Graben Pty. Ltd.

Surf Port Douglas

Engineering Report

June 2021

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Appendices

1. Introduction

GHD Pty Ltd have been commissioned by Graben Pty Ltd to prepare an engineering report to accompany a Development Application to Douglas Shire Council for a proposed Outdoor Recreation and Short-Term Accommodation facility located on land immediately to the south or the Mowbray River.

This report identifies the required general civil engineering development works and compliance with the following Douglas Shire Council codes:

- Filling & Excavation Code

2. The site

The site for the proposed development is described as Lot 123 SR687 and has an area of 40.21 Ha and is located south of Port Douglas immediately south of the Mowbray River and east of the Captain Cook Highway. The site is zoned Rural and is currently used for agricultural activities involved in the production of sugar cane. Existing access for rural activities is from the state-controlled Captain Cook Highway.

The exiting site vegetation is predominantly sugar cane however includes minor vegetation present through drainage channels and a small section of mangroves/marine plants on the lot border to the north west currently not planned to be cleared.

Figure 1 Site Location

3. Proposed development

Graben Pty. Ltd proposes to reconfigure land described as Lot 123 SR687, shown in Figure 1 below, from the current 1 lot into a community title scheme containing a resort, surf pool, internal lagoon, villas and 42 short term accommodation lots shown in Figure 2 below. All buildings, facilities and infrastructure will be body corporate controlled and managed. A copy of the proposed architectural by Hunt Design will be provided in the overall submission package.

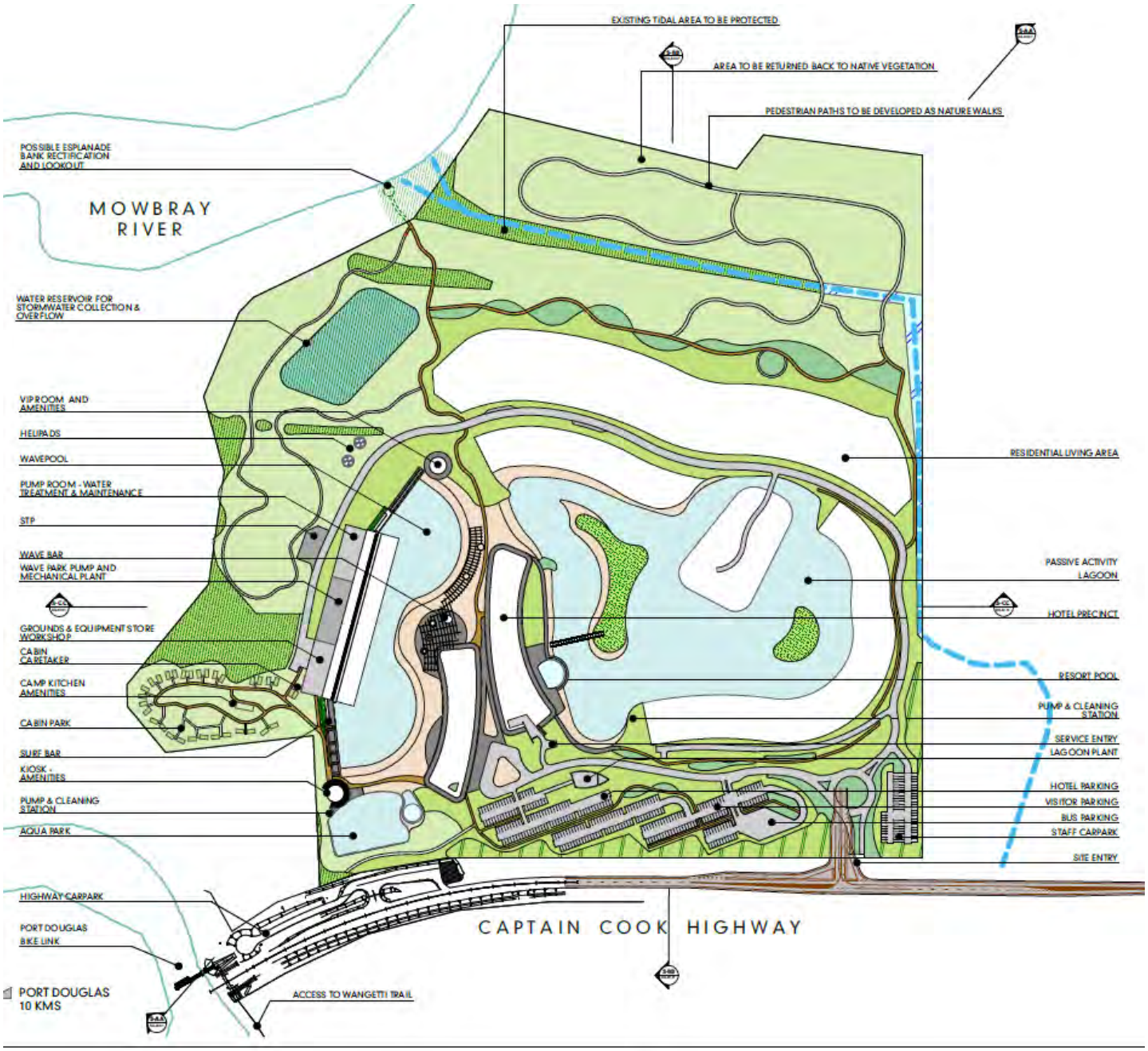


Figure 2 Site master plan

4. Engineering Issues

4.1 Earthworks

4.1.1 Earthworks

A preliminary bulk earthworks model, with building pads developed above the 1% AEP storm surge level of 3.05 m, has been developed for the proposed site layout.

The preliminary cut and fill volumes indicate a balance outcome is likely to be achieved at the detailed design stage based on the following assumptions:

- 150 mm topsoil strip
- Bulking Factor of 15% applied to the fill

Preliminary earthworks volumes approximate 190,700 m3 of fill (extra fill required being imported) and 165,200 m3 of cut.

Refer to Sketch 12544036 SK002 in Appendix A for the Concept Earthworks.

The geotechnical report produced by Golders indicates that there may be a high probability of encountering some acid sulphate soils around the mangroves of Mowbray River or deep excavations within the site. Refer to Golders Report 20446551-001-R-Rev0 in Appendix B for further information. Prior to an operation works submissions further testing will be completed to determine the liming rates required during earthworks and earthworks are expected to be undertaken in accordance with an acid sulphate soil management plan.

4.1.2 Flood model assessment

A TUFLOW hydraulic model on the earthworks design was undertaken by JBP consultants to assess the impact the cut/fill would have on the surrounding environment. A risk-based approach was taken to analyse the site, the following is a results section of the executive summary from JBP's Report *2021s0206-JBAP-00-00-RP-Z-0001-A1-C01-Flood Report,*

The assessment of potential exposure to flooding and severity of flood hazards analysed using a risk-based approach consistent with ISO31000, which considers the likelihood of flooding and consequence of flooding hazard, has demonstrated the proposed development does not increase existing flood risk in an unacceptable manner.

Refer to JBP's report in Appendix D for further information.

4.2 Stormwater Management

4.2.1 Site water storage

A water balance study was undertaken to analyse water availability in the proposed water bodies (Recreational Lagoon) to determine the make-up water requirements to offset evaporative losses through the drier months.

In the drier seasons, water levels in the Recreational Lagoon will constantly reduce due to daily evaporation losses and potential bather usage, with minimal inflow from rainfall. Conversely, the wetter season will see increased water levels, possibly resulting in spillage at some stage. The rationale behind capturing this spill via a Water Storage Lagoon is to provide sufficient water in the drier seasons so that a minimum operating level in the Recreational Lagoon is maintained throughout the year.

A Water Storage Lagoon with 1.5 hectares surface area and 50 mega-litre capacity was sized based on the 85th percentile driest year using historical climatic data (rainfall and evaporation). It is assumed that excess flows during wet seasons from the Recreational Lagoon and surrounding site catchments will be captured in the Water Storage Lagoon and pumped back during dry seasons. More detail on this assessment can be found in Appendix C.

Further to providing a self-sufficient site in terms of water supply for the recreational lagoon and wave pool, the water supply lagoon will also have the added benefit of operating as a sediment basin to settle out suspended solids during the operational phase of the development thus helping to polish stormwater runoff before discharge into Mowbray River.

Internal roads will be one-way crossfall with all runoff captured via grass lined and landscaped swale drains which convey runoff to the water storage lagoon.

These vegetated overland flow swales are approximate 3,500 m which also act as a treatment train in achieving stormwater quality treatment

Refer to Sketch 12544036 SK003 In Appendix A for the Concept Drainage.

Carparking onsite will be sloped to open swales and conveyed towards the water storage lagoon, through new and existing drainage paths.

Roof water downpipes will be fitted with first flush devices before discharging into grass lined and landscaped swale drains via a piped system designed in accordance with FNQROC and QUDM.

Stormwater quality objectives will be achieved by those treatment trains measures discussed above, namely:

- Downpipe first flush devices with trickle feeds to garden beds
- Approximately 3,500 m of vegetated swales drains
- Water supply lagoon for final polishing

A MUSIC model of the proposed treatment train will be undertaken at operational works stage to confirm compliance with the SPP and FNQROC.

5. Engineering Code Assessment (DSC)

5.1 Filling & Excavation Code

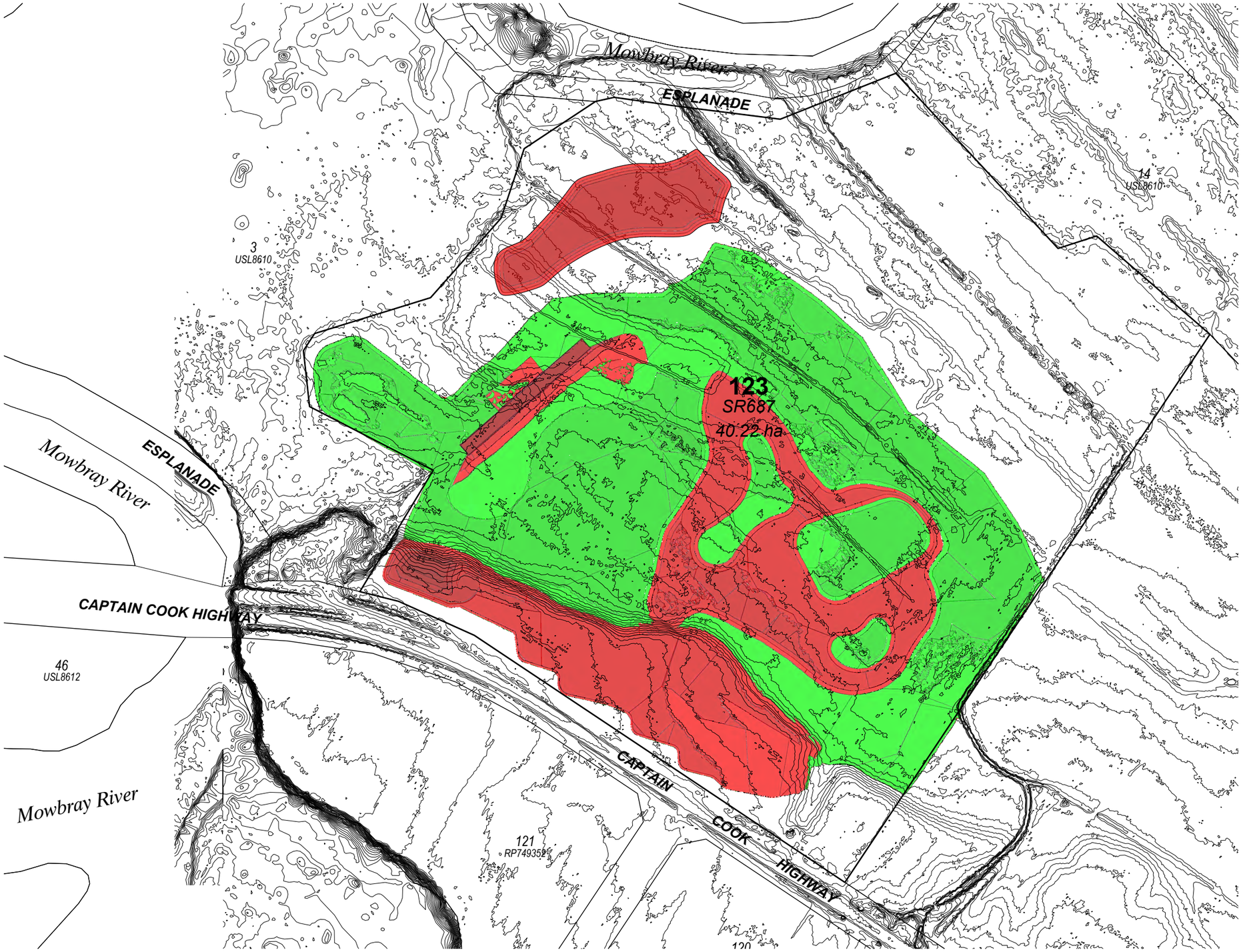
Performance outcomes	Acceptable outcomes	Development compliance
For self-assessable and assessable development		
Filling and excavation – General		
PO1 All filling and excavation work does not create a detrimental impact on the slope stability, erosion potential or visual amenity of the site or the surrounding area.	**AO1.1** The height of cut and/or fill, whether retained or not, does not exceed 2 metres in height. and Cuts in excess of those stated in A1.1 above are separated by benches/ terraces with a minimum width of 1.2 metres that incorporate drainage provisions and screen planting. **AO1.2** Cuts are supported by batters, retaining or rock walls and associated benches/terraces are capable of supporting mature vegetation. **AO1.3** Cuts are screened from view by the siting of the building/structure, wherever possible. **AO1.4** Topsoil from the site is retained from cuttings and reused on benches/terraces. **AO1.5** No crest of any cut or toe of any fill, or any part of any retaining wall or structure is closer than 600mm to any boundary of the property, unless the prior written approval of the adjoining landowner has been obtained. **AO1.6** Non-retained cut and/or fill on slopes are stabilised and protected against scour and erosion by suitable measures, such as grassing, landscaping or other protective/aesthetic measures.	Complies earthworks onsite will be battered accordingly to geotechnical advice per controlled filling. ECS measures are to be implemented to reduce erosion potential of excavation and filling activities.
Visual impact and site stability		
PO2 Filling and excavation are carried out in such a manner that the visual/scenic amenity of the area and the privacy and stability of adjoining properties is not compromised.	**AO2.1** The extent of filling and excavation does not exceed 40% of the site area, or 500m2 whichever is the lesser, except that AO2.1 does not apply to reconfiguration of 5 lots or more. **AO2.2** Filling and excavation does not occur within 2 metres of the site boundary.	Excavation and filling exceed the acceptable outcome of 40% however, visual/scenic amenity is not impacted with filling to a maximum of 2 m onsite and below adjoining road levels. Stability of adjoining properties are not compromised as earthworks are minimal to the lot boundaries.

6. Conclusion

The Surf Port Douglas development is feasible from an engineering construction and internal stormwater collection and reuse infrastructure viewpoint. Bulk earthworks will be design and managed to not compromise or impact the surrounding properties.

Appendices

Appendix A – Preliminary Sketches



DEPTH RANGE TABLE		
DEPTH FROM (m)	DEPTH TO (m)	COLOUR
-7.0	-6.0	
-6.0	-5.0	
-5.0	-4.0	
-4.0	-3.0	
-3.0	-2.0	
-2.0	-1.0	
-1.0	0.0	
0.0	1.0	
1.0	2.0	
2.0	3.0	

EARTHWORKS VOLUME

- 100mm TOPSOIL STRIPPING
- 15% COMPACTION FACTORS
- TOPSOIL RE-SPREAD ON SITE

TOPSOIL STRIPPING VOLUME	- 25,500 m³
TOTAL CUT VOLUME	- 165,200 m³
TOTAL FILL VOLUME	- 190,700 m³

(BALANCED EARTHWORKS)

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PORT DOUGLAS SURF PARK

CONCEPT EARTHWORKS

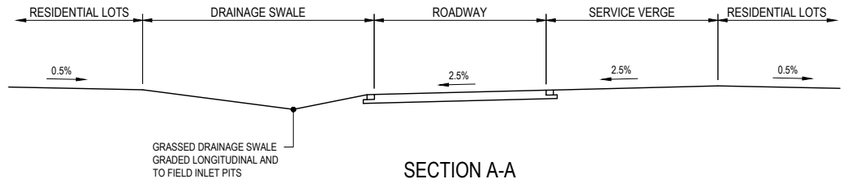
date: MARCH 2021
job no: 12544036
drawing: SK002

LEGEND

EXISTING DRAINAGE PATH

PROPOSED DRAINAGE PATH

PROPOSED DRAINAGE STRUCTURE



SECTION A-A

NOT TO SCALE

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PORT DOUGLAS SURF PARK

CONCEPT DRAINAGE

date: MARCH 2021

job no: 12544036

drawing: SK003

LEGEND

PROPOSED WATER
(SIZE TO BE CONFIRMED)

www.ghd.com

PORT DOUGLAS SURF PARK

date: MARCH 2021
job no: 12544036
drawing: SK004

CONCEPT WATER

LEGEND

PROPOSED VACUUM SEWER

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PORT DOUGLAS SURF PARK

CONCEPT SEWERAGE

date: MARCH 2021

job no: 12544036

drawing: SK005

GHD

Appendix B – Geotechnical Study (Golders)

GOLDER

REPORT

Geotechnical Studies

Port Douglas Wave Park

Submitted to:

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20446551-001-R-Rev0

Record of Issue

Company	Client Contact	Version	Date Issued	Method of Delivery
Graben Pty Ltd	David Imgraben	Rev 0	5 Feb 2021	Email

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PLATES

FIGURES

APPENDICES

1.0 INTRODUCTION

Graben Pty Ltd (Graben) engaged Golder Associates Pty Ltd (Golder) to carry out geotechnical studies related to a proposed wave park development located at Mowbray near Port Douglas. Preliminary information provided by Hunt Design indicates that the development is proposed to extend across predominantly low lying sugar cane fields between the Captain Cook Highway and the Mowbray River. In general terms development of the park would require bulk earthworks to raise the level of the site where required, plus construction of ponds and associated infrastructure and buildings.

The aims of the studies were to provide a broadscale assessment of near-surface ground and groundwater conditions across the site and to provide an initial assessment of potential geotechnical constraints and opportunities associated with the project (e.g. potential presence of soft compressible soils or Acid Sulfate Soils).

The studies were carried out in accordance with our proposal CX20446551-001-L-Rev0, dated 3 December 2020. This report presents the initial results of the studies.

2.0 SITE INVESTIGATIONS

A desktop review of published geological, soils and acid sulfate risk maps was initially conducted to assess potential variations in ground conditions across the site. A site walkover was conducted by Golder on 18 December 2020 to assess general site conditions and to set-out proposed investigation locations.

The field investigation was carried out on 21 and 22 December 2020 and involved:

- Excavation and sampling of eight test pits (designated TP1 to TP8) to depths ranging from about 2.5 m to 3.2 m;
- Drilling of four boreholes (designated BH1 to BH4) to depths ranging from about 5.2 m to 6.1 m. The boreholes were drilled using a trailer mounted drill rig using a combination of auguring and wash boring drilling techniques;
- Performance of a Dynamic Cone Penetrometer (DCP) test adjacent to each test pit and borehole location; and
- Installation and development of groundwater monitoring wells at each borehole location. Field measurements of groundwater depth, pH and EC. Collection of groundwater samples for assessment of ASS indicators. Installation of data loggers in each well.

Geotechnical staff from Golder recorded the subsurface conditions encountered in the test pits and boreholes, plus recovered soil and groundwater samples for laboratory testing.

Test locations are shown in Figure 001. Test pit, borehole and DCP reports are presented in Appendix A. Ground surface elevations at each investigation location were interpolated from contours from drawing No. PR148361-1 A, dated 17 November 2020 (Site Plan – Port Douglas Wave Park, Lot 123 SR687, prepared by RPS Australia East Pty Ltd).

3.0 LABORATORY TESTING

ASS screening tests were conducted by Golder on 29 selected soil samples recovered during the site investigation.

Selected soil samples recovered from the test pits were submitted to NATA accredited laboratories for the assessment of the following:

- 6 no. moisture content;

- 6 no. particle size distribution (grading);
- 6 no. Atterberg limits and linear shrinkage (plasticity);
- 6 no. Emerson Class number; and
- 8 no. Chromium suite analysis.

Groundwater samples from the four wells were submitted to a NATA accredited laboratory for analysis of:

- Metals including iron and aluminium; and
- Major cations and anions including chloride and sulfate.

Laboratory test certificates are presented in Appendix B and C.

4.0 RESULTS OF INVESTIGATION

4.1 Review of existing information

4.1.1 Geology

An excerpt of the regional geology map published electronically by the Queensland Department of Natural Resources and Mines (DNRM) is presented in Plate 1. The map indicates that the site is underlain by the following geological units:

- Qhcb - Quaternary (Holocene) age deposits comprising sand ridges in the lower lying areas of the site;
- TQa – Quaternary/Tertiary age high-level alluvial deposits comprising sand, silt, clay and minor gravel in the area along the Captain Cook Highway nearer the Mowbray River; and
- TQr – Quaternary/Tertiary age colluvial and residual soil deposits (generally on older land surfaces) comprising clay, silt, sand, and gravel in the area along the Captain Cook Highway further away from the Mowbray River.

Plate 1 Regional geology (DNRM)

4.1.2 Soils

An excerpt from the soils map (1:50,000 scale on Queensland Globe) is shown on Plate 2. The map indicates the presence of Hull series soils over most of the site. Clifton series soils are present in the area along the Captain Cook Highway and Mangroves series soils are present in parts of the site near the north western and north eastern site boundaries.

Hull series soils are formed on sand ridges and are generally associated with acid sulfate soils below the water table. Mangrove soils are undifferentiated soils subject to tidal inundation and may be associated with acid sulfate soils. Clifton series soils are not typically associated with acid sulfate soils.

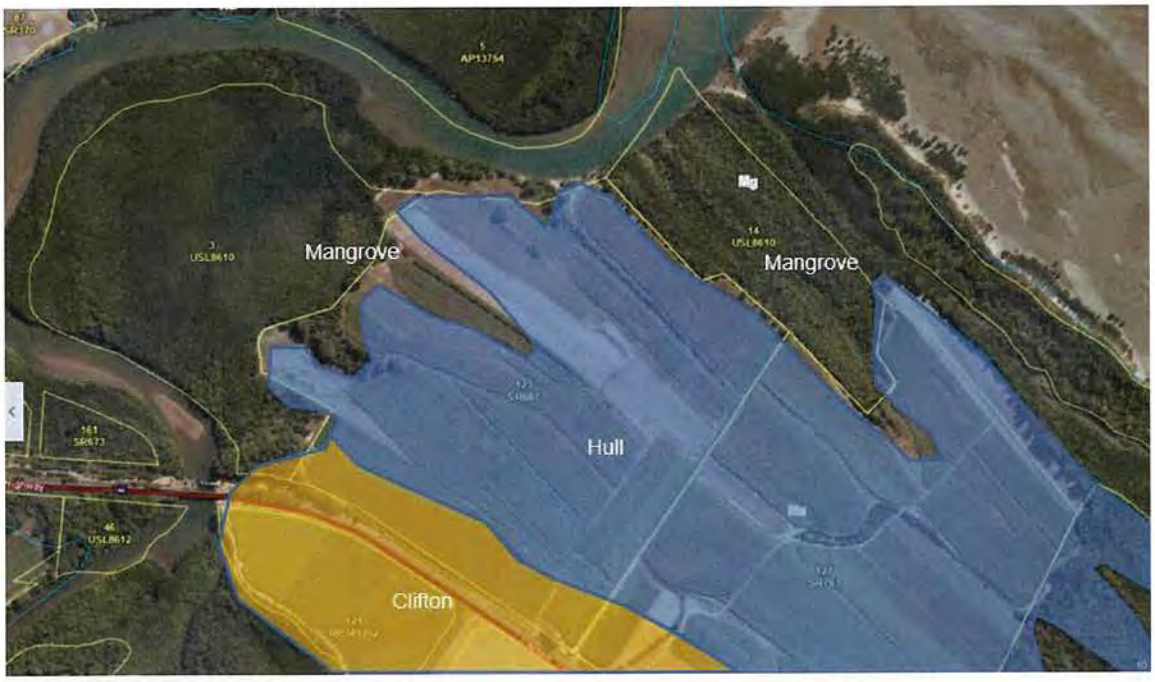


Plate 2 Soils Map

4.1.3 Acid sulfate soils

An excerpt from the ASRIS ASS risk map is shown on Plate 3. The map indicates a low probability of occurrence across most of the site. The map also indicates a high probability of ASS occurrence near parts of the north western and north eastern site boundaries.

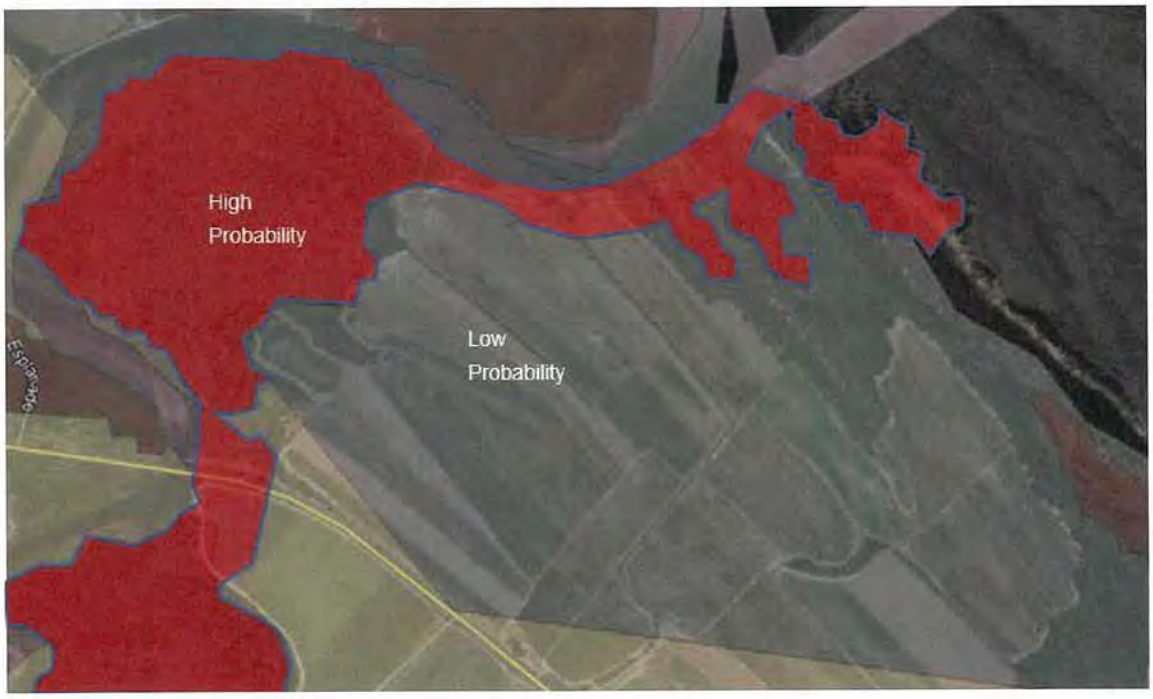


Plate 3 ASS Risk Map

4.2 Surface conditions

At the time of the site investigation, most of the site was covered with sugar cane. The site gently grades north east towards the Mowbray River and the coast with surface elevations ranging from about RL ~6 m AHD (where the site adjoins the Captain Cook Highway) to RL ~1 m AHD (within creeks/ drains that cross the site typically in a north-west direction towards the Mowbray River). The site is bounded by vegetated land and the Mowbray River to the north east and north west; adjacent cane farms to the south east; and the Captain Cook Highway and cane farms to the south west.

For discussion purposes the site has been divided into three main areas (northern, central, southern) based on subsurface conditions encountered during the investigation. These areas are shown in Plate 4.

Plate 4: Site areas

Selected site photographs at the time of the site investigation are presented in Plate 5.

Plate 5: Selected photographs at time of investigation

4.3 Subsurface conditions

Subsurface conditions encountered within the test pits and boreholes can generally be summarised as follows:

Southern area (TP1, TP3 and BH1, BH2)

- Firm to stiff sandy clay (inferred disturbed/ reworked ground) to depths ranging from about 0.2 m to 0.5 m underlain by;
- Stiff to hard sandy clay/ clay to depths ranging from about 3.2 m to 6.1 m depth (i.e. depth of investigation in test pits and boreholes). A layer of firm sandy clay (i.e. lower strength clay) was observed at depths ranging from about 0.6 m to 1.6 m in TP3 located near a creek inlet.

Central area (TP2, TP4, TP5)

- Medium dense to very dense clayey sand/ sand (inferred disturbed/ reworked ground) to depths ranging from about 0.2 m to 0.5 m underlain by;
- Medium dense to dense clayey sand/ sand to depths ranging from about 0.7 m to 1.2 m underlain by;
- Stiff to hard sandy clay/ clay to depths ranging to about 3.1 m depth (i.e. depth of investigation in test pits). A layer firm sandy clay (i.e. lower strength clay) was observed at depths ranging from about 1.7 m to 2.4 m in TP5 located near a drain/ creek).

Northern area (TP6, TP7, TP8 and BH3, BH4)

- Loose to medium dense sand (inferred disturbed/ reworked ground) to depths ranging from about 0.2 m to 0.5 m, underlain by;
- Medium dense to dense sand (with some gravel bands) to depths ranging from about 2.5 m to 3.1 m in the test pits (i.e. depth of investigation) and to a depth of about 4.2 m depth in the boreholes, underlain by;
- Very stiff to hard clay / sand clay to a depth of about 5.5 m (i.e. depth of borehole investigations).

Figure 002 presents a typical section through the site with inferred subsurface conditions.

4.4 Groundwater

A summary of groundwater levels measured within monitoring wells (BH1 to BH4) is presented in Table 1.

Table 1: Summary groundwater levels within monitoring wells

Location ID	Surface RL (m AHD)	Depth to groundwater (m bgl)	
		13 Jan 2021	15 Jan 2021
BH1	2.3	0.96	0.75
BH2	2.3	0.16	0.15
BH3	2.3	0.57	0.35
BH4	2.2	0.76	0.57

It should be noted that groundwater levels may fluctuate seasonally and be higher during heavy rainfall periods. In addition, groundwater levels may be tidally influenced given the proximity to the Mowbray River and associated creeks/ drains.

Instrumentation has been installed in each monitoring well to allow continued monitoring of groundwater levels and groundwater quality until mid 2021. Further comments regarding groundwater levels and quality are proposed to be provided following the monitoring period.

4.5 Laboratory Testing - Geotechnical

Results of laboratory testing are summarised in Table 2 and Table 3. Laboratory test certificates are presented in Appendix B.

Table 2: Results of classification testing.

Test pit	Sample depth (m bgl)	MC[1] (%)	Particle size distribution			Atterberg limits			LS[2] (%)	Material classification
			Fines (%)	Sand (%)	Gravel (%)	Liquid limit (%)	Plastic limit (%)	Plasticity Index (%)		
TP1	0.80 – 0.90	13.7	66	32	2	36	20	16	7	Sandy CLAY (CI)
TP2	1.10 – 1.20	19.1	94	6	0	37	20	17	8	CLAY (CI)
TP3	0.50 – 0.60	13.0	42	58	0	23	16	7	3.5	Sandy CLAY (CL)
TP4	1.50 – 1.60	22.2	74	26	0	28	16	12	6	CLAY (CL)
TP6	1.50 – 1.60	5.8	2	98	0	NO[3]	NO	NP[4]	0	SAND (SP)
TP8	1.80 – 1.90	31.1	11	66	23	NO	NO	NP	0	SAND (SW)

Notes:
1 – MC - Moisture Content
2 – LS – Linear Shrinkage
3 – NO – Not Obtainable
4– NP – Non Plastic

Table 3: Results of Emerson Class testing

Test pit	Sample depth (m bgl)	Material classification	Emerson Class Number
TP1	0.80 – 0.90	Sandy CLAY (CI)	6
TP2	1.10 – 1.20	CLAY (CI)	6
TP3	0.50 – 0.60	Sandy CLAY (CL)	6
TP4	1.50 – 1.60	CLAY (CL)	2
TP6	1.50 – 1.60	SAND (SP)	6
TP8	1.80 – 1.90	SAND (SW)	4

4.6 Acid Sulfate Soils

4.6.1 ASS Action Criteria

The following key guidance documents were considered for this ASS assessment:

- *National Acid Sulfate Soils Guidance: National acid sulfate soils sampling and identification methods manual*, June 2018, Water Quality Australia, Department of Agriculture and Water Resources, Commonwealth of Australia
- *National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual*, June 2018, Water Quality Australia, Department of Agriculture and Water Resources, Commonwealth of Australia
- *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines*. 2014. Department of Science, Information Technology, Innovation and the Arts, Queensland Government.

Table 4 summarises ASS action criteria. These categories are used to identify whether action / management of ASS disturbances is required, based on 'net acidity'. For this assessment, an action criterion of 0.03% Equivalent Sulfur has been adopted conservatively as the volume of disturbance during site development is yet to be confirmed.

Table 4: ASS Action Criteria (National Acid Sulfate Soils Guidance, 2018)

Type of Material		Net Acidity			
		1-1000 tonnes materials disturbed		> 1000 tonnes materials disturbed (and major fill projects)	
Texture Range	**Approx. Clay** Content (%)	**Equivalent sulfur** %S oxidisable	**Equivalent acid** mol H^+/tonne	**Equivalent sulfur** %S oxidisable (oven-dry basis)	**Equivalent acid** mol H^+/tonne (oven-dry basis)
Fine Texture Light medium to heavy clays	> 40	≥ 0.10	≥ 62	≥ 0.03	≥ 18
Medium Texture Clayey sand to light clays	5 – 40	≥ 0.06	≥ 36	≥ 0.03	≥ 18
Coarse Texture and Peats Sands to loamy sands	< 5	≥ 0.03	≥ 18	≥ 0.03	≥ 18

4.6.2 ASS Screening Tests

The pH_F and pH_{FOX} screening method consists of two steps; determining the field pH of 1:5 soil/water suspension, and by the addition of 30% Hydrogen Peroxide, allowing the sample time to oxidise, before determining the pH_{FOX} (pH after oxidation) of the reacted sample. The screening tests are used to indicate the likelihood of a soil containing actual acidity (i.e. Actual ASS [AASS]) and/or potential acidity (Potential ASS [PASS]).

The following interpretation of screening tests has been used:

1) AASS potential is indicated by: $pH_F \leq 4.0$

2) PASS potential is indicated by:

   - Strong indication: $pH_{FOX} < 3$, large ΔpH and a strong reaction with hydrogen peroxide.
   - Inconclusive: pH_{FOX} 3 – 4 and low, medium or strong reaction with hydrogen peroxide
   - Low indication: $pH_{FOX} > 4$ and low, medium or strong reaction with hydrogen peroxide.

Soil screening test results on recovered soil samples from this investigation are summarised in Table A in Appendix C.

The screening test results indicated the following:

- A low AASS potential was indicated in all soil samples tested.
- Low to inconclusive indication of PASS for all investigation locations, except for a sample of clay at location TP5 at a depth of 2.2 to 2.3 m (i.e. 0.0 to -0.1 m AHD) which had a strong indication of PASS.

4.6.3 Chromium Suite Analysis

Based on screening test results, 8 soil samples were selected for Chromium suite analysis. These soil samples were selected to provide a broad coverage of the soil profile.

Results of laboratory testing, including Acid-Base Accounting (ABA) to calculate net acidity and liming rates, are summarised in Table B in Appendix C. As recommended in the *National acid sulfate soils identification and laboratory methods manual*, ANC has not been included in the calculation of net acidity as incubation testing has not been conducted.

The laboratory results indicated the following:

- The absence of AASS in the samples tested.
- The presence of PASS in soil samples tested below 0 m AHD at the following locations:
   - Location TP5 clay from a depth of 2.2 to 2.3 m (0 to -0.1 m AHD)
   - Location TP8 sand from a depth of 1.8 to 1.9 m (0 to -0.1 m AHD) and 2.5 to 2.6 m (-0.7 to -0.8 m AHD)
- Lime treatment rates range from 14 kg lime/m^3 to 39 kg lime/m^3 to neutralise the calculated net acidity in these identified PASS soils.

4.6.4 Groundwater Quality

ASS indicator parameter results for groundwater are summarised in Table 5.

Table 5: Groundwater Quality Test Results

Parameter	BH1	BH2	BH3	BH4
Sample Date	15/01/2021	15/01/2021	15/01/2021	15/01/2021
pH (field reading)	6.2	6.8	7.2	7.5
EC µS/cm (field reading)	23641	12955	498	6614
Sulfate mg/L	-	-	8.3	300
Chloride mg/L	-	-	44	1900
Total Alkalinity mg/L	-	-	160	220
Dissolved Aluminium mg/L	-	-	0.017	0.027
Dissolved Iron mg/L	-	-	0.066	0.9

These field and laboratory test results indicated:

- Electrical conductivity (EC) of all locations was brackish, except location BH3 which was fresh.
- pH readings ranged from 6.2 to 7.5 indicating slightly acidic conditions to neutral conditions.
- Total alkalinity indicates a high buffering capacity in groundwater and is interpreted to be Class 1 buffering capacity (i.e. generally adequate to maintain acceptable pH levels in the future).
- Aluminum concentrations do not indicate the presence of active ASS.

5.0 ENGINEERING COMMENTS

5.1 Ground conditions

As outlined in Section1.0, the aims of the studies were to provide a broadscale assessment of near-surface ground and groundwater conditions across the site. On this basis the site has been divided into three main areas (northern, central, southern) based on subsurface conditions encountered during the investigation. The inferred extent of each area is shown in plan on Plate 4 in Section 4.2 and in cross section on Figure 2. Ground conditions encountered in each area are summarised as follows:

- Southern Area – Predominantly stiff to hard clays to depths greater than about 4 m;
- Central Area – Variable thickness of loose to dense sands to depths ranging to about 4 m, overlying stiff to hard clays; and
- Northern Area - Predominantly loose to dense sands to depths greater than about 4 m.

In general terms groundwater measured in mid January 2021 ranged from a depth of about 0.3 m or a level of about 2.0 m AHD in the south eastern part of the site (i.e. BH2 and BH3) dropping to a depth of about 0.7 m or a level of about 1.5 m AHD in the north western part of the site (i.e. BH1 and BH4).

5.2 Proposed development

Existing surface levels range from ~6 m AHD along the Captain Cook Highway dropping to ~2 m AHD about 100m north east of the highway. The remainder of the site is generally around ~2 m AHD dropping locally to ~1 m AHD within creeks/ drains that cross the site. Cut and fill earthworks are proposed to achieve design levels for the proposed development.

A copy of the schematic layout of the proposed development from a drawing provided by Hunt Design is presented in Plate 6.

Plate 6: Schematic layout of proposed development

In general terms the main features of the proposed development include the following:

- Wave pool – located in the north western part of the site;
- Lagoon – located in the central and south eastern part of the site;
- Hotel and amenities buildings – located between the wave pool and the lagoon;
- Residential development – around the north eastern and south eastern sides of the lagoon, plus on an island within the lagoon; and
- Access roads throughout the site, plus carparking along the Captain Cook Highway site boundary.

Comments on geotechnical issues relating to the proposed development are presented in the following sections.

5.3 Bulk earthworks

5.3.1 Cut and fill areas

A copy of the schematic layout of the proposed cut and fill earthworks from a drawing provided by Hunt Design is presented in Plate 7.

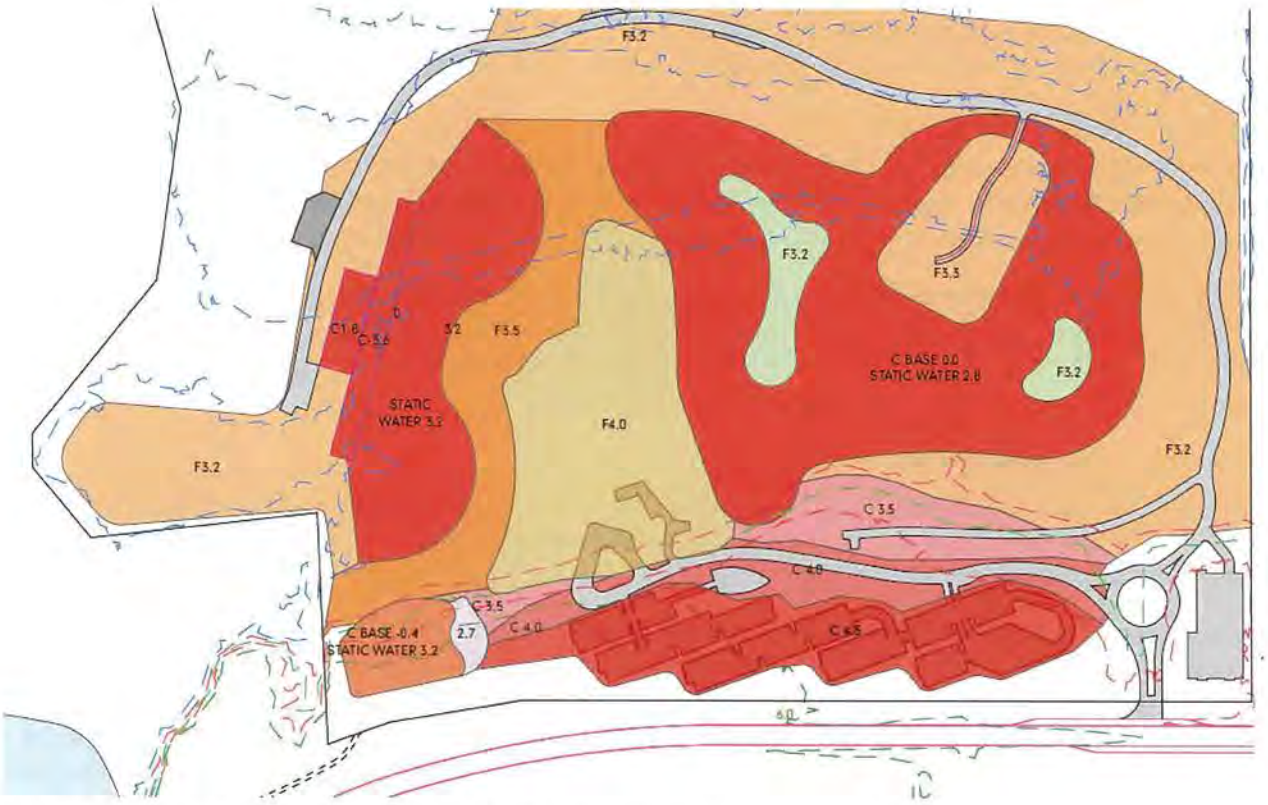


Plate 7: Schematic layout of proposed cut and fill earthworks

In general terms the proposed earthworks are summarised as follows:

- Carparking area – Excavation to levels ranging from 3.5 m to 4.5 m AHD. Maximum depth of excavation expected to be ~1.5 m. Excavated materials expected to comprise mainly clays. Groundwater not expected to be encountered.
- Wave Pool and Lagoons - Excavation to a level of 0.0 m AHD in both features. Maximum depth of excavation expected to be ~2 m. Excavated materials expected to comprise mainly clays in the Southern Area, grading to variable mixtures of clays and sands in the Central Area and sands in the Northern Area. Groundwater expected to be encountered near the surface during the wet season and at a depth of about 1 m to 1.5 m in the dry season.
- Residential areas and areas surrounding wave pool and lagoon – Filling to levels ranging from 3.2 m to 3.5 m AHD. Maximum depth of fill expected to be about 1.5 m. Fill expected to comprise materials won from bulk excavations for the carparking area, wave pool and lagoon.
- Hotel area – Filling to a level of 4.0 m AHD. Maximum depth of fill expected to be about 1.5 m. Fill expected to comprise materials won from bulk excavations for the carparking area, wave pool and lagoon.

