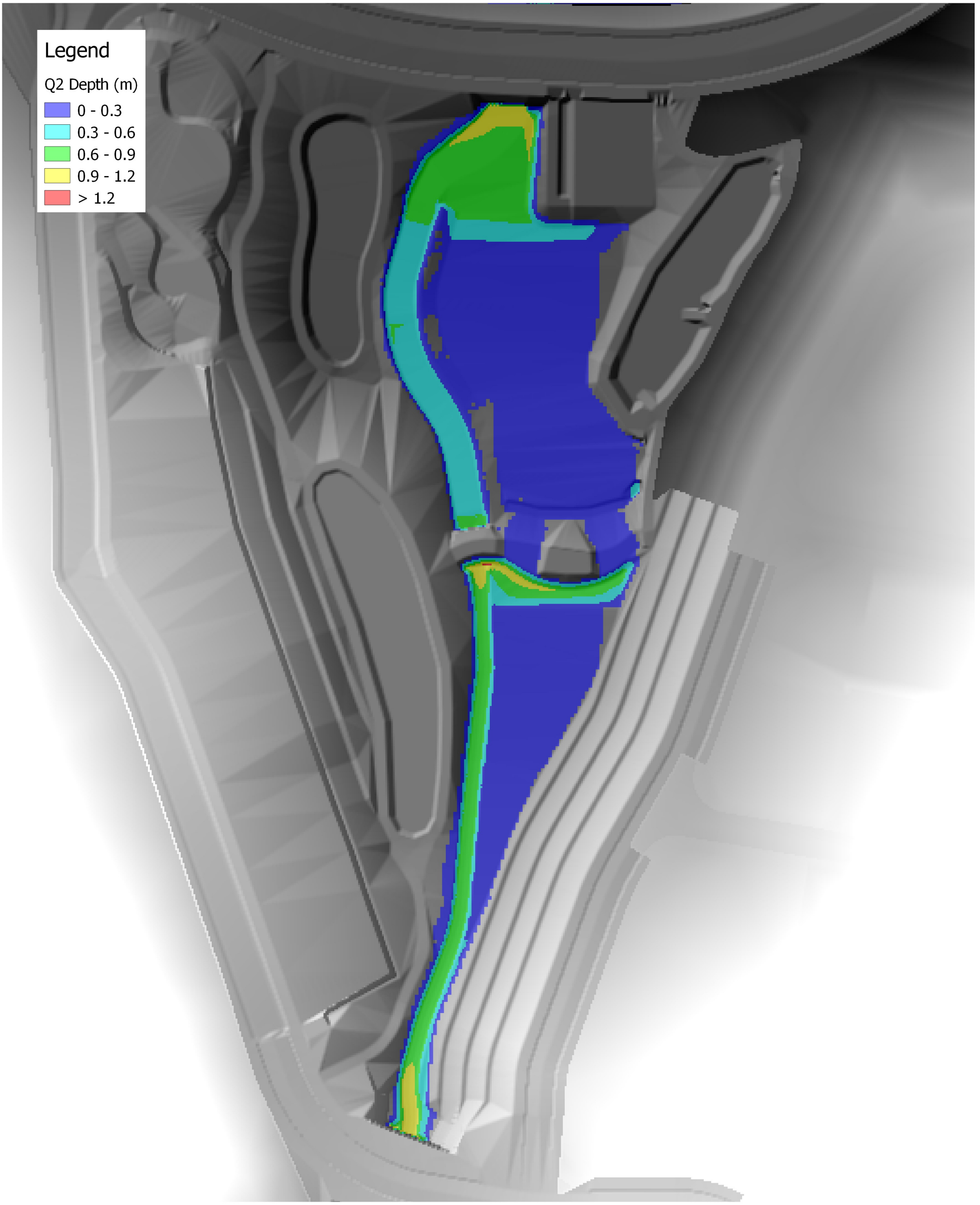

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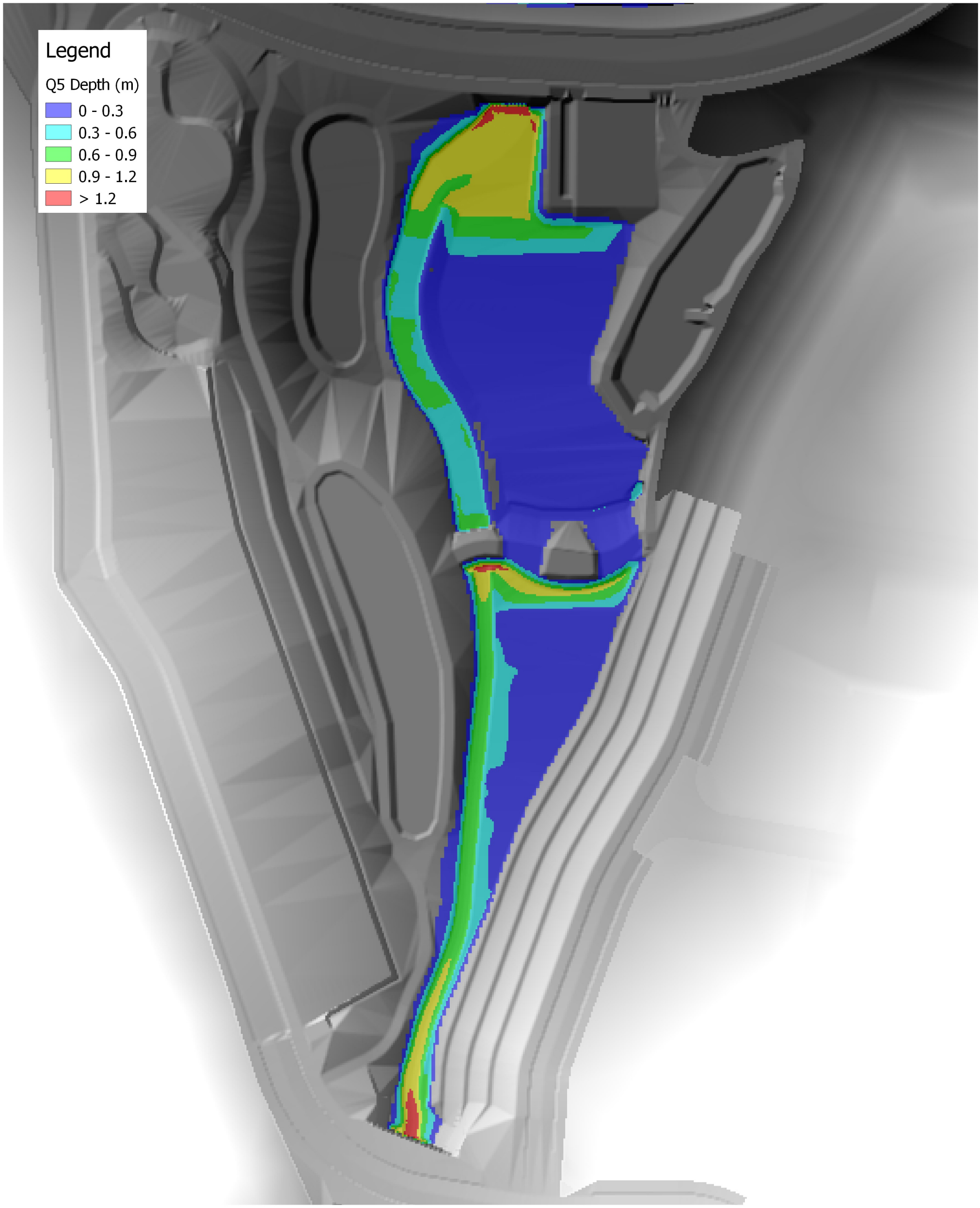

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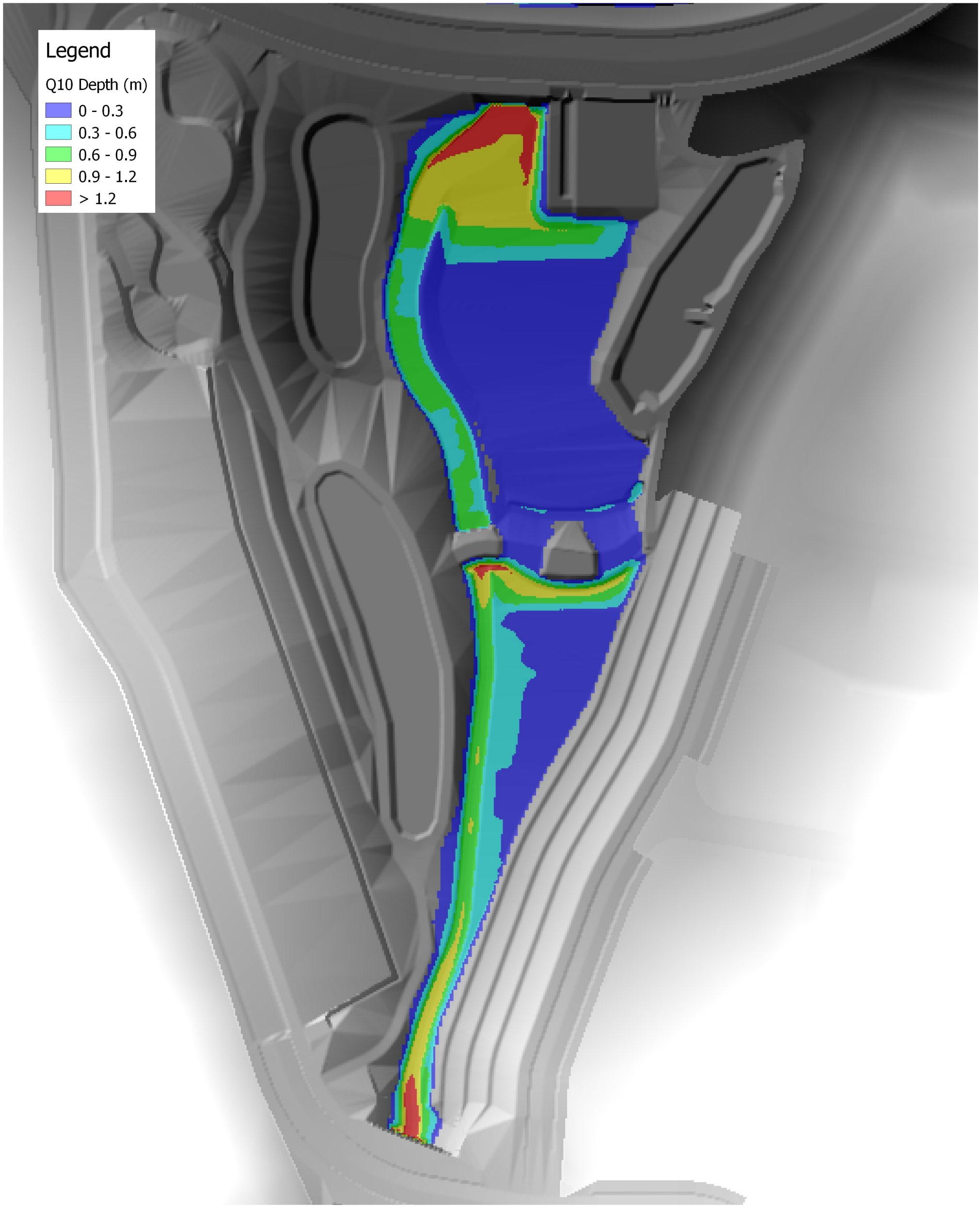

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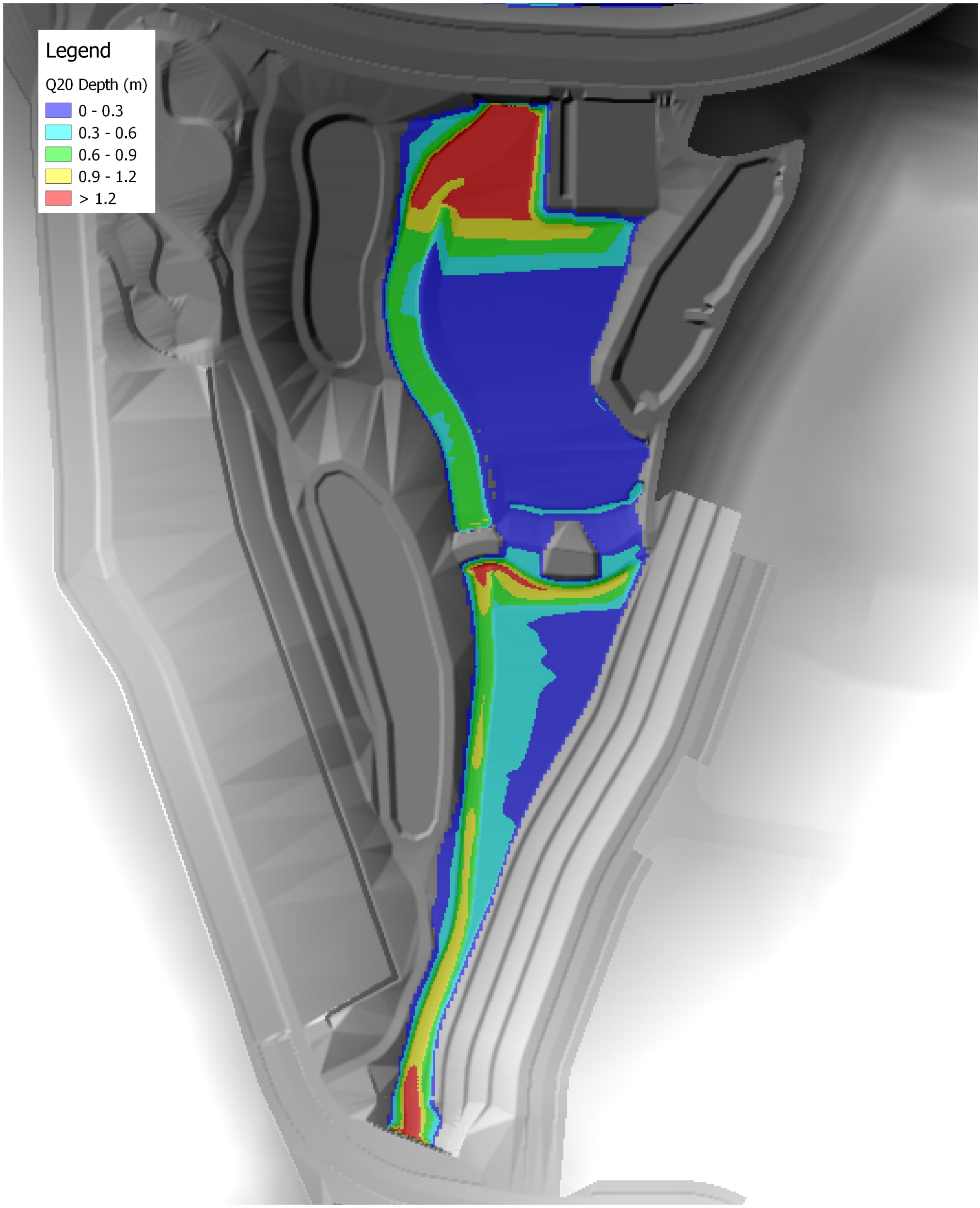

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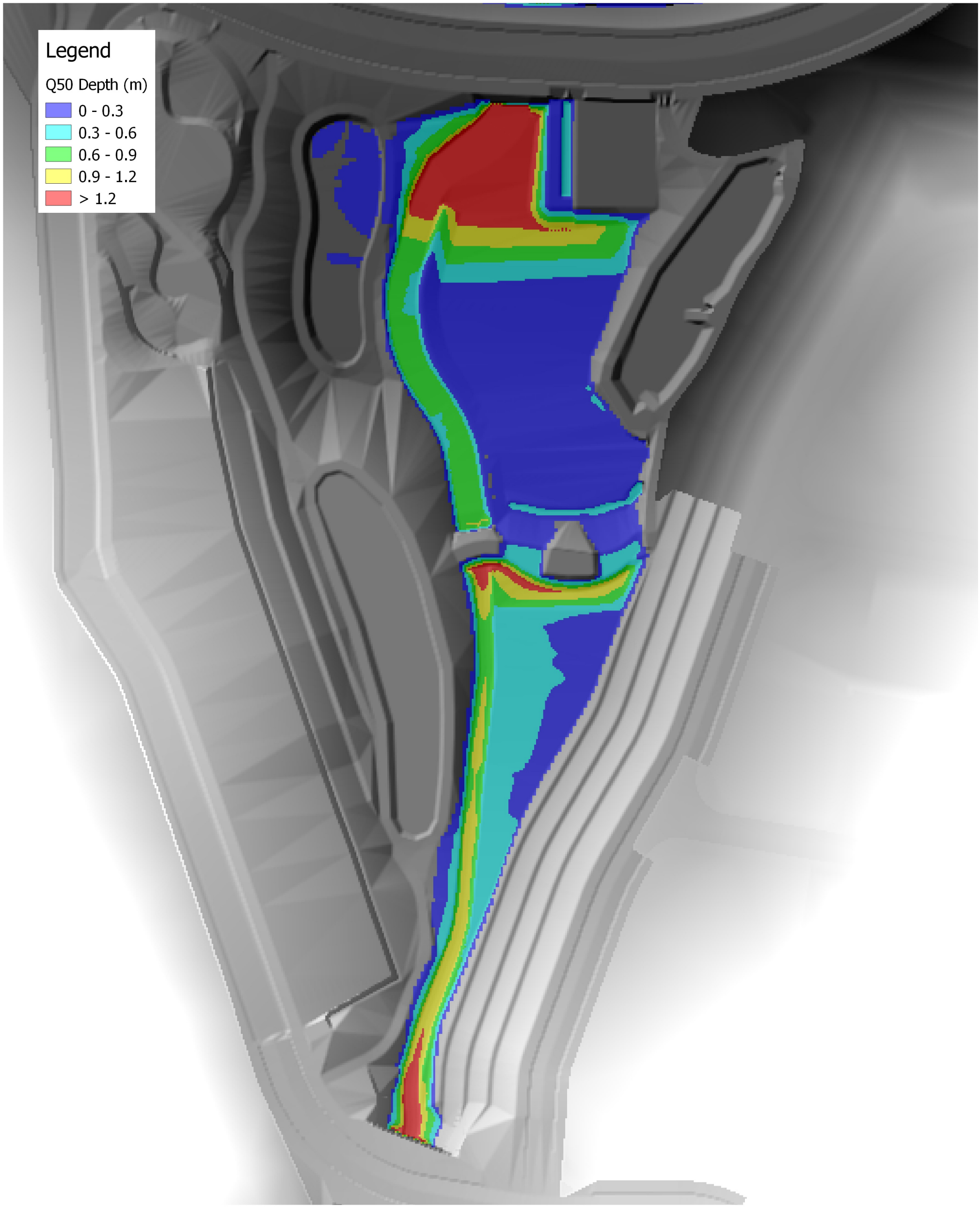

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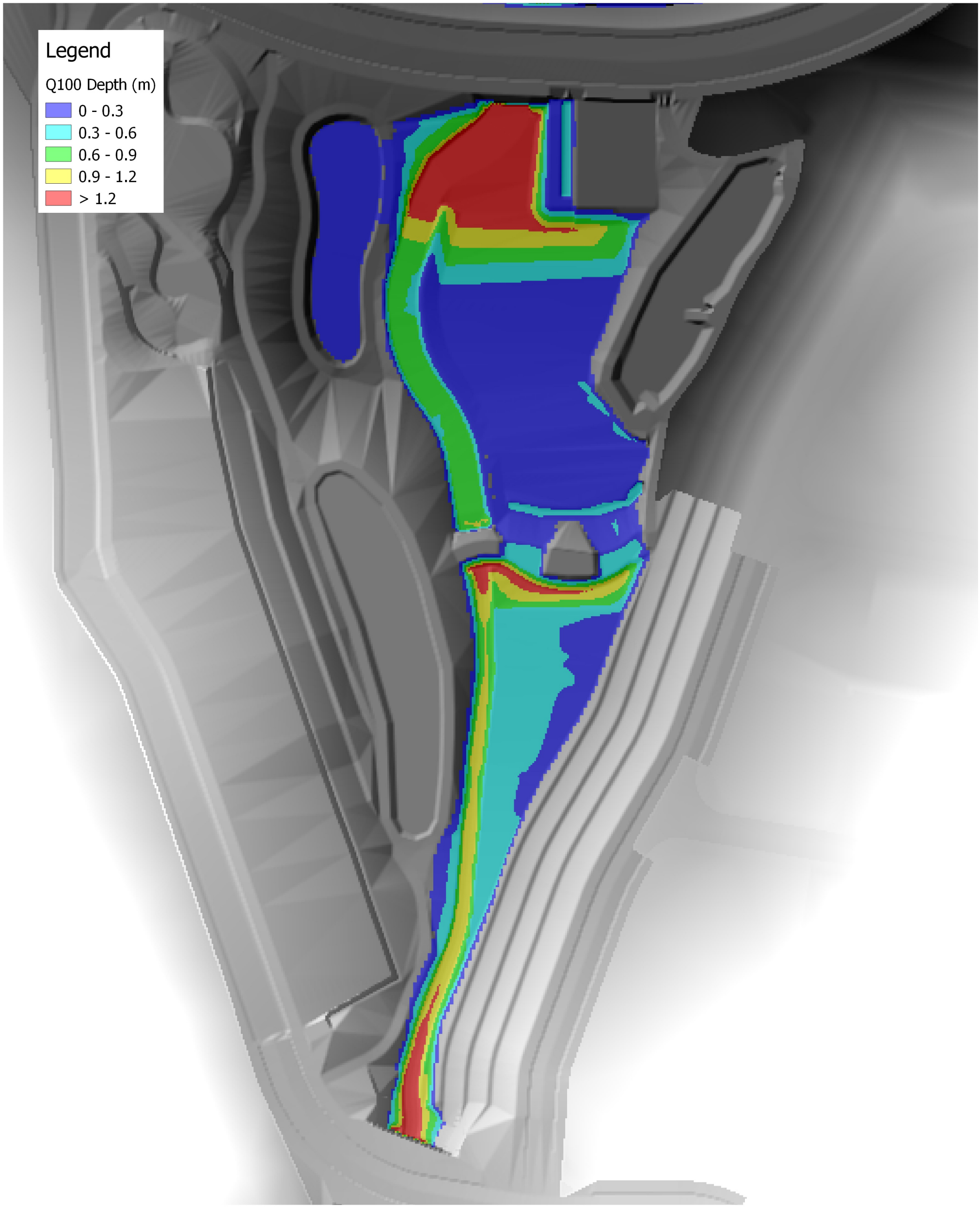