5.3.2 Fill materials

As outlined above fill materials won from excavations are expected comprise mainly clays in the Southern Area, variable amounts of clays and sands in the Central Area (with the amount of sand increasing towards the Northern Area), and mainly sands in the Northern Area. All of these materials are considered to be suitable for use as controlled (or engineered) fill, subject to appropriate moisture conditioning for compaction.

Filling operations should be managed such that specific areas are filled using one material (i.e. clays, sands or blended mixtures of clays and sands). For example, filling for the hotel area should comprise consistent materials throughout, rather than clay fill at the southern end and sand fill at the northern end.

5.3.3 Excavation conditions

Excavations to depths ranging to about 6 m (i.e. the maximum depth investigated) should encounter clays ranging from firm to hard and sands ranging from loose to dense. Excavation of these materials should be achievable using conventional earthmoving equipment (e.g. large tracked excavators).

Excavations for the proposed wave pool and lagoon are generally not expected to be greater than about 2 m in depth, however these excavations are likely to encounter groundwater at depths ranging from just below the surface in the wet season to about 1.5 m in the dry season. Earthworks should be carried out in the dry season to minimise the depth of excavation required underwater.

5.3.4 Unsuitable materials

Near surface materials containing significant amounts of organic material should not be used for controlled filling. Given that most of the site is used for sugar cane farming allowance will need to be made for stripping to depths ranging from about 0.2 m to 0.5 m to remove soils containing organics from both cut and fill areas.

Previous experience with development on cane fields indicates that there is a potential for unsuitable materials to be encountered in some areas of the site where earthworks were carried out previously to improve the farming area. Such areas include former creeks, gullies or other low lying areas that were backfilled (often with trees and other vegetation) to level the surface. No areas of this type of backfilling were encountered during the recent site investigation, however further investigation of suspect areas identified from aerial photos should be carried out when access is not restricted by the sugar cane.

5.3.5 Acid sulfate soils

ASS risk mapping generally indicated a low potential for ASS in the near surface soils across most of the site, however there is a high probability of encountering ASS in mangrove areas surrounding the site. The preliminary ASS investigation detected PASS in soil samples analysed below 0 m AHD at two locations. These locations are considered to be associated with surrounding mangroves and/or former drainage features and may not be representative of conditions under all site areas. Deposits of ASS may be present in deeper layers of soils below the investigated depth.

Groundwater testing results suggest a historically undisturbed environment and a buffering capacity generally adequate to maintain acceptable pH levels in the future.

Results to date suggest that there is a relatively low potential that ASS will be encountered in materials above the seasonal water table across most of the site. Excavations and dewatering in or adjacent to higher risk mangrove areas should be avoided (refer Plate 3 in Section 4.1.3). More detailed ASS investigations and preparation of an ASS Management Plan are recommended when design has advanced such that the extent of project disturbances (i.e. excavation and dewatering) are better known.

5.3.6 Groundwater

As outlined above excavations for the proposed wave pool and lagoon are generally not expected to be greater than about 2 m in depth, however these excavations are likely to encounter groundwater at depths

ranging from just below the surface in the wet season to about 1.5 m in the dry season. It is understood that the base of the wave pool and the lagoon is proposed to be at about 0.0 m AHD. The base of the wave pool is proposed to be concrete lined and the lagoon may need to be lined (with clay or geosynthetics) to minimise seepage and maintain a water level at about 2.8 m AHD. If this is the case these excavations will probably need to be dewatered for construction of the liners.

5.4 Proposed water features

As outlined above the base of the water features is proposed to be at about 0.0 m AHD. The base of the pool is proposed to be concrete lined and the base of the lagoon may have to be lined. Based on the results of the limited investigations to date and the currently proposed location of the pool and lagoon, indications are that the foundation conditions in the base of both features should be mainly very stiff to hard clays.

5.5 Proposed buildings

5.5.1 Proposed hotel

It is understood that the proposed hotel buildings are to be three level structures constructed on a fill platform at about 4.0 m AHD. It may be feasible to support the structures on high level footings founded in controlled fill, depending on building loads and tolerable settlements.

5.5.2 Proposed residential buildings

Proposed residential buildings are likely to be one or two level structures constructed on various fill platforms around and within the lagoon. These structures are likely to be able to be supported on high level footings founded in controlled fill.

6.0 FURTHER GEOTECHNICAL INPUT

As outlined previously the aims of these studies were to provide a broadscale assessment of near-surface ground and groundwater conditions across the site and to provide an initial assessment of potential geotechnical constraints and opportunities associated with the project. Once development details are advanced additional geotechnical investigations will be required. Potential issues that may need to be addressed include, but are not limited to, the following:

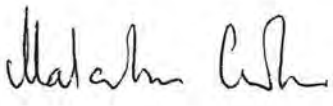
- Further investigation to better assess ground conditions in the footprint of the proposed wave pool and lagoon (i.e. excavation conditions and fill material quality);
- Further investigation to better assess groundwater conditions in the area of the proposed wave pool and lagoon (i.e. permeability conditions and dewatering options);
- Further investigation to better assess ground conditions in the footprint of development areas, particularly the proposed hotel area.
- Deeper investigations to assess whether soft compressible clays are present at depth in the Central and Northern Areas, particularly areas of proposed development near mangrove areas (refer Plate 3 in Section 4.1.3);
- Further ASS investigations and preparation of an ASS Management Plan once project disturbances are known.

7.0 IMPORTANT INFORMATION

Your attention is drawn to the document titled - "Important Information Relating to this Report", which is included as Appendix D of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder Associates has under the contract between it and its client.

Signature Page

Golder Associates Pty Ltd



Samuel Bogue
Senior Geotechnical Engineer

Malcolm Cook
Principal Geotechnical Engineer

SBB/MSC/ow

A.B.N. 64 006 107 857

https://golderassociates.sharepoint.com/sites/138729/project files/6 deliverables/ror/20446551-001-r-rev0 geotech site assessment msc review.docx

LEGEND

- Test Pits
- Boreholes
- Land Parcel

0 250

1:5,000 METRES

CLIENT
GARBEN PTY LTD

CONSULTANT
GOLDER

DD-MM-YYYY	03-02-2021
DESIGNED	NP
PREPARED	NP
REVIEWED	CD
APPROVED	SB

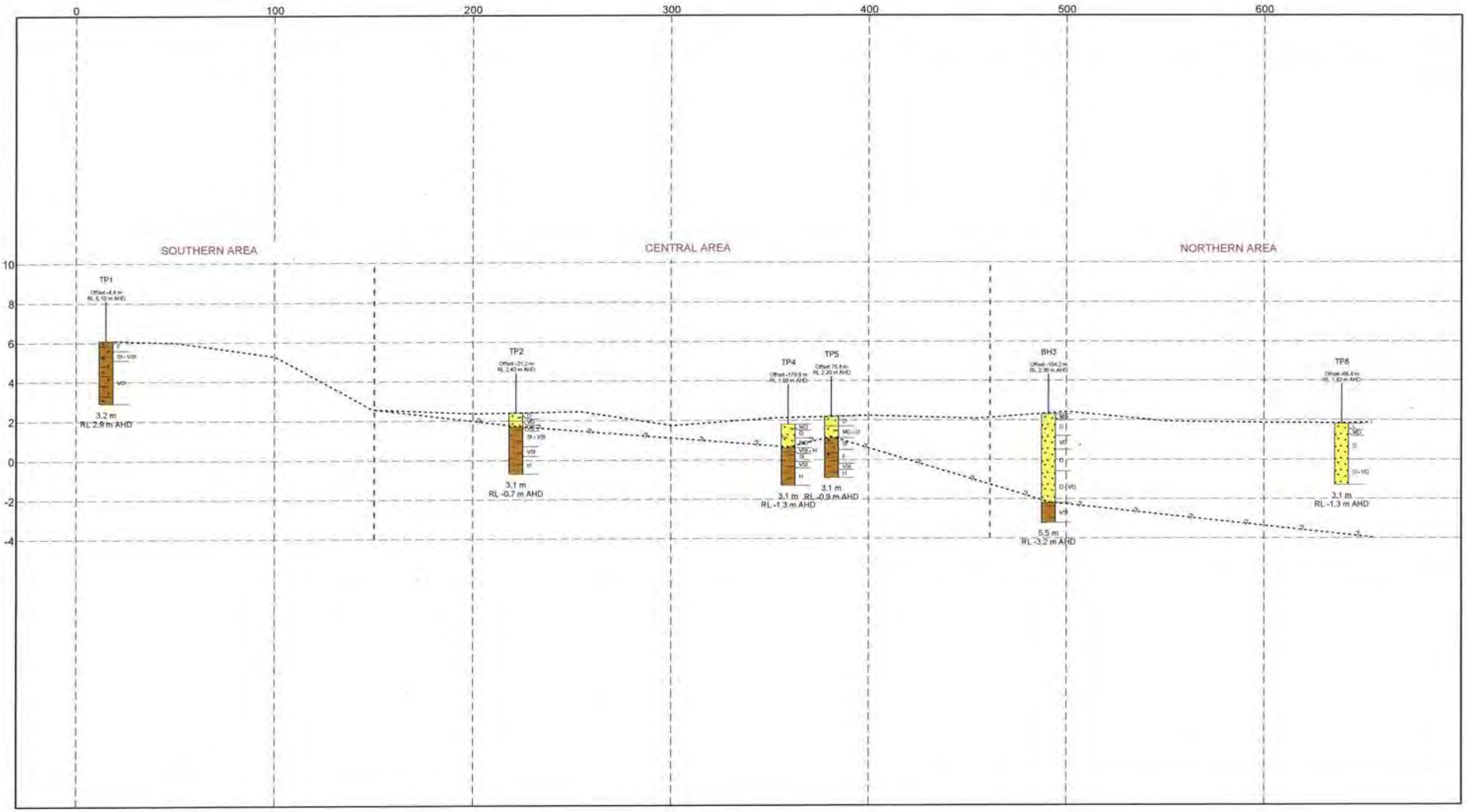
NOTE(S)
1. COORDINATE SYSTEM: GDA2020 MGA ZONE 55

REFERENCE(S)
Service Layer Credits: © State of Queensland (Department of Natural Resources, Mines and Energy) 2020
Includes material © The State of Queensland © Planet Labs Netherlands B.V. 2020

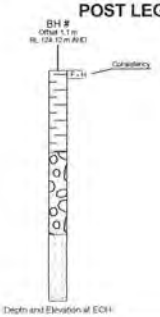
PROJECT
GEOTECHNICAL SITE ASSESSMENT
PORT DOUGLAS WAVE PARK

TITLE
SITE INVESTIGATION PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
20446551	001	1	001



POST LEGEND



MATERIAL GRAPHIC

- SAND
- Clayey SAND
- CLAY
- Gravelly CLAY
- Sandy CLAY

H 1:2000
0 20 40 60 80 100m
V 1:200
0 2 4 6 8 10m
Coord.System: MGA 2020 Zone 55 Height Datum: AHD

CLIENT: Graben Pty Ltd

CONSULTANT: GOLDER

YYYY-MM-DD	2021-02-03
PREPARED	NLP
DESIGN	NLP
REVIEW	SBB
APPROVED	SBB

PROJECT: GEOTECHNICAL SITE ASSESSMENT
PORT DOUGLAS WAVE PARK

TITLE: **Inferred Subsurface Section A-A'**

PROJECT No.	CONTROL	Rev.	FIGURE
20446551	001	0	002

Appendix A

Geotechnical Borehole Test Pit & DCP Reports and Explanatory Notes

GOLDER

REPORT OF TEST PIT: TP1

CLIENT: Graben Pty Ltd
PROJECT: Wave Park
LOCATION: Mowbray
JOB NO: 20446551

COORDS: 338377.0 m 8169175.0 m MGA2020 55
SURFACE RL: 6.10 m DATUM: AHD
WIDTH: 0.45 m
PIT DEPTH: 3.20 m
BUCKET TYPE: 450 mm toothed bucket

SHEET: 1 OF 1
MACHINE: New Holland E55Bx
CONTRACTOR: Saxon Drilling
LOGGED: CD DATE: 21/12/20
CHECKED: SB DATE: 14/1/21

Excavation					Sampling		Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
EX	L	GNE	0.0	6.10	DS 0.20-0.30 m			CI	Sandy CLAY medium plasticity, brown, fine to medium grained sand		F	Inferred disturbed/ re-worked ground (cane farming)	0 5 10 15 20 25
			0.5	0.50 5.60	DS 0.80-0.90 m				red		St - VSt	ALLUVIAL SOIL	
			1.0										
			1.5	1.40 4.70	DS 1.60-1.70 m				pale brown	w > PL			
	M		2.0								VSt		
			2.5	2.40 3.70					pale brown mottled red				
			3.0	2.90					TEST PIT DISCONTINUED @ 3.20 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED				
			3.5										
			4.0										

This report of test pit must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F01i RL3

GOLDER

REPORT OF TEST PIT: TP2

CLIENT: Graben Pty Ltd
PROJECT: Wave Park
LOCATION: Mowbray
JOB NO: 20446551

COORDS: 338520.0 m 8169325.0 m MGA2020 55
SURFACE RL: 2.40 m DATUM: AHD
WIDTH: 0.45 m
PIT DEPTH: 3.10 m
BUCKET TYPE: 450 mm toothed bucket

SHEET: 1 OF 1
MACHINE: New Holland E55Bx
CONTRACTOR: Saxon Drilling
LOGGED: CD DATE: 21/12/20
CHECKED: SB DATE: 14/1/21

Excavation					Sampling		Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
EX	M	GNE	0.0	2.40	DS 0.00-0.10 m			SC	Clayey SAND fine to medium grained, brown, low plasticity clay	M	D VD	Inferred re-worked ground (cane farming)	
				0.40									
			0.5	2.00	DS 0.40-0.50 m			SP	SAND fine to medium grained, poorly graded, grey		VD	ALLUVIAL SOIL	
				0.70									
				1.70				CI	CLAY medium plasticity, orange mottled grey, trace fine to medium grained sand		St - VSt		
			1.0		DS 1.00-1.10 m								
				1.10									
				1.30	DS 1.10-1.20 m			CH	CLAY high plasticity, red mottled grey, with fine grained sand				
			1.5		DS 1.50-1.60 m					w > PL			
			2.0		DS 2.00-2.10 m						VSt		
			2.5		DS 2.50-2.60 m						H		
			3.0	*3.00*									
				-0.60	DS 3.00-3.10 m				trace fine grained gravel				
				-0.70					TEST PIT DISCONTINUED @ 3.10 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED				
			3.5										
			4.0										

DCP TEST (AS1289.6.3.2) Blows per 100 mm: 0 5 10 15 20 25

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GOLDER

REPORT OF TEST PIT: TP3

CLIENT: Graben Pty Ltd
PROJECT: Wave Park
LOCATION: Mowbray
JOB NO: 20446551

COORDS: 338279.0 m 8169469.0 m MGA2020 55
SURFACE RL: 2.20 m DATUM: AHD
WIDTH: 0.45 m
PIT DEPTH: 3.10 m
BUCKET TYPE: 450 mm toothed bucket

SHEET: 1 OF 1
MACHINE: New Holland E55Bx
CONTRACTOR: Saxon Drilling
LOGGED: CD DATE: 21/12/20
CHECKED: SB DATE: 14/1/21

Excavation					Sampling		Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
EX	L	GNE	0.0	2.20	DS 0.10-0.20 m			CI	Sandy CLAY medium plasticity, brown, fine to medium grained sand	w > PL	St	Inferred re-worked ground (cane farming)	
				0.20 2.00				CL	Sandy CLAY low plasticity, grey mottled orange, fine to medium grained sand	M	St - VSt	ALLUVIAL SOIL	
			0.5		DS 0.50-0.60 m								
			1.0		DS 1.00-1.10 m						F		
			1.5	*1.60* 0.60	DS 1.50-1.60 m			CI	CLAY medium plasticity, grey mottled orange, with fine grained sand		VSt		
					DS 1.80-1.90 m								
	M		2.0		DS 2.00-2.10 m					w > PL			26
			2.5		DS 2.50-2.60 m						H		
			3.0		DS 3.00-3.10 m								
				-0.90					TEST PIT DISCONTINUED @ 3.10 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED				
			3.5										
			4.0										

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GAP gINT FN, F01i RL3

GOLDER

REPORT OF TEST PIT: TP4

CLIENT: Graben Pty Ltd
PROJECT: Wave Park
LOCATION: Mowbray
JOB NO: 20446551

COORDS: 338730.0 m 8169332.0 m MGA2020 55
SURFACE RL: 1.80 m DATUM: AHD
WIDTH: 0.45 m
PIT DEPTH: 3.10 m
BUCKET TYPE: 450 mm toothed bucket

SHEET: 1 OF 1
MACHINE: New Holland E55Bx
CONTRACTOR: Saxon Drilling
LOGGED: CD DATE: 21/12/20
CHECKED: SB DATE: 14/1/21

Excavation					Sampling		Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
EX	L	GNE	0.0	1.80	DS 0.10-0.20 m			SC	Clayey SAND fine to medium grained, brown, medium plasticity clay	M	MD	Inferred re-worked ground (cane farming)	0 5 10 15 20 25
				0.20									
				1.60					pale orange-brown			ALLUVIAL SOIL	
			0.5		DS 0.40-0.50 m						D		
					DS 0.90-1.00 m						MD		
			1.0	1.00									
				0.80					grey, trace fine grained gravel				
				1.20									
				0.60	DS 1.20-1.30 m			CH	Gravelly CLAY high plasticity, red, fine grained gravel, with fine to medium grained sand		VSt - H		
				1.40									
				0.40				CL	CLAY low plasticity, grey mottled pale orange, with fine grained sand				
			1.5		DS 1.50-1.60 m						St		
	M		2.0		DS 2.00-2.10 m					W > PL	VSt		
			2.5		DS 2.50-2.60 m						H		
			3.0		DS 3.00-3.10 m								
				-1.30					TEST PIT DISCONTINUED @ 3.10 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED				
			3.5										
			4.0										

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GAP gINT FN. F01i RL3

GOLDER

REPORT OF TEST PIT: TP5

CLIENT: Graben Pty Ltd
PROJECT: Wave Park
LOCATION: Mowbray
JOB NO: 20446551

COORDS: 338545.0 m 8169510.0 m MGA2020 55
SURFACE RL: 2.20 m DATUM: AHD
WIDTH: 0.45 m
PIT DEPTH: 3.10 m
BUCKET TYPE: 450 mm toothed bucket

SHEET: 1 OF 1
MACHINE: New Holland E55Bx
CONTRACTOR: Saxon Drilling
LOGGED: CD DATE: 21/12/20
CHECKED: SB DATE: 14/1/21

Excavation					Sampling		Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
EX	L	GNE	0.0	2.20	DS 0.10-0.20 m			SP-SC	SAND fine to medium grained, poorly graded, pale brown, with low plasticity clay	D	D	ALLUVIAL SOIL	
			0.5	0.50 1.70	DS 0.50-0.60 m			SC	Clayey SAND fine to medium grained, grey, medium plasticity clay	M	MD - D		
			1.0	1.10	DS 1.00-1.10 m								
				1.10				CI	Sandy CLAY medium plasticity, grey mottled orange, fine to medium grained sand	w > PL	St		
			1.5		DS 1.50-1.60 m								
			2.0	2.10 0.10	DS 2.20-2.30 m			CI	CLAY medium plasticity, dark grey, with fine grained sand, trace shells	w ~ LL	F		
	M			2.40 -0.20				CI	CLAY medium plasticity, grey mottled pale orange, with fine grained sand	w > PL	VSt H		
			2.5		DS 2.50-2.60 m								
			3.0		DS 3.00-3.10 m								
				-0.90					TEST PIT DISCONTINUED @ 3.10 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED BACKFILLED				
			3.5										
			4.0										

This report of test pit must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F01i RL3

GOLDER

REPORT OF TEST PIT: TP6

CLIENT: Graben Pty Ltd
PROJECT: Wave Park
LOCATION: Mowbray
JOB NO: 20446551

COORDS: 338311.0 m 8169598.0 m MGA2020 55
SURFACE RL: 2.60 m DATUM: AHD
WIDTH: 1.20 m
PIT DEPTH: 2.50 m
BUCKET TYPE: 1200 mm mud bucket

SHEET: 1 OF 1
MACHINE: New Holland E55Bx
CONTRACTOR: Saxon Drilling
LOGGED: CD DATE: 21/12/20
CHECKED: SB DATE: 14/1/21

Excavation					Sampling		Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
EX	L	▽	0.0	2.60	DS 0.10-0.20 m			SP	SAND fine to medium grained, poorly graded, pale brown, trace clay	D	L	Inferred re-worked ground (cane farming)	0 5 10 15 20 25
			0.5		DS 0.50-0.60 m						MD	ALLUVIAL SOIL	
			1.0		DS 1.00-1.10 m					M			
			1.5		DS 1.50-1.60 m						D		
			2.0		DS 2.10-2.20 m							water inflow at 2.1 m	
				2.40						W			
				0.20	DS 2.40-2.50 m			GP	Sandy GRAVEL fine to coarse grained, grey, fine to coarse grained sand, with cobbles		VD		
			2.5	0.10					TEST PIT DISCONTINUED @ 2.50 m SIDEWALL COLLAPSE FROM 2.1 M GROUNDWATER ENCOUNTERED @ 2.10 m DEPTH BACKFILLED				
			3.0										
			3.5										
			4.0										

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GAP gINT FN. F01i RL3

GOLDER

REPORT OF TEST PIT: TP7

CLIENT: Graben Pty Ltd
PROJECT: Wave Park
LOCATION: Mowbray
JOB NO: 20446551

COORDS: 338618.0 m 8169597.0 m MGA2020 55
SURFACE RL: 2.80 m DATUM: AHD
WIDTH: 1.20 m
PIT DEPTH: 2.90 m
BUCKET TYPE: 1200 mm mud bucket

SHEET: 1 OF 1
MACHINE: New Holland E55Bx
CONTRACTOR: Saxon Drilling
LOGGED: CD DATE: 21/12/20
CHECKED: SB DATE: 14/1/21

Excavation					Sampling		Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
EX	L	▽	0.0	2.80				SP	SAND fine to medium grained, brown	D		Inferred re-worked ground (cane farming)	0 5 10 15 20 25
				0.20 2.60					pale yellow		MD	ALLUVIAL SOIL	
			0.5		DS 0.50-0.60 m								
			1.0		DS 1.00-1.10 m					M	D		
			1.5		DS 1.50-1.60 m								
				1.60 1.20					shells, partially cemented zone		MD - D		
			2.0	2.00 0.80					shells				
					DS 2.10-2.20 m					W	D		
			2.5		DS 2.80-2.90 m								
				-0.10					TEST PIT DISCONTINUED @ 2.90 m SIDEWALL COLLAPSE FROM 2.5 M GROUNDWATER ENCOUNTERED @ 2.10 m DEPTH BACKFILLED				
			3.0										
			3.5										
			4.0										

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GAP gINT FN. F01i RL3

GOLDER

REPORT OF TEST PIT: TP8

CLIENT: Graben Pty Ltd
PROJECT: Wave Park
LOCATION: Mowbray
JOB NO: 20446551

COORDS: 338818.0 m 8169621.0 m MGA2020 55
SURFACE RL: 1.80 m DATUM: AHD
WIDTH: 1.20 m
PIT DEPTH: 3.10 m
BUCKET TYPE: 1200 mm mud bucket

SHEET: 1 OF 1
MACHINE: New Holland E55Bx
CONTRACTOR: Saxon Drilling
LOGGED: CD DATE: 21/12/20
CHECKED: SB DATE: 14/1/21

Excavation					Sampling		Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	DCP TEST (AS1289.6.3.2) Blows per 100 mm
EX	L		0.0	1.80	DS 0.10-0.20 m			SP	SAND fine to medium grained, poorly graded, brown, trace medium plasticity clay		L	Inferred re-worked ground (cane farming)	0 5 10 15 20 25
				0.40 1.40								ALLUVIAL SOIL	
			0.5		DS 0.50-0.60 m				grey		MD		
										M			
			1.0	1.00 0.80	DS 1.00-1.10 m				pale grey		D		
			1.5	1.50 0.30	DS 1.50-1.60 m				trace organic material				
				1.80 0.00	DS 1.80-1.90 m			SW	fine to coarse grained, well graded, grey, with fine to medium gravel, with silt, with shell fragments	M - W			
		▽	2.0	2.10 -0.30				SP	fine to medium grained, poorly graded, trace medium plasticity clay				
			2.5		DS 2.50-2.60 m					W	D - VD		
			3.0		DS 3.00-3.10 m								
				-1.30					TEST PIT DISCONTINUED @ 3.10 m TARGET DEPTH GROUNDWATER ENCOUNTERED @ 2.10 m DEPTH BACKFILLED				
			3.5										
			4.0										

This report of test pit must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F01i RL3

GOLDER

REPORT OF BOREHOLE: BH1

SHEET: 1 OF 1

CLIENT: Graben Pty Ltd
PROJECT: Wave Park
LOCATION: Mowbray
JOB NO: 20446551

COORDS: 338321.0 m 8169340.0 m MGA2020 55
SURFACE RL: 2.30 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 5.20 m

DRILL RIG: Scout 1750
CONTRACTOR: Saxon Drilling
LOGGED: CD DATE: 22/12/20
CHECKED: SB DATE: 14/1/21

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS
			-1									Monument
ADV	M		0	2.30				CI	Sandy CLAY medium plasticity, pale brown, fine to medium grained sand		St - VS H St VSt	Grout Bentonite
			1									
			2							w > PL		
	H		3	2.80 -0.50	DS 2.80-2.90 m			CI	CLAY medium plasticity, pale orange brown, with fine grained sand		VSt - H	Sand
			4									
			5									Bentonite
			6	-2.90					END OF BOREHOLE @ 5.20 m TARGET DEPTH GROUNDWATER ENCOUNTERED @ 4.80 m DEPTH			

GOLDER

REPORT OF BOREHOLE: BH2

SHEET: 1 OF 1

CLIENT: Graben Pty Ltd
PROJECT: Wave Park
LOCATION: Mowbray
JOB NO: 20446551

COORDS: 338640.0 m 8169209.0 m MGA2020 55
SURFACE RL: 2.30 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 6.10 m

DRILL RIG: Scout 1750
CONTRACTOR: Saxon Drilling
LOGGED: CD DATE: 22/12/20
CHECKED: SB DATE: 14/1/21

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS
ADV	M	GNE	0	2.30				CI	Sandy CLAY medium plasticity, brown, fine to medium grained sand		F - St	Monument Grout Bentonite
			1	1.30 1.00	DS 1.50-1.60 m			CI	CLAY medium plasticity, pale orange brown, with fine grained sand	w > PL	VSt VSt - H	Sand
			6	-3.80					END OF BOREHOLE @ 6.10 m TARGET DEPTH GROUNDWATER NOT ENCOUNTERED			Bentonite

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GAP gINT FN. F01d RL3

GOLDER

REPORT OF BOREHOLE: BH3

SHEET: 1 OF 1

CLIENT: Graben Pty Ltd
PROJECT: Wave Park
LOCATION: Mowbray
JOB NO: 20446551

COORDS: 338754.0 m 8169482.0 m MGA2020 55
SURFACE RL: 2.30 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 5.50 m

DRILL RIG: Scout 1750
CONTRACTOR: Saxon Drilling
LOGGED: CD DATE: 22/12/20
CHECKED: SB DATE: 14/1/21

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS
ADV	L	▽	0	2.30	DS 0.30-0.40 m			SP	SAND fine to medium grained, brown, trace medium plasticity clay	M	MD	Monument
				0.50								
				1.80					pale orange		D	Grout
			1									Bentonite
				1.50								
				0.80					pale brown, trace shells		VD	
			2	2.00								
				0.30	DS 2.00-2.10 m				grey		D	
			3							W		Sand
			4								D - VD	
				4.50								
	M			-2.20				CI	CLAY medium plasticity, pale brown mottled orange, with fine grained sand	w > PL	VSt	
			5		DS 4.90-5.00 m							
				-3.20					END OF BOREHOLE @ 5.50 m TARGET DEPTH GROUNDWATER ENCOUNTERED @ 2.00 m DEPTH			
			6									
			7									

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GOLDER

REPORT OF BOREHOLE: BH4

SHEET: 1 OF 1

CLIENT: Graben Pty Ltd
PROJECT: Wave Park
LOCATION: Mowbray
JOB NO: 20446551

COORDS: 338435.0 m 8169675.0 m MGA2020 55
SURFACE RL: 2.20 m DATUM: AHD
INCLINATION: -90°
HOLE DEPTH: 5.50 m

DRILL RIG: Scout 1750
CONTRACTOR: Saxon Drilling
LOGGED: CD DATE: 22/12/20
CHECKED: SB DATE: 14/1/21

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	GROUP SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS
			-1									Monument
ADV	L	▽	0	2.20				SP	SAND fine to medium grained, pale brown	D	L	
				0.20								
				2.00	DS 0.20-0.30 m				pale orange		D	Grout Bentonite
			1									
				1.50							H	
				0.70	DS 1.50-1.60 m			GP	Sandy GRAVEL fine to medium grained, sub-rounded, pale grey, fine to coarse grained sand		D	
				2.00								
			2	0.20				SC	Clayey SAND fine to medium grained, grey, medium plasticity clay	M		
											MD - D	Sand
			3									
			4	4.20								
	M			-2.00				CI	CLAY medium plasticity, pale orange brown, with fine to medium grained sand	w > PL	VSt - H	
			5		DS 4.90-5.00 m							
				-3.30					END OF BOREHOLE @ 5.50 m TARGET DEPTH GROUNDWATER ENCOUNTERED @ 1.50 m DEPTH			
			6									
			7									

This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

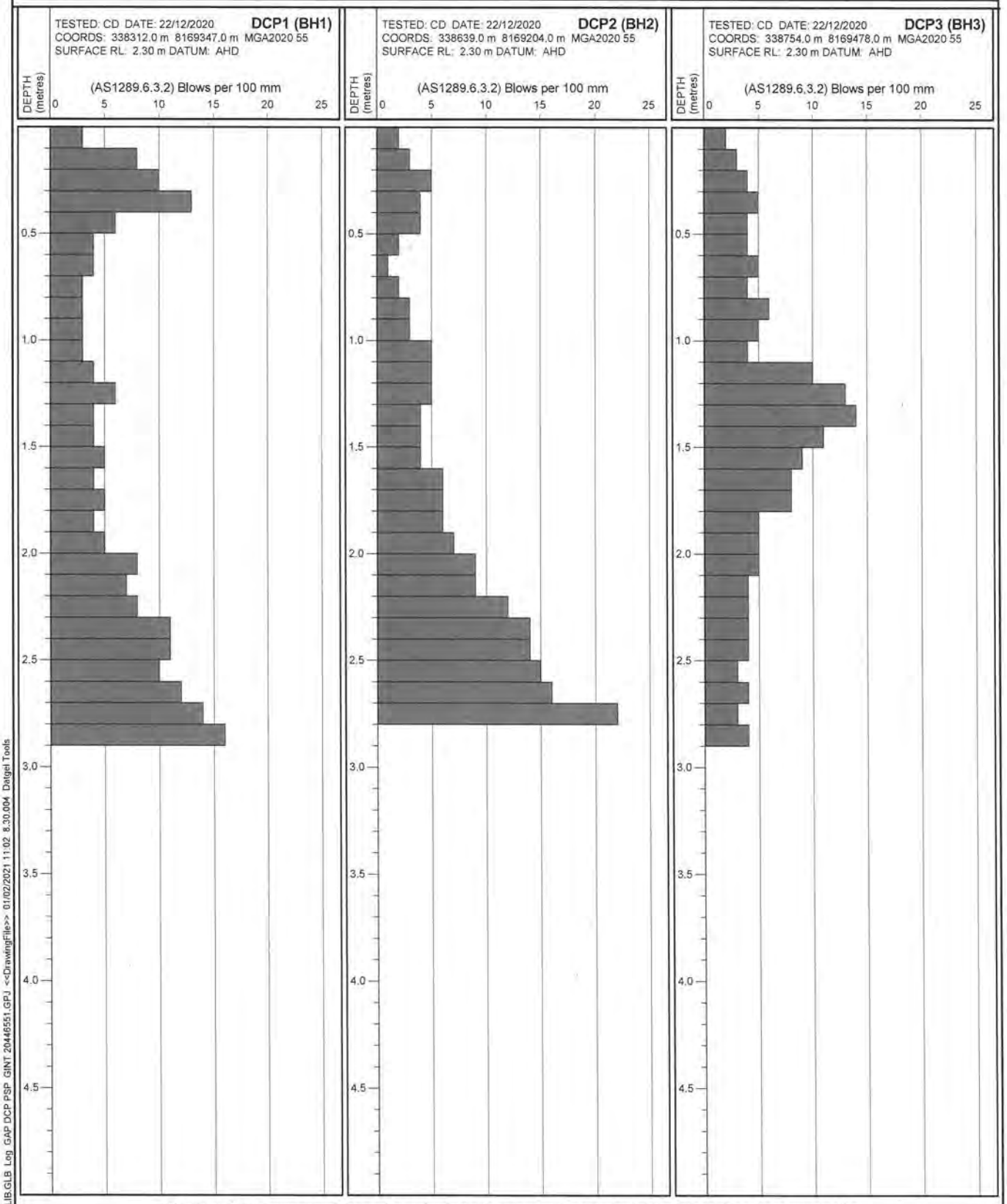
GAP gINT FN. F01d RL3

GOLDER

REPORT OF DCP TESTS

CLIENT: Graben Pty Ltd
PROJECT: Wave Park
LOCATION: Mowbray
JOB NO: 20446551

SHEET: 1 OF 2
CHECKED: SB DATE: 14/1/21



This report of penetrometer must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F04a
RL3

GOLDER

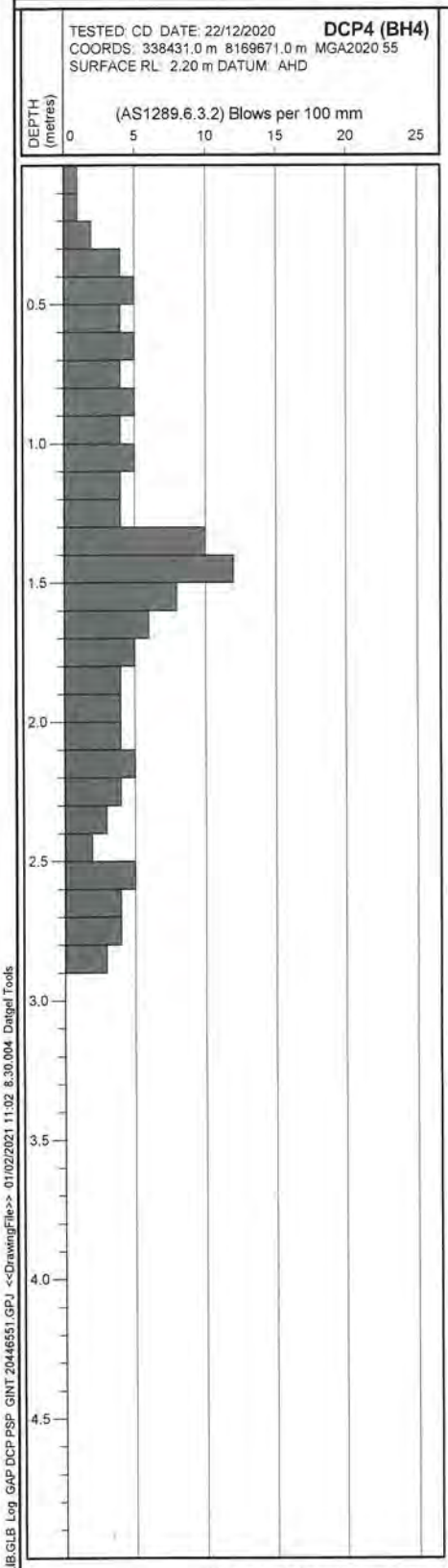
REPORT OF DCP TESTS

CLIENT: Graben Pty Ltd
PROJECT: Wave Park
LOCATION: Mowbray
JOB NO: 20446551

SHEET: 2 OF 2

CHECKED: SB DATE: 14/1/21

TESTED: CD DATE: 22/12/2020 **DCP4 (BH4)**
COORDS: 338431.0 m 8169671.0 m MGA2020 55
SURFACE RL: 2.20 m DATUM: AHD



This report of penetrometer must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

GAP gINT FN. F04a
RL3

Appendix B

Laboratory Testing Certificates - Geotechnical

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
Shed 3, 5 Commercial Place
Earlville QLD 4870

Laboratory: Cairns Laboratory
Phone: 07 4033 7815
Fax: 07 4054 6632
Email: Cairns@constructionsciences.net

MOISTURE CONTENT REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/32238-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/760
Project:	20446551 - Mowbray	Lot Number:	
Location:	Cairns	Internal Test Request:	11512/T/16458
Component:	20446551	Client Reference/s:	20446551 - Mowbray
Area Description:	Mowbray	Report Date / Page:	25/01/2021 Page 1 of 1

Test Procedures:	AS1289.2.1.1

Sample Number	11512/S/83624	11512/S/83625	11512/S/83626	11512/S/83627
ID / Client ID				
Lot Number	-	-	-	-
Date / Time Sampled	14/01/2021	14/01/2021	14/01/2021	14/01/2021
Sampling Method	Tested As Received	Tested As Received	Tested As Received	Tested As Received
Sampled By	Client Sampled	Client Sampled	Client Sampled	Client Sampled
Tested By	Jacqueline Pohlner	Jacqueline Pohlner	Jacqueline Pohlner	Jacqueline Pohlner
Date Tested	14/01/2021	14/01/2021	14/01/2021	14/01/2021
Material Source	Not Supplied	Not Supplied	Not Supplied	Not Supplied
Material Type	Not Supplied (Not Supplied)	Not Supplied (Not Supplied)	Not Supplied (Not Supplied)	Not Supplied (Not Supplied)
ID	TP1	TP2	TP3	TP4
Depth (M)	0.8-0.9	1.1-1.2	0.5-0.6	1.5-1.6
Moisture Content (%)	**13.7**	**19.1**	**13.0**	**22.2**

Sample Number	11512/S/83628	11512/S/83629		
ID / Client ID				
Lot Number	-	-		
Date / Time Sampled	14/01/2021	14/01/2021		
Sampling Method	Tested As Received	Tested As Received		
Sampled By	Client Sampled	Client Sampled		
Tested By	Jacqueline Pohlner	Jacqueline Pohlner		
Date Tested	14/01/2021	15/01/2021		
Material Source	Not Supplied	Not Supplied		
Material Type	Not Supplied (Not Supplied)	Not Supplied (Not Supplied)		
ID	TP6	TP8		
Depth (M)	1.5-1.6	1.8-1.9		
Moisture Content (%)	**5.8**	**31.1**		

Remarks	Results apply to the sample/s as received.

NATA

Accredited for compliance with ISO/IEC 17025 – Testing

Accreditation Number: 1986
Corporate Site Number: 11512

Approved Signatory: Craig Wilson
Form ID: W20Rep Rev 3

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
Shed 3, 5 Commercial Place
Earlville QLD 4870

Laboratory: Cairns Laboratory
Phone: 07 4033 7815
Fax: 07 4054 6632
Email: Cairns@constructionsciences.net

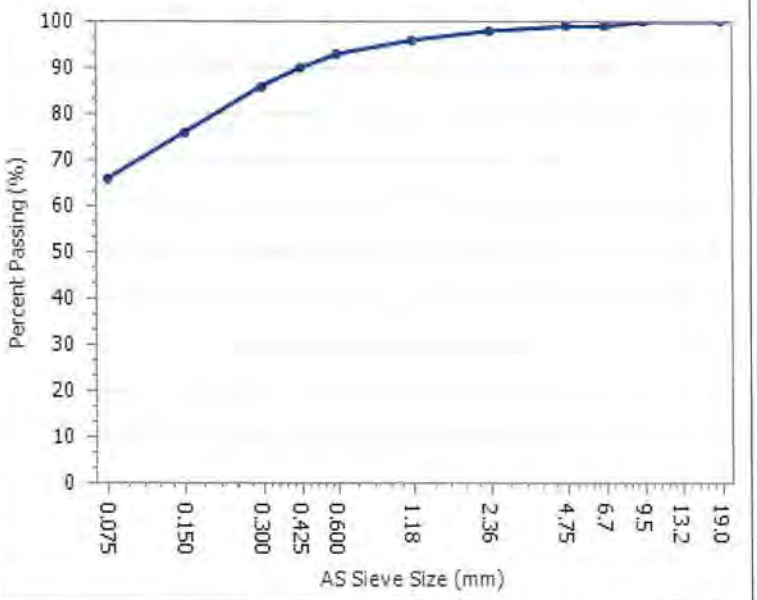
QUALITY OF MATERIALS REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/32239-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/760
Project:	20446551 - Mowbray	Lot Number:	
Location:	Cairns	Internal Test Request:	11512/T/16458
Component:	20446551	Client Reference/s:	20446551 - Mowbray
Area Description:	Mowbray	Report Date / Page:	25/01/2021 Page 1 of 6

Test Procedures	AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS1289.2.1.1, AS 1289.3.3.1		
Sample Number	11512/S/83624	ID	TP1
Sampling Method	Tested As Received	Depth (M)	0.8-0.9
Date Sampled	14/01/2021		
Sampled By	Client Sampled		
Date Tested	18/01/2021	Material Source	Not Supplied
Att. Drying Method	Oven Dried	Material Type	Not Supplied (Not Supplied)
Atterberg Preparation	Dry Sieved	Material Description	CI Sandy Clay, medium plasticity, trace of gravel, or

AS Sieve (mm)	Specification Minimum (%)	Percent Passing (%)	Specification Maximum (%)
19.0		100	
9.5		100	
6.7		99	
4.75		99	
2.36		98	
1.18		96	
0.600		93	
0.425		90	
0.300		86	
0.150		76	
0.075		66	

PARTICLE SIZE DISTRIBUTION GRAPH



Test Result	Specification Minimum (%)	Result	Specification Maximum (%)	Test Result	Specification Minimum (%)	Result (%)	Specification Maximum (%)
Liquid Limit (%)		36		0.075/0.425 Fines Ratio		0.73	
Plastic Limit (%)		20		PI x 0.425 Ratio (%)		1438.4	
Plastic Index (%)		16		LS x 0.425 Ratio (%)		629.3	
Linear Shrinkage (%)		7.0		Linear Shrinkage Defects	Cracking		

Remarks	Results apply to the sample/s as received.