DATE : 16.07.2018	*PROJECT :* DRAINAGE ASSESSMENT			
PROJECT No. : BC-16099	*DRAWING TITLE :* Q100 DEPTH			
DRAWING No. : DWG-708	*CLIENT :* NEWLAND DEVELOPERS PTY LTD			
REVISION No. : A	*ADDRESS :* ALTITUDE ASPIRE, TERRANORA			
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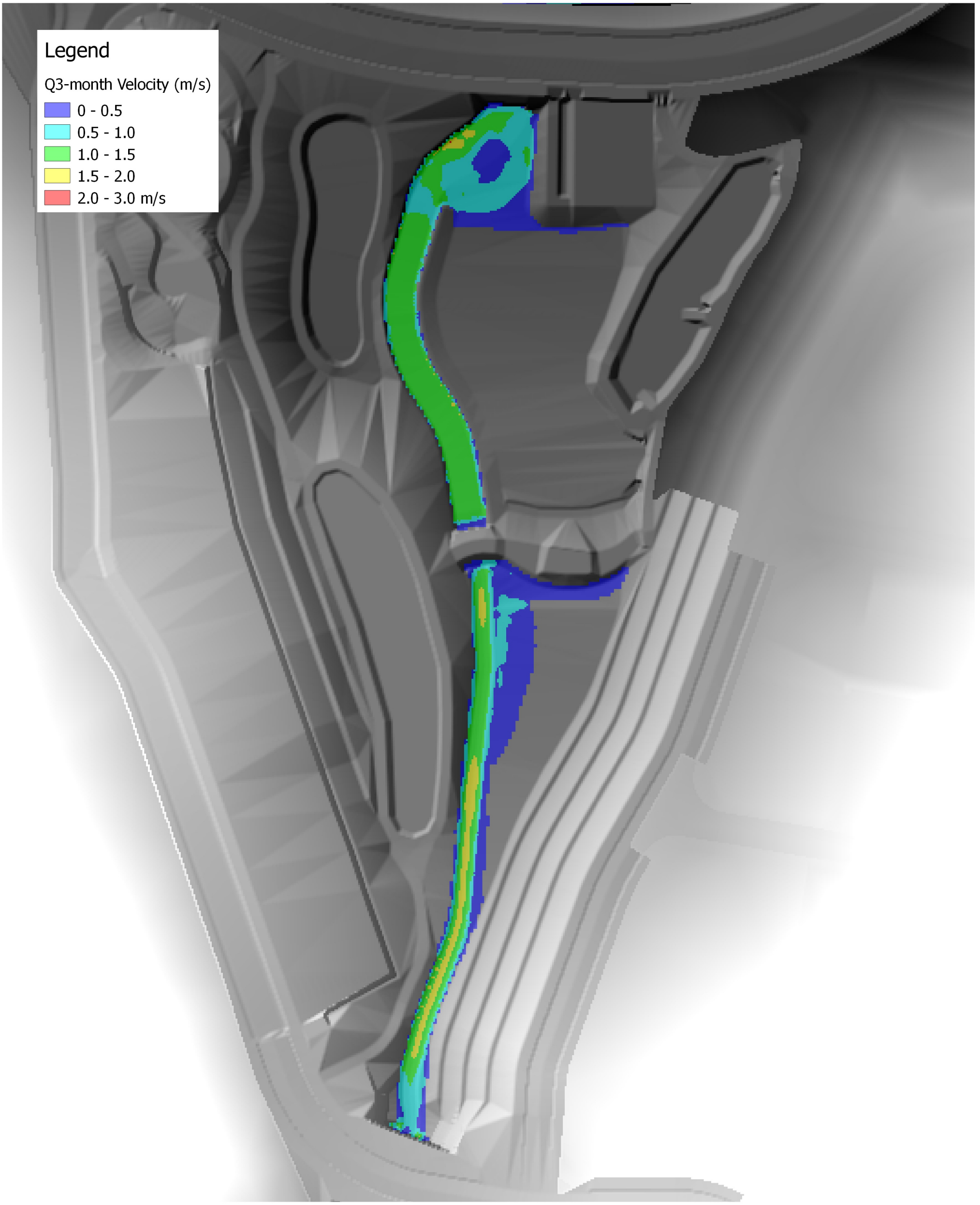

DATE :
16.07.2018

PROJECT No. :
BC-16099

DRAWING No. :
DWG-709

REVISION No. :
A

PROJECT : DRAINAGE ASSESSMENT

DRAWING TITLE : Q3-MONTH VELOCITY

CLIENT : NEWLAND DEVELOPERS PTY LTD

ADDRESS : ALTITUDE ASPIRE, TERRANORA

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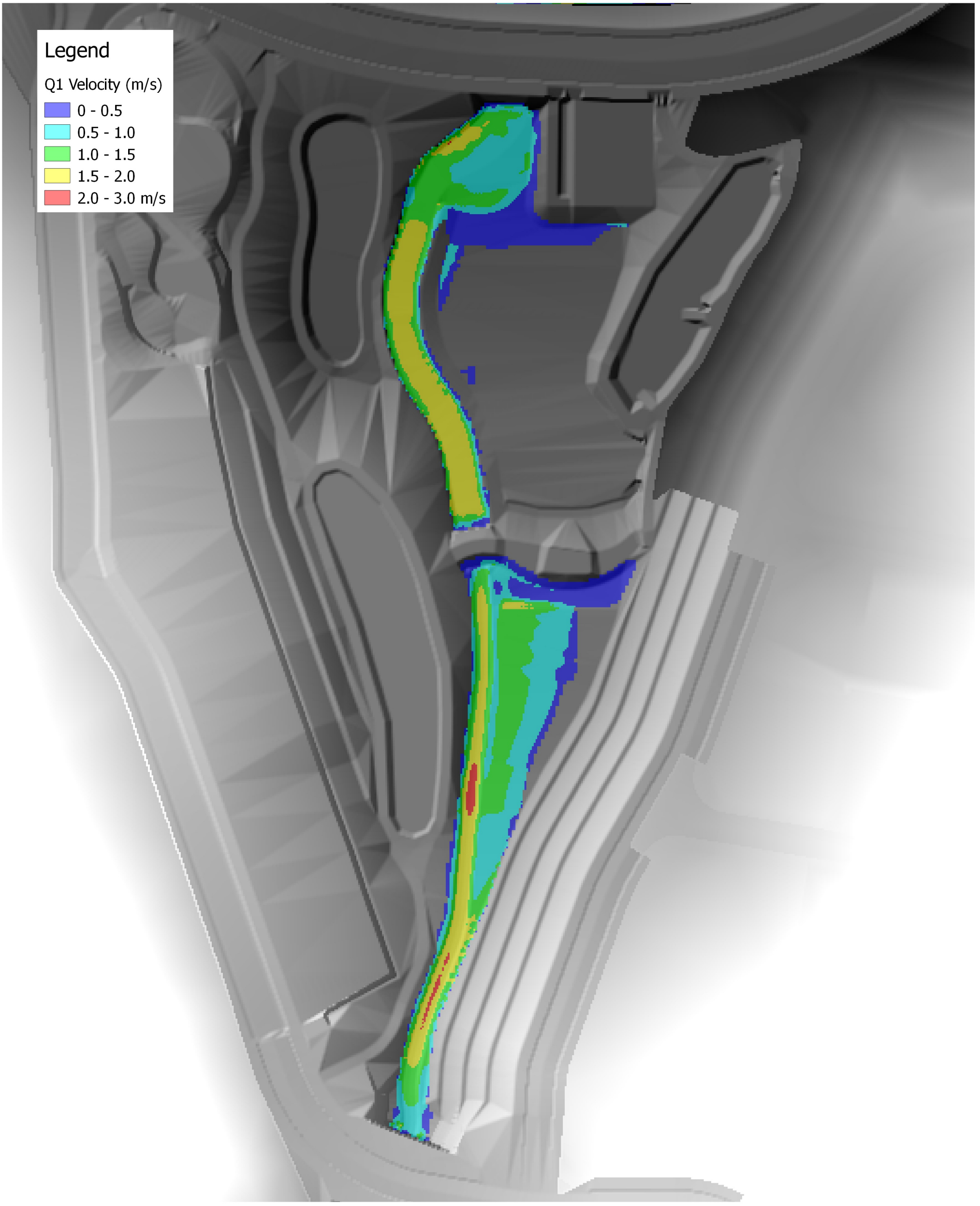

DATE :
16.07.2018

PROJECT No. :
BC-16099

DRAWING No. :
DWG-710

REVISION No. :
A

PROJECT :
DRAINAGE ASSESSMENT

DRAWING TITLE :
Q1 VELOCITY

CLIENT :
NEWLAND DEVELOPERS PTY LTD

ADDRESS :
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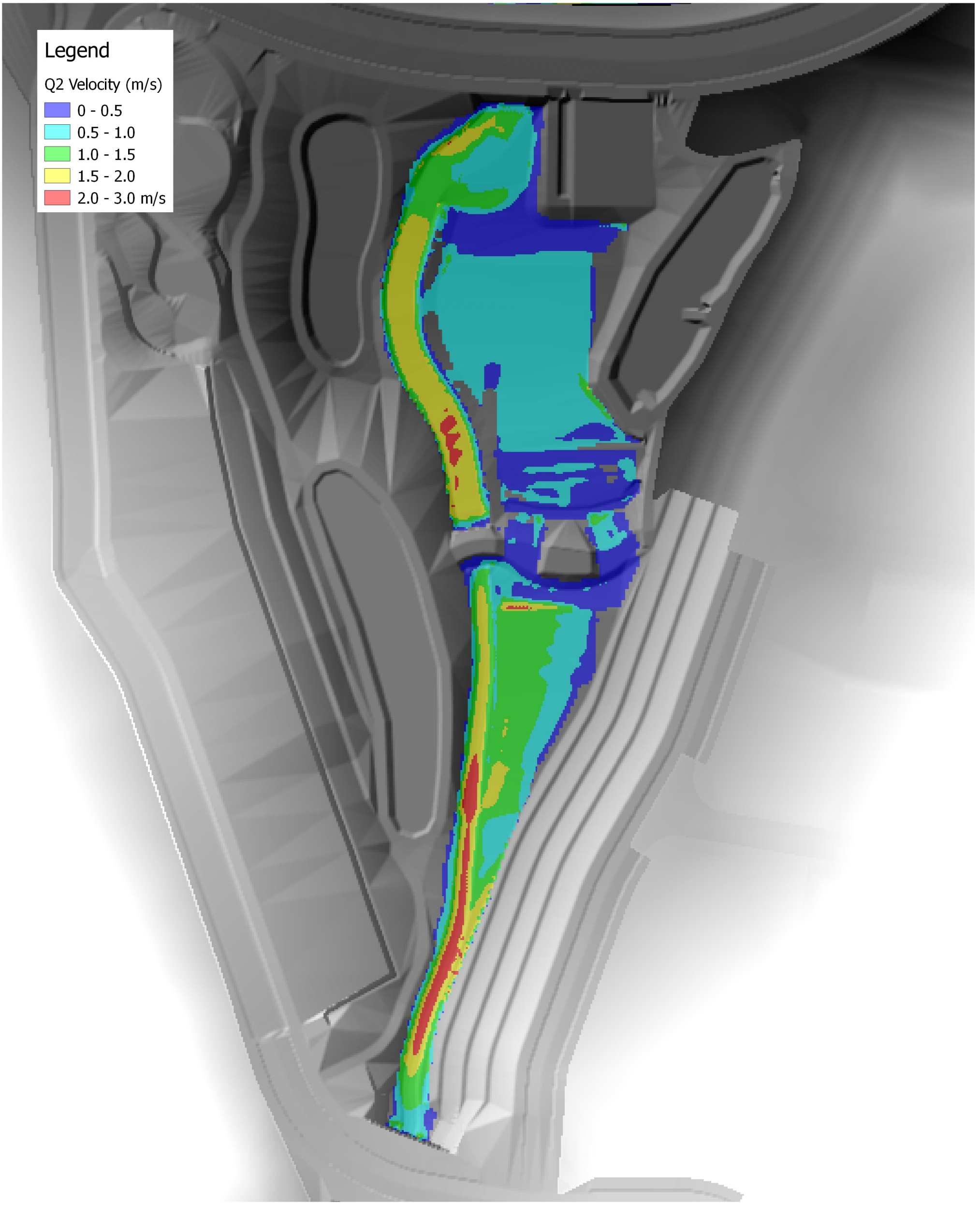

DATE :
16.07.2018

PROJECT No. :
BC-16099

DRAWING No. :
DWG-711

REVISION No. :
A

PROJECT :
DRAINAGE ASSESSMENT

DRAWING TITLE :
Q2 VELOCITY

CLIENT :
NEWLAND DEVELOPERS PTY LTD

ADDRESS :
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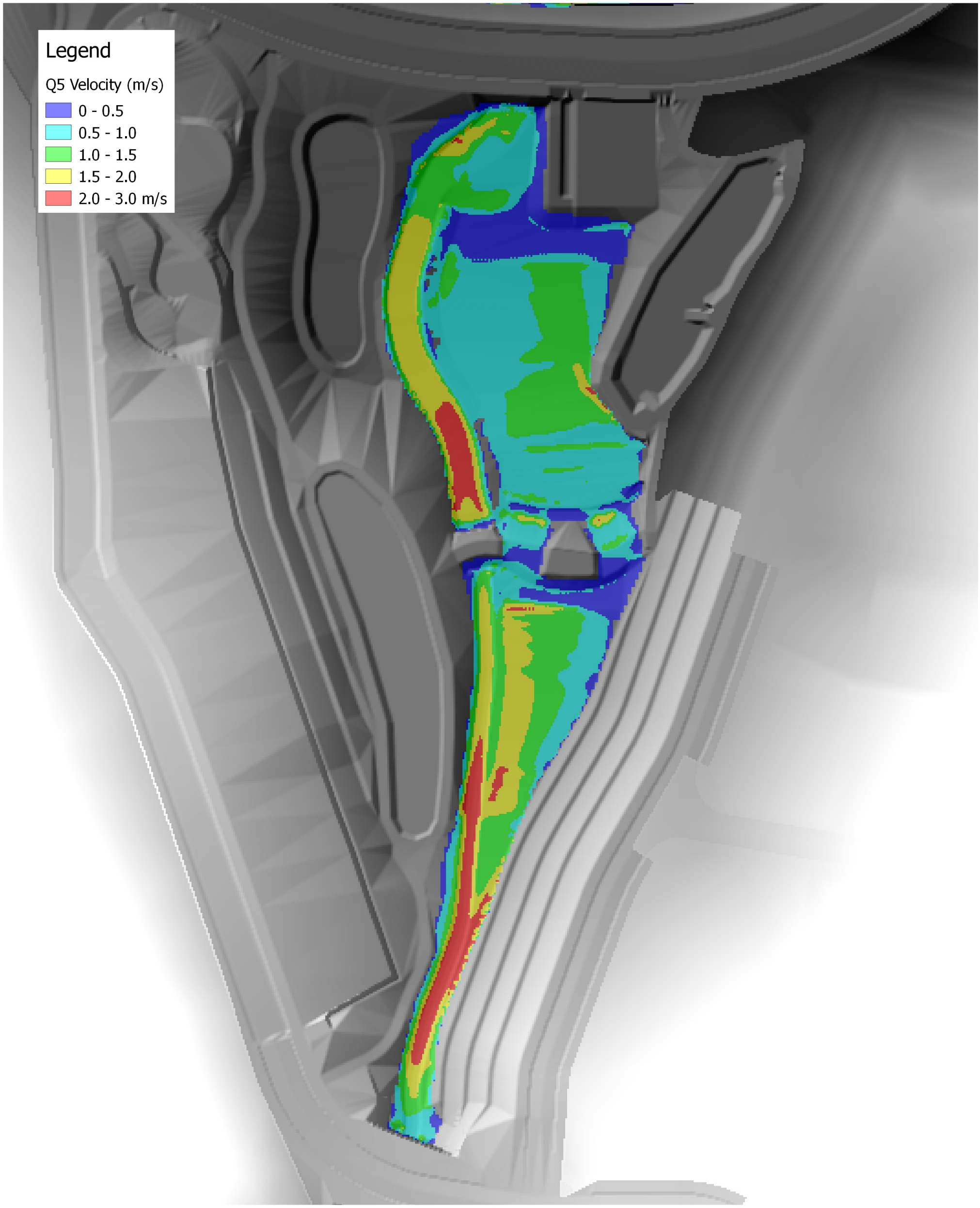

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PROJECT No. :
BC-16099

DRAWING No. :
DWG-712

REVISION No. :
A

PROJECT :
DRAINAGE ASSESSMENT

DRAWING TITLE :
Q5 VELOCITY

CLIENT :
NEWLAND DEVELOPERS PTY LTD

ADDRESS :
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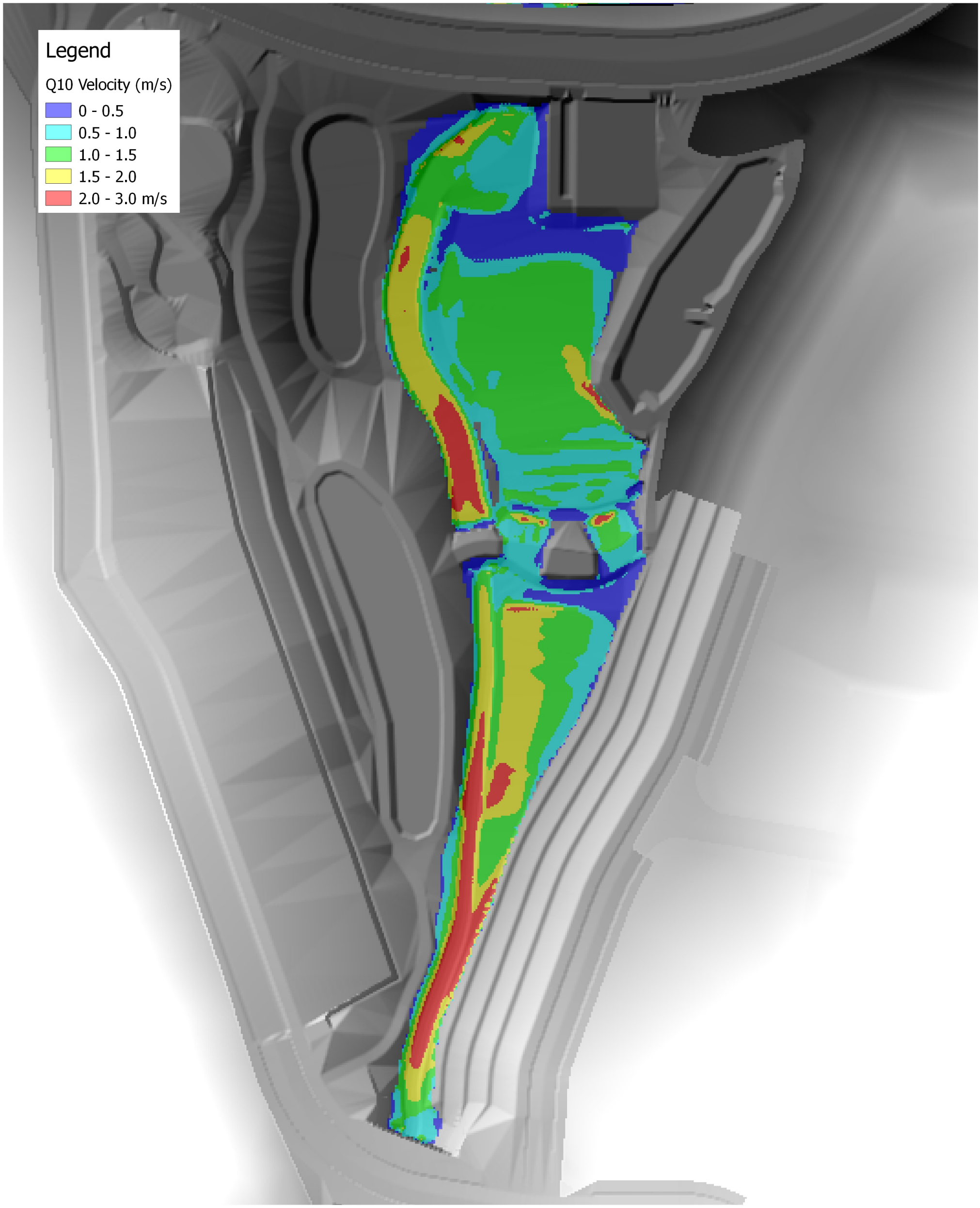