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

Accreditation Number: 1986
Corporate Site Number: 11512

Approved Signatory: Craig Wilson
Form ID: W85Rep Rev 2

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
Shed 3, 5 Commercial Place
Earlville QLD 4870

Laboratory: Cairns Laboratory
Phone: 07 4033 7815
Fax: 07 4054 6632
Email: Cairns@constructionsciences.net

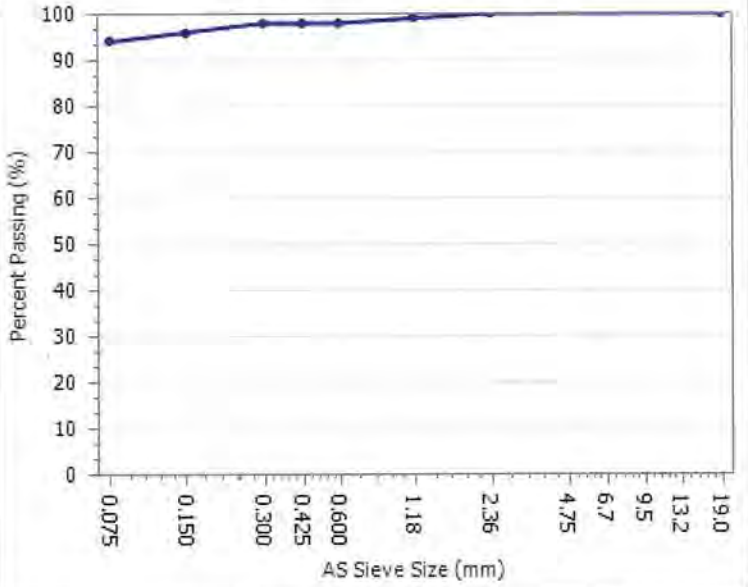
QUALITY OF MATERIALS REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/32239-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/760
Project:	20446551 - Mowbray	Lot Number:	
Location:	Cairns	Internal Test Request:	11512/T/16458
Component:	20446551	Client Reference/s:	20446551 - Mowbray
Area Description:	Mowbray	Report Date / Page:	25/01/2021 Page 2 of 6

Test Procedures	AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS1289.2.1.1, AS 1289.3.3.1		
Sample Number	11512/S/83625	ID	TP2
Sampling Method	Tested As Received	Depth (M)	1.1-1.2
Date Sampled	14/01/2021		
Sampled By	Client Sampled		
Date Tested	18/01/2021	Material Source	Not Supplied
Att. Drying Method	Oven Dried	Material Type	Not Supplied (Not Supplied)
Atterberg Preparation	Dry Sieved	Material Description	CI Clay, medium plasticity, trace of sand, red brown

AS Sieve (mm)	Specification Minimum (%)	Percent Passing (%)	Specification Maximum (%)
19.0		100	
2.36		100	
1.18		99	
0.600		98	
0.425		98	
0.300		98	
0.150		96	
0.075		94	

PARTICLE SIZE DISTRIBUTION GRAPH



Test Result	Specification Minimum (%)	Result	Specification Maximum (%)
Liquid Limit (%)		37	
Plastic Limit (%)		20	
Plastic Index (%)		17	
Linear Shrinkage (%)		8.0	

Test Result	Specification Minimum (%)	Result (%)	Specification Maximum (%)
0.075/0.425 Fines Ratio		0.96	
PI x 0.425 Ratio (%)		1667.7	
LS x 0.425 Ratio (%)		784.8	
Linear Shrinkage Defects	-		

Remarks: Results apply to the sample/s as received.

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

Accreditation Number: 1986
Corporate Site Number: 11512

Approved Signatory: Craig Wilson
Form ID: W85Rep Rev 2

Construction Sciences

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Email: Cairns@constructionsciences.net

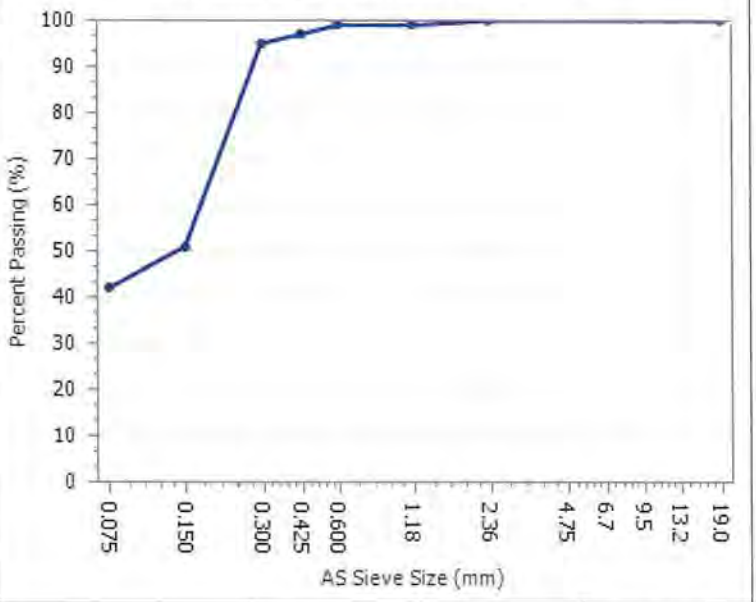
QUALITY OF MATERIALS REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/32239-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/760
Project:	20446551 - Mowbray	Lot Number:	
Location:	Cairns	Internal Test Request:	11512/T/16458
Component:	20446551	Client Reference/s:	20446551 - Mowbray
Area Description:	Mowbray	Report Date / Page:	25/01/2021 Page 3 of 6

Test Procedures	AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS1289.2.1.1, AS 1289.3.3.1		
Sample Number	11512/S/83626	ID	TP3
Sampling Method	Tested As Received	Depth (M)	0.5-0.6
Date Sampled	14/01/2021		
Sampled By	Client Sampled		
Date Tested	18/01/2021	Material Source	Not Supplied
Att. Drying Method	Oven Dried	Material Type	Not Supplied (Not Supplied)
Atterberg Preparation	Dry Sieved	Material Description	CL Sandy Clay, low plasticity, yellow brown.

AS Sieve (mm)	Specification Minimum (%)	Percent Passing (%)	Specification Maximum (%)
19.0		100	
2.36		100	
1.18		99	
0.600		99	
0.425		97	
0.300		95	
0.150		51	
0.075		42	

PARTICLE SIZE DISTRIBUTION GRAPH



Test Result	Specification Minimum (%)	Result	Specification Maximum (%)	Test Result	Specification Minimum (%)	Result (%)	Specification Maximum (%)
Liquid Limit (%)		23		0.075/0.425 Fines Ratio		0.43	
Plastic Limit (%)		16		PI x 0.425 Ratio (%)		681.8	
Plastic Index (%)		7		LS x 0.425 Ratio (%)		340.9	
Linear Shrinkage (%)		3.5		Linear Shrinkage Defects	-		

Remarks	Results apply to the sample/s as received.

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

Accreditation Number: 1986
Corporate Site Number: 11512

Approved Signatory: Craig Wilson
Form ID: W85Rep Rev 2

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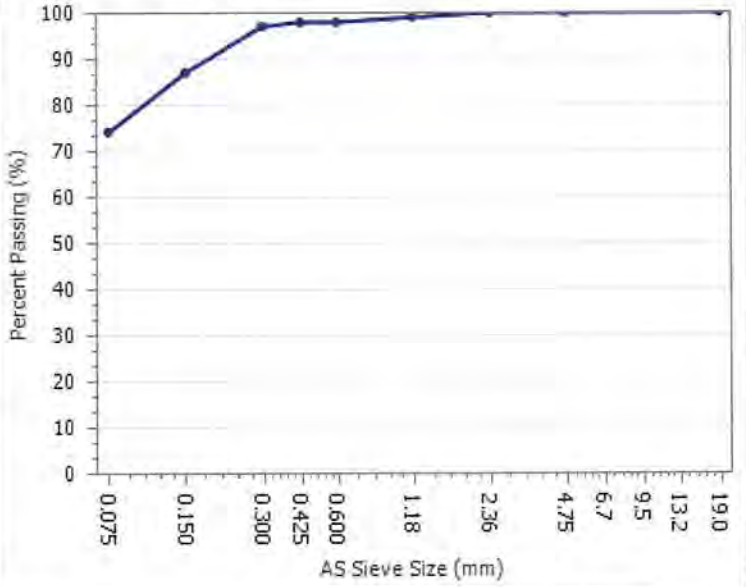
QUALITY OF MATERIALS REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/32239-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/760
Project:	20446551 - Mowbray	Lot Number:	
Location:	Cairns	Internal Test Request:	11512/T/16458
Component:	20446551	Client Reference/s:	20446551 - Mowbray
Area Description:	Mowbray	Report Date / Page:	25/01/2021 Page 4 of 6

Test Procedures	AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS1289.2.1.1, AS 1289.3.3.1		
Sample Number	11512/S/83627	ID	TP4
Sampling Method	Tested As Received	Depth (M)	1.5-1.6
Date Sampled	14/01/2021		
Sampled By	Client Sampled		
Date Tested	19/01/2021	Material Source	Not Supplied
Att. Drying Method	Oven Dried	Material Type	Not Supplied (Not Supplied)
Atterberg Preparation	Dry Sieved	Material Description	CL Clay, low plasticity, with sand, trace of gravel, ye

AS Sieve (mm)	Specification Minimum (%)	Percent Passing (%)	Specification Maximum (%)
19.0		100	
4.75		100	
2.36		100	
1.18		99	
0.600		98	
0.425		98	
0.300		97	
0.150		87	
0.075		74	

PARTICLE SIZE DISTRIBUTION GRAPH



Test Result	Specification Minimum (%)	Result	Specification Maximum (%)
Liquid Limit (%)		28	
Plastic Limit (%)		16	
Plastic Index (%)		12	
Linear Shrinkage (%)		6.0	

Test Result	Specification Minimum (%)	Result (%)	Specification Maximum (%)
0.075/0.425 Fines Ratio		0.76	
PI x 0.425 Ratio (%)		1172.4	
LS x 0.425 Ratio (%)		586.2	
Linear Shrinkage Defects	-		

Remarks: Results apply to the sample/s as received.

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

Accreditation Number: 1986
Corporate Site Number: 11512

Approved Signatory: Craig Wilson
Form ID: W85Rep Rev 2

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
Shed 3, 5 Commercial Place
Earlville QLD 4870

Laboratory: Cairns Laboratory
Phone: 07 4033 7815
Fax: 07 4054 6632
Email: Cairns@constructionsciences.net

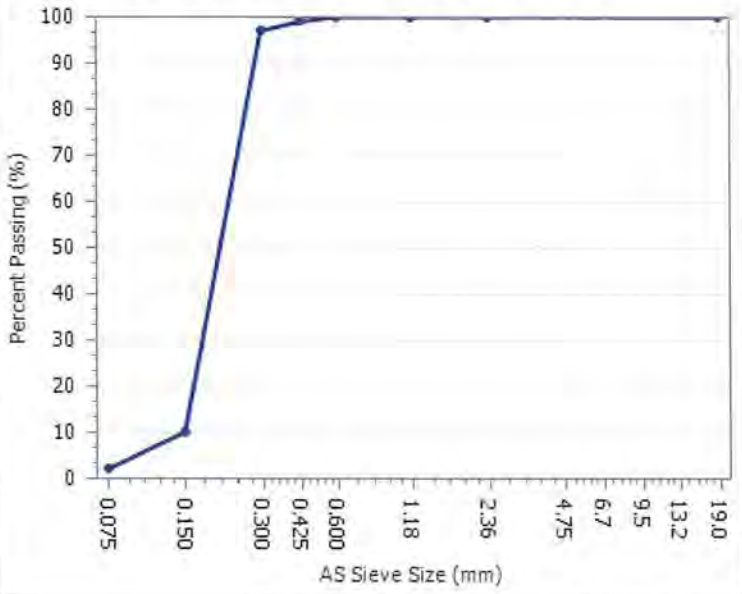
QUALITY OF MATERIALS REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/32239-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/760
Project:	20446551 - Mowbray	Lot Number:	
Location:	Cairns	Internal Test Request:	11512/T/16458
Component:	20446551	Client Reference/s:	20446551 - Mowbray
Area Description:	Mowbray	Report Date / Page:	25/01/2021 Page 5 of 6

Test Procedures	AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS 1289.3.3.1		
Sample Number	11512/S/83628	ID	TP6
Sampling Method	Tested As Received	Depth (M)	1.5-1.6
Date Sampled	14/01/2021		
Sampled By	Client Sampled		
Date Tested	19/01/2021	Material Source	Not Supplied
Att. Drying Method	Oven Dried	Material Type	Not Supplied (Not Supplied)
Atterberg Preparation	Dry Sieved	Material Description	SP SAND, with trace silt, yellow brown.

AS Sieve (mm)	Specification Minimum (%)	Percent Passing (%)	Specification Maximum (%)
19.0		100	
2.36		100	
1.18		100	
0.600		100	
0.425		99	
0.300		97	
0.150		10	
0.075		2	

PARTICLE SIZE DISTRIBUTION GRAPH



Test Result	Specification Minimum (%)	Result	Specification Maximum (%)	Test Result	Specification Minimum (%)	Result (%)	Specification Maximum (%)
Liquid Limit (%)		Not Obtainable		0.075/0.425 Fines Ratio		0.02	
Plastic Limit (%)		Not Obtainable		PI x 0.425 Ratio (%)		-	
Plastic Index (%)		Non Plastic		LS x 0.425 Ratio (%)		0.0	
Linear Shrinkage (%)		0.0		Linear Shrinkage Defects	-		

Remarks	Results apply to the sample/s as received.

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

Accreditation Number: 1986
Corporate Site Number: 11512

Approved Signatory: Craig Wilson
Form ID: W85Rep Rev 2

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
Shed 3, 5 Commercial Place
Earlville QLD 4870

Laboratory: Cairns Laboratory
Phone: 07 4033 7815
Fax: 07 4054 6632
Email: Cairns@constructionsciences.net

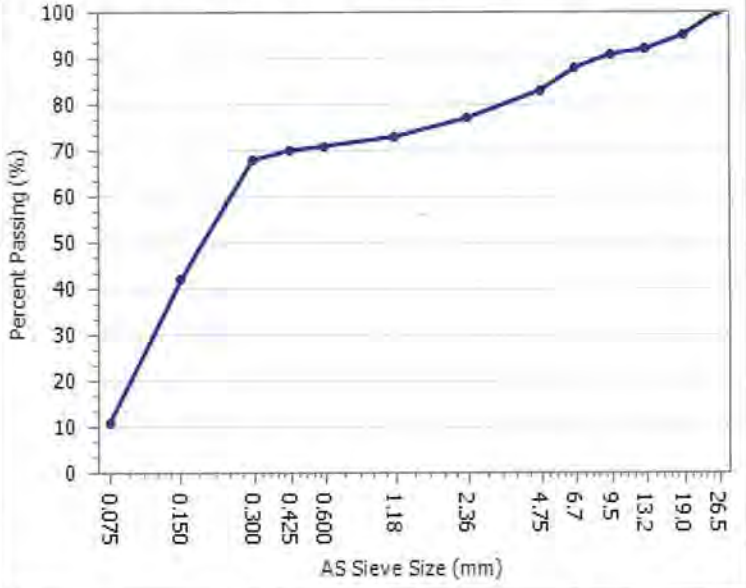
QUALITY OF MATERIALS REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/32239-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/760
Project:	20446551 - Mowbray	Lot Number:	
Location:	Cairns	Internal Test Request:	11512/T/16458
Component:	20446551	Client Reference/s:	20446551 - Mowbray
Area Description:	Mowbray	Report Date / Page:	25/01/2021 Page 6 of 6

Test Procedures	AS1289.3.6.1, AS1289.3.1.2, AS1289.3.2.1, AS1289.3.4.1, AS 1289.3.3.1		
Sample Number	11512/S/83629	ID	TP8
Sampling Method	Tested As Received	Depth (M)	1.8-1.9
Date Sampled	14/01/2021		
Sampled By	Client Sampled		
Date Tested	20/01/2021	Material Source	Not Supplied
Att. Drying Method	Oven Dried	Material Type	Not Supplied (Not Supplied)
Atterberg Preparation	Dry Sieved	Material Description	SW SAND, with some gravel and silt, black.

AS Sieve (mm)	Specification Minimum (%)	Percent Passing (%)	Specification Maximum (%)
26.5		100	
19.0		95	
13.2		92	
9.5		91	
6.7		88	
4.75		83	
2.36		77	
1.18		73	
0.600		71	
0.425		70	
0.300		68	
0.150		42	
0.075		11	

PARTICLE SIZE DISTRIBUTION GRAPH



Test Result	Specification Minimum (%)	Result	Specification Maximum (%)
Liquid Limit (%)		Not Obtainable	
Plastic Limit (%)		Not Obtainable	
Plastic Index (%)		Non Plastic	
Linear Shrinkage (%)		0.0	

Test Result	Specification Minimum (%)	Result (%)	Specification Maximum (%)
0.075/0.425 Fines Ratio		0.16	
PI x 0.425 Ratio (%)		-	
LS x 0.425 Ratio (%)		0.0	
Linear Shrinkage Defects	-		

Remarks: Results apply to the sample/s as received.

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

Accreditation Number: 1986
Corporate Site Number: 11512

Approved Signatory: Craig Wilson
Form ID: W85Rep Rev 2

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
Shed 3, 5 Commercial Place
Earlville QLD 4870

Laboratory: Cairns Laboratory
Phone: 07 4033 7815
Fax: 07 4054 6632
Email: Cairns@constructionsciences.net

EMERSON CLASS NUMBER REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/32240-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/760
Project:	20446551 - Mowbray	Lot Number:	
Location:	Cairns	Internal Test Request:	11512/T/16458
Component:	20446551	Client Reference/s:	20446551 - Mowbray
Area Description:	Mowbray	Report Date / Page:	25/01/2021 Page 1 of 2

Test Procedures:	AS1289.3.8.1

Sample Number	11512/S/83624	11512/S/83625	11512/S/83626	11512/S/83627
ID / Client ID				
Lot Number	-	-	-	-
Date / Time Sampled	14/01/2021	14/01/2021	14/01/2021	14/01/2021
Date Tested	15/01/2021	15/01/2021	15/01/2021	15/01/2021
Material Source	Not Supplied	Not Supplied	Not Supplied	Not Supplied
Material Type	Not Supplied (Not Supplied)	Not Supplied (Not Supplied)	Not Supplied (Not Supplied)	Not Supplied (Not Supplied)
Sampling Method	Tested As Received	Tested As Received	Tested As Received	Tested As Received
Water Type	Distilled	Distilled	Distilled	Distilled
Water Temperature (C°)	25	25	25	25
ID	TP1	TP2	TP3	TP4
Depth (M)	0.8-0.9	1.1-1.2	0.5-0.6	1.5-1.6
Soil Description	Cl Sandy Clay, medium plasticity,	Cl Clay, medium plasticity, trace of	CL Sandy Clay, low plasticity, yell	CL Clay, low plasticity, with sand,
Emerson Class Number	**6**	**6**	**6**	**2**

Remarks	Results apply to the sample/s as received.

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

Accreditation Number: 1986
Corporate Site Number: 11512

Approved Signatory: Craig Wilson
Form ID: W34Rep Rev 2

Construction Sciences

Construction Sciences Pty Ltd
ABN: 74 128 806 735

Address:
Shed 3, 5 Commercial Place
Earlville QLD 4870

Laboratory: Cairns Laboratory
Phone: 07 4033 7815
Fax: 07 4054 6632
Email: Cairns@constructionsciences.net

EMERSON CLASS NUMBER REPORT

Client:	Golder Associates Pty Ltd	Report Number:	11512/R/32240-1
Client Address:	216, Draper Street, Cairns	Project Number:	11512/P/760
Project:	20446551 - Mowbray	Lot Number:	
Location:	Cairns	Internal Test Request:	11512/T/16458
Component:	20446551	Client Reference/s:	20446551 - Mowbray
Area Description:	Mowbray	Report Date / Page:	25/01/2021 Page 2 of 2

Test Procedures:	AS1289.3.8.1			
Sample Number	11512/S/83628	11512/S/83629		
ID / Client ID				
Lot Number	-	-		
Date / Time Sampled	14/01/2021	14/01/2021		
Date Tested	15/01/2021	20/01/2021		
Material Source	Not Supplied	Not Supplied		
Material Type	Not Supplied (Not Supplied)	Not Supplied (Not Supplied)		
Sampling Method	Tested As Received	Tested As Received		
Water Type	Distilled	Distilled		
Water Temperature (C°)	24	26		
ID	TP6	TP8		
Depth (M)	1.5-1.6	1.8-1.9		
Soil Description	SP SAND, with trace silt, yellow br	SW SAND, with some gravel and		
Emerson Class Number	**6**	**4**		

Remarks: Results apply to the sample/s as received.

Accredited for compliance with ISO/IEC 17025 – Testing

NATA

Accreditation Number: 1986
Corporate Site Number: 11512

Approved Signatory: Craig Wilson
Form ID: W34Rep Rev 2

Appendix C

Acid Sulfate Soil Summary Results and Laboratory Certificates, Groundwater Quality Laboratory Test Certificates

GOLDER

Acid Sulfate Soil Screening Test Results

Client: GARBEN PTY LTD
Project: GEOTECHNICAL SITE ASSESMENT - PORT DOUGLAS WAVE PARK
Location: PROPOSED WAVE PARK
Job No: 20446551

Borehole ID	Sample Depth Range (m bgl)	Sample Depth Range (RL m AHD)	Sampled Date	Soil Type	pH (F) pH Units	AASS Likelihood	pH (Field ox) pH Units	Reaction Rate	PASS Likelihood
TP2	0 - 0.1	2.40 - 2.30	21/12/2020	Clayey SAND	4.3	Nil	4.4	L	Low
	0.4 - 0.5	2.00 - 1.90	21/12/2020	SAND	5.8	Nil	5.4	L	Low
	1 - 1.1	1.40 - 1.30	21/12/2020	Sandy CLAY	6.2	Nil	5.0	L	Low
	1.1 - 1.2	1.30 - 1.20	21/12/2020	CLAY	5.7	Nil	4.2	L	Low
	1.5 - 1.6	0.90 - 0.80	21/12/2020	CLAY	5.3	Nil	4.0	L	Low
	2 - 2.1	0.40 - 0.30	21/12/2020	CLAY	5.6	Nil	4.8	M	Low
	2.5 - 2.6	-0.10 - -0.20	21/12/2020	CLAY	6.3	Nil	5.7	L	Low
	3 - 3.1	-0.60 - -0.70	21/12/2020	CLAY	6.9	Nil	5.8	M	Low
TP3	0 - 0.1	2.20 - 2.10	21/12/2020	Silty Sandy CLAY	5.7	Nil	4.1	L	Low
	0.5 - 0.6	1.70 - 1.60	21/12/2020	Clayey SAND	4.5	Nil	3.3	L	Inconclusive
	1 - 1.1	1.20 - 1.10	21/12/2020	Clayey SAND	4.6	Nil	4.6	L	Low
	1.5 - 1.6	0.70 - 0.60	21/12/2020	CLAY	4.2	Nil	4.3	L	Low
	2 - 2.1	0.20 - 0.10	21/12/2020	CLAY	5.8	Nil	5.0	M	Low
	2.5 - 2.6	-0.30 - -0.40	21/12/2020	CLAY	6.5	Nil	5.5	L	Low
	3 - 3.1	-0.80 - -0.90	21/12/2020	CLAY	6.8	Nil	5.9	L	Low
TP5	0.1 - 0.2	2.10 - 2.00	21/12/2020	SAND	6.2	Nil	4.5	M	Low
	0.5 - 0.6	1.70 - 1.60	21/12/2020	Clayey SAND	5.5	Nil	4.2	L	Low
	1 - 1.1	1.20 - 1.10	21/12/2020	Clayey SAND	5.9	Nil	4.8	M	Low
	1.5 - 1.6	0.70 - 0.60	21/12/2020	Sandy CLAY	5.6	Nil	5.2	M	Low
	2.2 - 2.3	0.00 - -0.10	21/12/2020	CLAY	7.6	Nil	2.8	M	Strong Indication
	2.5 - 2.6	-0.30 - -0.40	21/12/2020	CLAY	6.2	Nil	5.8	L	Low
	3 - 3.1	-0.80 - -0.90	21/12/2020	CLAY	7.2	Nil	6.8	L	Low
TP8	0.1 - 0.2	1.70 - 1.60	21/12/2020	SAND	8.3	Nil	3.9	L	Inconclusive
	0.5 - 0.6	1.30 - 1.20	21/12/2020	SAND	7.2	Nil	6.4	L	Low
	1 - 1.1	0.80 - 0.70	21/12/2020	SAND	8.1	Nil	3.9	L	Low
	1.5 - 1.6	0.30 - 0.20	21/12/2020	SAND	6.2	Nil	4.7	L	Low
	1.8 - 1.9	0.00 - -0.10	21/12/2020	SAND	7.1	Nil	5.9	L	Low
	2.5 - 2.6	-0.70 - -0.80	21/12/2020	SAND	7.5	Nil	6.2	L	Low
	3 - 3.1	-1.20 - -1.30	21/12/2020	SAND	8.2	Nil	6.1	L	Low

Notes:

1) AASS potential is indicated by: $pH_F \leq 4.0$

2) PASS potenital is indicated by:

- Strong indication: $pH_{FOX} < 3$, large ΔpH and a strong reaction with hydrogen peroxide.
- Inconclusive: pH_{FOX} 3 – 4 and low, medium or strong reaction with hydrogen peroxide
- Low indication: $pH_{FOX} > 4$ and low, medium or strong reaction with hydrogen peroxide.

3) pH Fox Reaction Rate: L - Low; M - Medium; H - High; X - Extreme; V - Volcanic

GOLDER

Acid Sulfate Soil Summary of Chromium Suite Analysis

Client: Graben Pty Ltd
Project: Geotechnical Site Assesment
Location: Lot 123 on SR687, 5640 Captain Cook Highway, Mowbray
Job No: 20446551

Test Location	Depth Range (m bgl)		Sample Depth Range (RL m AHD)		Material Description	pH_{FIELD}	pH_{KCl}	sTAA (% pyrite S)	S_{NAS} (if pH less than 4.5)	Existing Acidity % S (sTAA + 0.75 x S_{NAS})	Chromium Reducible Sulfur (S_{CR}) % S	Acid Neutralising Capacity % CaCO3 (if pH more than 6.5)	Net Acidity (%S) (SCR+Existing Acidity) excluding ANC	Is This AASS	Is This PASS	Liming Rate (kg $CaCO_3$/m3)
TP2	0.4	0.5	2	1.9	SAND	5.8	6.3	<0.01		0.000	< 0.005		0.000	No	No	NA
TP3	0.1	0.2	2.1	2	Sandy CLAY	5.7	5.8	<0.01		0.000	< 0.005		0.000	No	No	NA
TP3	1	1.1	1.2	1.1	Clayey SAND	4.6	5.1	0.02		0.020	< 0.005		0.020	No	No	NA
TP5	1	1.1	1.2	1.1	Clayey SAND	5.9	6.2	<0.01		0.000	0.005		0.005	No	No	NA
TP5	2.2	2.3	0	-0.1	CLAY	7.6	6.4	<0.01		0.000	0.51		0.510	No	YES	38.6
TP6	2.1	2.2	0.5	0.4	SAND		9.7	<0.01		0.000	< 0.005	11	0.000	No	No	NA
TP8	1.8	1.9	0	-0.1	SAND	7.1	9.5	<0.01		0.000	0.21	11	0.210	No	YES	15.9
TP8	2.5	2.6	-0.7	-0.8	SAND	7.5	9.6	<0.01		0.000	0.19	4.7	0.190	No	YES	14.4
													ASS action criteria ≥0.03 %S			

Note:
1. Liming rates assume a bulk density of 1.60 t/m3
2. Fineness Factor = 1.5

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Calum Dunsworth	Manager	Anthony Nilsson
Client	GOLDER ASSOCIATES PTY LTD	Laboratory	SGS Cairns Environmental
Address	PO BOX 5823 216 DRAPER ST CAIRNS QLD 4870	Address	Unit 2, 58 Comport St Portsmith QLD 4870
Telephone	07 4054 8200	Telephone	+61 07 4035 5111
Facsimile	07 4054 8201	Facsimile	+61 07 4035 5122
Email	CDunsworth@golder.com.au	Email	AU.Environmental.Cairns@sgs.com
Project	**20446551**	SGS Reference	**CE150309 R0**
Order Number	(Not specified)	Date Received	13 Jan 2021
Samples	8	Date Reported	18 Jan 2021

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(3146/19038)

SIGNATORIES

Anthony NILSSON
Operations Manager

Jon DICKER
Manager Northern QLD

Parameter	Units	LOR	Sample Number: CE150309.001 Sample Matrix: Soil Sample Depth: 0.4-0.5 Sample Name: TP2	CE150309.002 Soil 0.1-0.2 TP3	CE150309.003 Soil 1.0-1.1 TP3	CE150309.004 Soil 1.0-1.0 TP5
Moisture Content Method: AN002 Tested: 14/1/2021						
% Moisture	%w/w	0.5	**4.1**	**16**	**12**	**13**
TAA (Titratable Actual Acidity) Method: AN219 Tested: 15/1/2021						
pH KCl	pH Units	-	**6.3**	**5.8**	**5.1**	**6.2**
Titratable Actual Acidity	kg H2SO4/T	0.25	<0.25	<0.25	**0.61**	<0.25
Titratable Actual Acidity (TAA) moles H+/tonne	moles H+/T	5	<5	<5	**12**	<5
Titratable Actual Acidity (TAA) S%w/w	%w/w S	0.01	<0.01	<0.01	**0.02**	<0.01
Sulphur (SKCl)	%w/w	0.005	-	-	-	-
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 18/1/2021						
Chromium Reducible Sulphur (Scr)	%	0.005	<0.005	<0.005	<0.005	<0.005
Chromium Reducible Sulphur (Scr)	moles H+/T	5	<5	<5	<5	<5
Acid Neutralising Capacity (ANC) Method: AN214 Tested: 15/1/2021						
Acid Neutralisation Capacity (ANCBT) as % $CaCO_3$	% CaCO3	0.1	-	-	-	-
Acid Neutralisation Capacity (ANCBT) as kg H_2SO_4/t	kg H2SO4/T	0.1	-	-	-	-
ANC as % $CaCO_3$	% CaCO3	0.1	-	-	-	-
Lime Equivalence	% CaCO3	0.1	-	-	-	-

Parameter	Units	LOR	Sample Number: CE150309.005 Sample Matrix: Soil Sample Depth: 2.2-2.3 Sample Name: TP5	CE150309.006 Soil 2.1-2.2 TP6	CE150309.007 Soil 1.8-1.9 TP8	CE150309.008 Soil 2.5-2.6 TP8
Moisture Content Method: AN002 Tested: 14/1/2021						
% Moisture	%w/w	0.5	16	21	26	24
TAA (Titratable Actual Acidity) Method: AN219 Tested: 15/1/2021						
pH KCl	pH Units	-	6.4	9.7	9.5	9.6
Titratable Actual Acidity	kg H2SO4/T	0.25	<0.25	<0.25	<0.25	<0.25
Titratable Actual Acidity (TAA) moles H+/tonne	moles H+/T	5	<5	<5	<5	<5
Titratable Actual Acidity (TAA) S%w/w	%w/w S	0.01	<0.01	<0.01	<0.01	<0.01
Sulphur (SKCl)	%w/w	0.005	-	-	-	-
Chromium Reducible Sulphur (CRS) Method: AN217 Tested: 18/1/2021						
Chromium Reducible Sulphur (Scr)	%	0.005	0.51	<0.005	0.21	0.19
Chromium Reducible Sulphur (Scr)	moles H+/T	5	319	<5	132	117
Acid Neutralising Capacity (ANC) Method: AN214 Tested: 15/1/2021						
Acid Neutralisation Capacity (ANCBT) as % $CaCO_3$	% CaCO3	0.1	-	11	11	4.7
Acid Neutralisation Capacity (ANCBT) as kg H_2SO_4/t	kg H2SO4/T	0.1	-	110	110	46
ANC as % $CaCO_3$	% CaCO3	0.1	-	11	11	4.7
Lime Equivalence	% CaCO3	0.1	-	11	11	4.7

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Acid Neutralising Capacity (ANC) Method: ME-(AU)-[ENV]AN214

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Acid Neutralisation Capacity (ANCBT) as % $CaCO_3$	LB085803	% CaCO3	0.1	<0.1	96%
Acid Neutralisation Capacity (ANCBT) as kg H_2SO_4/t	LB085803	kg H2SO4/T	0.1	<0.1	NA
ANC as % $CaCO_3$	LB085803	% CaCO3	0.1	<0.1	NA
Lime Equivalence	LB085803	% CaCO3	0.1	<0.1	

Chromium Reducible Sulphur (CRS) Method: ME-(AU)-[ENV]AN217

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chromium Reducible Sulphur (Scr)	LB085872	%	0.005	<0.005	0%	87%
Chromium Reducible Sulphur (Scr)	LB085872	moles H+/T	5	<5		

TAA (Titratable Actual Acidity) Method: ME-(AU)-[ENV]AN219

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH KCl	LB085801	pH Units	-	5.7	0 - 2%	98%
Titratable Actual Acidity	LB085801	kg H2SO4/T	0.25	<0.25	0%	NA
Titratable Actual Acidity (TAA) moles H+/tonne	LB085801	moles H+/T	5	<5	0%	92%
Titratable Actual Acidity (TAA) S%w/w	LB085801	%w/w S	0.01	<0.01	0%	92%

METHOD	METHODOLOGY SUMMARY
AN002	The test is carried out by drying (at either 40°C or 105°C) a known mass of sample in a weighed evaporating basin. After fully dry the sample is re-weighed. Samples such as sludge and sediment having high percentages of moisture will take some time in a drying oven for complete removal of water.
AN214	Acid Neutralising Capacity (ANC)or Neutralising Value (NV): The crushed or as received sample is reacted with excess normal acid (HCl) and then back titrated with standard sodium hydroxide to determine the acid consumed. The result is expressed as kg H2SO4/tonne or %CaCO3. Based on AS4969-13.
AN217	Dried pulped sample is mixed with acid and chromium metal in a rapid distillation unit to produce hydrogen sulfide (H2S) which is collected and titrated with iodine (I2(aq)) to measure SCR.
AN219	Dried pulped sample is extracted for 4 hours in a 1 M KCl solution. The ratio of sample to solution is 1:40. The extract is titrated for acidity. Calcium, magnesium, and sulfur are determined by ICP-AES.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
***	Indicates that both * and ** apply.	NVL	Not Validated

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the " Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au/en-gb/environment-health-and-safety .

SAMPLE RECEIPT ADVICE

CE150309

CLIENT DETAILS

Contact	Calum Dunsworth
Client	GOLDER ASSOCIATES PTY LTD
Address	PO BOX 5823 216 DRAPER ST CAIRNS QLD 4870
Telephone	07 4054 8200
Facsimile	07 4054 8201
Email	CDunsworth@golder.com.au
Project	**20446551**
Order Number	(Not specified)
Samples	8

LABORATORY DETAILS

Manager	Anthony Nilsson
Laboratory	SGS Cairns Environmental
Address	Unit 2, 58 Comport St Portsmith QLD 4870
Telephone	+61 07 4035 5111
Facsimile	+61 07 4035 5122
Email	AU.Environmental.Cairns@sgs.com
Samples Received	Wed 13/1/2021
Report Due	Thu 21/1/2021
SGS Reference	**CE150309**

SUBMISSION DETAILS

This is to confirm that 8 samples were received on Wednesday 13/1/2021. Results are expected to be ready by COB Thursday 21/1/2021.
Please quote SGS reference CE150309 when making enquiries. Refer below for details relating to sample integrity upon receipt.

Samples clearly labelled	Yes	Complete documentation received	Yes
Sample container provider	SGS	Sample cooling method	Ice Bricks
Samples received in correct containers	Yes	Sample counts by matrix	8 Soils
Date documentation received	13/1/2021	Type of documentation received	COC
Number of eskies/boxes received	1	Samples received in good order	Yes
Samples received without headspace	Yes	Sample temperature upon receipt	Chilled
Sufficient sample for analysis	Yes	Turnaround time requested	Standard

Unless otherwise instructed, water and bulk samples will be held for one month from date of report, and soil samples will be held for two months.

COMMENTS

SAMPLE RECEIPT ADVICE

CE150309

CLIENT DETAILS

Client GOLDER ASSOCIATES PTY LTD Project 20446551

SUMMARY OF ANALYSIS

No.	Sample ID	Acid Neutralising Capacity (ANC)	Chromium Reducible Sulphur (CRS)	HCl Extractable S, Ca and Mg in Soil ICP OES	Moisture Content	TAA (Titratable Actual Acidity)
001	TP2 0.4-0.5	4	2	1	1	5
002	TP3 0.1-0.2	4	2	1	1	5
003	TP3 1.0-1.1	4	2	1	1	5
004	TP5 1.0-1.0	4	2	1	1	5
005	TP5 2.2-2.3	4	2	1	1	5
006	TP6 2.1-2.2	4	2	1	1	5
007	TP8 1.8-1.9	4	2	1	1	5
008	TP8 2.5-2.6	4	2	1	1	5

The above table represents SGS' interpretation of the client-supplied Chain Of Custody document.
The numbers shown in the table indicate the number of results requested in each package.
Please indicate as soon as possible should your request differ from these details .
Testing as per this table shall commence immediately unless the client intervenes with a correction .

ANALYTICAL REPORT

Accreditation No. 2562

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Dustin Peacocke	Manager	Anthony Nilsson
Client	GOLDER ASSOCIATES PTY LTD	Laboratory	SGS Cairns Environmental
Address	PO BOX 5823 216 DRAPER ST CAIRNS QLD 4870	Address	Unit 2, 58 Comport St Portsmith QLD 4870
Telephone	07 4054 8200	Telephone	+61 07 4035 5111
Facsimile	07 4054 8201	Facsimile	+61 07 4035 5122
Email	DPeacocke@golder.com.au	Email	AU.Environmental.Cairns@sgs.com
Project	**20446551**	SGS Reference	**CE150386 R0**
Order Number	(Not specified)	Date Received	15 Jan 2021
Samples	2	Date Reported	28 Jan 2021

COMMENTS

Accredited for compliance with ISO/IEC 17025 - Testing. NATA accredited laboratory 2562(3146/19038)

Metals - The Limit of Reporting (LOR) has been raised due to interferences from the sample matrix.