DATE :
16.07.2018

PROJECT No. :
BC-16099

DRAWING No. :
DWG-713

REVISION No. :
A

PROJECT :
DRAINAGE ASSESSMENT

DRAWING TITLE :
Q10 VELOCITY

CLIENT :
NEWLAND DEVELOPERS PTY LTD

ADDRESS :
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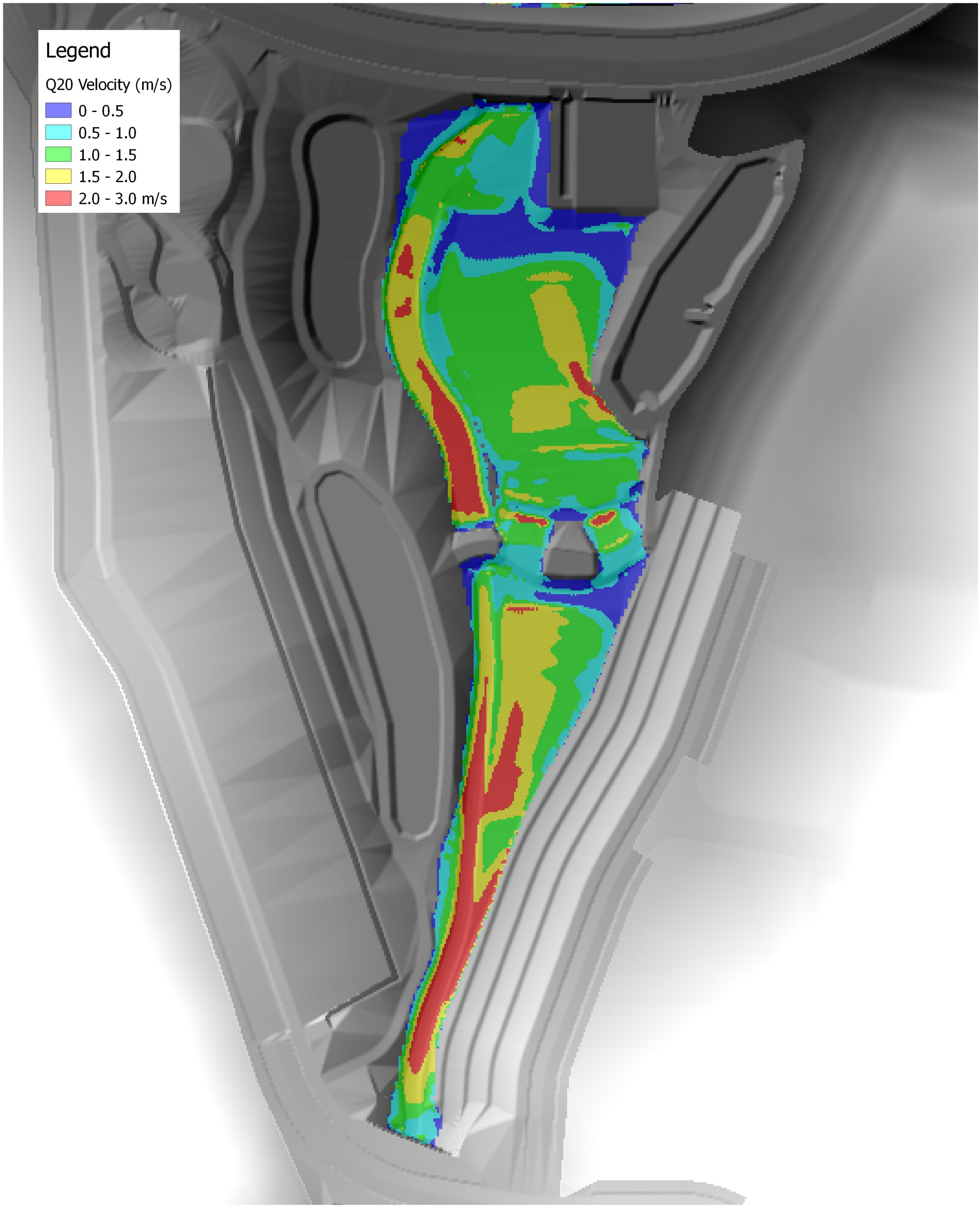

DATE :
16.07.2018

PROJECT No. :
BC-16099

DRAWING No. :
DWG-714

REVISION No. :
A

PROJECT :
DRAINAGE ASSESSMENT

DRAWING TITLE :
Q20 VELOCITY

CLIENT :
NEWLAND DEVELOPERS PTY LTD

ADDRESS :
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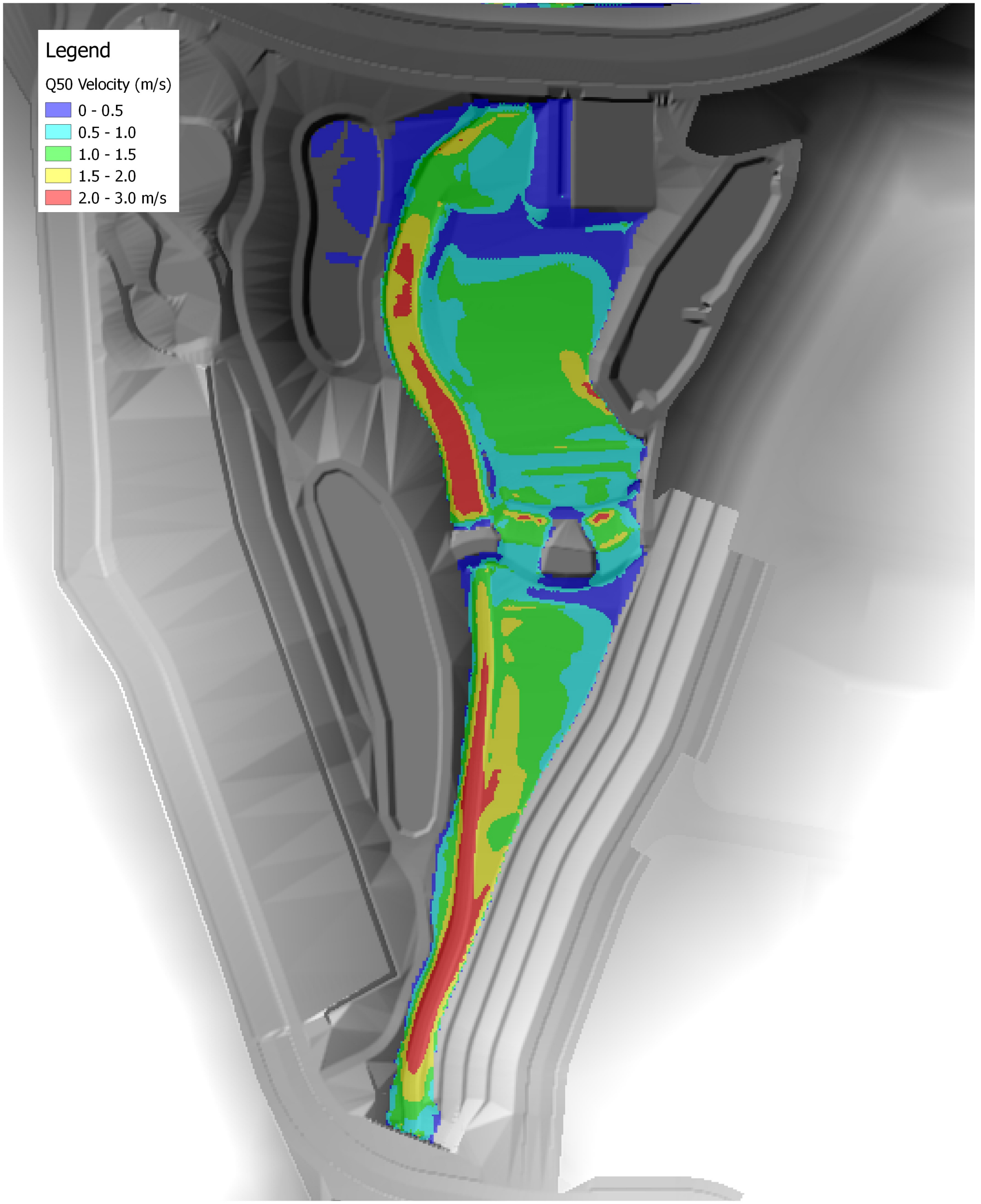

DATE :
16.07.2018

PROJECT No. :
BC-16099

DRAWING No. :
DWG-715

REVISION No. :
A

PROJECT :
DRAINAGE ASSESSMENT

DRAWING TITLE :
Q50 VELOCITY

CLIENT :
NEWLAND DEVELOPERS PTY LTD

ADDRESS :
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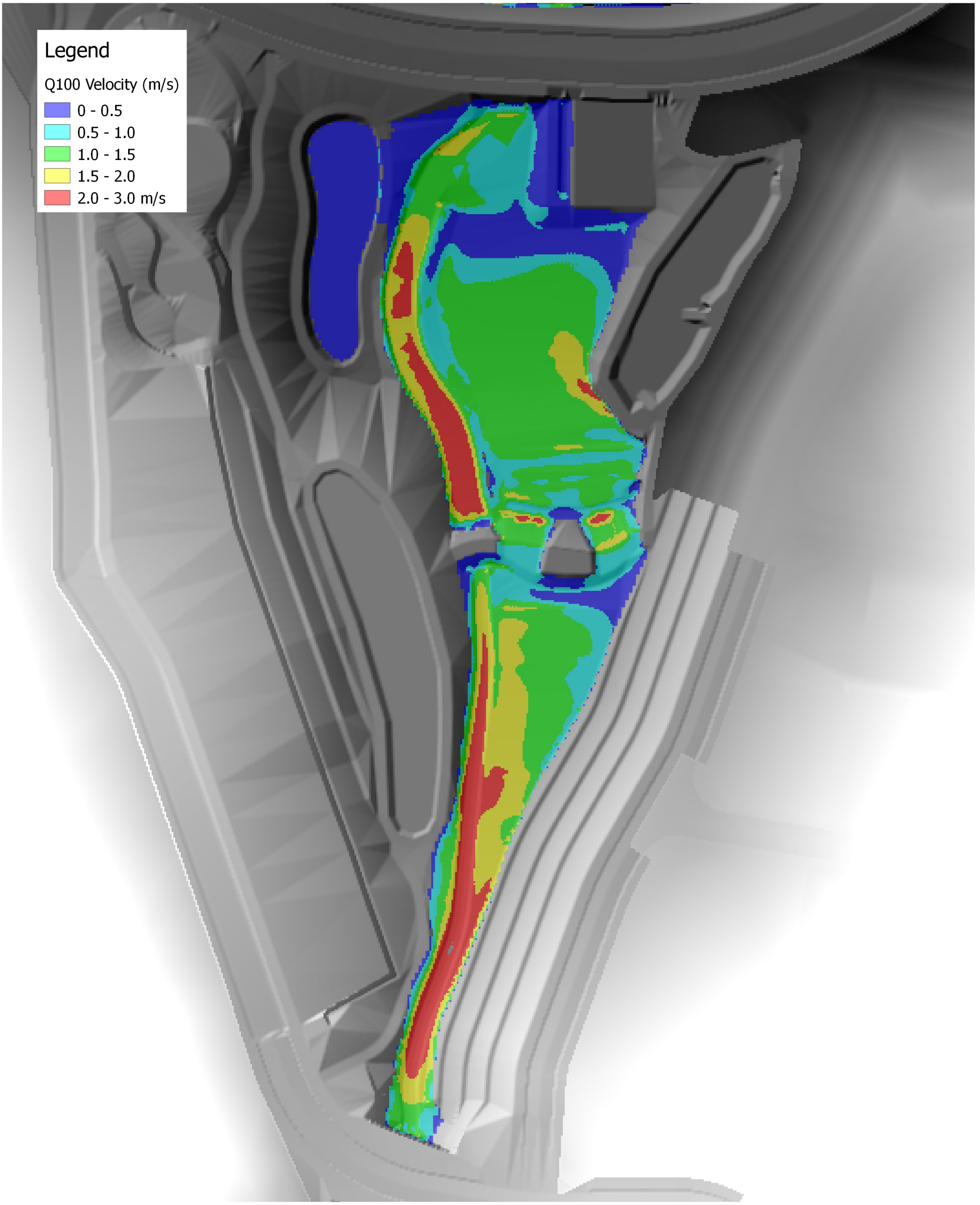