SIGNATORIES

Alyson BERGAMO
Senior Laboratory Technician

Anthony NILSSON
Operations Manager

Jon Dicker
Manager Northern QLD

Maristela GANZAN
Quality Coordinator

Parameter	Units	LOR	Sample Number: CE150386.001 Sample Matrix: Water Sample Date: 15 Jan 2021 Sample Name: BH3	Sample Number: CE150386.002 Sample Matrix: Water Sample Date: 15 Jan 2021 Sample Name: BH4
pH in water Method: AN101 Tested: 15/1/2021				
pH**	pH Units	0.1	7.8	7.8
Alkalinity Method: AN135 Tested: 15/1/2021				
Total Alkalinity as CaCO3	mg/L	5	160	220
Bicarbonate Alkalinity as CaCO3	mg/L	5	160	220
Carbonate Alkalinity as CaCO3	mg/L	5	<5	<5
Hydroxide Alkalinity as CaCO3	mg/L	5	<5	<5
Chloride by Discrete Analyser in Water Method: AN274 Tested: 27/1/2021				
Chloride, Cl	mg/L	1	44	1900
Metals in Water (Dissolved) by ICPOES Method: AN320 Tested: 22/1/2021				
Aluminium, Al	mg/L	0.005	0.017	0.027
Calcium, Ca	mg/L	0.1	88	97
Iron, Fe	mg/L	0.005	0.086	0.90
Magnesium, Mg	mg/L	0.1	3.6	130
Potassium, K	mg/L	0.1	2.2	82
Sodium, Na	mg/L	0.5	19	980
Sulfur asSulfate, SO4	mg/L	0.5	8.3	300
Zinc, Zn	mg/L	0.005	<0.005	0.006
Total Hardness by Calculation	mg CaCO3/L	1	180	790
Metals in Water (Dissolved) by ICPOES-USN Method: AN320/AN322 Tested: 22/1/2021				
Arsenic, As	mg/L	0.003	0.008	0.010
Cadmium, Cd	mg/L	0.0001	<0.0001	0.0003
Chromium, Cr	mg/L	0.001	<0.0010	<0.0020↑
Copper, Cu	mg/L	0.001	<0.001	<0.002↑
Lead, Pb	mg/L	0.001	<0.001	<0.002↑
Nickel, Ni	mg/L	0.001	<0.001	<0.002↑

Parameter	Units	LOR	Sample Number Sample Matrix Sample Date Sample Name	CE150386.001 Water 15 Jan 2021 BH3	CE150386.002 Water 15 Jan 2021 BH4
Mercury (dissolved) in Water Method: AN311(Perth)/AN312 Tested: 21/1/2021					
Mercury	mg/L	0.00005		<0.00005	<0.00005
Calculation of Anion-Cation Balance (SAR Calc) Method: AN121 Tested: 28/1/2021					
Sum of Cation Milliequivalents*	meq/L	-		**4.58**	**60.5**
Sum of Anion Milliequivalents*	meq/L	-		**4.66**	**63.9**
Anion-Cation Balance	%	-100		**-0.8**	**-2.7**

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Alkalinity Method: ME-(AU)-[ENV]AN135

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Alkalinity as CaCO3	LB085802	mg/L	5	<5	0 - 7%	107 - 115%
Bicarbonate Alkalinity as CaCO3	LB085802	mg/L	5	<5		
Carbonate Alkalinity as CaCO3	LB085802	mg/L	5	<5		
Hydroxide Alkalinity as CaCO3	LB085802	mg/L	5	<5		

Chloride by Discrete Analyser in Water Method: ME-(AU)-[ENV]AN274

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Chloride, Cl	LB086166	mg/L	1	<1	0 - 1%	105 - 106%

Mercury (dissolved) in Water Method: ME-(AU)-[ENV]AN311(Perth)/AN312

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Mercury	LB086014	mg/L	0.00005	<0.00005	0%	96 - 98%	93 - 96%

Metals in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN320

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Aluminium, Al	LB086080	mg/L	0.005	<0.005	102%
Calcium, Ca	LB086080	mg/L	0.1	<0.1	105%
Iron, Fe	LB086080	mg/L	0.005	<0.005	107%
Magnesium, Mg	LB086080	mg/L	0.1	<0.1	98%
Potassium, K	LB086080	mg/L	0.1	<0.1	103%
Sodium, Na	LB086080	mg/L	0.5	<0.5	102%
Sulfur asSulfate, SO4	LB086080	mg/L	0.5	<0.5	
Zinc, Zn	LB086080	mg/L	0.005	<0.005	103%
Total Hardness by Calculation	LB086080	mg CaCO3/L	1	<1	

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula : *the absolute difference of the two results divided by the average of the two results as a percentage.* Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Metals in Water (Dissolved) by ICPOES-USN Method: ME-(AU)-[ENV]AN320/AN322

Parameter	QC Reference	Units	LOR	MB	LCS %Recovery
Arsenic, As	LB086082	mg/L	0.003	<0.003	111%
Cadmium, Cd	LB086082	mg/L	0.0001	<0.0001	112%
Chromium, Cr	LB086082	mg/L	0.001	<0.0010	104%
Copper, Cu	LB086082	mg/L	0.001	<0.001	98%
Lead, Pb	LB086082	mg/L	0.001	<0.001	106%
Nickel, Ni	LB086082	mg/L	0.001	<0.001	105%

pH in water Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH**	LB085802	pH Units	0.1	5.8 - 8.5	0 - 4%	100 - 101%

METHOD	METHODOLOGY SUMMARY
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2510 B.
AN106	Salinity may be calculated in terms of NaCl from the sample conductivity. This assumes all soluble salts present, measured by the conductivity, are present as NaCl.
AN121	This method is used to calculation the balance of major Anions and Cations in water samples and converts major ion concentration to milliequivalents and then summed. Anions sum and Cation sum is calculated as a difference and expressed as a percentage.
AN135	Alkalinity (and forms of) by Titration: The sample is titrated with standard acid to pH 8.3 (P titre) and pH 4.5 (T titre) and permanent and/or total alkalinity calculated. The results are expressed as equivalents of calcium carbonate or recalculated as bicarbonate, carbonate and hydroxide. Reference APHA 2320. Internal Reference AN135
AN274	Chloride by Discrete Analyse: Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Reference APHA 4500Cl-
AN311(Perth)/AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN320	Metals by ICP-OES: Samples are preserved with 10% nitric acid for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components.
AN320	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B.
AN320/AN322	ICP-OES (Ultrasonic Nebuliser): After preservation with 10% nitric acid, a wide range of metals and some non-metals in solution can be measured by ICP- Ultrasonic nebulisation. Solutions are aspirated using an ultrasonic nebuliser into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components.
AN322	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B

METHOD	METHODOLOGY SUMMARY
Calculation	Free and Total Carbon Dioxide may be calculated using alkalinity forms only when the samples TDS is <500mg/L. If TDS is >500mg/L free or total carbon dioxide cannot be reported. APHA4500CO2 D.

FOOTNOTES

IS	Insufficient sample for analysis.	LOR	Limit of Reporting
LNR	Sample listed, but not received.	↑↓	Raised or Lowered Limit of Reporting
*	NATA accreditation does not cover the performance of this service.	QFH	QC result is above the upper tolerance
		QFL	QC result is below the lower tolerance
**	Indicative data, theoretical holding time exceeded.	-	The sample was not analysed for this analyte
***	Indicates that both * and ** apply.	NVL	Not Validated

Unless it is reported that sampling has been performed by SGS, the samples have been analysed as received.
Solid samples expressed on a dry weight basis.

Where "Total" analyte groups are reported (for example, Total PAHs, Total OC Pesticides) the total will be calculated as the sum of the individual analytes, with those analytes that are reported as <LOR being assumed to be zero. The summed (Total) limit of reporting is calcuated by summing the individual analyte LORs and dividing by two. For example, where 16 individual analytes are being summed and each has an LOR of 0.1 mg/kg, the "Totals" LOR will be 1.6 / 2 (0.8 mg/kg). Where only 2 analytes are being summed, the "Total" LOR will be the sum of those two LORs.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

If reported, measurement uncertainty follow the ± sign after the analytical result and is expressed as the expanded uncertainty calculated using a coverage factor of 2, providing a level of confidence of approximately 95%, unless stated otherwise in the comments section of this report.

Results reported for samples tested under test methods with codes starting with ARS-SOP, radionuclide or gross radioactivity concentrations are expressed in becquerel (Bq) per unit of mass or volume or per wipe as stated on the report. Becquerel is the SI unit for activity and equals one nuclear transformation per second.
Note that in terms of units of radioactivity:

a. 1 Bq is equivalent to 27 pCi
b. 37 MBq is equivalent to 1 mCi

For results reported for samples tested under test methods with codes starting with ARS-SOP, less than (<) values indicate the detection limit for each radionuclide or parameter for the measurement system used. The respective detection limits have been calculated in accordance with ISO 11929.

The QC and MU criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: www.sgs.com.au/en-gb/environment-health-and-safety.

STATEMENT OF QA/QC PERFORMANCE

CE150386 R0

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Dustin Peacocke	Manager	Anthony Nilsson
Client	GOLDER ASSOCIATES PTY LTD	Laboratory	SGS Cairns Environmental
Address	PO BOX 5823 216 DRAPER ST CAIRNS QLD 4870	Address	Unit 2, 58 Comport St Portsmith QLD 4870
Telephone	07 4054 8200	Telephone	+61 07 4035 5111
Facsimile	07 4054 8201	Facsimile	+61 07 4035 5122
Email	DPeacocke@golder.com.au	Email	AU.Environmental.Cairns@sgs.com
Project	**20446551**	SGS Reference	**CE150386 R0**
Order Number	(Not specified)	Date Received	15 Jan 2021
Samples	2	Date Reported	28 Jan 2021

COMMENTS

All the laboratory data for each environmental matrix was compared to SGS' stated Data Quality Objectives (DQO). Comments arising from the comparison were made and are reported below.

The data relating to sampling was taken from the Chain of Custody document.
This QA/QC Statement must be read in conjunction with the referenced Analytical Report.
The Statement and the Analytical Report must not be reproduced except in full.

All Data Quality Objectives were met (within the SGS Cairns Environmental laboratory).

SAMPLE SUMMARY

HOLDING TIME SUMMARY

CE150386 R0

SGS holding time criteria are drawn from current regulations and are highly dependent on sample container preservation as specified in the SGS "Field Sampling Guide for Containers and Holding Time" (ref: GU-(AU)-ENV.001). Soil samples guidelines are derived from NEPM "Schedule B(3) Guideline on Laboratory Analysis of Potentially Contaminated Soils". Water sample guidelines are derived from "AS/NZS 5667.1 : 1998 Water Quality - sampling part 1" and APHA "Standard Methods for the Examination of Water and Wastewater" 21st edition 2005.

Extraction and analysis holding time due dates listed are calculated from the date sampled, although holding times may be extended after laboratory extraction for some analytes. The due dates are the suggested dates that samples may be held before extraction or analysis and still be considered valid.

Extraction and analysis dates are shown in Green when within suggested criteria or Red with an appended dagger symbol (†) when outside suggested criteria. If the sampled date is not supplied then compliance with criteria cannot be determined. If the received date is after one or both due dates then holding time will fail by default.

Alkalinity — Method: ME-(AU)-[ENV]AN135

Sample Name	Sample No.	QC Ref	Sampled	Received	Extraction Due	Extracted	Analysis Due	Analysed
BH3	CE150386.001	LB085802	15 Jan 2021	15 Jan 2021	29 Jan 2021	15 Jan 2021	29 Jan 2021	15 Jan 2021
BH4	CE150386.002	LB085802	15 Jan 2021	15 Jan 2021	29 Jan 2021	15 Jan 2021	29 Jan 2021	15 Jan 2021

Chloride by Discrete Analyser in Water — Method: ME-(AU)-[ENV]AN274

Sample Name	Sample No.	QC Ref	Sampled	Received	Extraction Due	Extracted	Analysis Due	Analysed
BH3	CE150386.001	LB086166	15 Jan 2021	15 Jan 2021	12 Feb 2021	27 Jan 2021	12 Feb 2021	27 Jan 2021
BH4	CE150386.002	LB086166	15 Jan 2021	15 Jan 2021	12 Feb 2021	27 Jan 2021	12 Feb 2021	27 Jan 2021

Mercury (dissolved) in Water — Method: ME-(AU)-[ENV]AN311(Perth)/AN312

Sample Name	Sample No.	QC Ref	Sampled	Received	Extraction Due	Extracted	Analysis Due	Analysed
BH3	CE150386.001	LB086014	15 Jan 2021	15 Jan 2021	12 Feb 2021	21 Jan 2021	12 Feb 2021	25 Jan 2021
BH4	CE150386.002	LB086014	15 Jan 2021	15 Jan 2021	12 Feb 2021	21 Jan 2021	12 Feb 2021	25 Jan 2021

Metals in Water (Dissolved) by ICPOES — Method: ME-(AU)-[ENV]AN320

Sample Name	Sample No.	QC Ref	Sampled	Received	Extraction Due	Extracted	Analysis Due	Analysed
BH3	CE150386.001	LB086080	15 Jan 2021	15 Jan 2021	14 Jul 2021	22 Jan 2021	14 Jul 2021	24 Jan 2021
BH4	CE150386.002	LB086080	15 Jan 2021	15 Jan 2021	14 Jul 2021	22 Jan 2021	14 Jul 2021	24 Jan 2021

Metals in Water (Dissolved) by ICPOES-USN — Method: ME-(AU)-[ENV]AN320/AN322

Sample Name	Sample No.	QC Ref	Sampled	Received	Extraction Due	Extracted	Analysis Due	Analysed
BH3	CE150386.001	LB086082	15 Jan 2021	15 Jan 2021	14 Jul 2021	22 Jan 2021	14 Jul 2021	25 Jan 2021
BH4	CE150386.002	LB086082	15 Jan 2021	15 Jan 2021	14 Jul 2021	22 Jan 2021	14 Jul 2021	25 Jan 2021

pH in water — Method: ME-(AU)-[ENV]AN101

Sample Name	Sample No.	QC Ref	Sampled	Received	Extraction Due	Extracted	Analysis Due	Analysed
BH3	CE150386.001	LB085802	15 Jan 2021	15 Jan 2021	16 Jan 2021	15 Jan 2021	16 Jan 2021	15 Jan 2021
BH4	CE150386.002	LB085802	15 Jan 2021	15 Jan 2021	16 Jan 2021	15 Jan 2021	16 Jan 2021	15 Jan 2021

Surrogate results are evaluated against upper and lower limit criteria established in the SGS QA/QC plan (Ref: MP-(AU)-[ENV]QU-022). At least two of three routine level soil sample surrogate spike recoveries for BTEX/VOC are to be within 70-130% where control charts have not been developed and within the established control limits for charted surrogates. Matrix effects may void this as an acceptance criterion. Water sample surrogate spike recoveries are to be within 40-130%. The presence of emulsions, surfactants and particulates may void this as an acceptance criterion.

Result is shown in Green when within suggested criteria or **Red** with an appended reason identifer when outside suggested criteria. Refer to the footnotes section at the end of this report for failure reasons.

No surrogates were required for this job.

Blank results are evaluated against the limit of reporting (LOR), for the chosen method and its associated instrumentation, typically 2.5 times the statistically determined method detection limit (MDL).

Result is shown in Green when within suggested criteria or Red with an appended dagger symbol (†) when outside suggested criteria.

Alkalinity — Method: ME-(AU)-[ENV]AN135

Sample Number	Parameter	Units	LOR	Result
LB085802.001	Total Alkalinity as CaCO3	mg/L	5	<5
LB085802.055	Total Alkalinity as CaCO3	mg/L	5	<5
LB085802.082	Total Alkalinity as CaCO3	mg/L	5	<5
LB085802.136	Total Alkalinity as CaCO3	mg/L	5	<5

Chloride by Discrete Analyser in Water — Method: ME-(AU)-[ENV]AN274

Sample Number	Parameter	Units	LOR	Result
LB086166.001	Chloride, Cl	mg/L	1	<1
LB086166.026	Chloride, Cl	mg/L	1	<1
LB086166.051	Chloride, Cl	mg/L	1	<1

Mercury (dissolved) in Water — Method: ME-(AU)-[ENV]AN311(Perth)/AN312

Sample Number	Parameter	Units	LOR	Result
LB086014.001	Mercury	mg/L	0.00005	<0.00005
LB086014.026	Mercury	mg/L	0.00005	<0.00005

Metals in Water (Dissolved) by ICPOES — Method: ME-(AU)-[ENV]AN320

Sample Number	Parameter	Units	LOR	Result
LB086080.001	Aluminium, Al	mg/L	0.005	<0.005
	Calcium, Ca	mg/L	0.1	<0.1
	Iron, Fe	mg/L	0.005	<0.005
	Magnesium, Mg	mg/L	0.1	<0.1
	Potassium, K	mg/L	0.1	<0.1
	Sodium, Na	mg/L	0.5	<0.5
	Zinc, Zn	mg/L	0.005	<0.005

Metals in Water (Dissolved) by ICPOES-USN — Method: ME-(AU)-[ENV]AN320/AN322

Sample Number	Parameter	Units	LOR	Result
LB086082.001	Arsenic, As	mg/L	0.003	<0.003
	Cadmium, Cd	mg/L	0.0001	<0.0001
	Chromium, Cr	mg/L	0.001	<0.0010
	Lead, Pb	mg/L	0.001	<0.001
	Nickel, Ni	mg/L	0.001	<0.001

pH in water — Method: ME-(AU)-[ENV]AN101

Sample Number	Parameter	Units	LOR	Result
LB085802.001	pH**	pH Units	0.1	7.6
LB085802.055	pH**	pH Units	0.1	5.8
LB085802.082	pH**	pH Units	0.1	5.8
LB085802.136	pH**	pH Units	0.1	8.5

Duplicates are calculated as Relative Percentage Difference (RPD) using the formula: RPD = | OriginalResult - ReplicateResult | x 100 / Mean

The RPD is evaluated against the Maximum Allowable Difference (MAD) criteria and can be graphically represented by a curve calculated from the Statistical Detection Limit (SDL) and Limiting Repeatability (LR) using the formula: MAD = 100 x SDL / Mean + LR

Where the Maximum Allowable Difference evaluates to a number larger than 200 it is displayed as 200.

RPD is shown in Green when within suggested criteria or Red with an appended reason identifer when outside suggested criteria. Refer to the footnotes section at the end of this report for failure reasons.

NOTE: The RPD reported is calculated from the unrounded data for the original and replicate result. Manual calculation of the RPD from the rounded data reported may give a different calculated RPD.

Alkalinity

Method: ME-(AU)-[ENV]AN135

Original	Duplicate	Parameter	Units	LOR	Original	Duplicate	Criteria %	RPD %
CE150158A.001	LB085802.163	Total Alkalinity as CaCO3	mg/L	5	<5	<5	137	0
CE150316.001	LB085802.164	Total Alkalinity as CaCO3	mg/L	5	31	32	31	5
CE150317.001	LB085802.165	Total Alkalinity as CaCO3	mg/L	5	170	170	18	0
CE150324.001	LB085802.171	Total Alkalinity as CaCO3	mg/L	5	37.91984597890.3948324561		23	4
CE150334.001	LB085802.172	Total Alkalinity as CaCO3	mg/L	5	<5	<5	200	0
CE150341.001	LB085802.173	Total Alkalinity as CaCO3	mg/L	5	0	0	200	0
CE150342.001	LB085802.174	Total Alkalinity as CaCO3	mg/L	5	270	260	17	2
CE150343.001	LB085802.175	Total Alkalinity as CaCO3	mg/L	5	01.662207166	02.969283341	17	0
CE150345.001	LB085802.166	Total Alkalinity as CaCO3	mg/L	5	181.58469054	181.834077325	15	0
CE150345.011	LB085802.167	Total Alkalinity as CaCO3	mg/L	5	26.15489915325.839571519		16	0
CE150345.021	LB085802.168	Total Alkalinity as CaCO3	mg/L	5	99.11665534898.717104565		17	0
CE150354.001	LB085802.176	Total Alkalinity as CaCO3	mg/L	5	7.85445705536.3327511244		85	21
CE150355.001	LB085802.177	Total Alkalinity as CaCO3	mg/L	5	07.101019135	18.947250589	19	10
CE150355.011	LB085802.178	Total Alkalinity as CaCO3	mg/L	5	4.01661828124.2141652937		136	0
CE150356.001	LB085802.179	Total Alkalinity as CaCO3	mg/L	5	1.45038806291.1742045742		200	0
CE150365.001	LB085802.180	Total Alkalinity as CaCO3	mg/L	5	36.166979490	03.543471675	20	7
CE150390.001	LB085802.184	Total Alkalinity as CaCO3	mg/L	5	127.07	27.069381211	19	0

Chloride by Discrete Analyser in Water

Method: ME-(AU)-[ENV]AN274

Original	Duplicate	Parameter	Units	LOR	Original	Duplicate	Criteria %	RPD %
CE150343A.001	LB086166.005	Chloride, Cl	mg/L	1	599.323	607.631	15	1
CE150390.002	LB086166.016	Chloride, Cl	mg/L	1	3.516	3.515	43	0
CE150423.005	LB086166.030	Chloride, Cl	mg/L	1	27.122	27.52	19	1
CE150436.003	LB086166.041	Chloride, Cl	mg/L	1	78.934	78.776	16	0
CE150452.007	LB086166.055	Chloride, Cl	mg/L	1	74.91	75.099	16	0

Mercury (dissolved) in Water

Method: ME-(AU)-[ENV]AN311(Perth)/AN312

Original	Duplicate	Parameter	Units	LOR	Original	Duplicate	Criteria %	RPD %
CE150345.007	LB086014.014	Mercury	µg/L	0.00005	-0.00795	-0.0081	200	0
CE150345.017	LB086014.025	Mercury	µg/L	0.00005	-0.006	-0.0054	200	0
CE150423.001	LB086014.039	Mercury	µg/L	0.00005	0	0	200	0
CE150423.009	LB086014.048	Mercury	µg/L	0.00005	-0.0045	-0.0048	200	0

pH in water

Method: ME-(AU)-[ENV]AN101

Original	Duplicate	Parameter	Units	LOR	Original	Duplicate	Criteria %	RPD %
CE150158A.001	LB085802.163	pH**	pH Units	0.1	6.6	6.5	17	1
CE150316.001	LB085802.164	pH**	pH Units	0.1	7.0	7.1	16	1
CE150317.001	LB085802.165	pH**	pH Units	0.1	8.6	8.6	16	0
CE150324.001	LB085802.171	pH**	pH Units	0.1	7.20985317237.1813025474		16	0
CE150330.001	LB085802.170	pH**	pH Units	0.1	8.3	8.1	16	2
CE150334.001	LB085802.172	pH**	pH Units	0.1	4.90330410004.6953697204		17	4
CE150341.001	LB085802.173	pH**	pH Units	0.1	3.46037197113.4611387252		18	0
CE150342.001	LB085802.174	pH**	pH Units	0.1	7.9	7.9	16	0
CE150343.001	LB085802.175	pH**	pH Units	0.1	7.47227859497.4825768470		16	0
CE150345.001	LB085802.166	pH**	pH Units	0.1	7.56721591947.4133534431		16	2
CE150345.011	LB085802.167	pH**	pH Units	0.1	7.36174201967.3371310234		16	0
CE150345.021	LB085802.168	pH**	pH Units	0.1	7.98976039888.0061254501		16	0
CE150348.001	LB085802.169	pH**	pH Units	0.1	7.70394849777.7659287452		16	1
CE150354.001	LB085802.176	pH**	pH Units	0.1	6.02195739745.9263834953		17	2
CE150355.001	LB085802.177	pH**	pH Units	0.1	7.29598903657.3759446144		16	1
CE150355.011	LB085802.178	pH**	pH Units	0.1	5.75763034825.8917431831		17	2
CE150356.001	LB085802.179	pH**	pH Units	0.1	5.14752483365.1414790153		17	0
CE150365.001	LB085802.180	pH**	pH Units	0.1	7.40876340867.4023962020		16	0
CE150374.001	LB085802.181	pH**	pH Units	0.1	7.62157058717.7176961898		16	1
CE150380.001	LB085802.182	pH**	pH Units	0.1	7.40502452857.4111571311		16	0
CE150388.001	LB085802.183	pH**	pH Units	0.1	7.56489181517.6389203071		16	1
CE150390.001	LB085802.184	pH**	pH Units	0.1	7.36166381837.2796912193		16	1

Laboratory Control Standard (LCS) results are evaluated against an expected result, typically the concentration of analyte spiked into the control during the sample preparation stage, producing a percentage recovery. The criteria applied to the percentage recovery is established in the SGS QA /QC plan (Ref: MP-(AU)-[ENV]QU-022). For more information refer to the footnotes in the concluding page of this report.

Recovery is shown in Green when within suggested criteria or Red with an appended dagger symbol (†) when outside suggested criteria.

Alkalinity — Method: ME-(AU)-[ENV]AN135

Sample Number	Parameter	Units	LOR	Result	Expected	Criteria %	Recovery %
LB085802.002	Total Alkalinity as CaCO3	mg/L	5	65	59.5	80 - 120	110
LB085802.003	Total Alkalinity as CaCO3	mg/L	5	230	229	80 - 120	102
LB085802.056	Total Alkalinity as CaCO3	mg/L	5	64	59.5	80 - 120	107
LB085802.057	Total Alkalinity as CaCO3	mg/L	5	240	229	80 - 120	103
LB085802.083	Total Alkalinity as CaCO3	mg/L	5	64	59.5	80 - 120	107
LB085802.084	Total Alkalinity as CaCO3	mg/L	5	230	229	80 - 120	102
LB085802.137	Total Alkalinity as CaCO3	mg/L	5	68	59.5	80 - 120	115
LB085802.138	Total Alkalinity as CaCO3	mg/L	5	230	229	80 - 120	102

Chloride by Discrete Analyser in Water — Method: ME-(AU)-[ENV]AN274

Sample Number	Parameter	Units	LOR	Result	Expected	Criteria %	Recovery %
LB086166.002	Chloride, Cl	mg/L	1	130	125	80 - 120	104
LB086166.003	Chloride, Cl	mg/L	1	11	10	80 - 120	106
LB086166.027	Chloride, Cl	mg/L	1	140	125	80 - 120	108
LB086166.028	Chloride, Cl	mg/L	1	11	10	80 - 120	105
LB086166.052	Chloride, Cl	mg/L	1	130	125	80 - 120	106
LB086166.053	Chloride, Cl	mg/L	1	11	10	80 - 120	106

Mercury (dissolved) in Water — Method: ME-(AU)-[ENV]AN311(Perth)/AN312

Sample Number	Parameter	Units	LOR	Result	Expected	Criteria %	Recovery %
LB086014.002	Mercury	mg/L	0.00005	0.0019	0.002	80 - 120	96
LB086014.027	Mercury	mg/L	0.00005	0.0020	0.002	80 - 120	98

Metals in Water (Dissolved) by ICPOES — Method: ME-(AU)-[ENV]AN320

Sample Number	Parameter	Units	LOR	Result	Expected	Criteria %	Recovery %
LB086080.002	Aluminium, Al	mg/L	0.005	1.0	1	80 - 120	102
	Calcium, Ca	mg/L	0.1	21	20	80 - 120	105
	Iron, Fe	mg/L	0.005	1.1	1	80 - 120	107
	Magnesium, Mg	mg/L	0.1	20	20	80 - 120	98
	Potassium, K	mg/L	0.1	21	20	80 - 120	103
	Sodium, Na	mg/L	0.5	20	20	80 - 120	102
	Zinc, Zn	mg/L	0.005	1.0	1	80 - 120	103

Metals in Water (Dissolved) by ICPOES-USN — Method: ME-(AU)-[ENV]AN320/AN322

Sample Number	Parameter	Units	LOR	Result	Expected	Criteria %	Recovery %
LB086082.002	Arsenic, As	mg/L	0.003	<0.003	0.002	80 - 120	111
	Cadmium, Cd	mg/L	0.0001	0.011	0.01	80 - 120	112
	Chromium, Cr	mg/L	0.001	0.010	0.01	80 - 120	104
	Copper, Cu	mg/L	0.001	0.010	0.01	80 - 120	98
	Lead, Pb	mg/L	0.001	0.011	0.01	80 - 120	106
	Nickel, Ni	mg/L	0.001	0.011	0.01	80 - 120	105

pH in water — Method: ME-(AU)-[ENV]AN101

Sample Number	Parameter	Units	LOR	Result	Expected	Criteria %	Recovery %
LB085802.006	pH**	pH Units	0.1	7.5	7.415	98 - 102	101
LB085802.060	pH**	pH Units	0.1	7.5	7.415	98 - 102	101
LB085802.087	pH**	pH Units	0.1	7.4	7.415	98 - 102	100
LB085802.141	pH**	pH Units	0.1	7.5	7.415	98 - 102	101

Matrix Spike (MS) results are evaluated as the percentage recovery of an expected result, typically the concentration of analyte spiked into a field sub -sample during the sample preparation stage. The original sample's result is subtracted from the sub-sample result before determining the percentage recovery. The criteria applied to the percentage recovery is established in the SGS QA/QC plan (ref: MP-(AU)-[ENV]QU-022). For more information refer to the footnotes in the concluding page of this report.

Recovery is shown in Green when within suggested criteria or Red with an appended reason identifer when outside suggested criteria. Refer to the footnotes section at the end of this report for failure reasons.

Mercury (dissolved) in Water

Method: ME-(AU)-[ENV]AN311(Perth)/AN312

QC Sample	Sample Number	Parameter	Units	LOR	Result	Original	Spike	Recovery%
CE150341.001	LB086014.004	Mercury	mg/L	0.00005	0.0019	-0.00525	-	93
CE150345.018	LB086014.029	Mercury	mg/L	0.00005	0.0019	-0.00675	-	96

MATRIX SPIKE DUPLICATES

CE150386 R0

Matrix spike duplicates are calculated as Relative Percent Difference (RPD) using the formula: RPD = | OriginalResult - ReplicateResult | x 100 / Mean

The original result is the analyte concentration of the matrix spike. The Duplicate result is the analyte concentration of the matrix spike duplicate.

The RPD is evaluated against the Maximum Allowable Difference (MAD) criteria and can be graphically represented by a curve calculated from the Statistical Detection Limit (SDL) and Limiting Repeatability (LR) using the formula: MAD = 100 x SDL / Mean + LR

Where the Maximum Allowable Difference evaluates to a number larger than 200 it is displayed as 200.

RPD is shown in Green when within suggested criteria or Red with an appended reason identifer when outside suggested criteria. Refer to the footnotes section at the end of this report for failure reasons.

No matrix spike duplicates were required for this job.

Samples analysed as received.

Solid samples expressed on a dry weight basis.

QC criteria are subject to internal review according to the SGS QA/QC plan and may be provided on request or alternatively can be found here: https://www.sgs.com.au/~/media/Local/Australia/Documents/Technical Documents/MP-AU-ENV-QU-022 QA QC Plan.pdf

*	NATA accreditation does not cover the performance of this service.
**	Indicative data, theoretical holding time exceeded.
***	Indicates that both * and ** apply.
-	Sample not analysed for this analyte.
IS	Insufficient sample for analysis.
LNR	Sample listed, but not received.
LOR	Limit of reporting.
QFH	QC result is above the upper tolerance.
QFL	QC result is below the lower tolerance.

①	At least 2 of 3 surrogates are within acceptance criteria.
②	RPD failed acceptance criteria due to sample heterogeneity.
③	Results less than 5 times LOR preclude acceptance criteria for RPD.
④	Recovery failed acceptance criteria due to matrix interference.
⑤	Recovery failed acceptance criteria due to the presence of significant concentration of analyte (i.e. the concentration of analyte exceeds the spike level).
⑥	LOR was raised due to sample matrix interference.
⑦	LOR was raised due to dilution of significantly high concentration of analyte in sample.
⑧	Reanalysis of sample in duplicate confirmed sample heterogeneity and inconsistency of results.
⑨	Low surrogate recovery due to the sample emulsifying during extraction.
⑩	Sample was retested due to suspected contamination during field filtering.
⑪	Sample was retested due to suspected carry-over from previous high level sample.
⑫	Sample was retested from Non Preserved bottle due to Total metals bottle result < Filtered.
†	Refer to relevant report comments for further information.

SGS EHS Cairns COC

CE150386

SAMPLE CHAIN OF CUSTODY DOCUMENTATION

Sheet: of

Project No:	20446551	**Phone:**		**Lab Name:**	SGS
Site ID No.:		**Site Location:**		**Quote No.**	
Sampled By:	Dustin Peacocke			**Order No.:**	
Turnaround Time	24hrs ☐	48hrs ☐	Standard ■		
	36hrs ☐	3 Day ☐	Date Required By:		
Delivery Option	HARD ☐	FAX ☐	DISK ☐	EMAIL ■	BULLETIN BOARD ☐
Report Format	PDF ■	EXCEL ■		ESDAT ■	EQUIS ■

Comments/Special Instructions:
ESDAT FORMAT PLEASE

LAB ID	SAMPLE ID	SAMPLE DEPTH	SAMPLE DATE	SAMPLE COUNT	SAMPLE MATRIX			Dissolved Metals (As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, Al and Fe)	Major cations and anions															Comments
	BH3		15-1-21	2	WATER			X	X															
	BH4		15.1-21	2	WATER			X	X															

SAMPLE MATRIX = Soil/Sediment/Fill/Water/Other

SAMPLE TYPE = Composite(C)/Discrete(DC)/Disturbed(DS)/Core(CR), Grab Sample (GS)

HIGH CONCENTRATION: circle expected parameters in analysis list

	SIGNATURE	COMPANY	DATE	TIME
RELEASED BY	Dustin Peacocke D.Peacocke	GOLDER	15-1-21	14:30
RECEIVED BY	JB	SGS	15/1/21	2:30pm
RELEASED BY				
RECEIVED BY				
RELEASED BY				
RECEIVED BY				

	SIGNATURE	COMPANY	DATE	TIME	Method of Shipment
RELEASED BY					Shipping Ref:
RECEIVED BY					

To Be Filled Out By Analysing Laboratory

Security Seal	✓	Chilled	✓	LAB. BATCH NUMBER	
Suitable Containers	✓	Frozen		Bill to:	
Cool Box	✓	Ambient		Address	

2×500NP
2×125AW

THIS FORM IS TO BE SIGNED BY GOLDER STAFF; COURIER/S; LABORATORY ON RECEIPT OF SAMPLES.

GOLDER ASSOCIATES PTY LTD
216 Draper St, Cairns, 4870
Phone: 07 54 8200
Fax: 07 54 8281
Project Manager: Sin Bogue
Reviewed:
Job Contact: Dustin Peacocke
Phone: 0431 790 929 Email:
Golder Associates

SAMPLE RECEIPT ADVICE

CE150386

CLIENT DETAILS

Contact	Dustin Peacocke
Client	GOLDER ASSOCIATES PTY LTD
Address	PO BOX 5823 216 DRAPER ST CAIRNS QLD 4870
Telephone	07 4054 8200
Facsimile	07 4054 8201
Email	DPeacocke@golder.com.au
Project	**20446551**
Order Number	(Not specified)
Samples	2

LABORATORY DETAILS

Manager	Anthony Nilsson
Laboratory	SGS Cairns Environmental
Address	Unit 2, 58 Comport St Portsmith QLD 4870
Telephone	+61 07 4035 5111
Facsimile	+61 07 4035 5122
Email	AU.Environmental.Cairns@sgs.com
Samples Received	Fri 15/1/2021
Report Due	Fri 22/1/2021
SGS Reference	**CE150386**

SUBMISSION DETAILS

This is to confirm that 2 samples were received on Friday 15/1/2021. Results are expected to be ready by COB Friday 22/1/2021. Please quote SGS reference CE150386 when making enquiries. Refer below for details relating to sample integrity upon receipt.

Samples clearly labelled	Yes	Complete documentation received	Yes
Sample container provider	SGS	Sample cooling method	Ice Bricks
Samples received in correct containers	Yes	Sample counts by matrix	2 Water
Date documentation received	15/1/2021	Type of documentation received	COC
Number of eskies/boxes received	1	Samples received in good order	Yes
Samples received without headspace	Yes	Sample temperature upon receipt	Chilled
Sufficient sample for analysis	Yes	Turnaround time requested	Standard

Unless otherwise instructed, water and bulk samples will be held for one month from date of report, and soil samples will be held for two months.

COMMENTS

SAMPLE RECEIPT ADVICE

CE150386

CLIENT DETAILS

Client GOLDER ASSOCIATES PTY LTD Project 20446551

SUMMARY OF ANALYSIS

No.	Sample ID	Alkalinity	Calculation of Anion-Cation Balance	Chloride by Discrete Analyser in Water	Mercury (dissolved) in Water	Metals in Water (Dissolved) by ICPOES	Metals in Water (Dissolved) by	pH in water
001	BH3	4	3	1	1	9	6	1
002	BH4	4	3	1	1	9	6	1

The above table represents SGS' interpretation of the client-supplied Chain Of Custody document.
The numbers shown in the table indicate the number of results requested in each package.
Please indicate as soon as possible should your request differ from these details .
Testing as per this table shall commence immediately unless the client intervenes with a correction .

Appendix D

Important Information Relating to This Report

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

This Report constitutes or is part of services ("Services") provided by Golder to its client ("Client") under and subject to a contract between Golder and its Client ("Contract"). The contents of this page are not intended to and do not alter Golder's obligations (including any limits on those obligations) to its Client under the Contract.

This Report is provided for use solely by Golder's Client and persons acting on the Client's behalf, such as its professional advisers. Golder is responsible only to its Client for this Report. Golder has no responsibility to any other person who relies or makes decisions based upon this Report or who makes any other use of this Report. Golder accepts no responsibility for any loss or damage suffered by any person other than its Client as a result of any reliance upon any part of this Report, decisions made based upon this Report or any other use of it.

This Report has been prepared in the context of the circumstances and purposes referred to in, or derived from, the Contract and Golder accepts no responsibility for use of the Report, in whole or in part, in any other context or circumstance or for any other purpose.

The scope of Golder's Services and the period of time they relate to are determined by the Contract and are subject to restrictions and limitations set out in the Contract. If a service or other work is not expressly referred to in this Report, do not assume that it has been provided or performed. If a matter is not addressed in this Report, do not assume that any determination has been made by Golder in regards to it.

At any location relevant to the Services conditions may exist which were not detected by Golder, in particular due to the specific scope of the investigation Golder has been engaged to undertake. Conditions can only be verified at the exact location of any tests undertaken. Variations in conditions may occur between tested locations and there may be conditions which have not been revealed by the investigation and which have not therefore been taken into account in this Report.

Golder accepts no responsibility for and makes no representation as to the accuracy or completeness of the information provided to it by or on behalf of the Client or sourced from any third party. Golder has assumed that such information is correct unless otherwise stated and no responsibility is accepted by Golder for incomplete or inaccurate data supplied by its Client or any other person for whom Golder is not responsible. Golder has not taken account of matters that may have existed when the Report was prepared but which were only later disclosed to Golder.

Having regard to the matters referred to in the previous paragraphs on this page in particular, carrying out the Services has allowed Golder to form no more than an opinion as to the actual conditions at any relevant location. That opinion is necessarily constrained by the extent of the information collected by Golder or otherwise made available to Golder. Further, the passage of time may affect the accuracy, applicability or usefulness of the opinions, assessments or other information in this Report. This Report is based upon the information and other circumstances that existed and were known to Golder when the Services were performed and this Report was prepared. Golder has not considered the effect of any possible future developments including physical changes to any relevant location or changes to any laws or regulations relevant to such location.

Where permitted by the Contract, Golder may have retained subconsultants affiliated with Golder to provide some or all of the Services. However, it is Golder which remains solely responsible for the Services and there is no legal recourse against any of Golder's affiliated companies or the employees, officers or directors of any of them.

By date, or revision, the Report supersedes any prior report or other document issued by Golder dealing with any matter that is addressed in the Report.

Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification

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Appendix C – Water Balance Study (GHD)

Memorandum

22 March 2021

To	Pat Flanagan		
Copy to	Gregory Applin		
From	Ryan Gray	Tel	+61 7 40442281
Subject	Water Balance Study	Job no.	12544036

1 Background

As requested and based on your engagement by Graben Pty Ltd, a water balance study was undertaken to accompany a Development Application to be submitted to Douglas Shire Council for a proposed Surf Park, immediately south of the Mowbray River mouth in Port Douglas.

2 Data used

The following data were used for the study:

- Selected daily climate data from the 01/01/1889 – 02/03/2021 record obtained from SILO grid point at Latitude 16°33' S, Longitude 145°30' E
- Preliminary Master Plan Diagram by Hunt Design (See Appendix A)

3 Assumptions

This water balance is based on a series of assumptions as tabulated in Table 3-1. Should any of these assumptions be incorrect, or change in the future, this water balance will need to be updated accordingly. Further, should more certainty be required, a detailed rainfall-runoff modelling approach with stochastic water balance modelling could be undertaken.

Table 3-1 Assumptions

Parameter	Value	Comment
Recreational Lagoon		
Number of water bodies (no)	1	All water bodies except for 'Kids Splash' within the water park have modelled as a single unit
Stage-storage relationship	Linear	Recreational Lagoon assumed to have the same surface area at the full and empty levels
Percentage of initial volume of water (%)	100	Recreational Lagoon assumed to be filled before the analysis

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Parameter	Value	Comment
External catchments (m^2)	0	All water bodies sit elevated from the surrounding terrain and as such, have no external catchment
Spillage	varies	All spillage has been assumed to be directed to the Water Storage Lagoon
Water usage by one bather per day (m^3)	0.00378	Bathers assumed to use 1 US gallon based on client supplied information via email correspondence to GHD
Peak number of bathers per day (no.)	600	Assumed for this study, as provided by the Client
Variation of bathers per day throughout the year		Assumed for this study based on occupancy rates provided by H_2O Consultants
Minimum operating water level (depth below surface) (mm)	150	Minimum required level of water during all seasons
Water Storage Lagoon		
Percentage of initial volume of water (%)	0	The Water Storage Lagoon is sized assuming it is empty at the beginning of the analysis
Pervious external catchment (m^2)	50,000	Approximately one-thirds of the 'Re-vegetation area' is assumed to contribute to the Water Storage Lagoon (See Appendix A)
Impervious external catchment (m^2)	48,927	Area of carpark, concrete path, deck, granitic sand and road assumed to contribute to the Water Storage Lagoon (See Appendix A)
Spillage	varies	All spillage has been considered as losses from the site
Water usage (m^3)	0	No usage from the Water Storage Lagoon has been assumed other than refilling the Recreational Lagoon

4 Events modelled

Five events ranging from the wettest to the driest years were modelled, as presented in Table 4-1. The 85th percentile driest year was used to size the Lagoon.

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Table 4-1 Modelled years with corresponding values of rainfall and evaporation

Events	Year	Rainfall (mm)			Evaporation (mm)		
		Total Annual	Mean Monthly	Mean Daily	Total Annual	Mean Monthly	Mean Daily
Driest year	1915	656.1	54.7	1.8	1927.0	160.6	5.3
85th percentile driest year	1900	1271.7	106.0	3.5	1932.8	161.1	5.3
50th percentile year (median)	1929	1786.1	148.8	4.9	1927.0	160.6	5.3
85th percentile wettest year	2004	2407.9	200.7	6.6	2003.7	167.0	5.5
Wettest year	1911	4368.7	364.1	12.0	1927.0	160.6	5.3

5 Water balance components

5.1 Recreational Lagoon

Table 5-1 lists the assumed properties of the Recreational Lagoon used in the development of this water balance.

5.2 Table 5-1 Assumed properties of the Recreational Lagoon

Parameter	Value	Units	Comment
Surface area	62,478	m^2	Combined area of Recreational Lagoon under consideration
Maximum Volume	120,418	m^3	Combined volume of Recreational Lagoon under consideration
External catchment area	0	m^2	None

5.3 Water Storage Lagoon

Table 5-2 lists the assumed properties of the Water Storage Lagoon used in the development of this water balance.

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Table 5-2 Assumed properties of the Water Storage Lagoon

Parameter	Value	Units	Comment
Surface area	15,000	m^2	Proposed maximum surface area of the Water Storage Lagoon
Volume	50,000	m^3	Proposed maximum capacity of the Water Storage Lagoon
Average depth	3.33	m	Assumed average depth of the Water Storage Lagoon
Minimum Operating Level	0	m^3	It was assumed that water can be pumped from the lowest storage level and, as such, access to all the storage volume was possible
External pervious catchment area	50,000	m^2	As stated in Section 3
External impervious catchment area	48,927	m^2	As stated in Section 3

5.4 Other parameters

To determine the amount of runoff generated by the site, as a contribution to the Water Storage Lagoon and Recreational Lagoon, a simple rainfall-runoff coefficient approach was adopted. The relevant coefficients that were used in the water balance study are tabulated in Table 5-3. The table also provides the assumed Lake Evaporation factor to convert A-pan evaporation to that of a large water body.

Table 5-3 Other parameters used in the analysis

Parameter	Evaporation factor	Pervious runoff coefficient	Impervious runoff coefficient
Values	0.8	0.4	0.9

6 Water balance results

Results for the 85th percentile driest year event has been presented in this section (refer to Appendix B for results from other scenarios). Figure 6-1 presents the interaction of water between the water bodies. A time-series graph for the storage of Recreational Lagoon is presented in Figure 6-2, which shows that, although the basin doesn't operate at the Full Supply Level (FSL) for majority of the year, it never drops below the minimum operating level set at 150 mm below the FSL. The loss of water during the dry season is compensated with the water being pumped to the Recreational Lagoon from

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the Water Storage Lagoon. The size of the Water Storage Lagoon was optimized to achieve the minimum water level requirement in the Recreational Lagoon. It is evident from Figure 6-3 that the Water Storage Lagoon never goes empty throughout the simulated 85th percentile driest year and still has some volume of water left before the start of next year.

A sensitivity analysis was undertaken, assessing two 85 % dry years back-to-back, with the results highlighting that there would be sufficient residual storage in the Water Storage Lagoon to keep the Recreational Lagoon above the minimum operating level in the second year, while the rainfall simulated in that year was sufficient to begin filling both water bodies. It is important to note that this is based on a specific historical time-series of rainfall from 1900 and, future rainfall may vary in quantity and variability, which could differ from the results presented here-in.

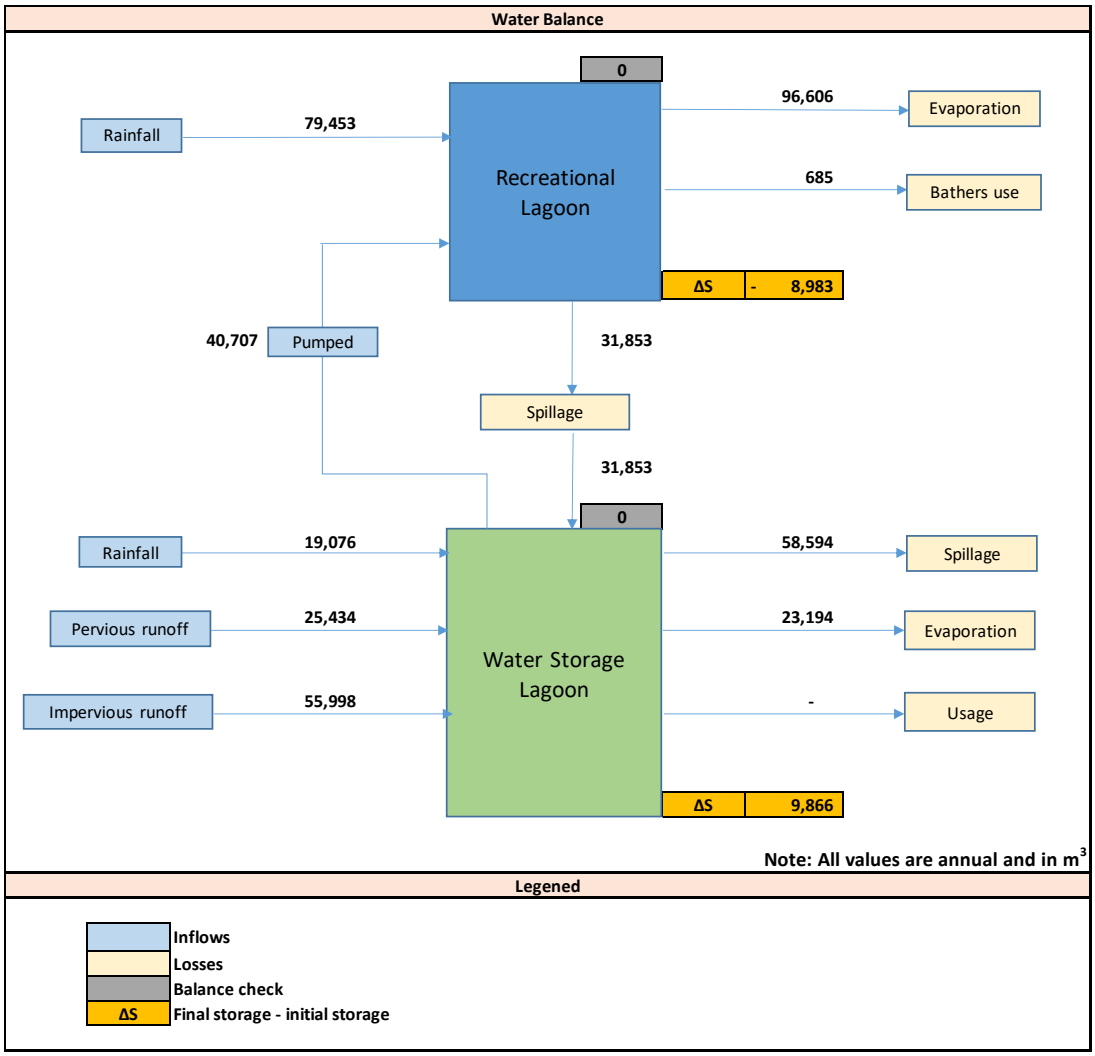

Figure 6-1 Water balance for 85th percentile driest year (units in m³)

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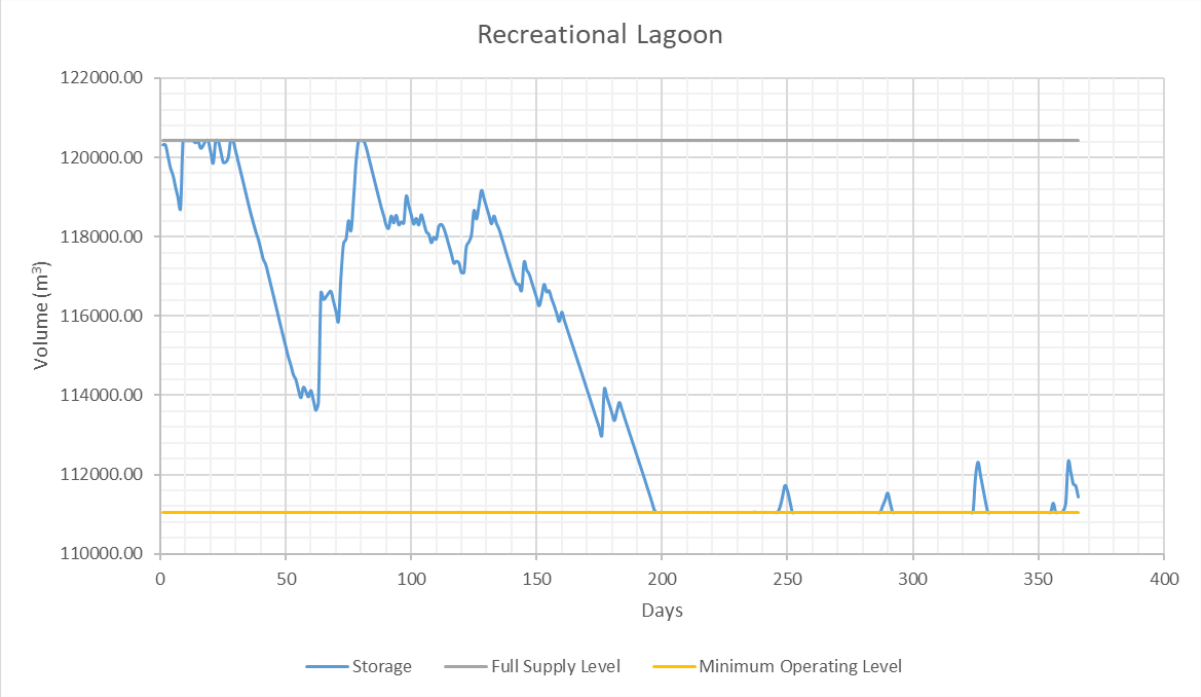

Figure 6-2 Time series storage graph of Recreational Lagoon for 85th percentile driest year

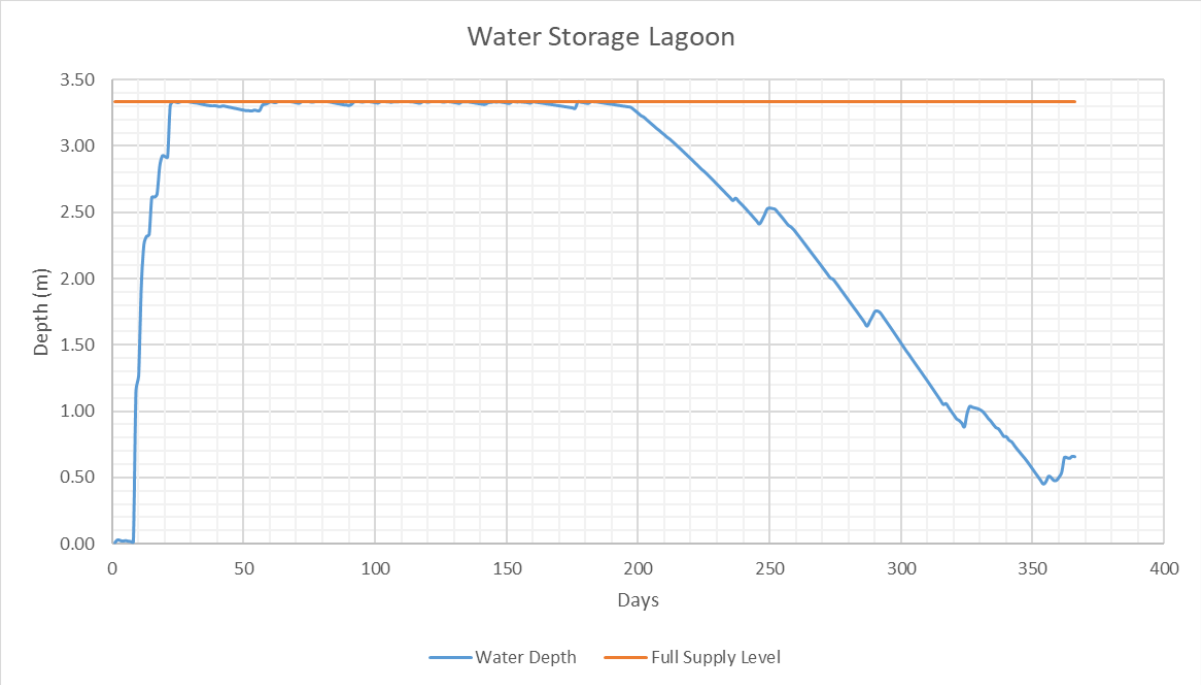

Figure 6-3 Time series depth graph of Water Storage Lagoon for 85th percentile driest year

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7 Conclusion

A Water Storage Lagoon with 1.5 hectares (15,000 m^2) surface area and 50,000 m^3 capacity was sized to capture excess runoff the surrounding surfaces, treated waste-water inflows and spills from the proposed Recreational Lagoon. It was sized such that a minimum operating level of water in the Recreational Lagoon are maintained throughout the year. The 85th percentile driest year was used as the design case and as such, statistically, there is a 15% chance of water not being available in any given year.

Regards

Ryan Gray
Team Leader - Surface Water, Cairns and Townsville

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Memorandum

Appendix A - Site Master Plan Diagrams

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LOCATION PLAN 1
SCALE @ A1:1:5000

PRELIMINARY

PORT DOUGLAS WAVE PARK

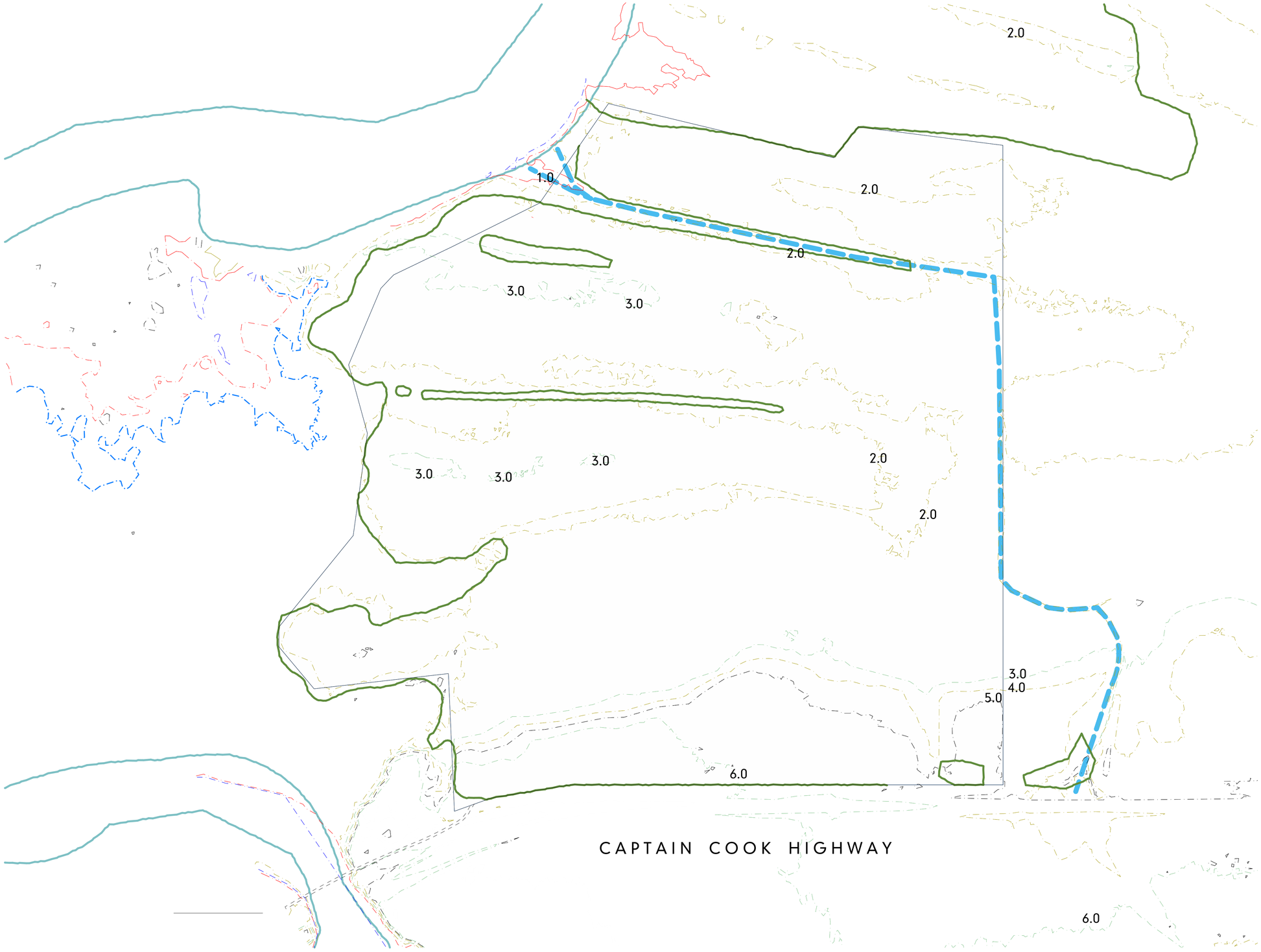
SCHEMATIC DESIGN
FOR : DAVID INGRABEN

MASTER PLAN DIAGRAMS
LOCATION MAP

N

PROJECT NO.	WAVE001
DRAWING NO.	DA-01.1
REVISION NO.	01
DATE	19/2/21

HUNT DESIGN



LEGEND
SURVEY - EXISTING CONDITIONS

- MAJOR CONTOUR LINE
- EXISTING TREE LINE
- RIVER/NATURAL WATER LINE

SITE CONTOURS 1
SCALE @ A1:1:2000

PRELIMINARY

PORT DOUGLAS WAVE PARK

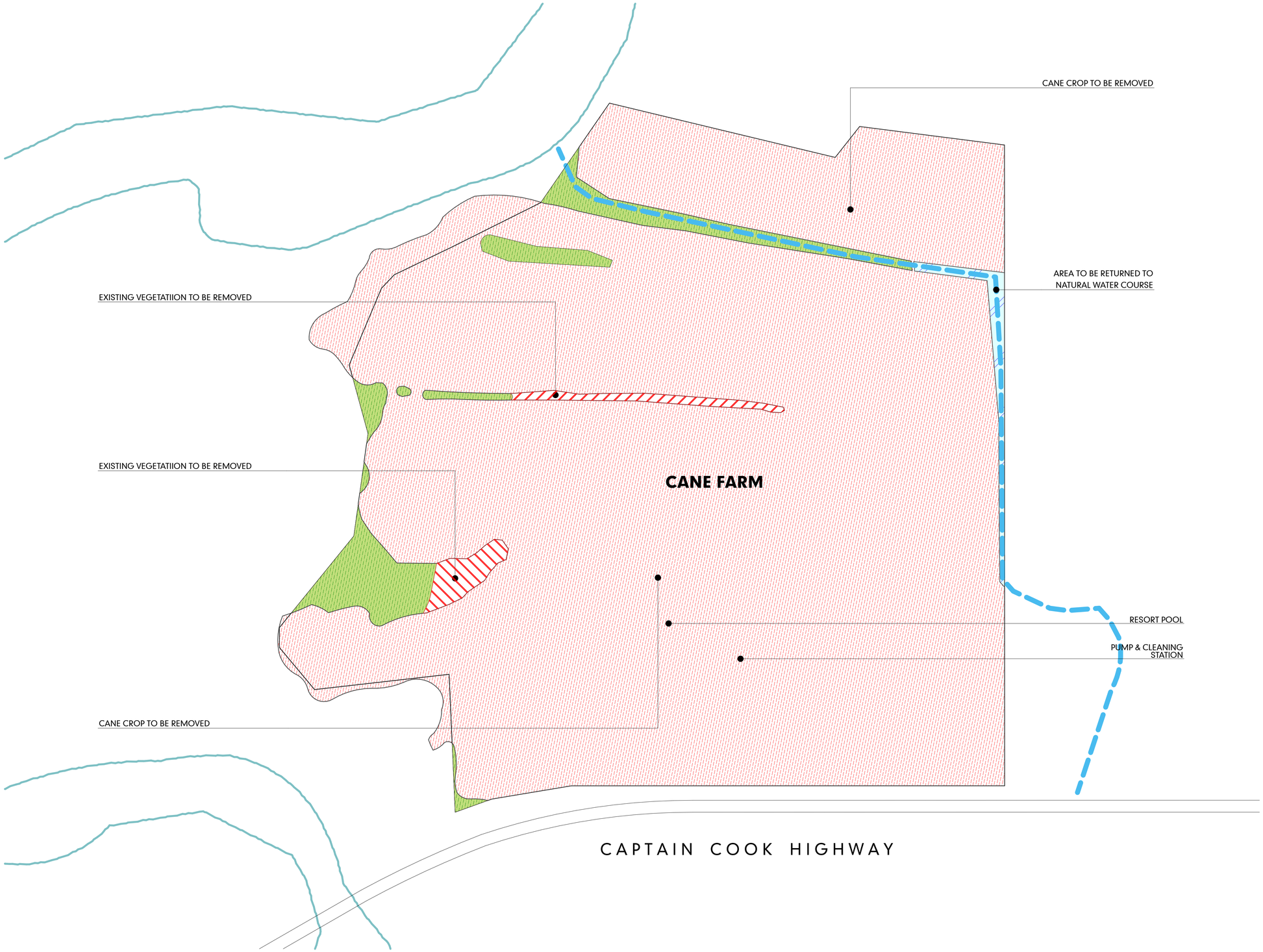
SCHEMATIC DESIGN
FOR : DAVID INGRABEN

MASTER PLAN DIAGRAMS
SURVEY - EXISTING CONDITIONS

N

PROJECT NO.	WAVE001
DRAWING NO.	DA-01.2
REVISION NO.	01
DATE	19/2/21

HUNT DESIGN



EXISTING SITE **01**
SCALE1:2000

100 EXISTING SITE		
TYPE	AREA	FILL
CANE	377,671	
CREEK	3,385	
EXISTING	18,402	
TO BE CLEARED	4,856	
	404,314 m²	

EXISTING SITE **100**
SCALE1:1

PRELIMINARY

PORT DOUGLAS WAVE PARK

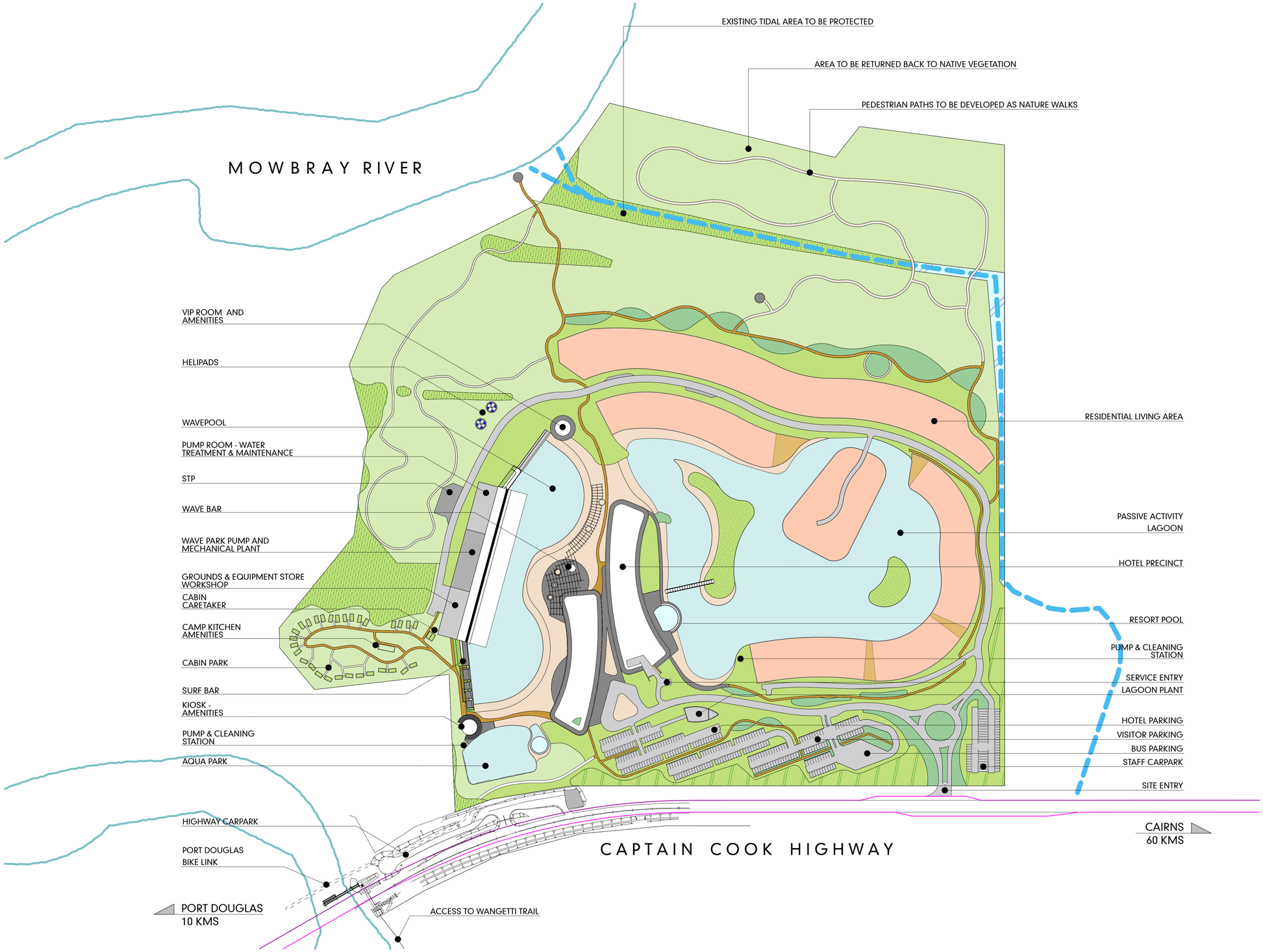
SCHEMATIC DESIGN
FOR : DAVID INGRABEN

MASTER PLAN DIAGRAMS
EXISTING SITE PLAN

N

PRELIMINARY
PROJECT NO. **WAVE001**
DRAWING NO. **DA-01.3**
REVISION NO. **01**
DATE **19/2/21**

HUNT DESIGN



MASTER PLAN **01**

SCALE1:2000

PORT DOUGLAS WAVE PARK

PRELIMINARY

SCHEMATIC DESIGN

FOR : DAVID INGRABEN

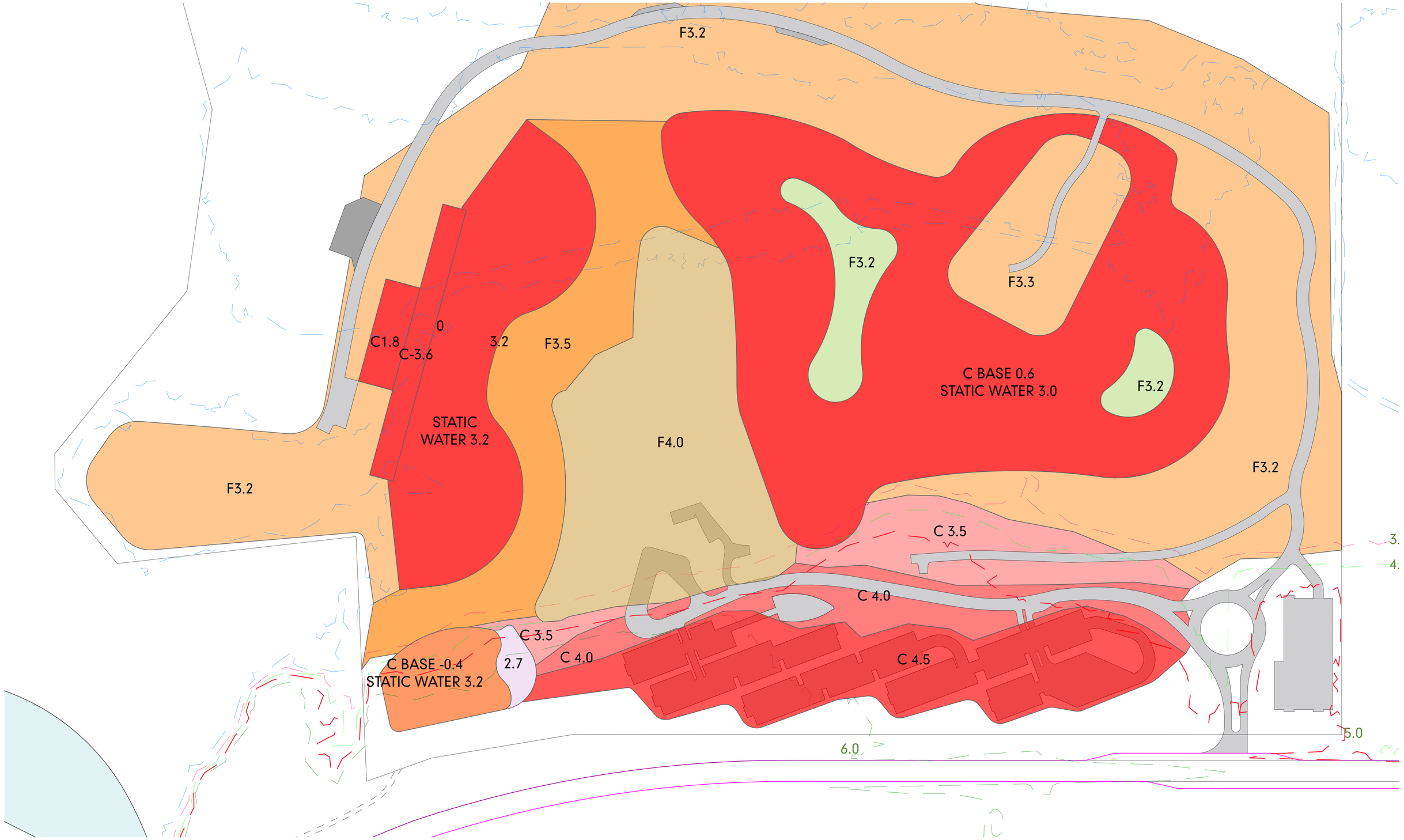
MASTER PLAN DIAGRAMS

MASTER PLAN

N

PRELIMINARY
PROJECT NO. **WAVE001**
DRAWING NO. **DA-01.4**
REVISION NO. **01**
DATE **19/2/21**

HUNT DESIGN



SITE CUT FILL
SCALE1:1000

2.

PRELIMINARY

PORT DOUGLAS WAVE PARK

SCHEMATIC DESIGN
FOR : DAVID INGRABEN

MASTER PLAN DIAGRAMS
SITE CUT - FILL DIAGRAM

N

PRELIMINARY	
PROJECT NO.	WAVE001
DRAWING NO.	DA-01.5
REVISION NO.	01
DATE	19/2/21

HUNT DESIGN

LANDSCAPE %

	Area	%
COASTAL LANDSCAPING / BEACH		
	705	0.18
	464	0.12
	450	0.11
	12	0.00
	27	0.01
	297	0.07
	4	0.00
	629	0.16
	1,427	0.35
	5,631	1.40
	538	0.13
	1,630	0.41
	1,091	0.27
	2,649	0.66
	15,557 m²	3.87
EXISTING		
	6,304	1.57
	2,174	0.54
	1,135	0.28
	401	0.10
	7,441	1.86
	161	0.04
	647	0.16
	119	0.03
	18,402 m²	4.58
GARDEN		
	131	0.03
	1,057	0.26
	261	0.06
	707	0.18
	14	0.00
	92	0.02
	835	0.21
	41	0.01
	288	0.07
	378	0.09
	45	0.01
	432	0.11
	385	0.10
	418	0.10
	747	0.19
	1,744	0.43
	459	0.11
	90	0.02
	200	0.05
	17	0.00
	136	0.03
	726	0.18
	72	0.02
	79	0.02
	26	0.01
	228	0.06
	338	0.08
	270	0.07
	181	0.04
	150	0.04
	447	0.11
	10,994 m²	2.73
GRASS		
	1,470	0.18
	5,071	1.26
	299	0.07
	9,816	2.44
	3,337	0.83
	1,255	0.31
	3,899	0.97
	1,924	0.48
	4,147	1.03
	930	0.23
	32,149 m²	7.99
ISLAND		
	5,649	1.40
	3,206	0.80
	1,276	0.32
	17	0.00
	4,484	1.12
	14,632 m²	3.64
RE-VEGETATION		
	21,909	5.45
	649	0.16
	22,966	5.71
	17,960	4.47
	12,187	3.03
	544	0.14
	8,705	2.16
	2,556	0.64
	9,075	2.26
	24,581	6.11
	1,519	0.38
	1,265	0.31
	655	0.16
	10,929	2.72
	135,478 m²	33.69
TREE BUFFER		
	5,253	1.31
	2,600	0.65
	7,853 m²	1.95
TROPICAL PLANTER		
	7	0.00
	1,388	0.35
	114	0.03
	10	0.00
	16	0.00
	17	0.00
	2	0.00
	19	0.00
	27	0.01
	102	0.03
	116	0.03
	93	0.02
	8	0.00
	1,908 m²	0.47
	236,971 m²	**58.93**

LANDSCAPE AREAS

Name	Area	Plan
COASTAL LANDSCAPING / BEACH	15,557	
EXISTING	18,402	
GARDEN	10,994	
GRASS	32,149	
ISLAND	14,632	
RE-VEGETATION	135,478	
TREE BUFFER	7,853	
TROPICAL PLANTER	1,908	
	236,971 m²	

LANDSCAPE TOTALS **100**
SCALE1:1

SITE VEGETATION **2.**
SCALE1:2000

PRELIMINARY

PORT DOUGLAS WAVE PARK

SCHEMATIC DESIGN
FOR : DAVID INGRABEN

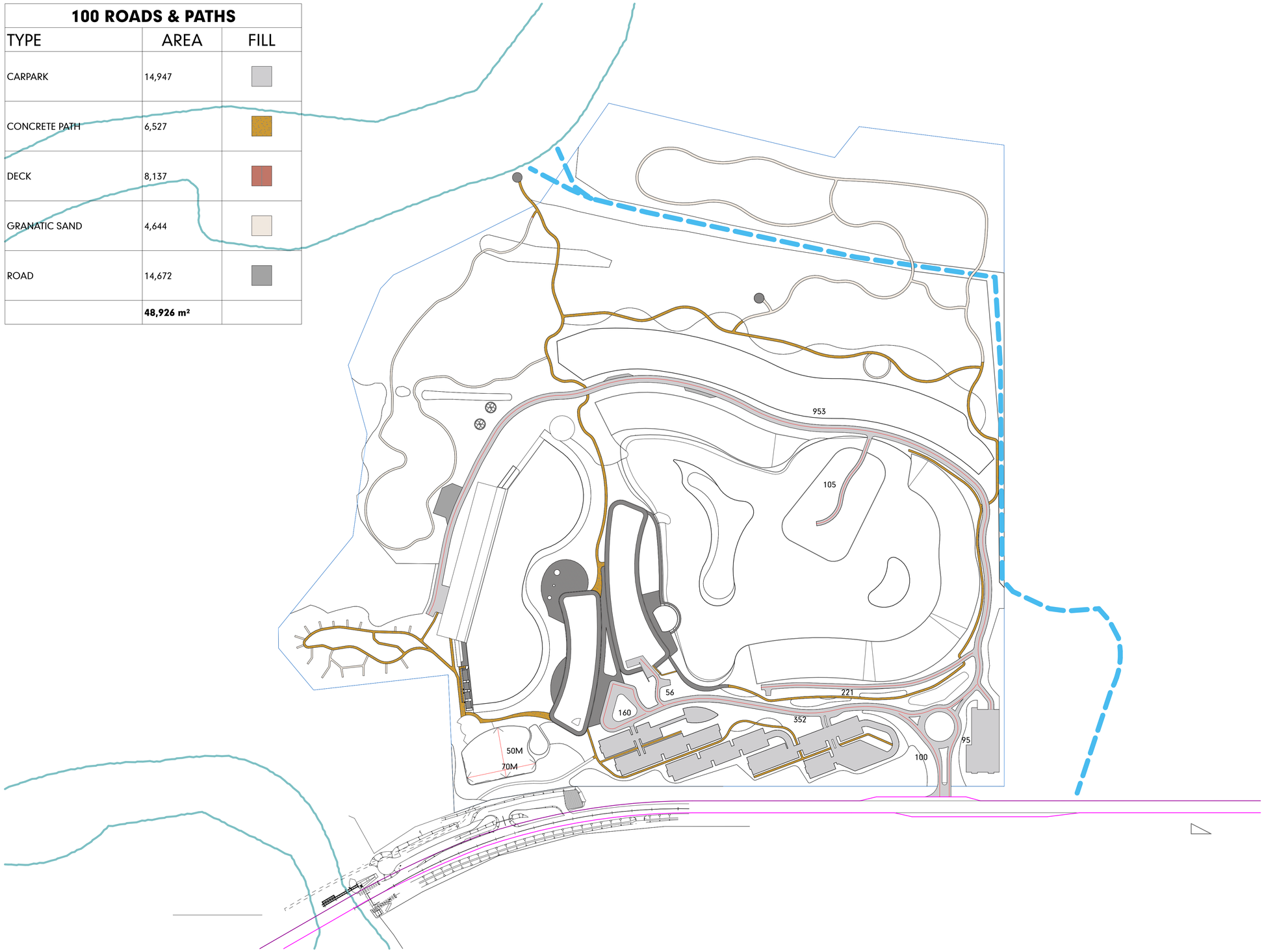
MASTER PLAN DIAGRAMS
SITE - LANDSCAPE AREAS

N

PRELIMINARY
PROJECT NO. **WAVE001**
DRAWING NO. **DA-01.6**
REVISION NO. **01**
DATE **19/2/21**

HUNT DESIGN

100 ROADS & PATHS		
TYPE	AREA	FILL
CARPARK	14,947	
CONCRETE PATH	6,527	
DECK	8,137	
GRANATIC SAND	4,644	
ROAD	14,672	
	48,926 m²	



Element Information

Last Selection

All Selected

Information Content:

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Length = 159,059 mm

Polyline
Length = 56,370 mm

Polyline
Length = 325,462 mm

Polyline
Length = 99,606 mm

Polyline
Length = 94,933 mm

Polyline
Length = 953,941 mm

Polyline
Length = 105,483 mm

Polyline
Length = 221,058 mm

SITE ROADS AND PATHS **2.**
SCALE1:2000

PRELIMINARY

PORT DOUGLAS WAVE PARK

SCHEMATIC DESIGN
FOR : DAVID INGRABEN

MASTER PLAN DIAGRAMS
SITE - ROADWAYS

N

PROJECT NO.	**WAVE001**
DRAWING NO.	**DA-01.7**
REVISION NO.	**01**
DATE	**19/2/21**

HUNT DESIGN

	CRYSTAL LAGOON
Surface Area	43,498.4 m²
Volume	97,668 m³
AV Depth	2,400 mm

	WAVE PARK
Surface Area	15,312.5 m²
Volume	11,841 m³
AV Depth	3,500 mm

	WATERPARK
Surface Area	3,182.3 m²
Volume	10,140 m³
AV Depth	3,600 mm

	KIDS SPLASH
Surface Area	397.5 m²
Volume	198 m³
AV Depth	500 mm

	RESORT POOL
Surface Area	484.7 m²
Volume	769 m³
AV Depth	1,600 mm

WATER VOLUMES

WATER BODY	VOLUME	AREA	FILL	NOTE
CRYSTAL LAGOON	97,668	43,498		
KIDS SPLASH	198	398		
RESORT POOL	769	485		
WATERPARK	10,140	3,182		
WAVE PARK	11,841	15,312		Total Water Surface area (Static): 12,429m²
	120,615 m³	**62,875 m²**		

SITE WATER VOLUME **2.**
SCALE1:2000

PORT DOUGLAS WAVE PARK

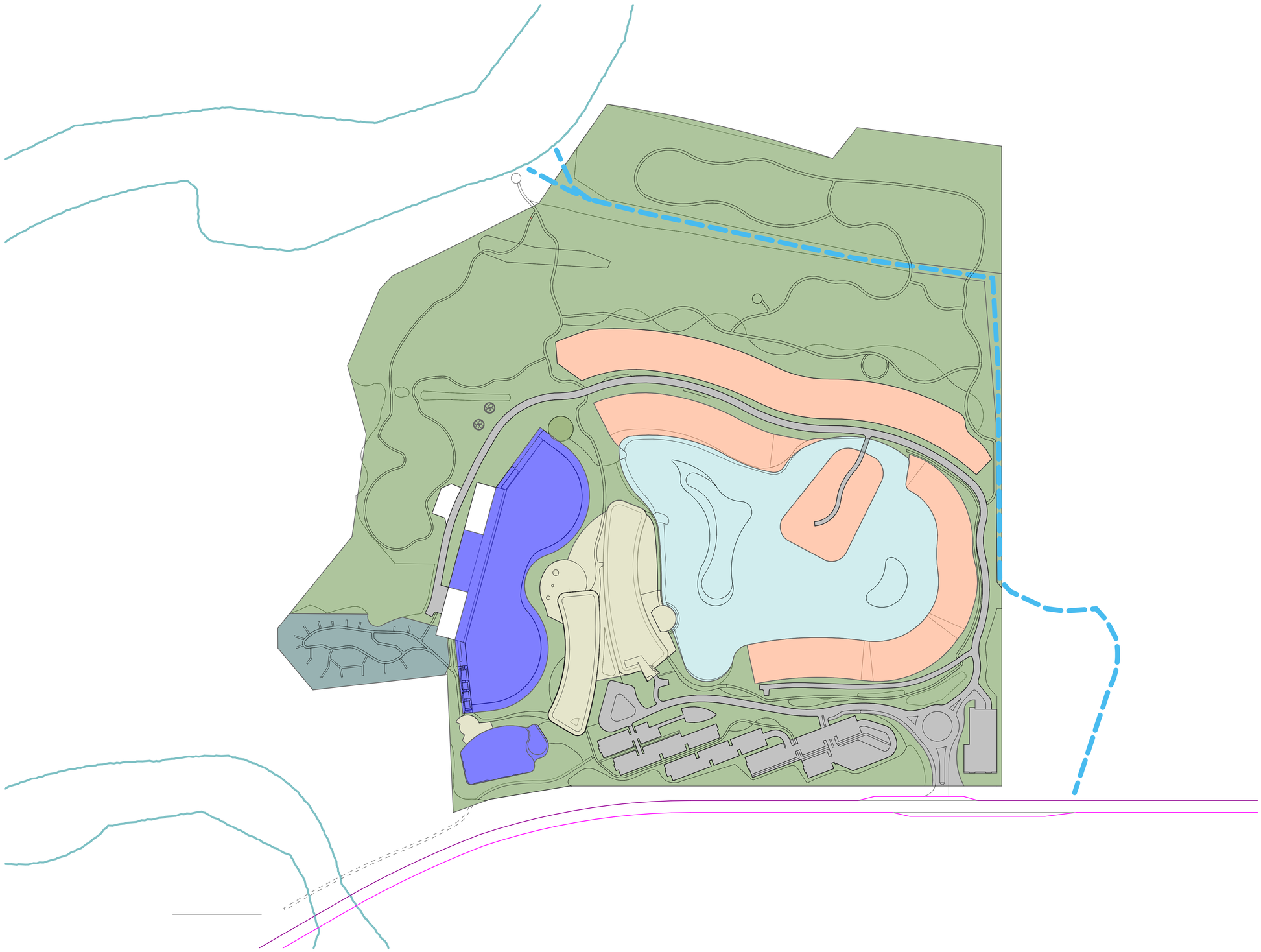
PRELIMINARY

SCHEMATIC DESIGN
FOR : DAVID INGRABEN

MASTER PLAN DIAGRAMS
SITE - WATER VOLUMES

PRELIMINARY
PROJECT NO. **WAVE001**
DRAWING NO. **DA-01.8**
REVISION NO. **01**
DATE **19/2/21**

HUNT DESIGN



SITE RESIDENTIAL AREA PLAN **2.**
SCALE1:2000

PRELIMINARY

PORT DOUGLAS WAVE PARK

SCHEMATIC DESIGN
FOR : DAVID INGRABEN

MASTER PLAN DIAGRAMS
SITE - RESIDENTIAL AREA PLAN

N

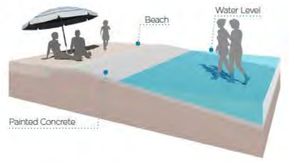
PROJECT NO.	WAVE001
DRAWING NO.	DA-01.9
REVISION NO.	01
DATE	19/2/21

HUNT DESIGN

LAGOON EDGE **2.**
SCALE1:1000

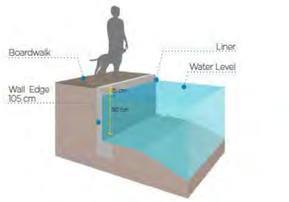
BEACH ACCES PAINTED CONCRETE SECTION

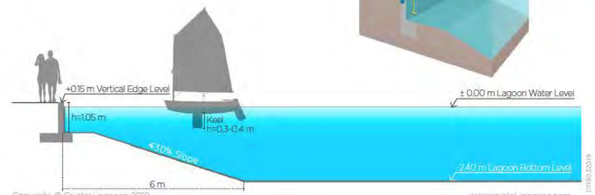
This solution creates a more seamless transition into the water. It is generally more expensive than the liner solution and paint maintenance may be required.)