DATE :
16.07.2018

PROJECT No. :
BC-16099

DRAWING No. :
DWG-716

REVISION No. :
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PROJECT : DRAINAGE ASSESSMENT

DRAWING TITLE : Q100 VELOCITY

CLIENT : NEWLAND DEVELOPERS PTY LTD

ADDRESS : ALTITUDE ASPIRE, TERRANORA

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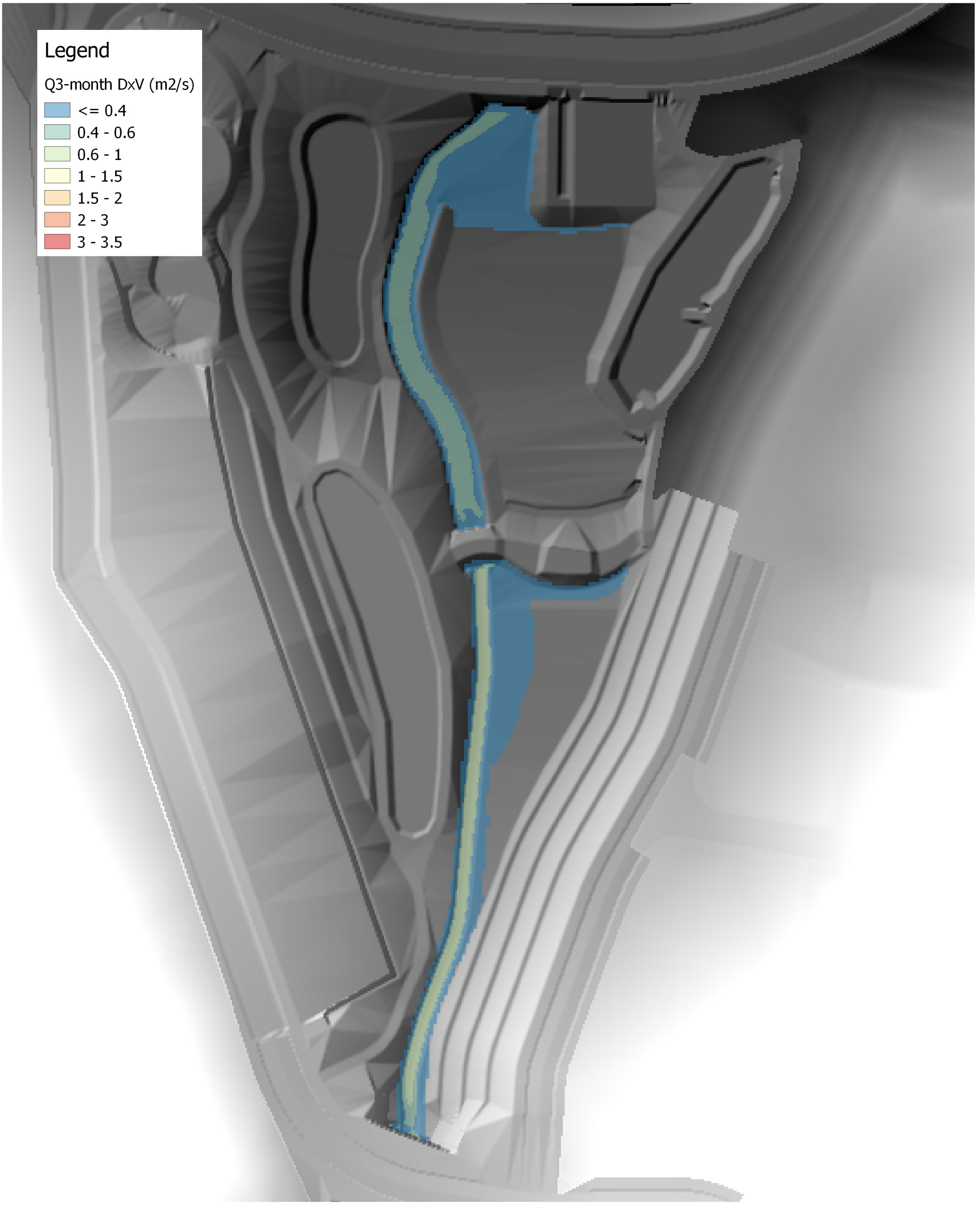

DATE : 16.07.2018

PROJECT No. : BC-16099

DRAWING No. : DWG-717

REVISION No. : A

PROJECT : DRAINAGE ASSESSMENT

DRAWING TITLE : Q3-MONTH DxV

CLIENT : NEWLAND DEVELOPERS PTY LTD

ADDRESS : ALTITUDE ASPIRE, TERRANORA

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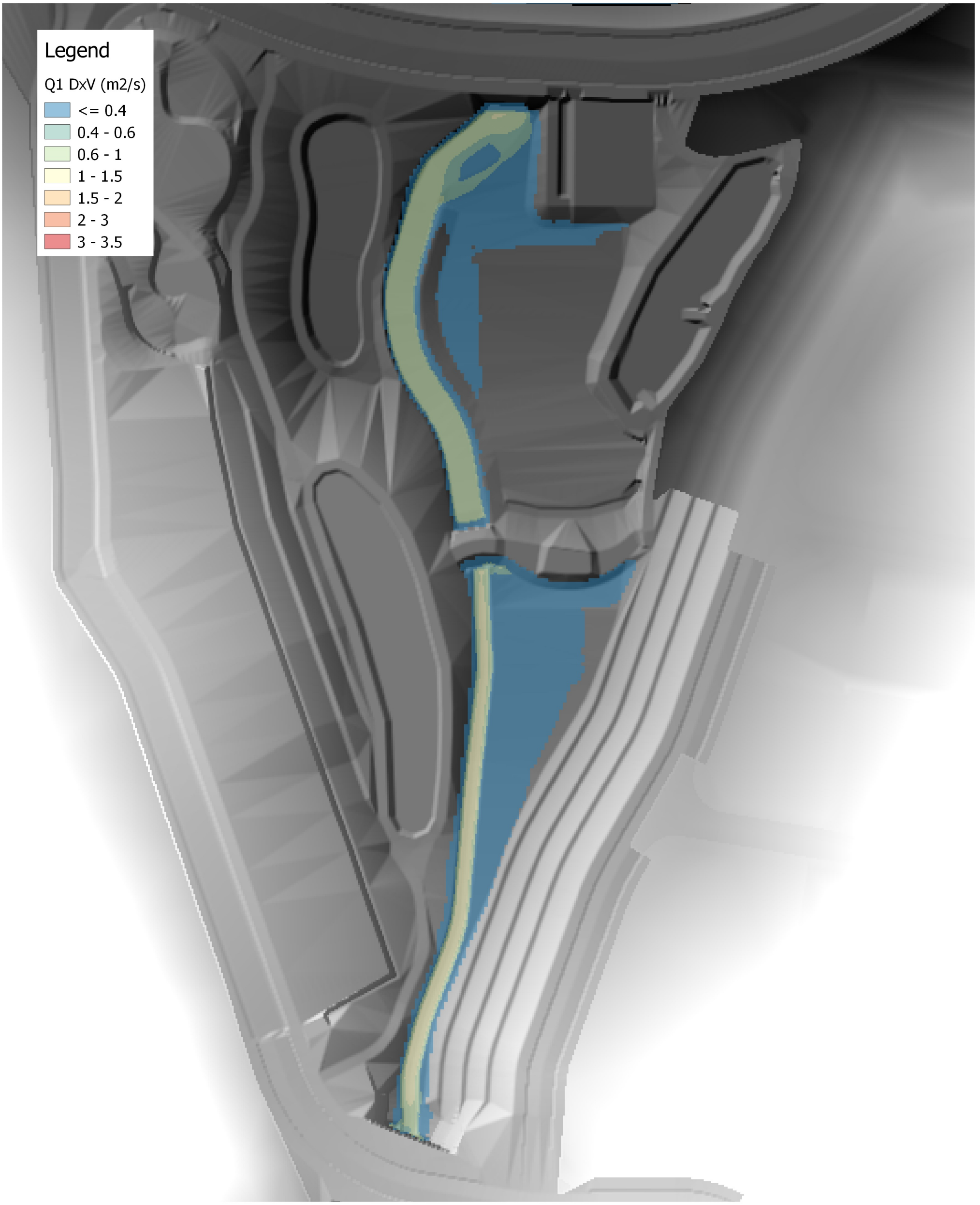

DATE :
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PROJECT No. :
BC-16099

DRAWING No. :
DWG-718

REVISION No. :
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PROJECT : DRAINAGE ASSESSMENT

DRAWING TITLE : Q1 DxV

CLIENT : NEWLAND DEVELOPERS PTY LTD

ADDRESS : ALTITUDE ASPIRE, TERRANORA

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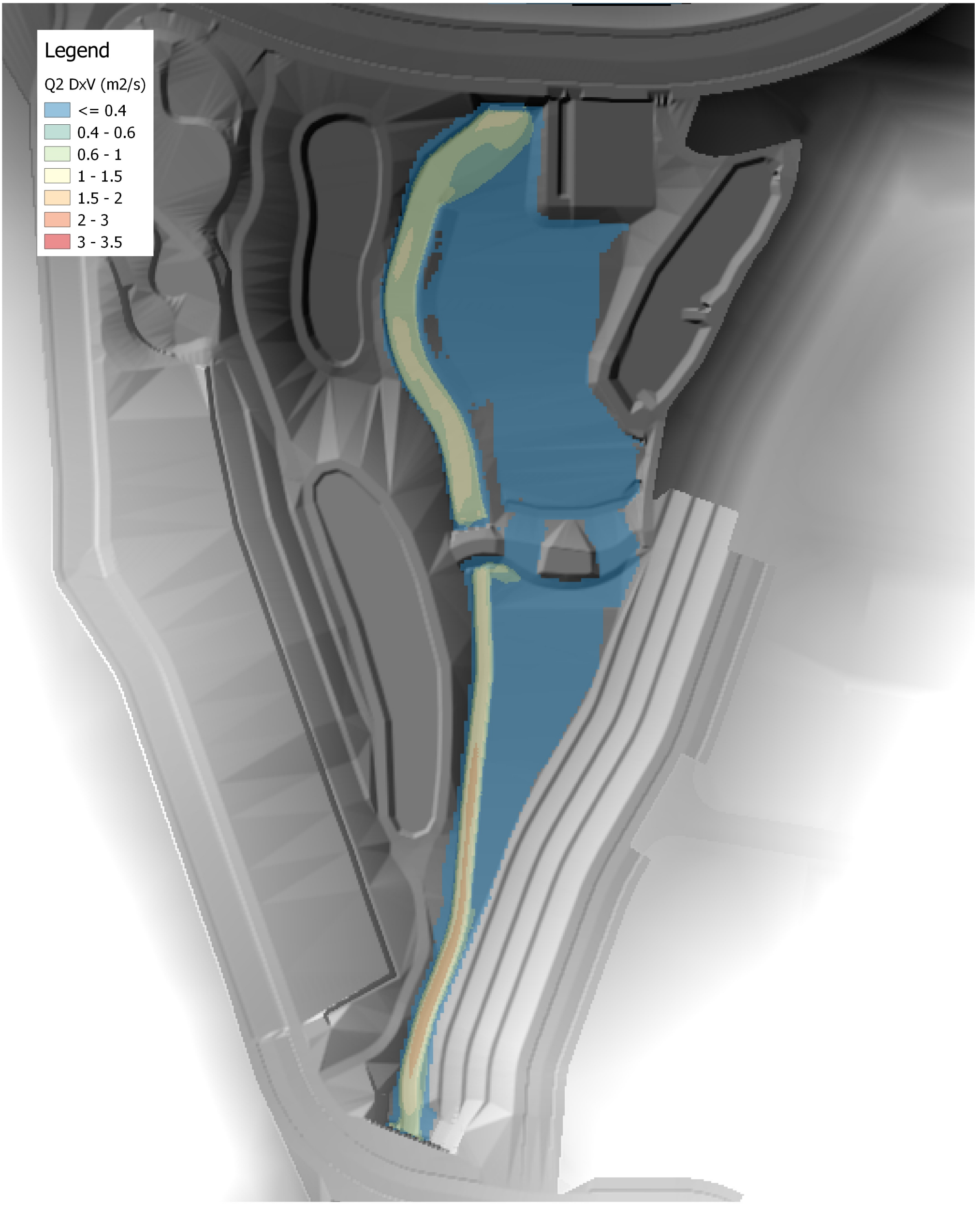