MEDIUM VERTICAL EDGE SECTION

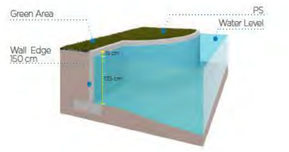
Recommended for lagoons larger tan 2.5 ha.
This depth allows for sailing vessels with keels.





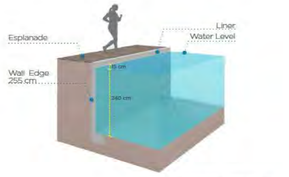
VERTICAL EDGE PERIMETER STRUCTURE (PS)

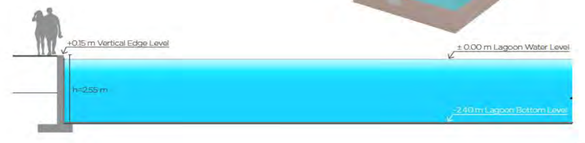
A 1.5 meter concrete wall used where the PS is located. This is the point where the majority of lagoon maintenance and cleaning systems are installed.



LONG VERTICAL EDGE SECTION

This solution is used in narrow stretches of lagoon and certain islands. It can also be specifically requested by the client for special uses and/or where there is insufficient space to achieve the signature turquoise water color with traditional slope solutions.





PORT DOUGLAS WAVE PARK

PRELIMINARY

SCHEMATIC DESIGN
FOR : DAVID INGRABEN

MASTER PLAN DIAGRAMS
SITE - LAGOON EDGE

N

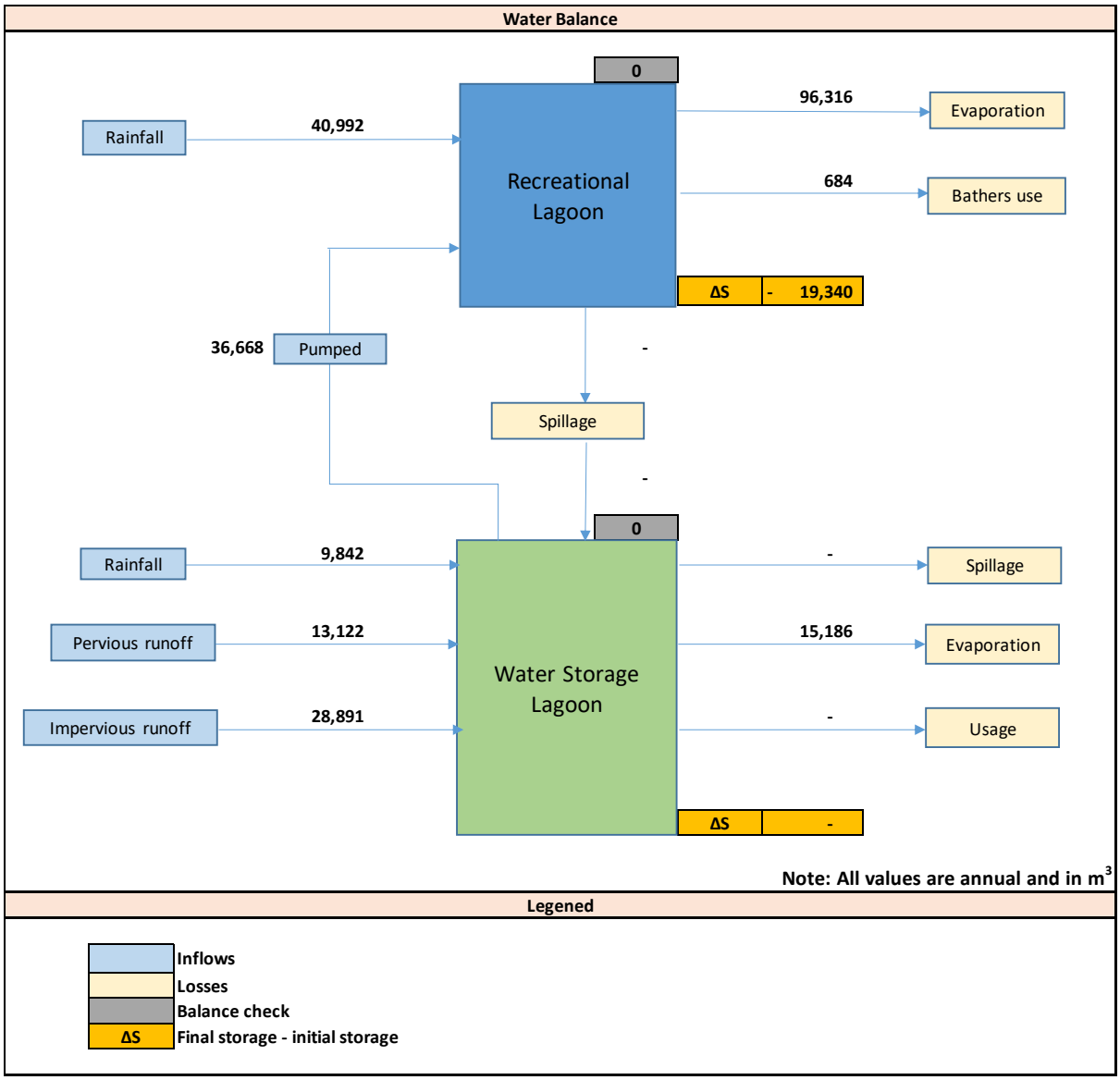
PROJECT NO.	**WAVE001**
DRAWING NO.	**DA-01.10**
REVISION NO.	**01**
DATE	**19/2/21**

HUNT DESIGN

Memorandum

Appendix B - Water Balance Results for different scenarios

Driest Year



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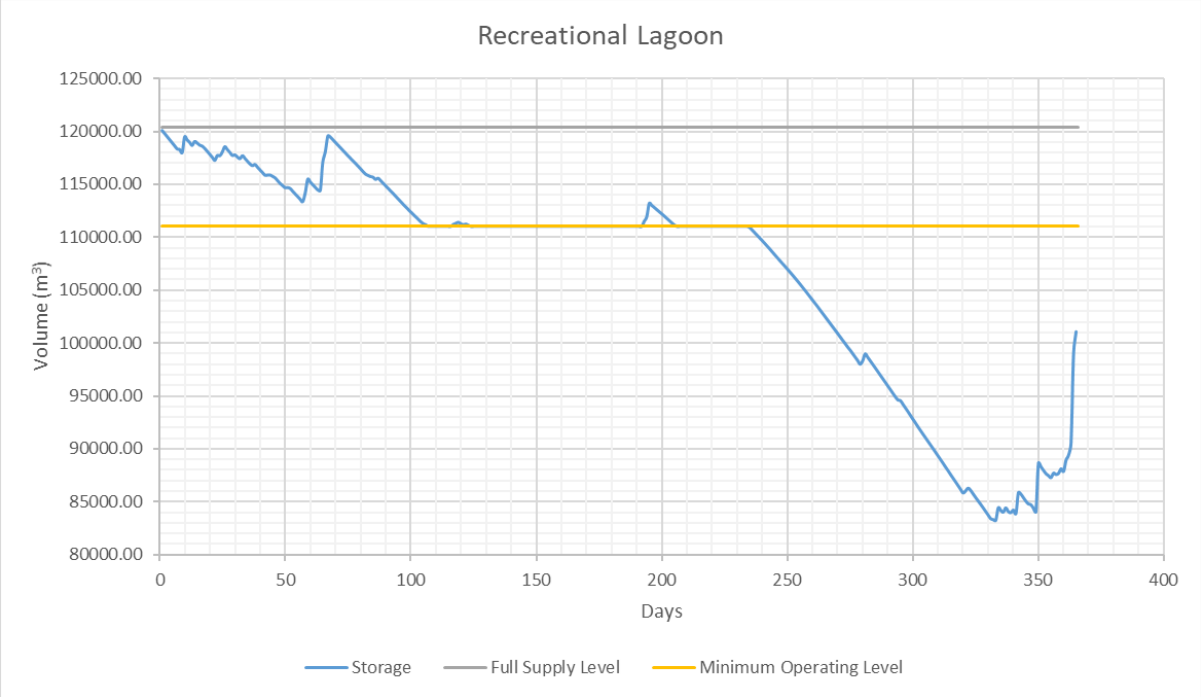

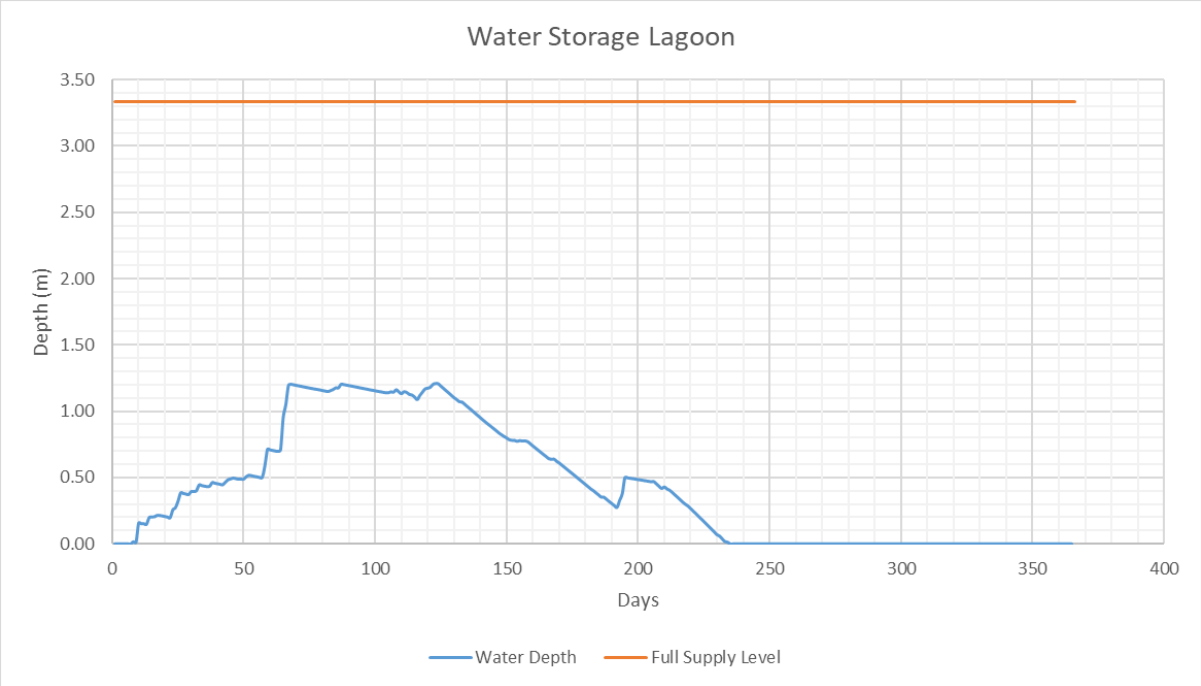

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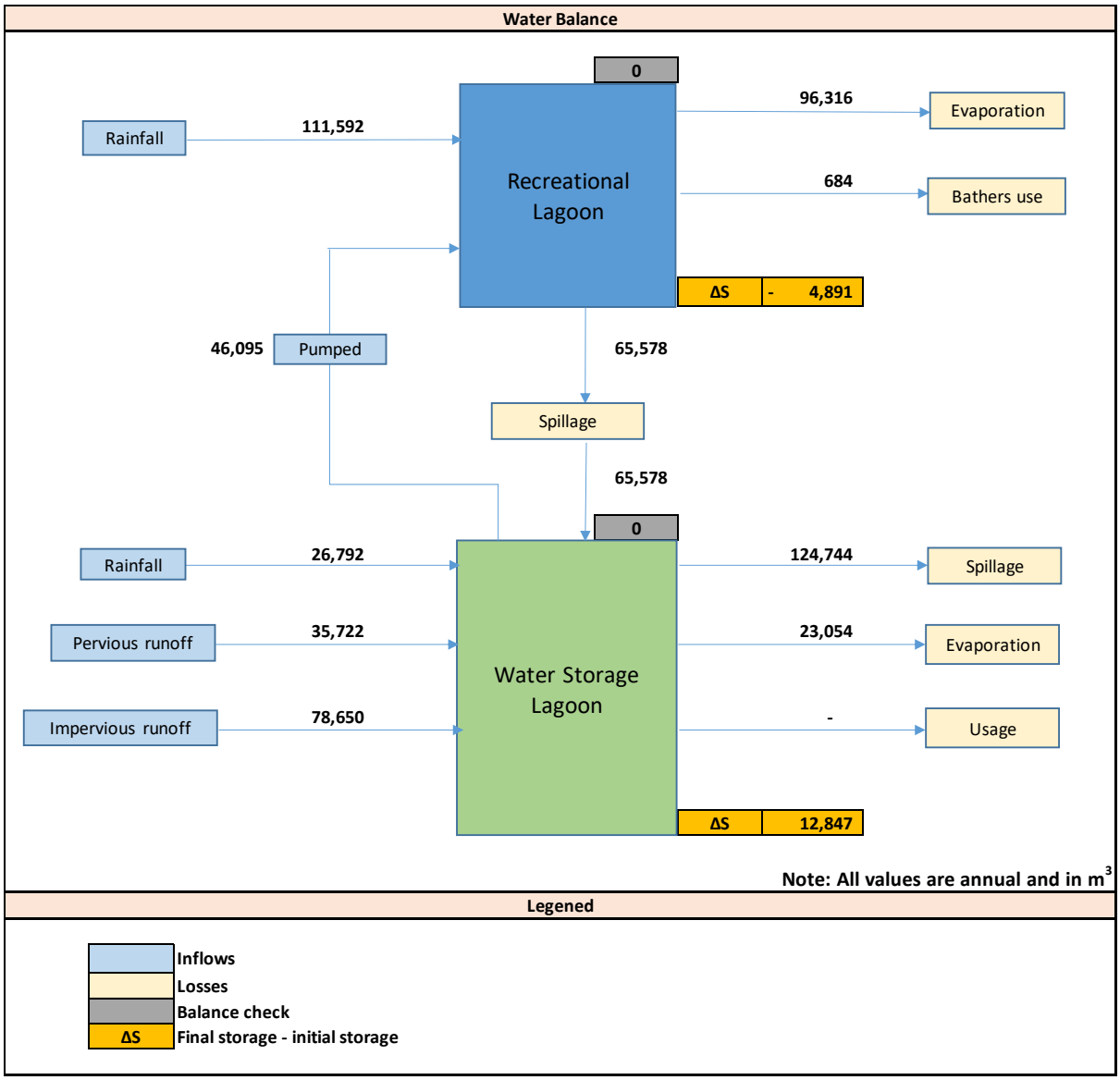
Median Year



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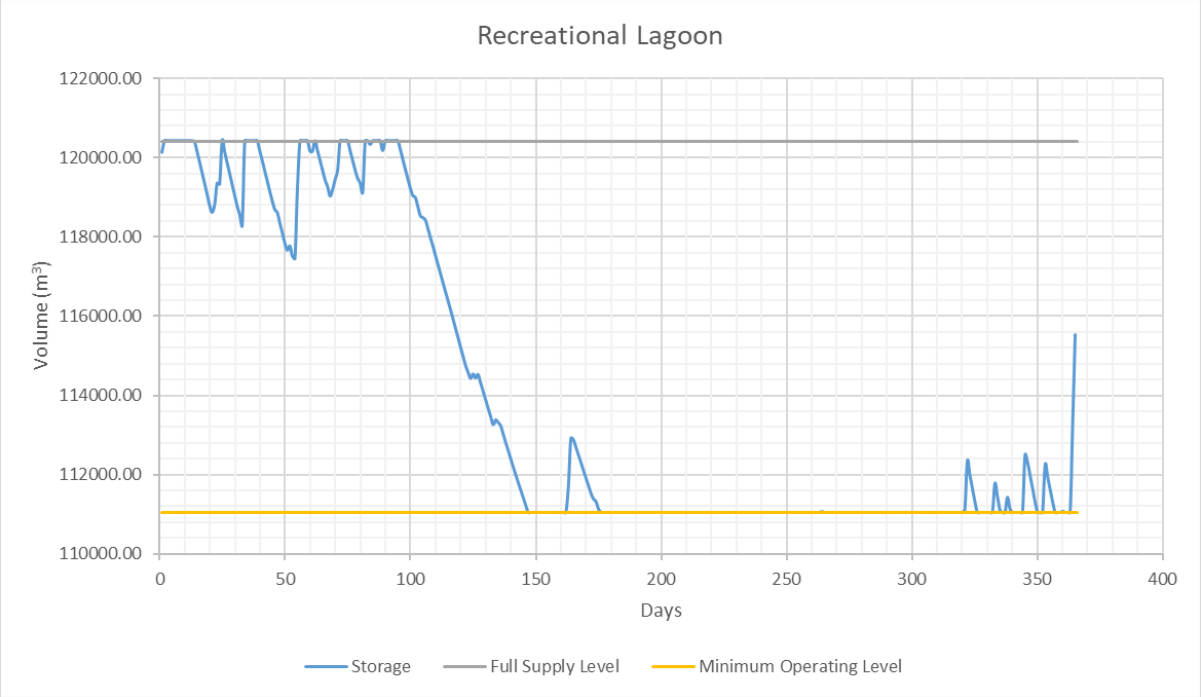

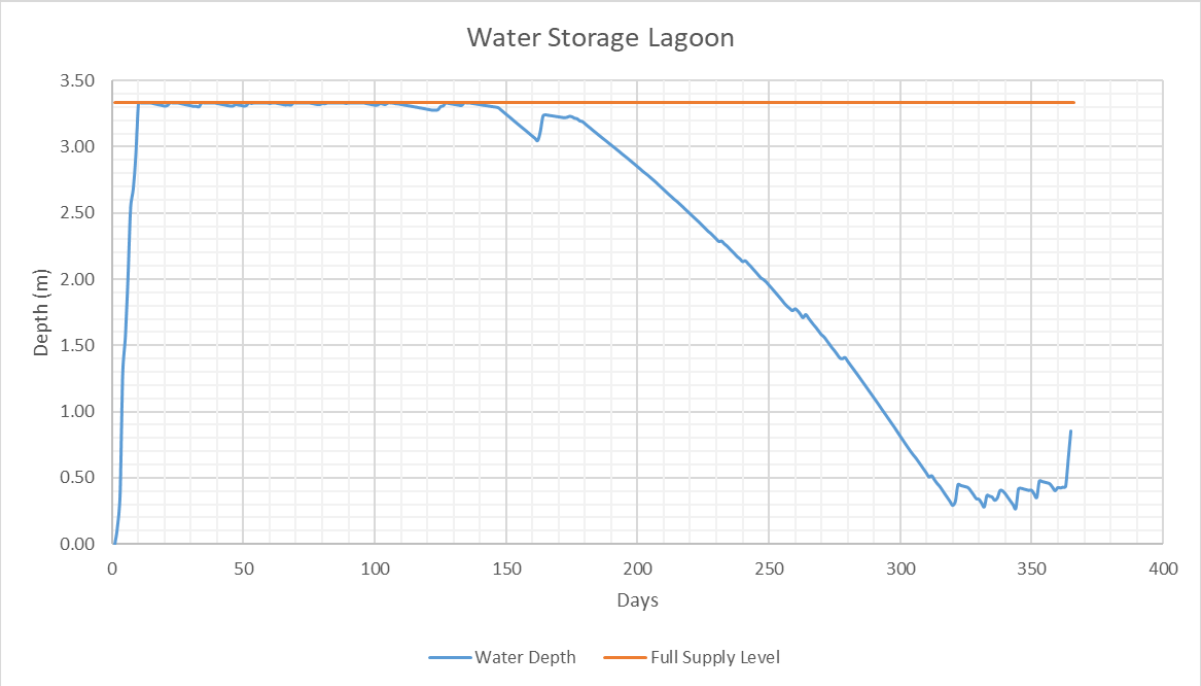

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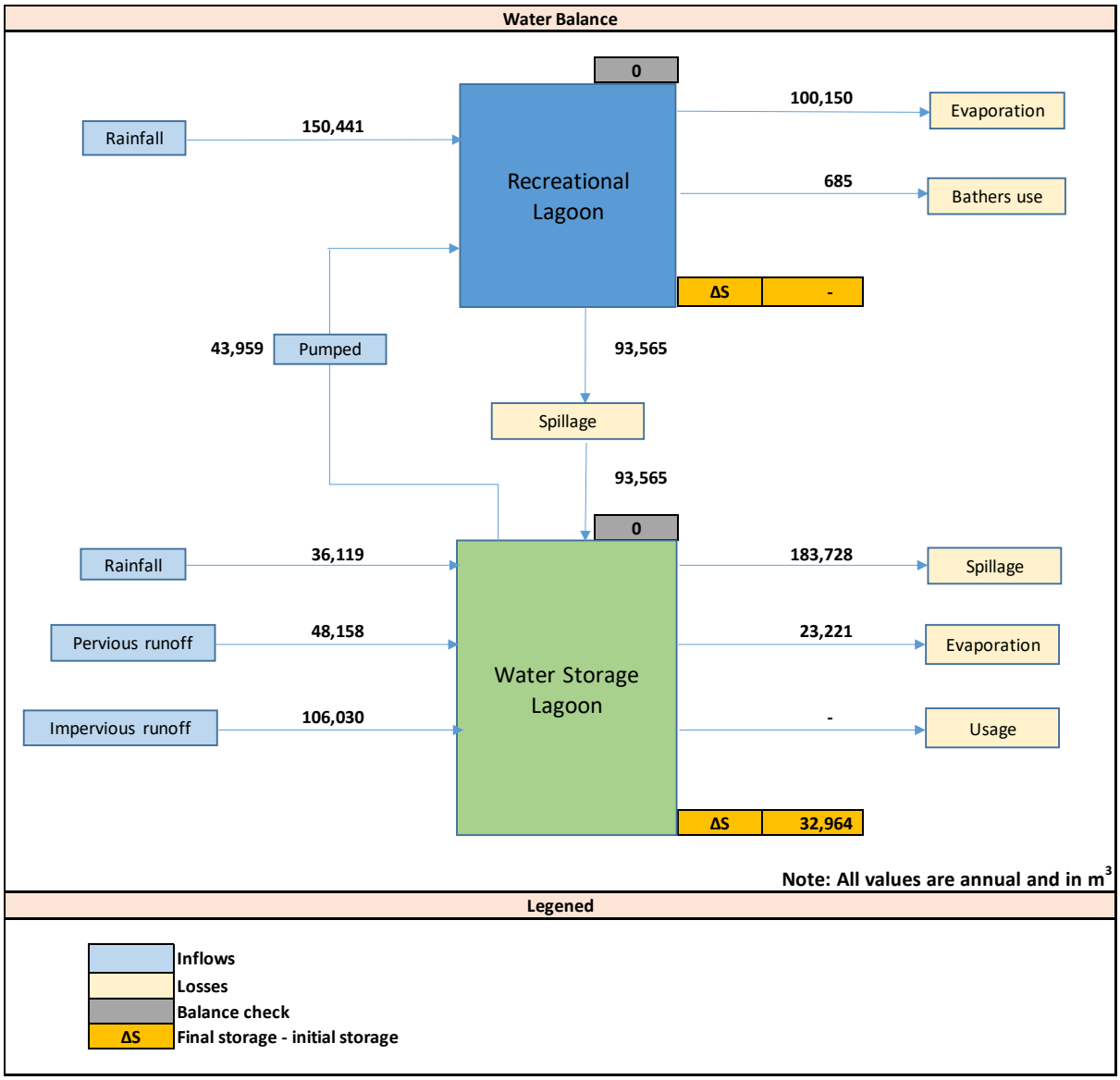
85th percentile Wettest Year



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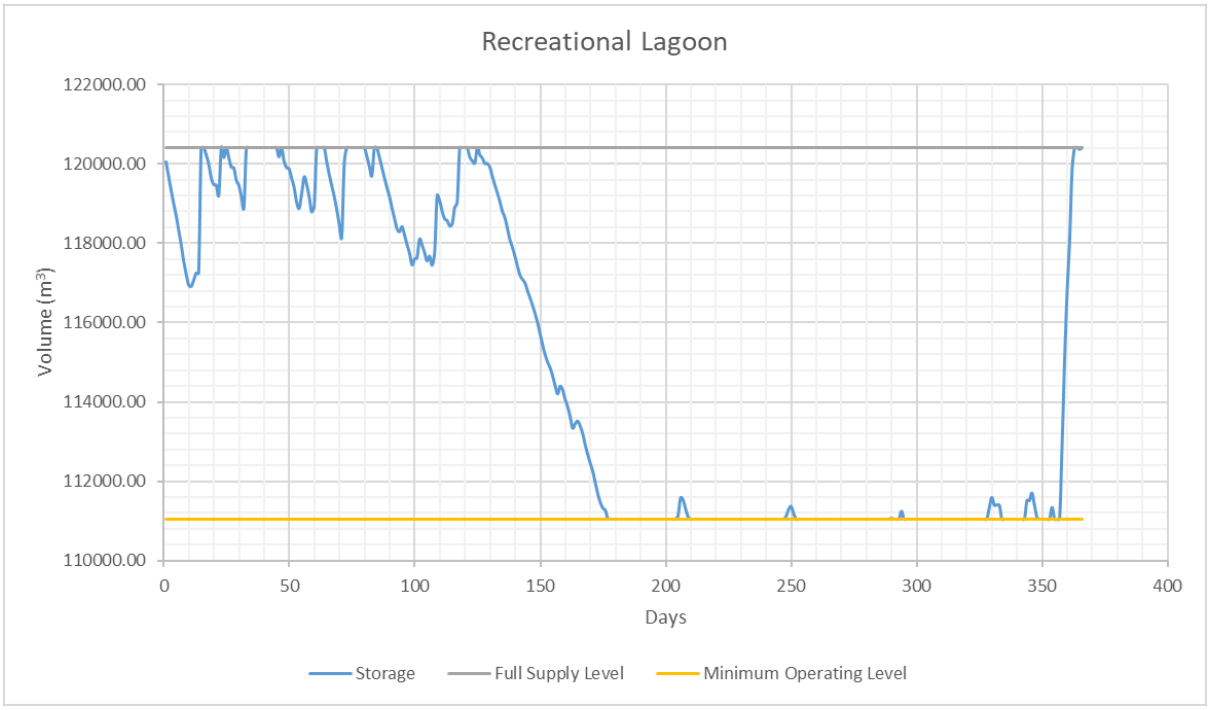

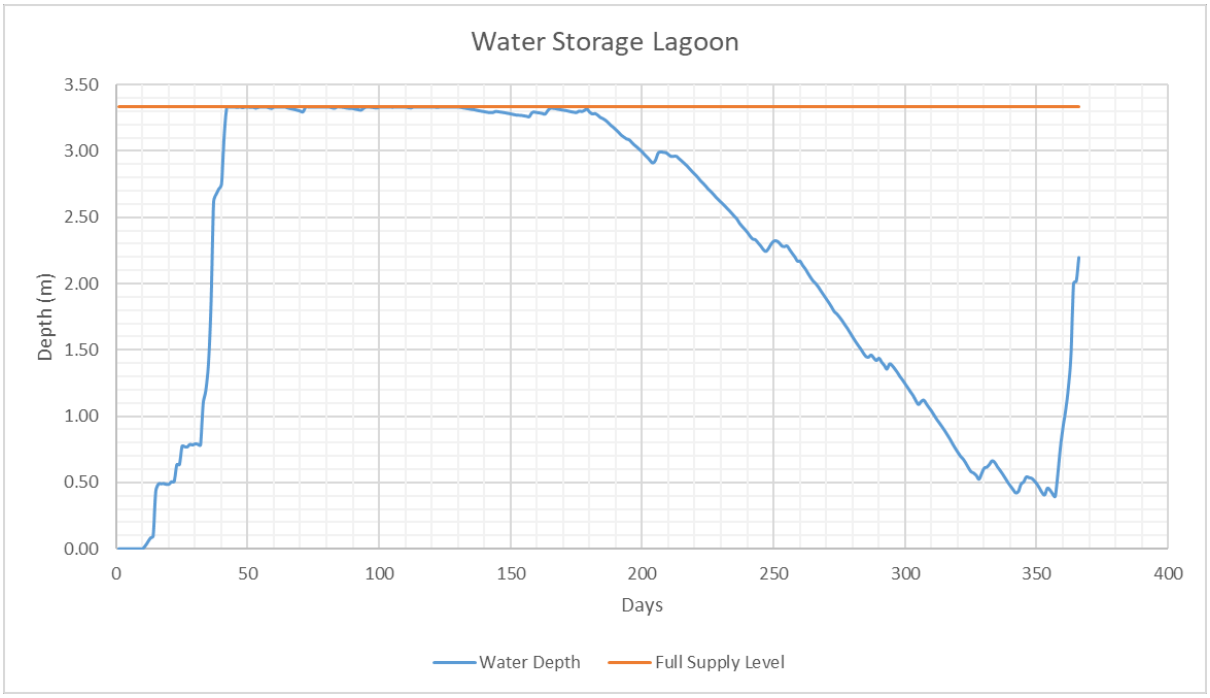

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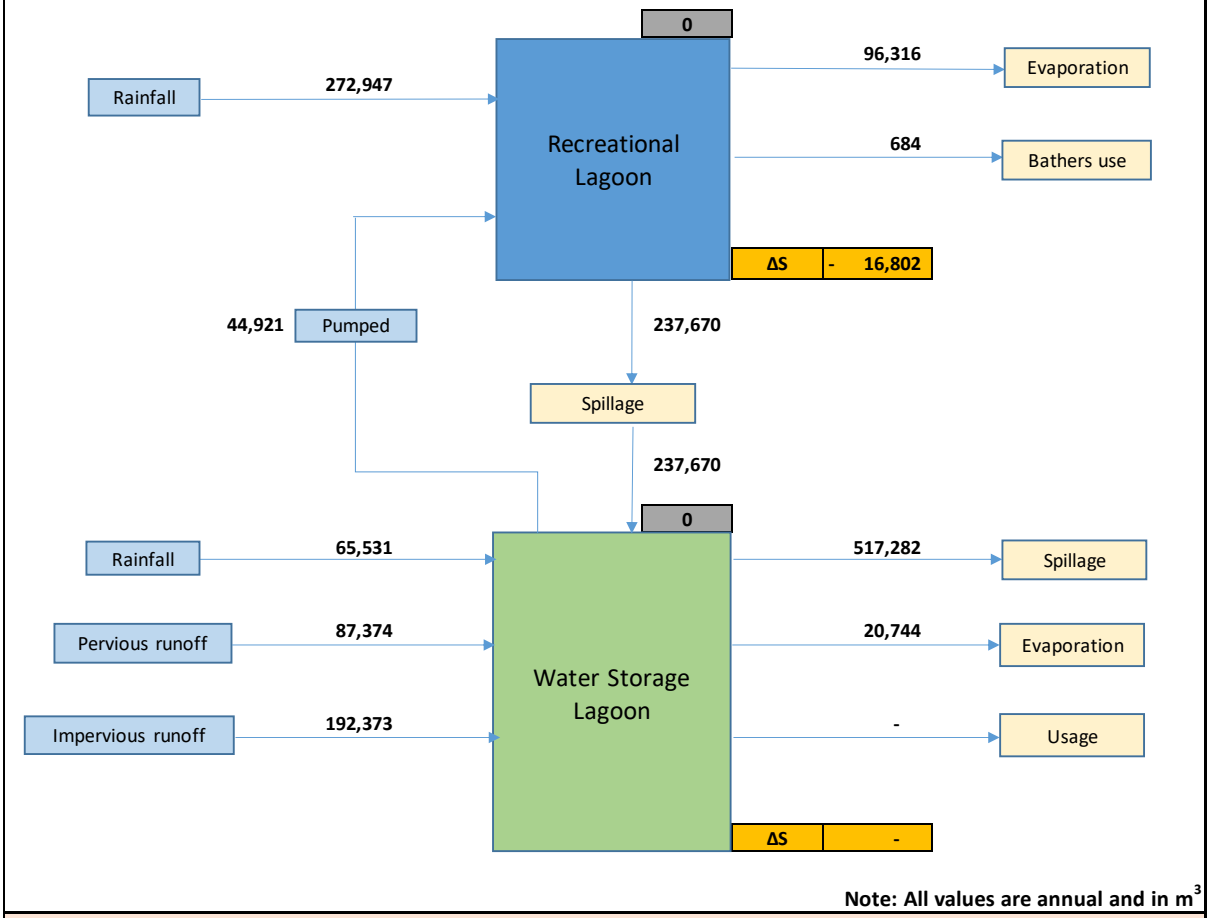
Wettest Year

Water Balance



Note: All values are annual and in m^3

Legened

	Inflows
	Losses
	Balance check
ΔS	**Final storage - initial storage**

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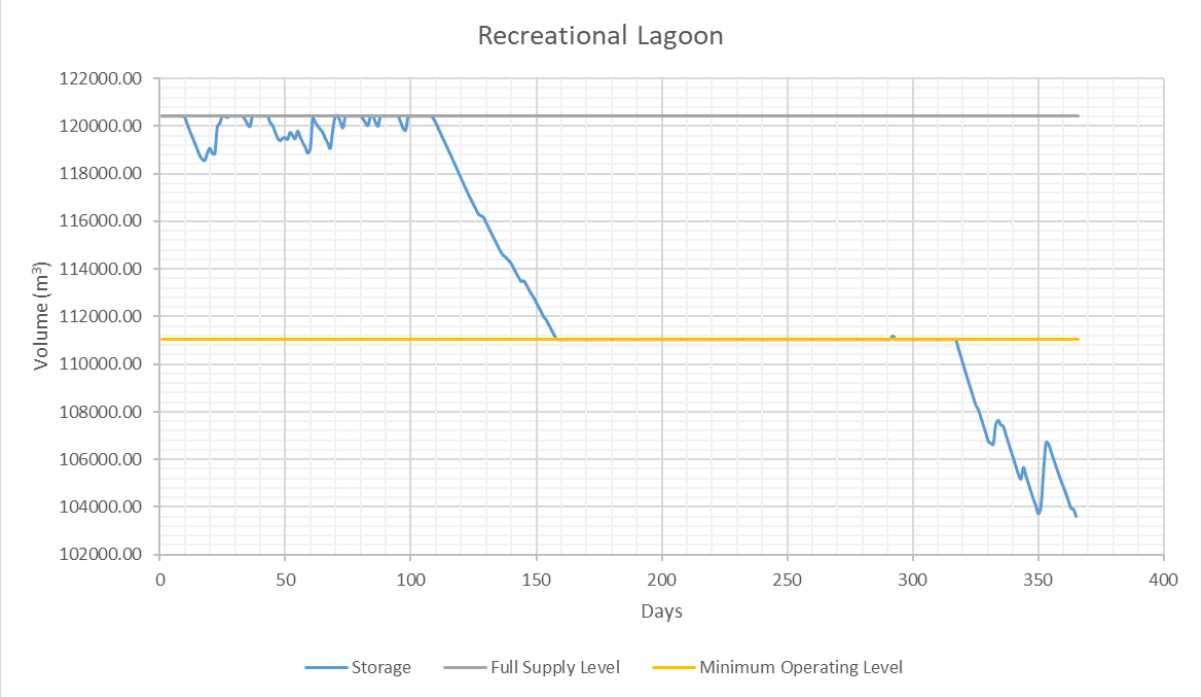

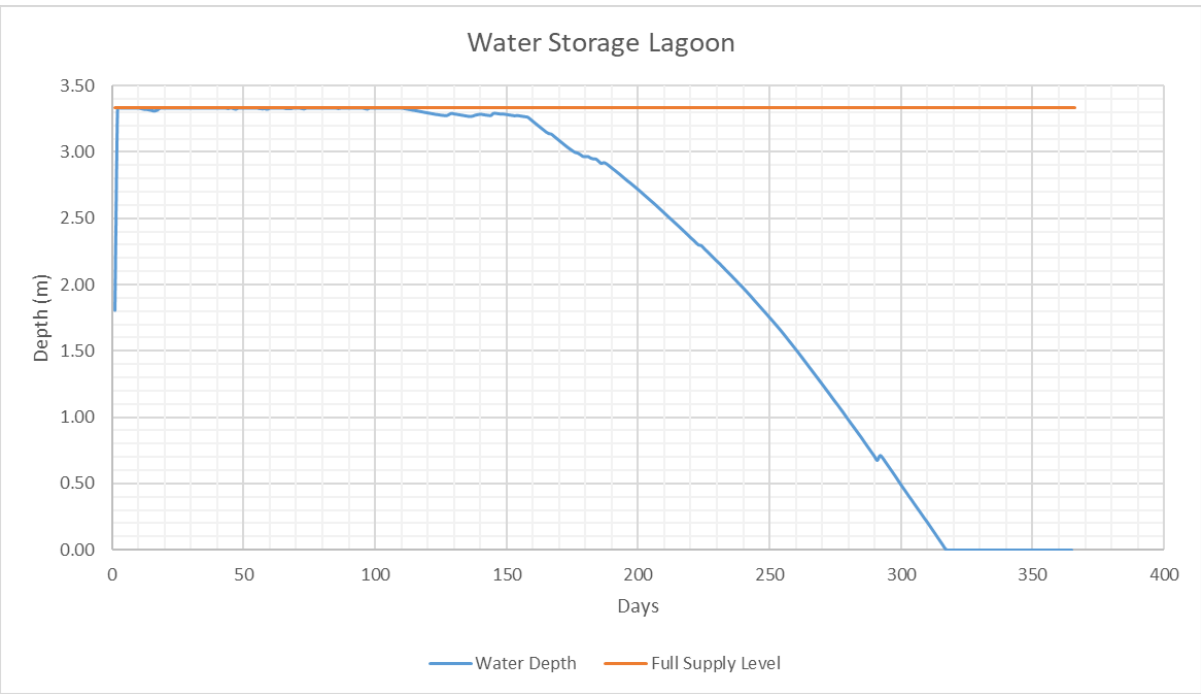

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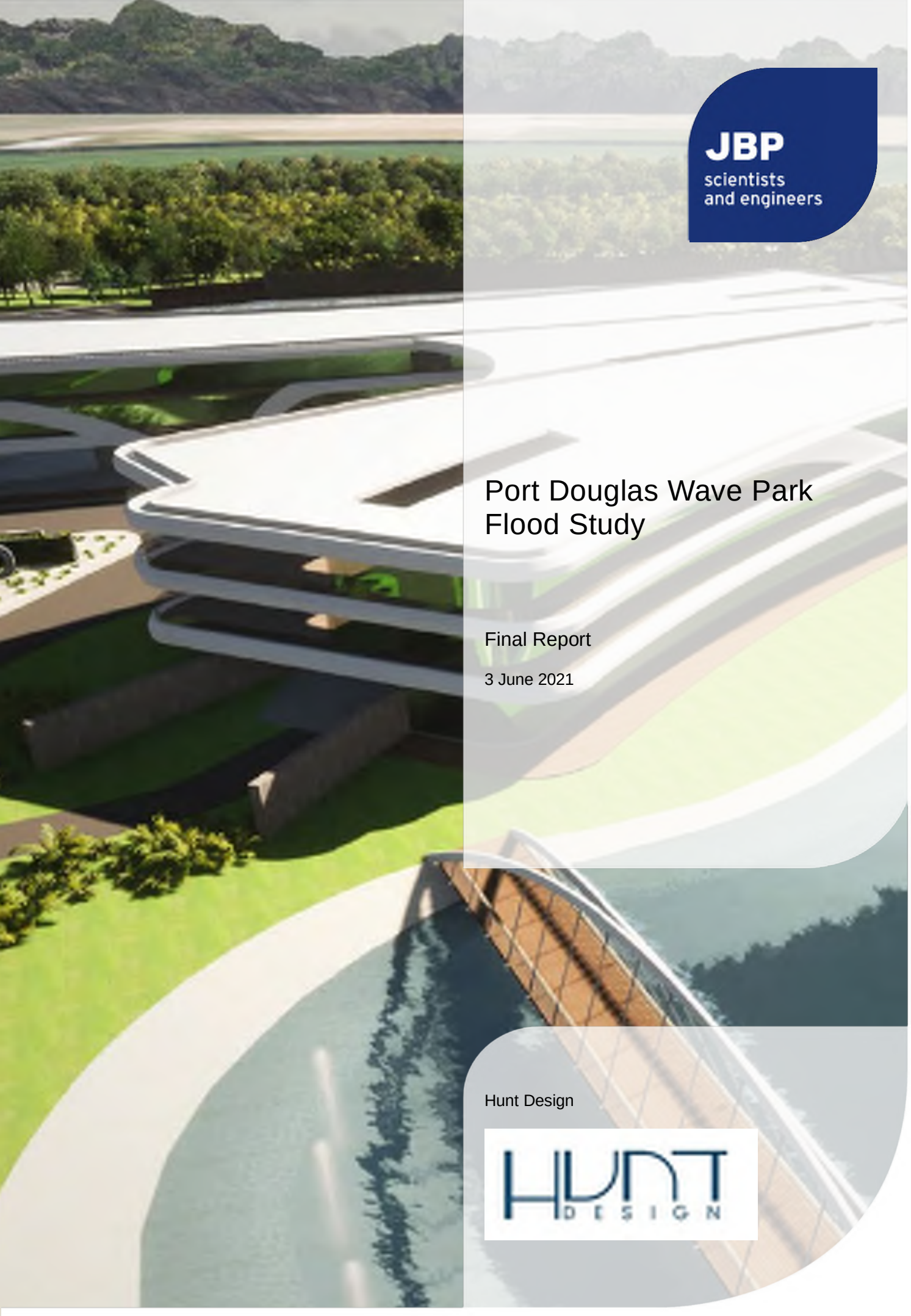
Appendix D – Flood Study (JBP)



JBP
scientists
and engineers

Port Douglas Wave Park Flood Study

Final Report

3 June 2021

Hunt Design

HUNT DESIGN

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Revision History

Revision Ref / Date Issued	Amendments	Issued to
S3-P01 / March 2021		JR
S4-P01 / April 2021		JR
A1-C01 / June 2021		JR

Contract

This report describes work commissioned by Jarrod Ryan on behalf of Hunt Design, Dr Ellie Vahidi of JBP carried out this work.

Prepared by .....Dr Ellie Vahidi PhD, MEng, BEng
Hydraulic Engineer

Reviewed and approved by .....William Prentice BEng, MIEAust, CPEng, NER, FMA
Technical Director

Purpose

Jeremy Benn Pacific ("JBP") has prepared this report for the sole use of Hunt Design (the “Client”) and its appointed agents in accordance with the Agreement under which our services were performed.