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PROJECT No. :
BC-16099

DRAWING No. :
DWG-719

REVISION No. :
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PROJECT : DRAINAGE ASSESSMENT

DRAWING TITLE : Q2 DxV

CLIENT : NEWLAND DEVELOPERS PTY LTD

ADDRESS : ALTITUDE ASPIRE, TERRANORA

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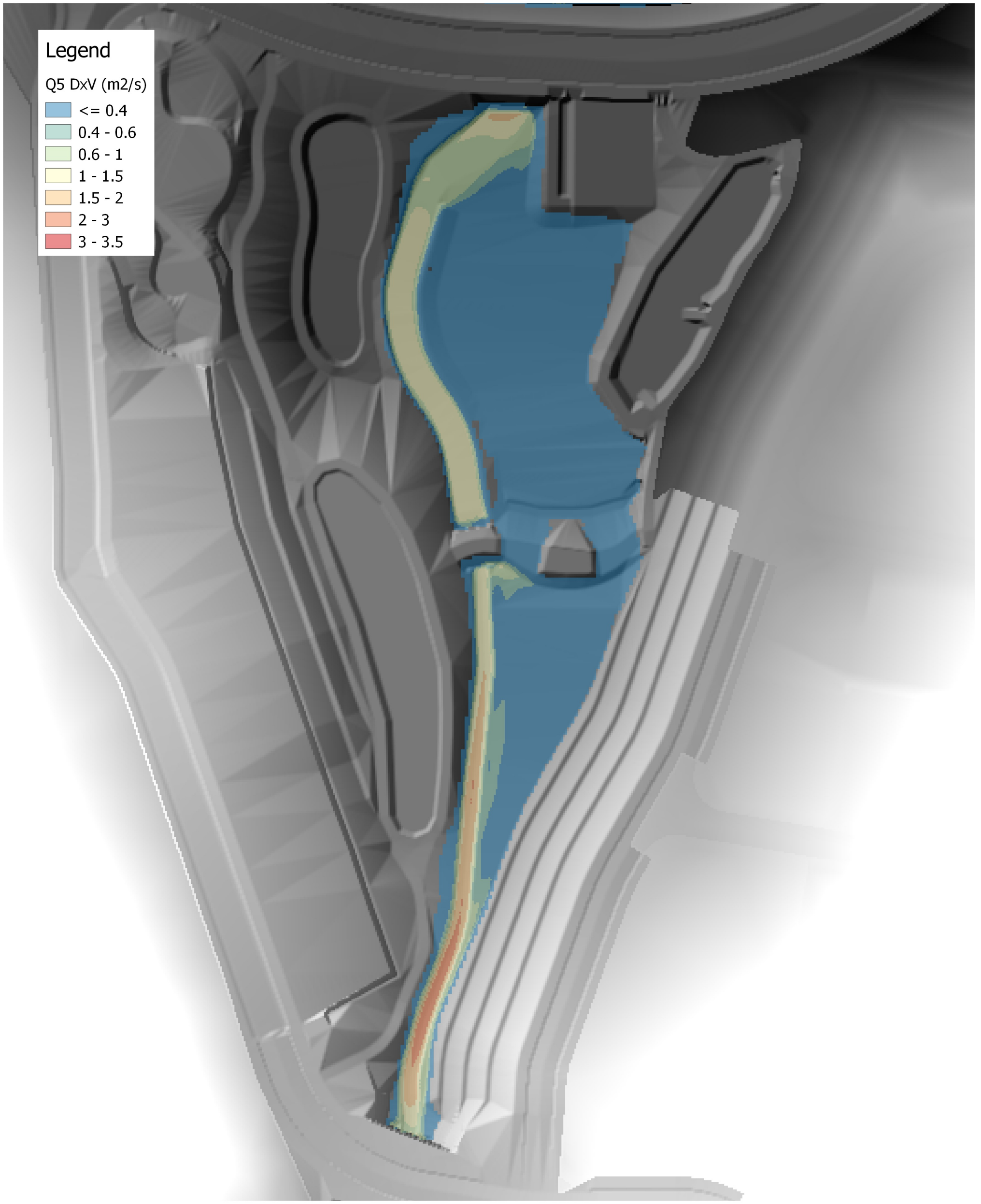

DATE : 16.07.2018

PROJECT No. : BC-16099

DRAWING No. : DWG-720

REVISION No. : A

PROJECT : DRAINAGE ASSESSMENT

DRAWING TITLE : Q5 DxV

CLIENT : NEWLAND DEVELOPERS PTY LTD

ADDRESS : ALTITUDE ASPIRE, TERRANORA

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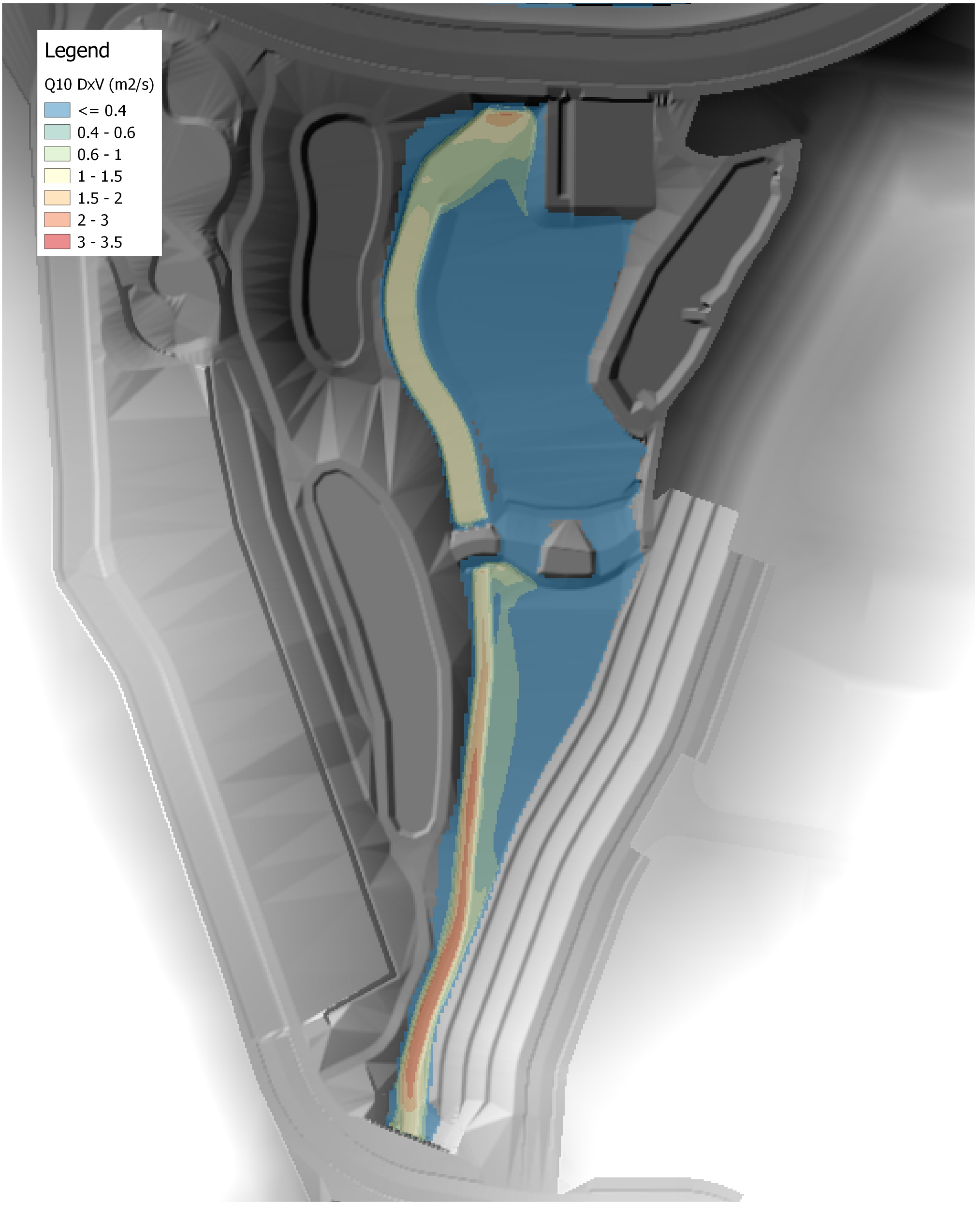