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The conclusions and recommendations contained in this report are based upon information provided by others and upon the assumption that all relevant information has been provided by those parties from whom it has been requested and that such information is accurate. Information obtained by JBP has not been independently verified by JBP, unless otherwise stated in the report.

The methodology adopted and the sources of information used by JBP in providing its services are outlined in this report. The work described in this report was undertaken between February 2021 to March 2021 and is based on the conditions encountered and the information available during this period of time. The scope of this report and the services are accordingly factually limited by these circumstances.

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Executive Summary

JBPacific were commissioned by Hunt Design to deliver hydrological and hydraulic modelling within the Mowbray River catchment, to support the proposed integrated development of a recreational 'wave park', at Lot 123 on SR687, located 5km south of Port Douglas on the Captain Cook Highway.

An URBS hydrological model was developed estimate rainfall-runoff and streamflow in the Mowbray River catchment. Design flood estimation for the 1% Annual Exceedance Probability (AEP) flood event was completed to provide inflow hydrograph information to the hydraulic modelling.

The hydrodynamic modelling software TUFLOW using its 'Classic' engine was adopted as the basis of the hydraulic analysis. An existing TUFLOW model, developed for Douglas Shire Council as part of the draft Storm Tide Inundation Methodologies Study (JBPacific, 2020) project, was available as basis for modelling the proposed development. The TUFLOW model was modified to ensure that it appropriately simulated river flooding in the vicinity of the proposed development.

The hydraulic modelling was run to simulate both the existing catchment conditions and the post-development scenario. The results of the hydraulic modelling indicate flood impacts are restricted to the portion of the floodplain downstream of the Captain Cook Highway, Mowbray.

Results of the flood study demonstrate:

- The largest flood level impacts are evident to the west (upstream) side of the site between the proponents land and the Highway. The maximum afflux in this location is 183mm, however this is on State-owned conservation land and as such, the flood impacts are not anticipated to result in adverse impacts to people or property.
- There is only a minor increase in inundation extent, to the north of the site on the opposite bank to the proposed development. The minor increase in flood liable land is generally restricted to property zoned for rural uses and a review of available aerial imagery does not indicate the increase in flooded area will impact any existing dwellings in the lower catchment.
- The maximum impact on residential property is 18mm. It should be noted that whilst this land is zoned as low density residential in the Douglas Planning Scheme 2018, aerial imagery indicates it is currently vegetated, undeveloped land. Additionally, flood impacts are limited to an existing low-laying area of lot, which represents approximately 2% of the total lot area.
- Maximum flood impacts on rural land external of the proponents land is 37mm, which is located opposite the proposed development on agricultural land. An increase of 37mm is not expected to adversely affect the existing land owners ability to farm the land.
- Analysis of velocity afflux was conducted to demonstrate the impact the proposed development has on the flood velocity compare to the existing case. There are some increases in flood velocity within the proposed development site (up to 0.5 m/s); however, the maximum velocity change external of the site is less than 0.2 m/s.
- The supplied concept earthwork plan shows the total cut and fill volumes of 165,200m^3 and 190,700 m^3 respectively, resulting in a nett fill of 25,500 m^3. If flood impacts are considered undesirable, reducing the nett fill volume, through further compensatory cut on the western side of the earthworks area will likely reduce post development peak flood levels.

The proposed development has been shown to result in localised increases to 1%AEP peak flood levels external of the site. The maximum afflux of 183mm is located to the south-west of the site immediately adjacent to the proposed development between the site and the Captain Cook Highway. The flood impacts at the location are not considered to result in material nuisance as the lot is State-owned conservation land. The maximum impact to 1%AEP flood event peak water levels on existing residential lots is 18mm.

A 13% increase in nett fill (as a proportion of total proposed fill) on the site is proposed, which will result in a decrease of floodplain storage. The placement (rather than nett volume) of the fill has the most significant impact on modelled post-development flood behaviour, specifically in the vicinity of the cabin/camping area. Filling in this location impacts the out-of-channel flood conveyance in the 1%AEP flood event.

Further modelling was undertaken to investigate if the addition of open channels through the cabin/camping grounds would improve floodplain conveyance and assess the potential benefit of adding a trapezoidal open channel in this location. The objective of testing these design iterations

was to determine if one or two channels - with an indicative 20 metre base, 1:4 sides and 500mm depth - would provide sufficient additional conveyance to compensate for the loss of floodplain conveyance arising from the proposed earthworks. The two design iterations were successful in reducing the maximum peak flood impacts, however they did not show material benefit in flood risk outcomes.

Whilst the design iterations were shown to improve floodplain conveyance and reduce flood level impacts in the post-development scenario, given the initial proposed design has been demonstrated to achieve acceptable flood risk outcomes outlined by the Douglas Planning Scheme, and the need for additional excavation and removal of vegetation to construct the channels, these design options may be contrary to the desired outcomes of the Planning Scheme in maintaining the protective function of existing vegetation.

The Douglas Planning Scheme does not provide a definition of 'acceptable flood impacts', so a risk assessment in line with ISO31000 has been undertaken to demonstrate the proposed development 'avoids an unacceptable increase in severity'. ISO31000 is the international standard for risk management, and defines risk as the consideration of the likelihood of a hazard occurring and the consequence when an event occurs.

The assessment of the potential for damage to other properties was based on the number of properties exposed to flood hazard given a specified likelihood. In this case, the Defined Flood Event of 1%AEP was analysed, with the number of properties at risk external of the development site shown in Table 7-1.

Table 1-1. Summary of at-risk properties by land use

Land Use	Count of properties within the 1%AEP flood extent	
	Existing	Post-development
Conservation	9	9
Environmental Management	1	1
Low Density Residential	1	1
Ocean	1	1
Rural	45*	45
Rural Residential	0	0
Special Purpose	1	1
Total	115	115

*Note: An additional rural property was counted in the existing conditions model on the eastern extremity of the hydraulic model. This was deemed to be an artifact of the flood model itself and was not considered to be a valid inclusion in comparison with post development property exposure.

The exposure analysis shows the existing catchment conditions and post-development catchment conditions result in the same number of properties at risk in the 1%AEP flood event, and as such the proposed development does not significantly increase the potential for damage on the site or other properties.

An analysis of flood hazard, using depth-velocity results from hydraulic modelling of the proposed development was undertaken to gain an understanding of the severity of flood hazard under pre and post development conditions. A comparison of existing and post-development flood hazard based on depth-velocity flood information, shows a minor increase in flood hazard within the channel immediately downstream of the Captain Cook Highway and negligible (+/-0.2m2/s) or minor reduction in depth-velocity product on all existing properties. A review of aerial imagery available from Google and NearMap, indicates there are currently no dwellings located within the mapped flood impact area. Figure 6-1. Comparison of existing and post development depth-velocity flood behaviour

The assessment of potential exposure to flooding and severity of flood hazards analysed using a risk-based approach consistent with ISO31000, which considers the likelihood of flooding and consequence of flooding hazard, has demonstrated the proposed development does not increase existing flood risk in an unacceptable manner.

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Abbreviations

AEP ..... Annual Exceedance Probability

AHD ..... Australian Height Datum

ARR ..... Australian Rainfall and Runoff guidelines 2019

BoM ..... Bureau of Meteorology

DEM ..... Digital Elevation Model

GBR ..... Great Barrier Reef

HAT ..... Highest Astronomical Tide

LiDAR ..... Light Distance and Ranging

JBP ..... Jeremy Benn Pacific or JBPacific

NDVI ..... Normalised Difference Vegetation Index

QLUMP ..... Queensland Land Use Mapping Program

URBS ..... Unified River Basin Simulator

1 Introduction

1.1 Background

JBPacific were commissioned by Hunt Design to deliver hydrological and hydraulic modelling within the Mowbray River catchment, to support the proposed integrated development of a recreational 'wave park', at Lot 123 on SR687, located 5km south of Port Douglas on the Captain Cook Highway.

The site is in located within the Mowbray River catchment which is approximately 115.7km^2. As shown in Figure 1-1, the Mowbray River is predominantly undeveloped with small areas of agricultural land located in the flatter, lower laying areas of the catchment and a coastal village along the coastline. The Mowbray River catchment falls in an easterly direction from its headwaters in the Mowbray National Park 10.5km to the west of the Captain Cook Highway to its outlet at Alexandra Reefs approximately 1 km downstream of the Highway.

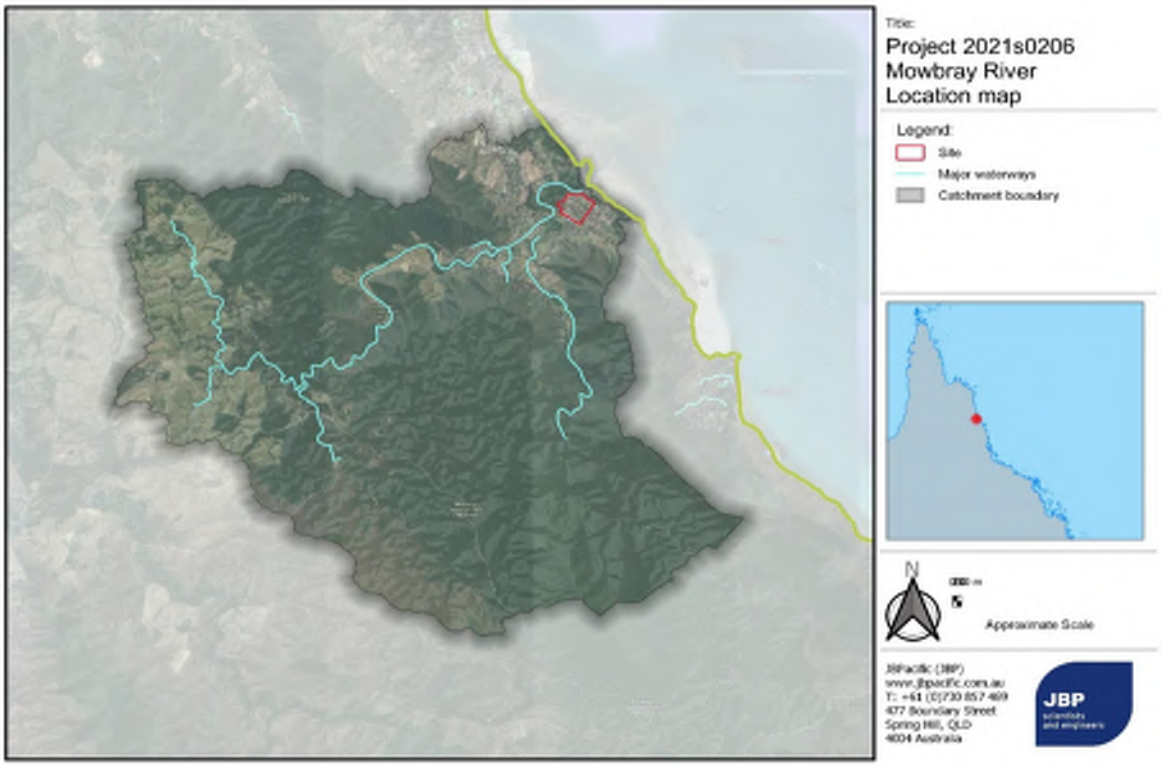

Figure 1-1: Study area

JBPacific's scope of work included hydrologic and hydraulic modelling as the basis for the flooding assessment. This included hydrologic modelling, to estimate design flows within the river. It also included development of a hydraulic model to simulate flood hydrodynamics for existing and post development conditions at the site, to demonstrate any potential impacts to peak flood levels due to the construction of the proposed wave park.

The hydrological model was used to simulate the 1%AEP flows in the Mowbray River catchment for the Defined Flood Event, which is the basis of flood assessments in the Douglas Shire Planning Scheme 2018. The existing hydraulic model from the draft Douglas storm tide study (JBPacific, 2020) was reviewed and updated for the current study proposes.

1.2 Structure of the report

In addition to this introductory chapter, this report contains the following:

- **Section 2:** Available Data
- **Section 3:** Study Methodology
- **Section 4:** Hydraulic Model
- **Section 5:** Flood Impacts
- **Section 6:** Conclusion

2 Available Data

2.1 Topographic data

Elevation data above mean sea level is available through the QLD 5m Light Detection and Ranging (LiDAR) Digital Elevation Model (DEM). The 5m LiDAR DEM has been sourced from more than 200 individual LiDAR surveys conducted between 2001 and 20151. For larger areas where the 5m dataset is not available, the 30m SRTM topographic data has been used. Additional 1m LiDAR tiles have been sourced from the Intergovernmental Committee on Surveying and Mapping (ICSM) for areas where higher-resolution is required.

2.2 Bathymetry data

Offshore bathymetry was obtained between the coastline to the outer GBR by the DeepReef 30m dataset[2]. The GBR30 bathymetric dataset was developed in collaboration between James Cook University, Geoscience Australia, and the Australian Hydrographic Office to compile all available digital bathymetry data to develop regional-scale, 30m resolution grids. This contains deep-water multibeam surveys, airborne lidar bathymetry and chart data, all edited as point clouds to remove noise, and merged into a consistent WGS84 horizontal datum, and an approximate mean sea level vertical datum.

2.3 Hydraulic structures

Details of bridge structures, Mowbray River bridge and Wangetti trail bridge, as shown in Figure 2-1, were obtained from GHD, who have also been engaged by Hunt Design on this project. The details of these structures were modelled in the TUFLOW model. Bridge information such as deck level, thickness, opening dimensions and guardrail height were estimated from supplied engineering drawings. The drawings are contained in Appendix – As Constructed Drawings.

Figure 2-1. Mowbray River bridge and Wangetti trail bridge

2.4 Tide information

The dynamic time varying tidal boundary was adopted to represent sinusoidal water level patterns with a peak level equivalent to a Highest Astronomical Tide (HAT), estimated at 1.78mAHD for present day (2021).

2.5 Gauge data

The catchment is currently ungauged and as such, data on historical river heights and rainfall in the catchment are currently unavailable.

1 Geoscience Australia 2015. Digital Elevation Model (DEM) of Australia derived from LiDAR 5 Metre Grid. Geoscience Australia, Canberra. http://pid.geoscience.gov.au/dataset/ga/89644

2 Beaman, R.J. (2018) "100/30 m-resolution bathymetry grids for the Great Barrier Reef", SSSI Hydrography Commission Seminar, March 2018. Surveying and Spatial Sciences Institute (SSSI), Canberra, Australia.

3 Study Methodology

3.1 Hydrologic model development

A hydrologic model has been developed to estimate rainfall-runoff and streamflow throughout the Mowbray River catchment. The Unified River Basin Simulator (URBS) model adopted for this project is a semi-distributed nonlinear rainfall-runoff model. The URBS model has been applied in a 'split' mode, where the effects of the sub-catchment and channel routing are calculated separately. First, the excess rainfall on a sub-catchment is routed to the creek channel, with the inflow assumed to occur at the centroid of the sub-catchment. The lag of the sub-catchment storage is assumed proportional to the square root of the sub-catchment area. Next, the inflow is routed along a reach using a linear Muskingum method, where lag time is assumed to be proportional to the length of the reach.

Catchment delineation within the model has been based on a 30 metre Digital Elevation Model (DEM). The catchment was divided into 112 sub-catchments, ranging between 1 and 2 km^2. The catchment delineation is shown in Figure 3-1.

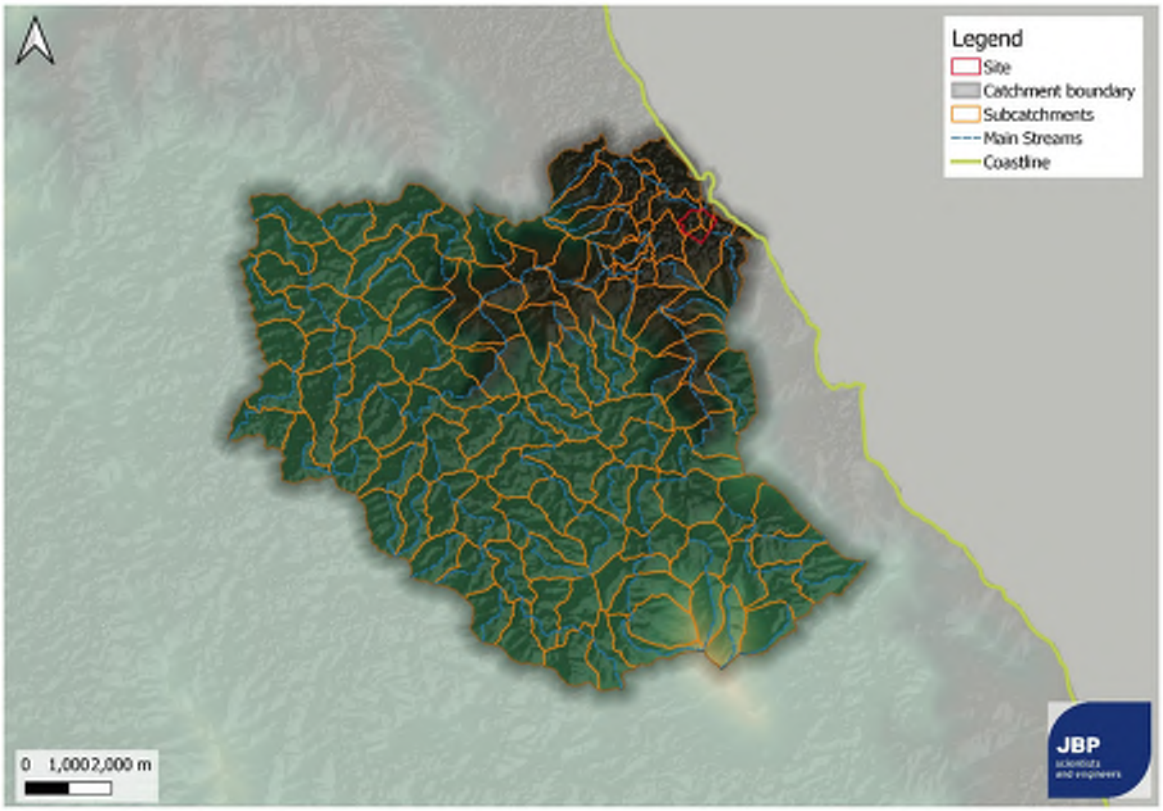

Figure 3-1. Mowbray River sub-catchment delineation

Given the absence of gauging station in the study area, a review of hydrological modelling of nearby catchments was undertaken. JBPacific has completed comprehensive, calibrated hydrologic modelling of the nearby adjoining Mossman River catchment. The Mossman River outlet is located approximately 14km to the north of the mouth of the Mowbray River. The two catchments have similar fan-shapes and are both small-medium catchments with comparative areas approximately 208km^2 and 116km^2 respectively.

The initial hydrologic model build used the same URBS model parameters as for the Mossman River and was jointly-validated by comparing hydrological results with obtained results from the TUFLOW hydraulic model. The validation resulted in a refining of the alpha parameter, which decreased from 0.3 to 0.2. This is a reasonable change as decreasing the alpha value results in faster flood wave celerity which is likely given the shorter, smaller catchment. The adopted URBS parameters are summarised in Table 3-1.

Table 3-1: Adopted URBS model parameters

Parameter	Mowbray River
Number of sub-catchments	112
Initial Loss	16
Continuing Loss	3.5 mm/hr
Alpha, α	0.2
m	0.8
Beta, β	1.2

3.1.1 Design inputs

The hydrological model was used to simulate the 1%AEP flows in the Mowbray River catchment. Design hydrographs were estimated at the upstream boundary of the TUFLOW model, representing the inflow of the Mowbray River and Spring Creek. Local catchment runoff was calculated at the outlet of the rest of the sub-catchments in the study area. Rainfall data was downloaded from the Australian Rainfall and Runoff (ARR2019) data hub.

3.1.2 Intensity-Frequency-Duration (IFD) Curves

Due to the topographic variability and size of the catchment, it was deemed that using one IFD would not accurately represent the catchment, and on the other end of the spectrum, it was not considered practical, or necessary to generate an IFD for 112 individual sub-catchments. As displayed in Figure 3-2 the catchment was delineated into six regions, with the centroids of each IFD region used to download the Bureau of Meteorology's (BoM's) IFD data.

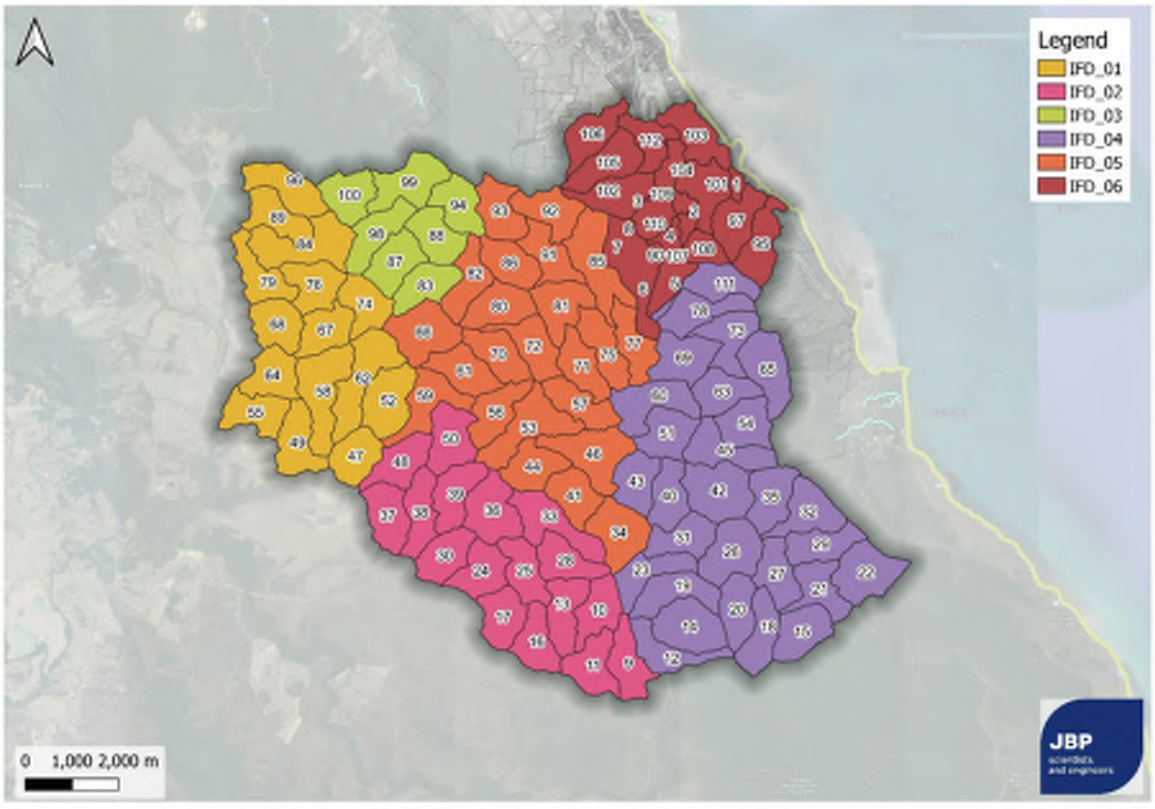

Figure 3-2. Application of IFDs to hydrological modelling across the catchment

3.1.3 Temporal Patterns

The ARR DataHub was used to obtain temporal pattern ensembles for the catchment. Two sets of temporal patterns were obtained which represent “rare” events and events within the areal “North East Coast” region for the catchment. The rare temporal pattern sets contained storm durations of 4.5 hours, 6 hours, 9 hours, 12 hours, 18 hours, 24 hours, 30 hours, 36 hours, 48 hours, 72 hours, 96 hours and 120 hours while the areal set contained storm durations of 12hours, 18 hours, 24 hours, 36 hours, 48 hours, 72 hours, 96 hours and 120 hours. Each of the two temporal pattern sets contained 10 ensembles for each duration.

3.1.4 URBS ARR19 Results

Given the lack of stream gauges within the Mowbray River, the URBS model cannot be formally calibrated. Instead, in line with Australian Rainfall and Runoff (ARR2019) guidelines a validation of the URBS model using an analytical approach, regional flood frequency estimation and generalised rational method was undertaken.

Various duration hydrographs from 6 hour to 120 hours were assessed to determine the critical duration for each sub-catchment. The approach adopted for the design flood estimation was to select the pattern and duration that was closest to the median (or one higher than the median) as an input to the hydraulic model. Figure 3-3 shows the ensemble results for each duration and 1%AEP as box and whisker plot for catchment outlet. Critical inflow duration for that location was 48 hours. It is noted that these critical durations may differ from the hydraulic model critical durations as any floodplain storage will be more accurately modelled in the hydraulic model. The validity of estimated peak flood discharge at the catchment outlet was investigated by Regional Flood Frequency Estimation Model, ARR, which the results show consistency with lower confidence limit of 1%AEP peak flow.

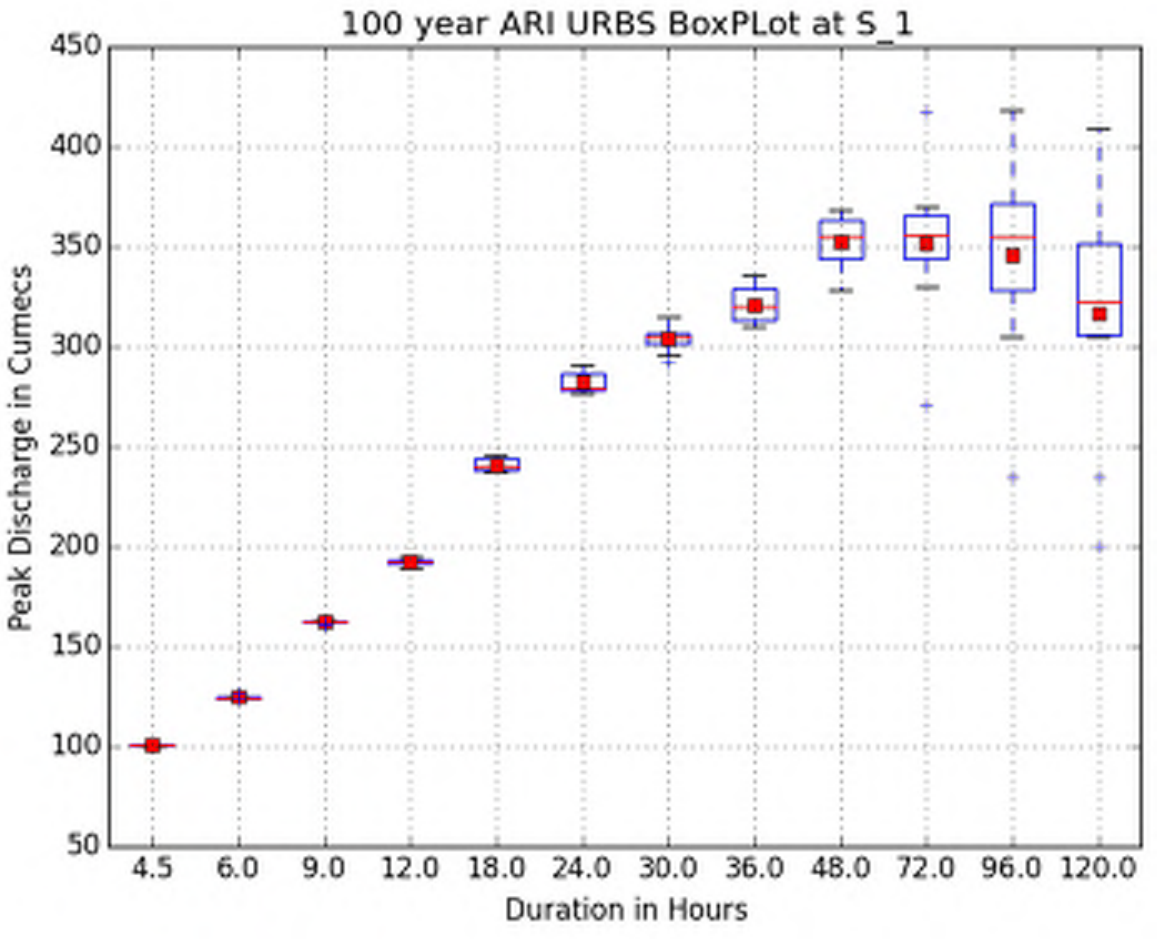

Figure 3-3. Box and whisker plot of ensemble temporal patterns modelled in the URBS hydrological model. Reported at river outlet (sub-catchemnt1)

3.2 Hydraulic model development

3.2.1 Overview

The existing 2-dimensional hydrodynamic TUFLOW model developed as part of the draft Storm Tide Inundation Methodologies Study (JBPacific, 2020) was used as a basis for the hydraulic modelling undertaken in this project. The model was updated to ensure it was fit-for-purpose for this current study and run to simulate flood behaviour at the site for the 1%AEP flood event.

3.2.2 Model extent

A schematic of the hydraulic model domain is shown in Figure 3-4, showing the TUFLOW model covers an area of approximately 12.89 km^2 with a downstream boundary located along the tidal

waters offshore of the Mowbray River mouth. The tidal boundary was positioned at the -3mAHD depth contour and adopted a dynamic time varying tidal boundary with a peak value equivalent to Highest Astronomical Tide (HAT).

Three inflow location were included in the model, they were schematised to represent:

- the Mowbray River inflow from the west
- the Spring Creek inflow from the south and
- a local catchment inflow from the north.

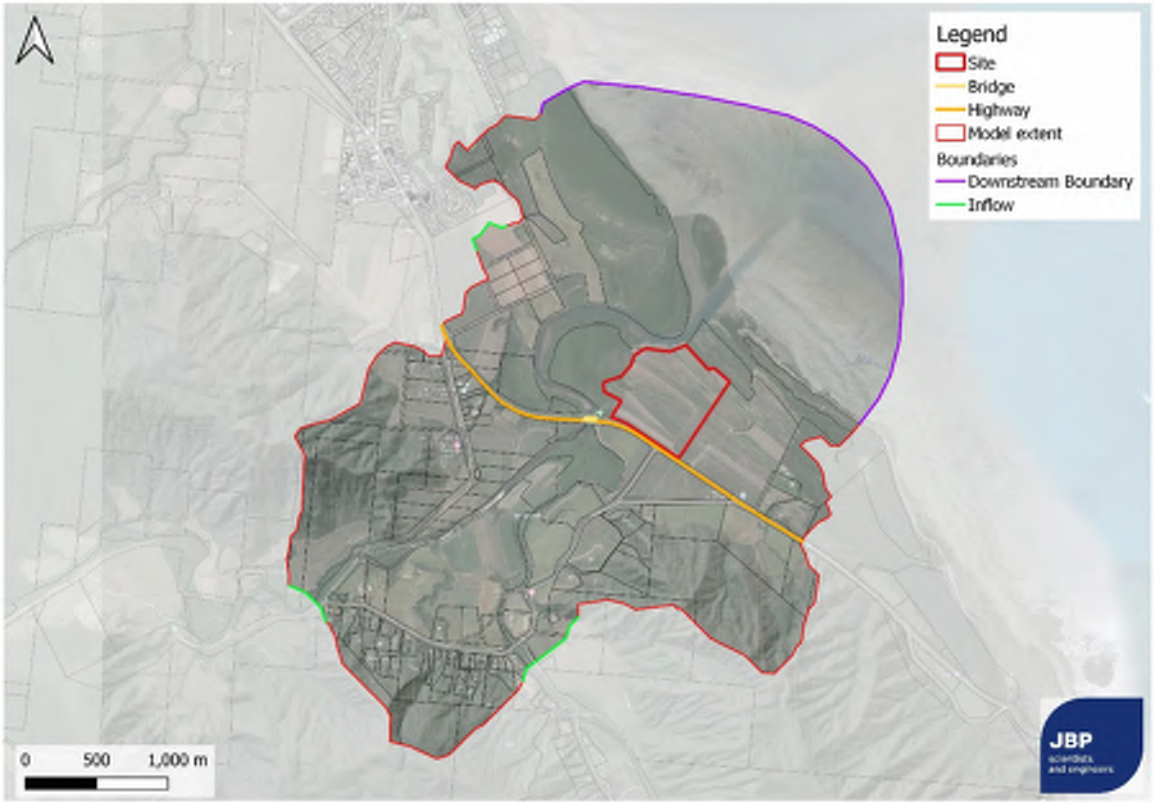

Figure 3-4. TUFLOW model configuration

3.2.3 Topography and bathymetry data

The existing case digital elevation model (DEM) was derived by merging the available topography and bathymetry data as described in Section 2-1.

3.2.4 Grid and Timestep

A 5m model grid resolution was used for the existing hydraulic model. Considering the topography is generally defined by widespread agricultural land and scattered to dense vegetation with a wide floodplain this grid resolution is considered appropriate for the floodplain areas of the catchment. The TUFLOW model was developed as a classic model with the timestep of 2 seconds to produce reasonable hydraulic model simulation times.

3.2.5 Roughness

Surface roughness conditions have been represented through the application of Manning's 'n' values. The Douglas Shire contains estuaries, mangrove forest and rivers, which each can influence the extent and depth of flooding. The Manning values were adopted from DRAFT Storm Tide Inundation Methodologies Study (JBPacific, 2020) which, were mapped from the combination of Queensland Land Use Mapping Program (QLUMP) and NDVI vegetation analysis. The adopted roughness values are shown in Table 3-1.

Table 3-2. Model roughness

Vegetation class	Mannings 'n;
Dense vegetation/mangrove	0.120
Other minimal use	0.120
Residential and farm infrastructure	0.040
Grazing native vegetation	0.035
Managed vegetation	0.030
River channel	0.030
Open water	0.030
Sandy beach	0.025

3.2.6 Existing Structures

Bridge structures were represented in the TUFLOW model. Details of these structures were obtained from GHD for the Wangetti trail bridge and included in the TUFLOW model. The modelled bridges are indicated on Figure 3-4. Bridge information such as deck level, thickness, opening dimensions and guardrail height were estimated from provided engineering drawings (Appendix – As Constructed Drawings). Bridges were modelled as 2d structures, which is common practice on the main watercourses.

3.2.7 Boundaries

Four boundaries have been established:

- A inflow Q-T boundary, as a time-varying hydrograph, representing the Mowbray river flows;
- A inflow Q-T boundary, as a time-varying hydrograph, representing the Spring Creek flows;
- A inflow Q-T boundary, as a time-varying hydrograph, representing a minor catchment inflow from the north of the catchment.; and
- A H-T tailwater boundary at the ocean.

Local sub-catchment inflows were included in the hydraulic model setup for more accurate simulation of hydrological process in the study area.

The downstream boundary has been established along the eastern seaboard of the TUFLOW model approximately 1.5 km offshore from the river mouth. As shown in Figure 3-5, the dynamic time varying tidal boundary was adopted to represent sinusoidal water level patterns with a peak value equivalent to an estimated Highest Astronomical Tide (HAT) level of 1.78mAHD for present day (2021). Three days of the tidal cycles were modelled with the present time timeframe. The flood wave from Mowbray river will coincide with a peak of highest tide of the second cycle as a conservative approach.

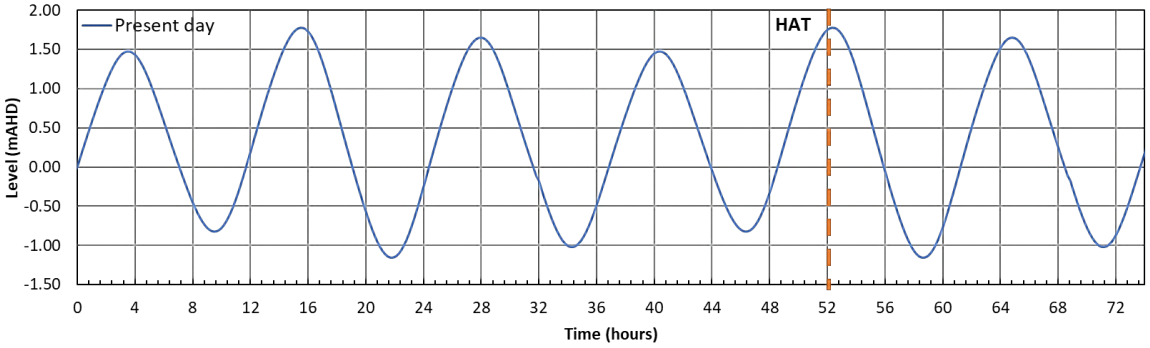

Figure 3-5. Tidal signature for present day

4 Hydraulic Model

As required by the Douglas Planning Scheme 2018, the Defined Flood Event or 1% Annual Exceedance Probability (AEP) flood event was the focus of the hydraulic model simulation.

4.1 Base case model

Once the TUFLOW Classic hydraulic model was setup, a base case scenario was established. The purpose of the base case was to establish flood behaviour in the catchment and vicinity of the site for existing catchment conditions.

As discussed in Section 3-1, the estimated inflow hydrographs were extracted from the hydrological model at the TUFLOW model inflow locations. Reporting location nearby the site and downstream of the bridge were used to compare the results between the hydrological and hydraulic models, for evaluating the performance of the hydraulic mode. As shown in Figure 4-1, a comparison of hydrologic and hydraulic model results, show good agreement between the two model. The small differences in the hydrograph shape and peak are most likely related to the fact that floodplain storages are more accurately modelled in the hydraulic model.

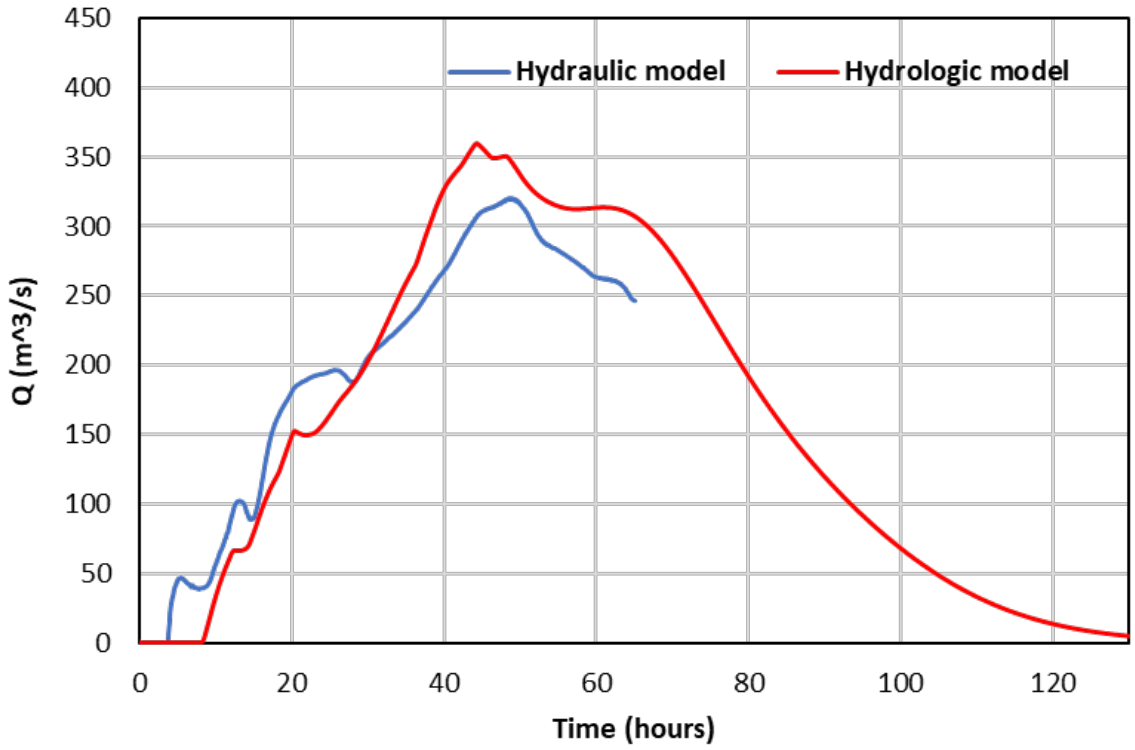

Figure 4-1. Comparison between hydrological and hydraulic model results near the site.

4.1.1 Base case results

The existing case flooding characteristics for the 1% AEP flood event in the vicinity of the site are described below:

- Hydraulic modelling indicates peak water levels within the lot subject to the development application, range from approximately 2.6 mAHD in the west side nearest the Mowbray River to approximately 2 mAHD in the north, as shown in Figure 4-2.
- The water depth ranges from 1.1m in the in the west side of the lot subject to the development application to 0.01m in the north of the site as shown in Figure 4-3.

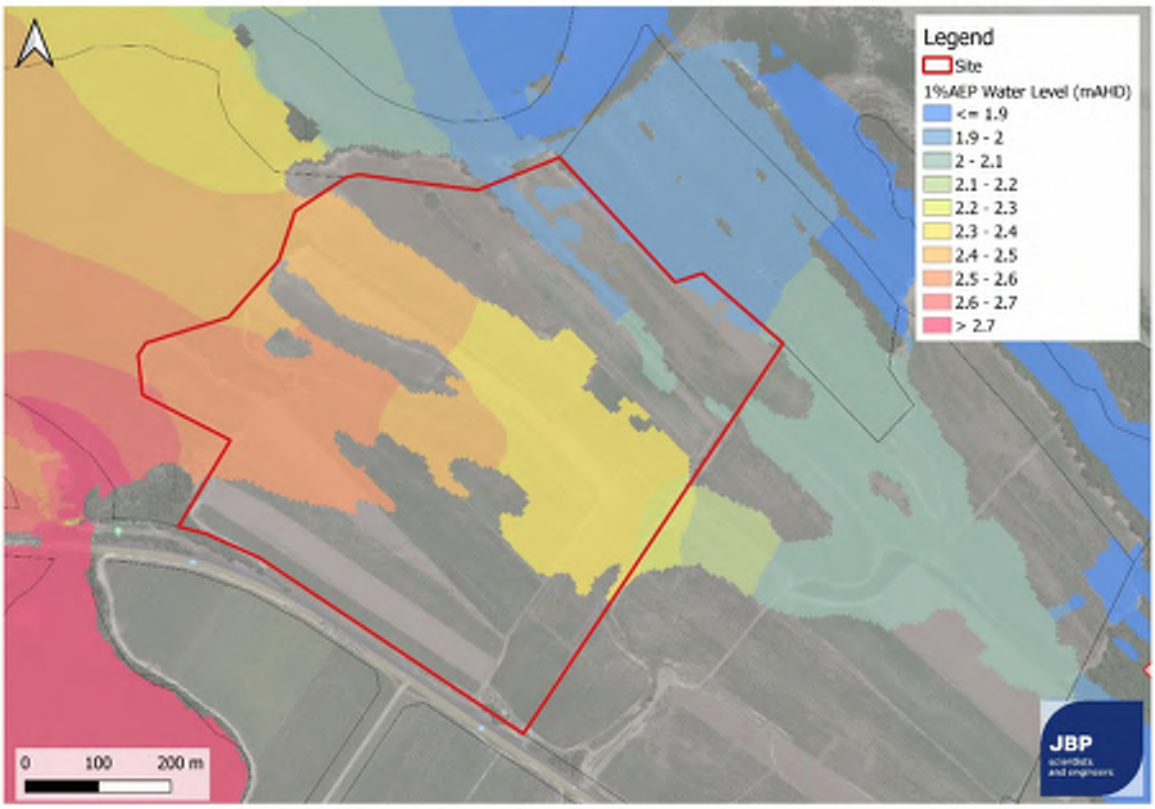

Figure 4-2. Peak water surface level in the 1%AEP flood for existing case

Figure 4-3. Peak flood depth in the 1%AEP flood for existing case

4.2 Post-development model

The hydraulic model was used to simulate the proposed (post-development) scenario and assess impacts on flood behaviour in the vicinity of the proposed development. Results of the post-development and analysis of flood impacts are provided in Section 5 of this report.