DATE : 16.07.2018

PROJECT No. : BC-16099

DRAWING No. : DWG-721

REVISION No. : A

PROJECT : DRAINAGE ASSESSMENT

DRAWING TITLE : Q10 DxV

CLIENT : NEWLAND DEVELOPERS PTY LTD

ADDRESS : ALTITUDE ASPIRE, TERRANORA

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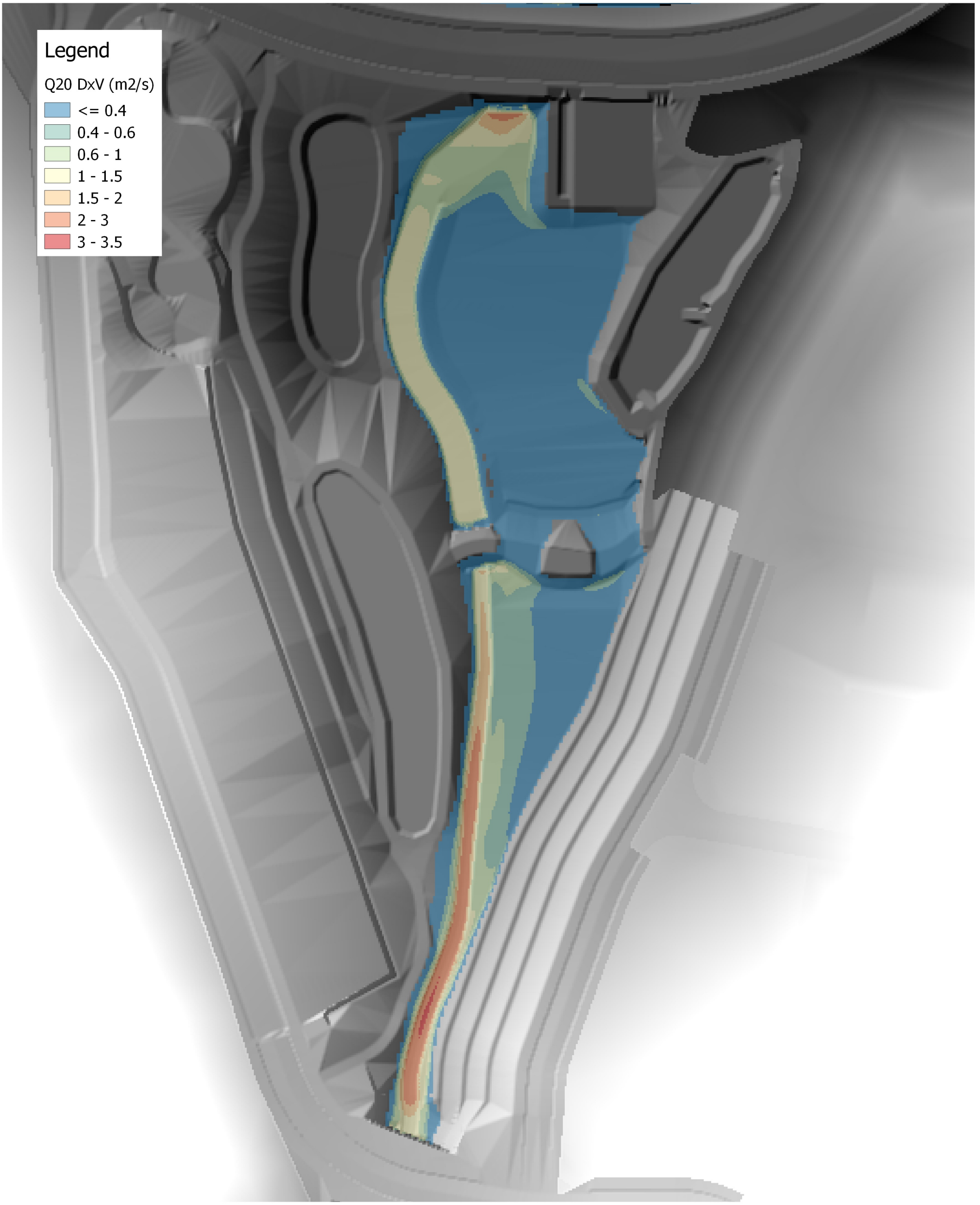

DATE : 16.07.2018

PROJECT No. : BC-16099

DRAWING No. : DWG-722

REVISION No. : A

PROJECT : DRAINAGE ASSESSMENT

DRAWING TITLE : Q20 DxV

CLIENT : NEWLAND DEVELOPERS PTY LTD

ADDRESS : ALTITUDE ASPIRE, TERRANORA

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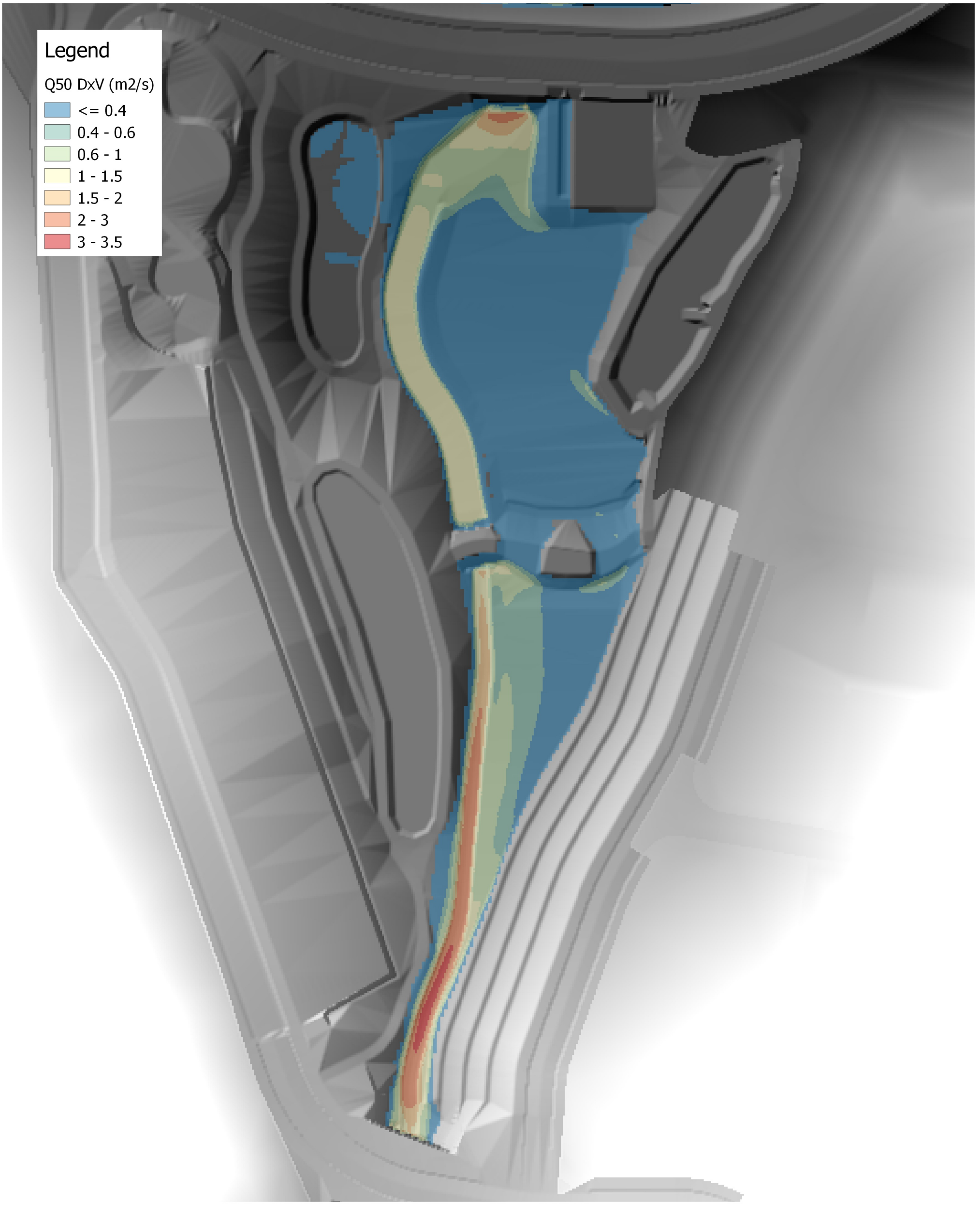

DATE : 16.07.2018

PROJECT No. : BC-16099

DRAWING No. : DWG-723

REVISION No. : A

PROJECT : DRAINAGE ASSESSMENT

DRAWING TITLE : Q50 DxV

CLIENT : NEWLAND DEVELOPERS PTY LTD

ADDRESS : ALTITUDE ASPIRE, TERRANORA

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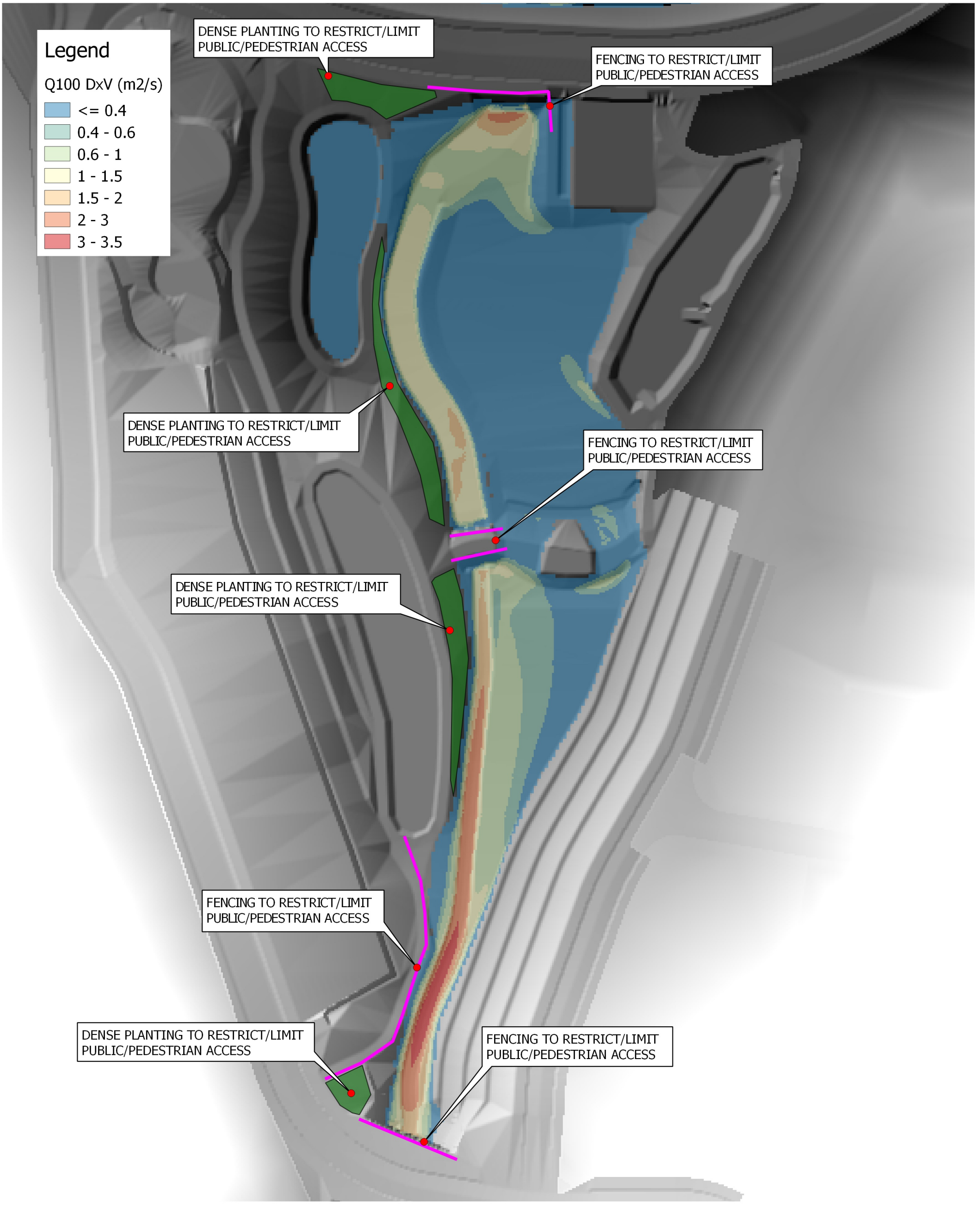

DATE :
16.07.2018

PROJECT No. :
BC-16099

DRAWING No. :
DWG-724

REVISION No. :
A

PROJECT :
DRAINAGE ASSESSMENT

DRAWING TITLE :
Q100 DxV

CLIENT :
NEWLAND DEVELOPERS PTY LTD

ADDRESS :
ALTITUDE ASPIRE, TERRANORA

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