4.2.1 Development footprint

The proposed development was modelled by using the preliminary digital train model provided by Hunt Design as shown in Figure 4-4. The surface roughness information was mapped and updated to the new development footprint. Consideration was not given to detailed elements for mapping the roughness as it was out of scope of this study.

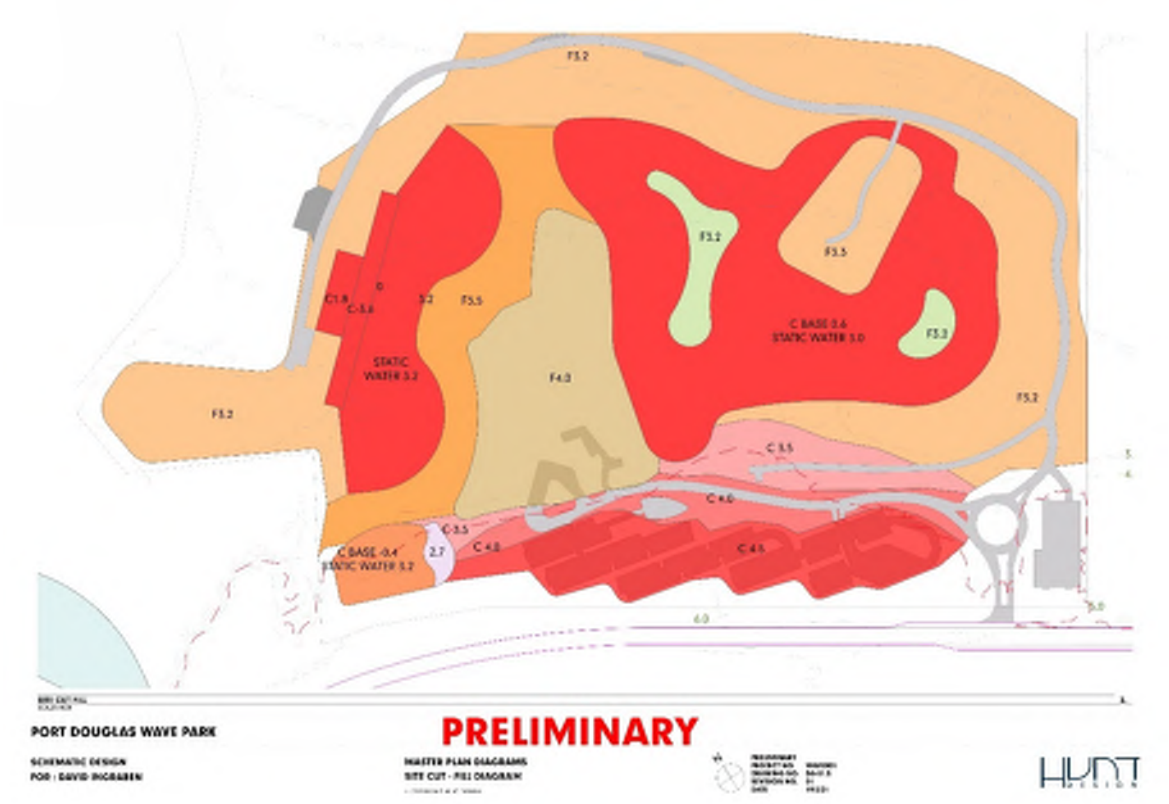

Figure 4-4. Configuration of preliminary earthwork

4.2.2 Developed case results

The developed case flooding characteristics for the 1% AEP flood event in the vicinity of the site are described below:

- Hydraulic modelling indicates peak water levels within the lot subject to the development application, range from approximately 2.7 mAHD in the west side nearest the Mowbray River to approximately 2 mAHD in the north, as shown in Figure 4-5
- The water depth ranges from 1.1m in the in the west side of the lot subject to the development application to 0.01m in the north of the site as shown in Figure 4-6.

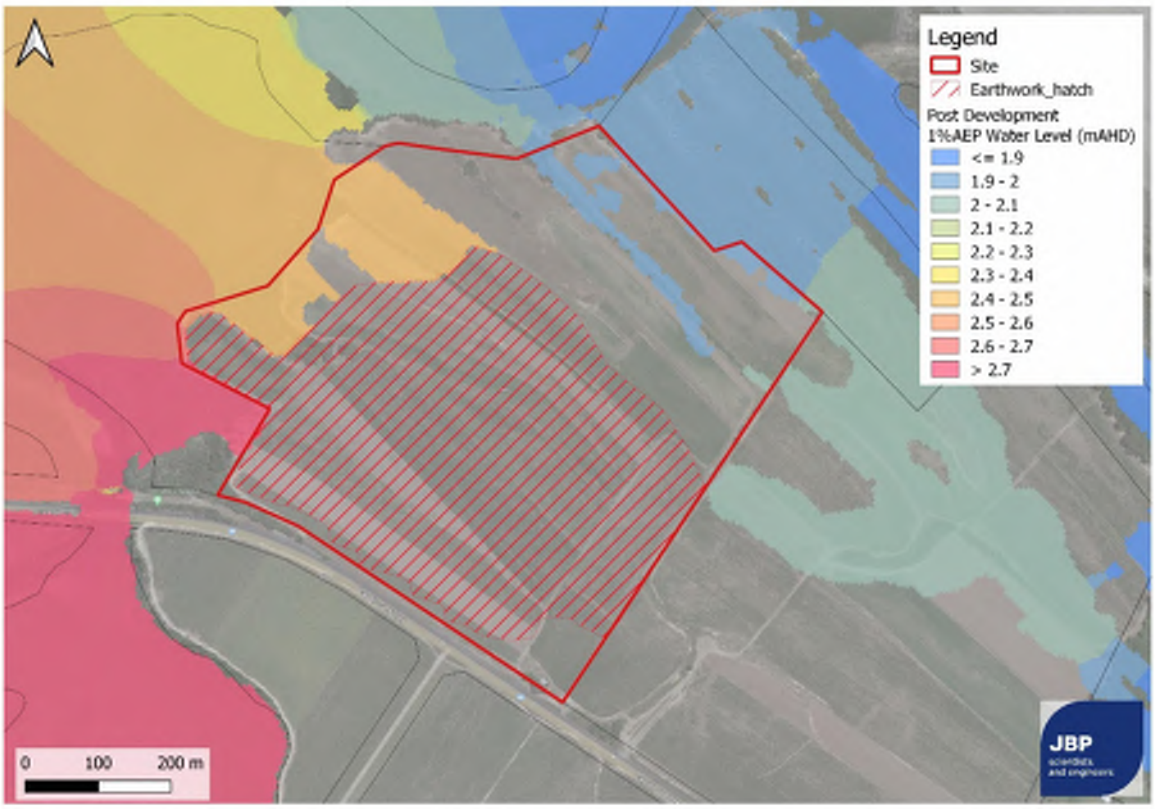

Figure 4-5. Post development 1%AEP peak water surface level

Figure 4-6. Post development 1%AEP peak flood depth

5 Flood Impacts

The hydraulic model was used to assess the possible impacts to the existing flood conditions for the proposed development.

Consideration was given to a range of flooding characteristics, including:

- Flood level impacts
- Flood velocity impacts
- Floodplain storage

5.1 Flood level impacts

Hydraulic model results for the post-development condition were compared to the pre-development, existing case flood results. As shown in Figure 5-1, the largest flood level impacts are generally observed in the immediate vicinity of the proposed development, with the greatest flood level impact of 183mm occurring adjacent to the lot subject of the development application.

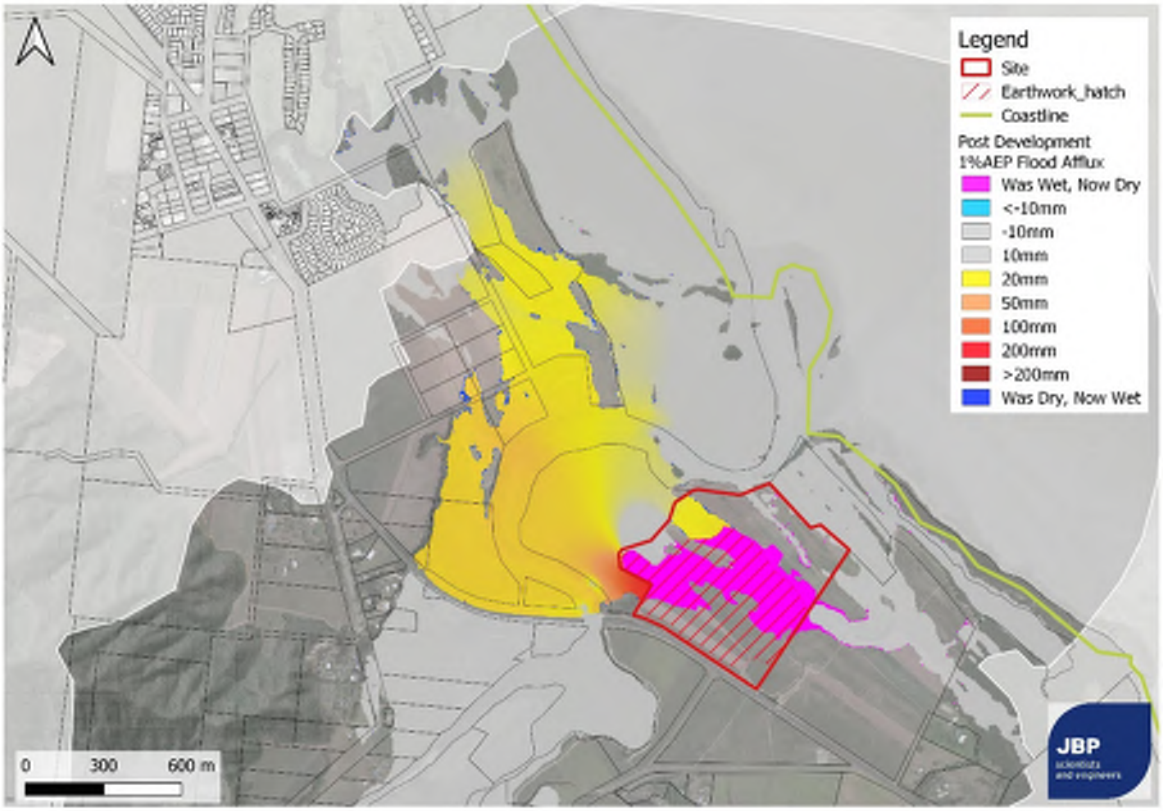

Figure 5-1. Flood level impacts in the 1%AEP flood event

The flood modelling indicates flood impacts are restricted to the portion of the floodplain downstream of the Captain Cook Highway, Mowbray. The largest flood level impacts are evident to the west (upstream) side of the site between the proponents land and the Highway. The maximum afflux in this location is 183mm, however this is on State-owned conservation land and as such, the flood impacts are not anticipated to result in adverse impacts to people or property.

There is only a minor increase in inundation extent, to the north of the site on the opposite bank to the proposed development. The minor increase in flood liable land is generally restricted to property zoned for rural uses and a review of available aerial imagery does not indicate this is will impact existing dwellings in the lower catchment.

As shown in Figure 5-1, flood impacts in the 1%AEP flood event are limited to downstream of the Captain Cook Highway. Given the modelling results indicate there is potentially some impact to peak flood levels, a further analysis of peak flood levels was undertaken at a lot scale. The results of this analysis are summarised in Table 5-1.

Table 5-1. Summary of peak flood impacts (by land use)

Lot	1%AEP Maximum Afflux (m)
Low Density Residential	0.018
Rural	0.037
Environmental Management	0.021
Conservation	0.183
Special Purpose	<0.001

Table 5-1 indicates the maximum impact on residential property is 18mm. It should be noted that whilst this land is zoned as low density residential in the Douglas Planning Scheme 2018, aerial imagery indicates it is currently vegetated, undeveloped land. Additionally, flood impacts are limited to an existing low-laying area of lot, which represents approximately 2% of the total lot area.

Maximum flood impacts on rural land external of the proponents land is 37mm, which is located opposite the proposed development on agricultural land. An increase of 37mm is not expected to adversely affect the existing land owners ability to farm the land.

5.2 Flood velocity impacts

Analysis of velocity afflux was conducted to demonstrate the impact the proposed development has on the flood velocity compare to the existing case. Figure 5-2 shows there are some increases in flood velocity in the west side of proposed development lot (up to 0.5 m/s), however, the maximum velocity afflux external of the site is less than 0.2 m/s.

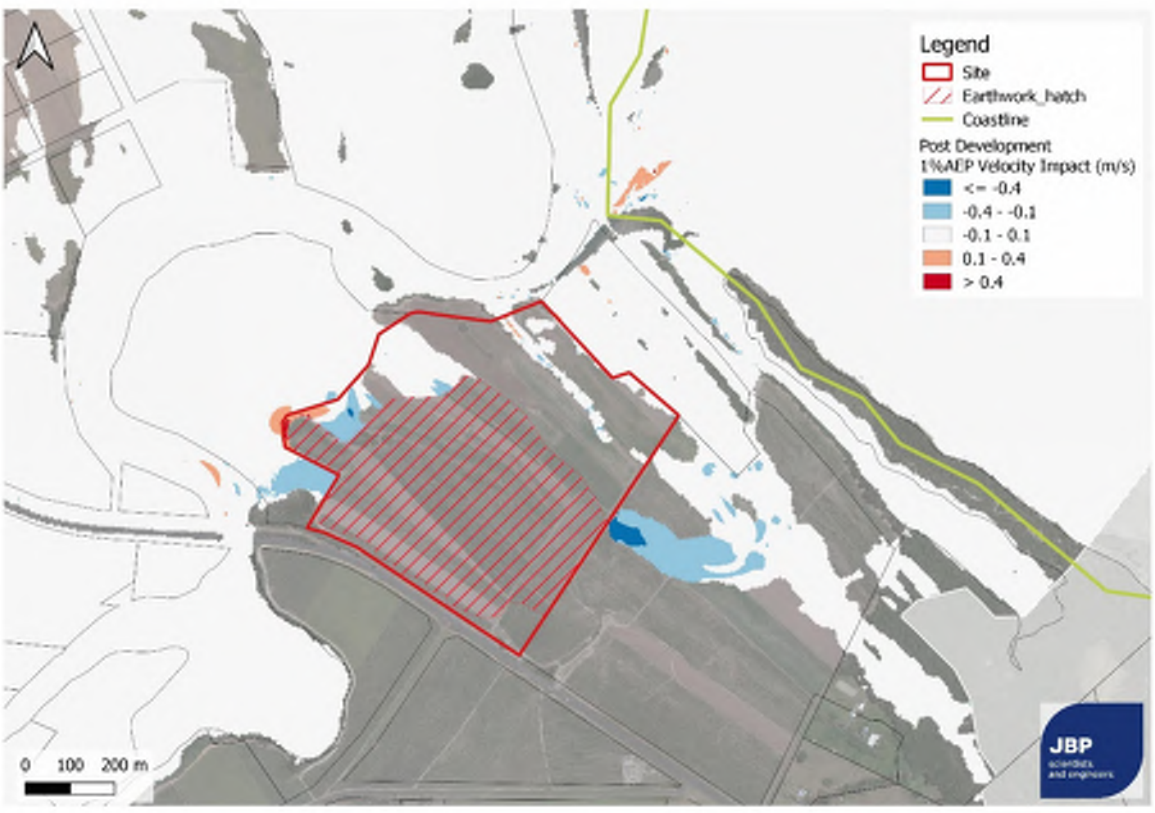

Figure 5-2. Flood velocity impact in the 1%AEP flood event

5.3 Floodplain storage

The purpose of this hydraulic impact assessment was to assess the impact on flooding behaviour resulting from the proposed development. The earthworks cut and fill balance has been provided by GHD in Figure 5-3.

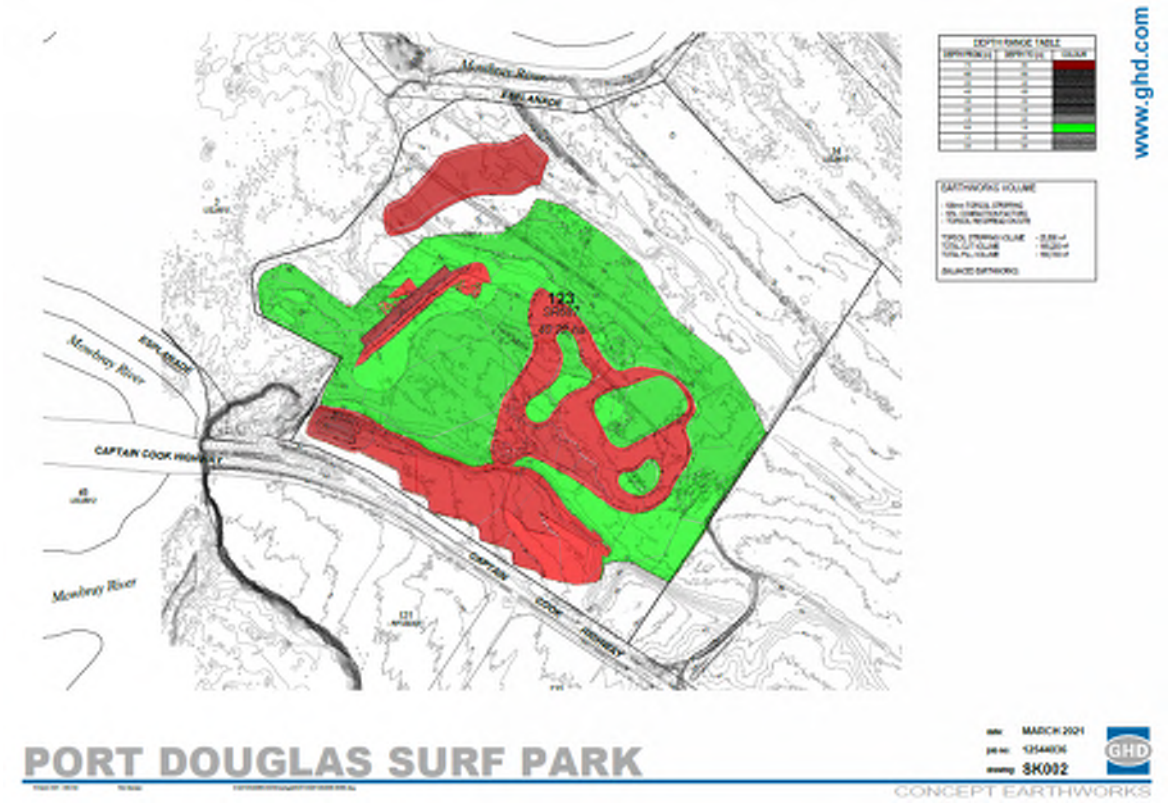

Figure 5-3. Earthworks plan

The earthwork concept design shows the total cut and fill are 165,200 m³ and 190,700 m³ respectively, with total balance value of 25,500 m³, excess of fill over cut, (Table 5-2). This loss of floodplain capacity is shown to affect flood levels on the areas immediately upstream of the proposed development (160mm) and slight effect on rural lots (summarised in Table 5-1). In general, reducing floodplain capacity cause upstream and downstream impacts, therefore any development should balance cut and fill by creating additional volume adjacent filling site to approach minimum impact to the floodplain.

Table 5-2. Summary of cut and fill (provided by Hunt Design Consultants)

Total Cut (m³)	Total Fill (m³)	Total Balance (m³)
165,200	190,700	25,500 fill

5.4 Design iterations

The initial proposed design, was shown to result in increased flood levels in the 1%AEP flood event of up to 18mm on residential zone lot-type parcels, 37mm on rural zone lot-type parcels and a maximum peak flood level increase of 183mm on conservation zone land. The highest impacts were shown in Figure 5-1 to occur immediately upstream of the site, in an area of filling that created a 'right angle of fill', reducing the cross-sectional area for floodplain conveyance in comparison to the existing catchment conditions. Reactivating the floodplain conveyance by including an open channel through the proposed development in the vicinity of the 'cabin park' on the south west of the site near the Wangetti Trail.

5.4.1 Single open channel

To improve floodplain conveyance through the site a single trapezoidal open channel with typical geometry, as shown in Figure 5-4, was added to the hydraulic model. The channel had a base width of 20m and a depth of 500mm, with 1:4 slope batters. The channel design adopted a longitudinal slope of 0.006 m/m (0.6%), which is slightly steeper than the existing ground levels and

would require additional minor excavation on the downstream end of the channel. The additional gradient was required to improve flow in the channel, given the ground levels on the neighbouring property at the upstream end of the channel are the limiting natural ground level for the indicative design of the open channel.

The alignment of the single open channel tested in the design iteration is shown in Figure 5-5, with resulting flood impacts shown in Figure 5-6.

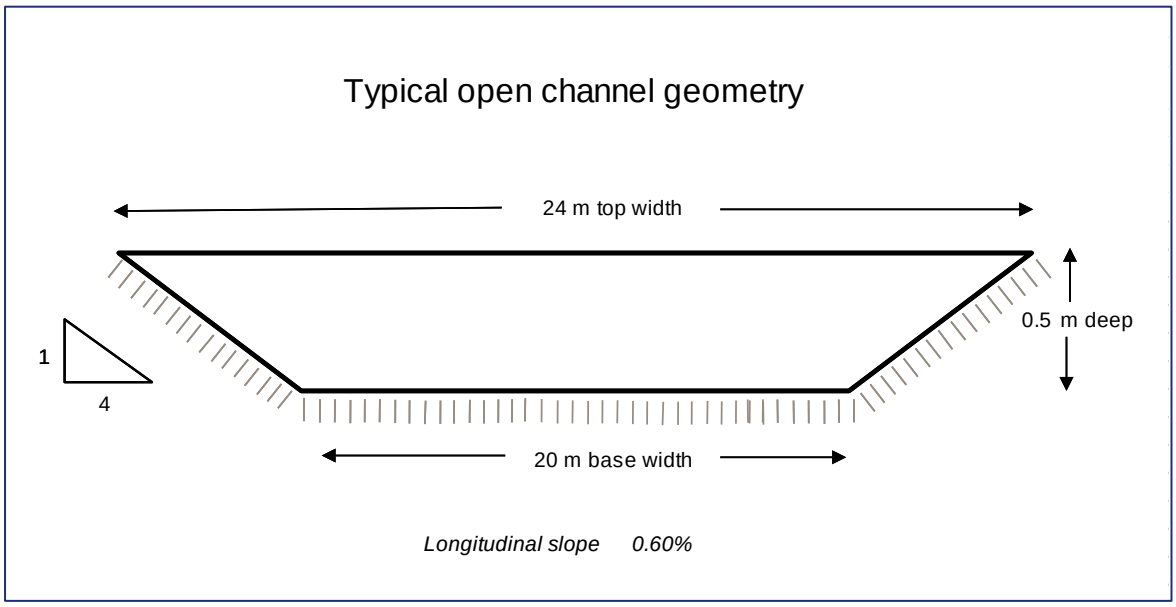

Figure 5-4. Typical section of indicative open channel

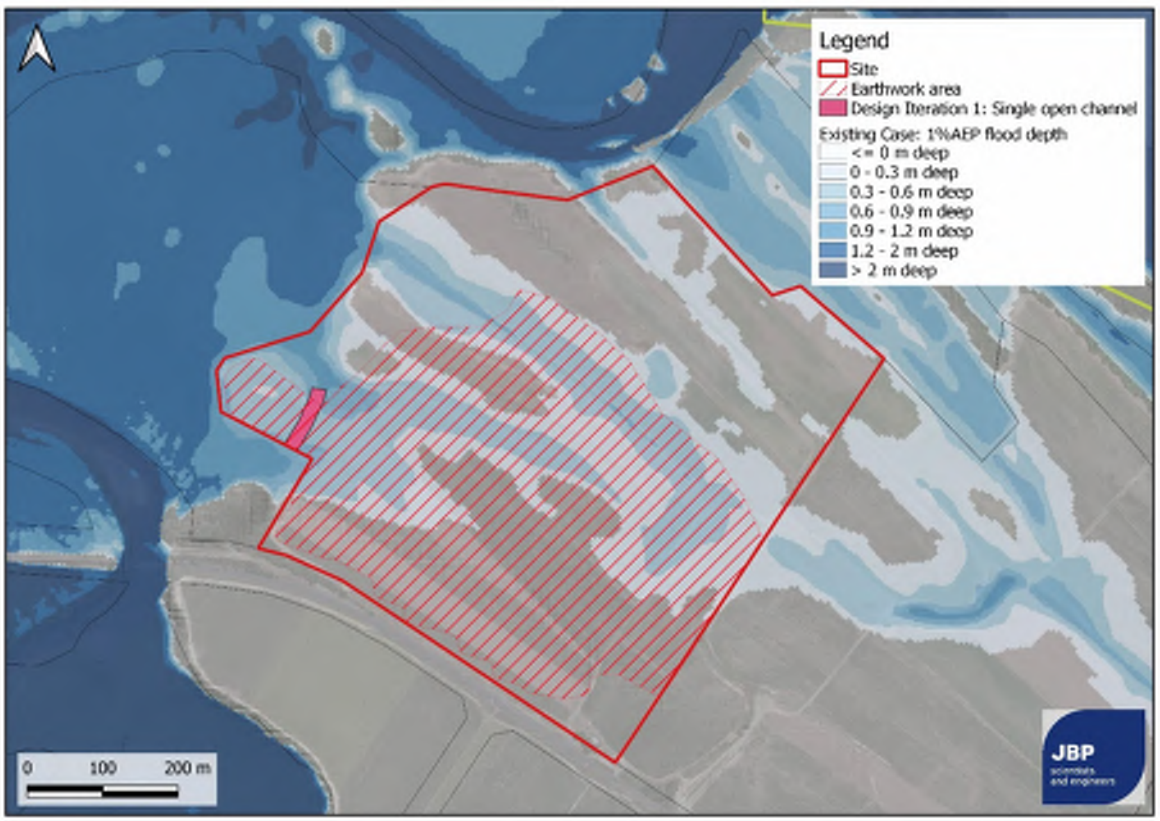

Figure 5-5. Location of indicative single open channel

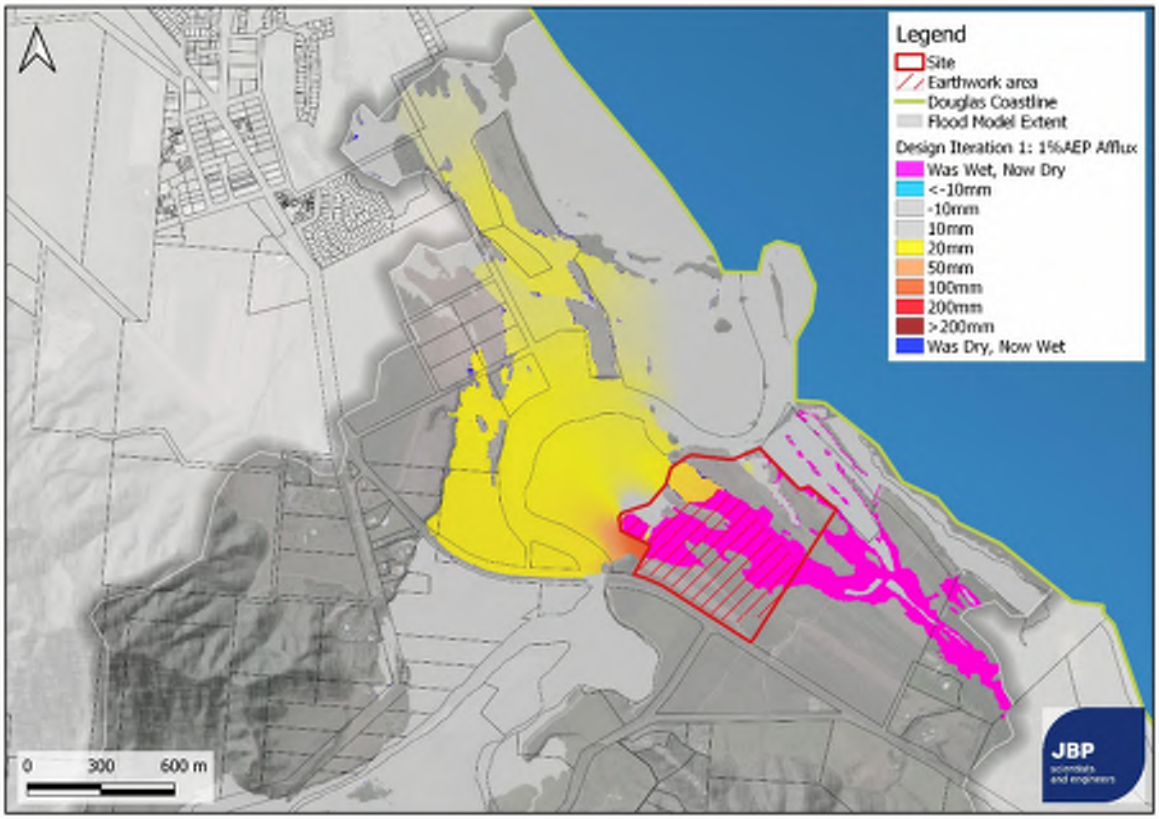

Figure 5-6. Flood impacts associated with indicative single open channel

The results of the design iteration incorporating the single trapezoidal open channel is summarised in Table 5-3, shows peak flood impacts external of the site are generally reduced, in comparison to the initial design, by the inclusion of the single open channel. Figure 5-6 shows the maximum flood level impact of 127mm is located on conservation land immediately upstream of the site between the proposed cabin/camp facilities and the Wangetti Trail.

Table 5-3 indicates the maximum impact on residential property is 15mm. It should be noted that whilst this land is zoned as low density residential in the Douglas Planning Scheme 2018, aerial imagery indicates it is currently vegetated, undeveloped land. Additionally, flood impacts are limited to an existing low-laying area of lot, which represents approximately 2% of the total lot area.

Maximum flood impacts on rural land external of the proponents land is 25mm, which is located opposite the proposed development on agricultural land. An increase of 25mm is not expected to adversely affect the existing land owners ability to farm the land.

Table 5-3. Summary of peak flood impacts (by land use)

Lot	Initial Design 1%AEP Maximum Afflux (m)	Design Iteration 1 (single channel) 1%AEP Maximum afflux (m)	Change in modelled 1%AEP flood impacts
Low Density Residential	0.018	0.015	3mm reduction
Rural	0.037	0.025	12mm reduction
Environmental Management	0.021	0.018	3 mm reduction
Conservation	0.183	0.127	56mm reduction
Special Purpose	<0.001	<0.001	negligible

5.4.2 Dual open channel

To improve floodplain conveyance through the site dual trapezoidal open channels with typical geometry, as shown in Figure 5-7Figure 5-4, was added to the hydraulic model. The channel had a base width of 20m and a depth of 500mm, with 1:4 slope batters. The channel design adopted a longitudinal slope of 0.006 m/m (0.6%), which is slightly steeper than the existing ground levels and would require additional minor excavation on the downstream end of the channel. The additional gradient was required to improve flow in the channel, given the ground levels on the neighbouring

property at the upstream end of the channel are the limiting natural ground level for the indicative design of the open channel.

The alignment of the single open channel tested in the design iteration is shown in Figure 5-8, with resulting flood impacts shown in Figure 5-9.

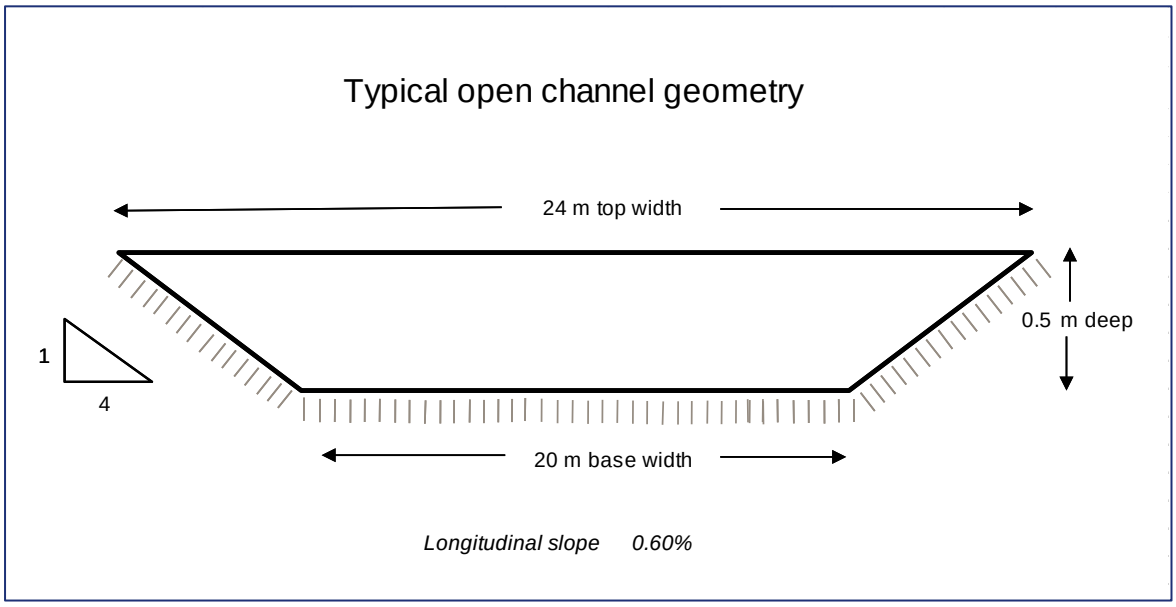

Figure 5-7. Typical section of indicative open channel

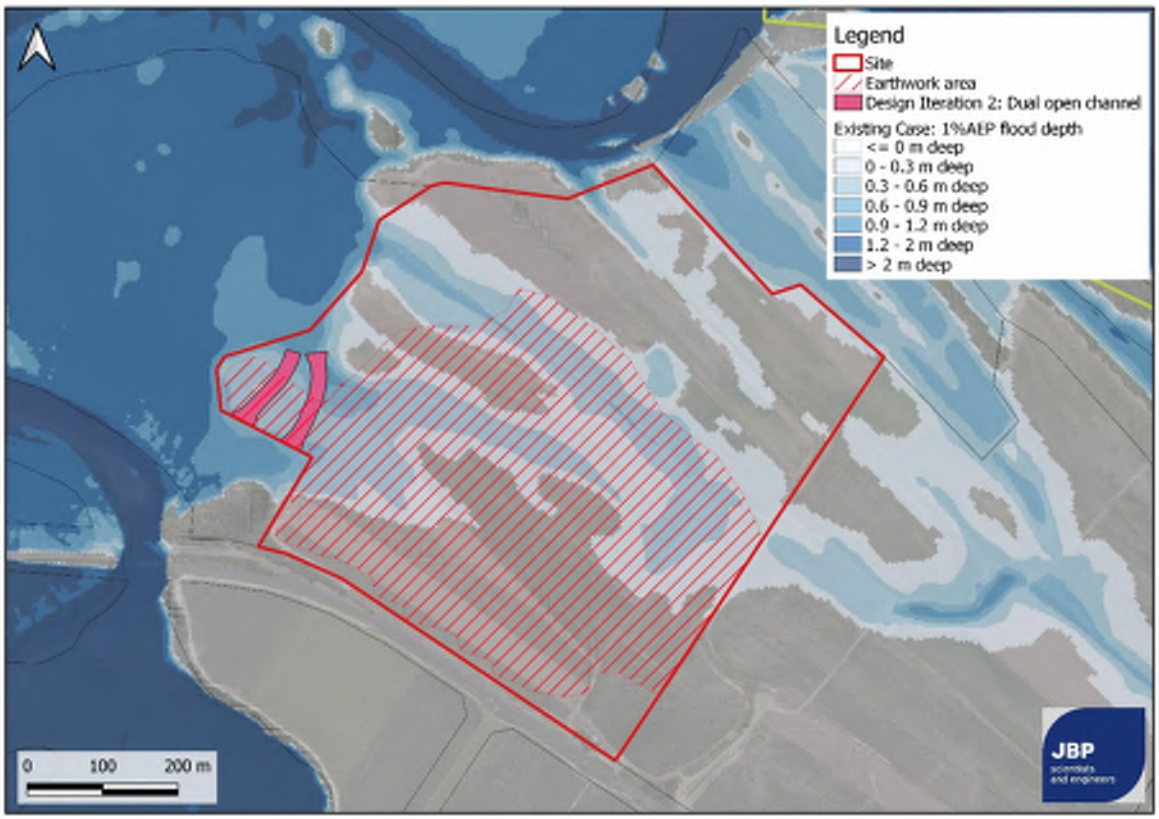

Figure 5-8. Location of indicative dual open channel

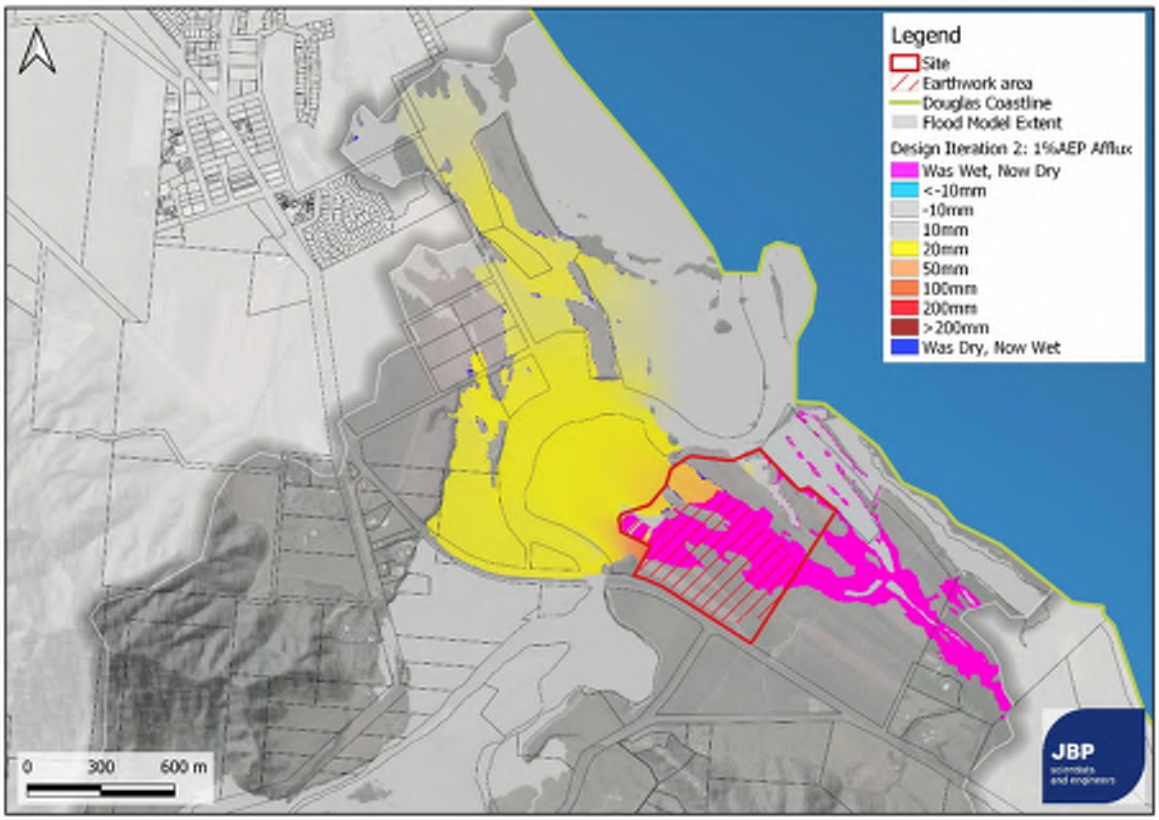

Figure 5-9. Flood impacts associated with indicative dual open channel

The results of the design iteration incorporating the single trapezoidal open channel is summarised in Table 5-4, shows peak flood impacts external of the site are generally reduced, in comparison to the initial design, by the inclusion of the single open channel. Figure 5-9 shows the maximum flood level impact of 88mm is located on conservation land immediately upstream of the site between the proposed cabin/camp facilities and the Wangetti Trail.

Table 5-4 indicates the maximum impact on residential property is 15mm. It should be noted that whilst this land is zoned as low density residential in the Douglas Planning Scheme 2018, aerial imagery indicates it is currently vegetated, undeveloped land. Additionally, flood impacts are limited to an existing low-laying area of lot, which represents approximately 2% of the total lot area.

Maximum flood impacts on rural land external of the proponents land is 25mm, which is located opposite the proposed development on agricultural land. An increase of 25mm is not expected to adversely affect the existing land owners ability to farm the land.

Table 5-4. Summary of peak flood impacts (by land use)

Lot	Initial Design 1%AEP Maximum Afflux (m)	Design Iteration 2 (dual channels) 1%AEP Maximum afflux (m)	Change in modelled 1%AEP flood impacts
Low Density Residential	0.018	0.015	3mm reduction
Rural	0.037	0.025	12mm reduction
Environmental Management	0.021	0.018	3 mm reduction
Conservation	0.183	0.088	95mm reduction
Special Purpose	<0.001	<0.001	negligible

5.4.3 Results of design iterations

Two design iterations were investigated to identify if potential changes to the proposed earthworks may reduce modelled flood impacts.

Only a minor reduction of 3mm in flood impacts was observed on low density residential and environmental management zoned land. A moderate reduction of 12mm was observed for rural

zoned land, bringing peak flood level impacts down from 37mm to 25mm. These results were consistent for the single open channel and dual open channel scenarios.

The 1%AEP flood impacts observed on conservation land immediately upstream of the site, on the south west of the proposed development near the Wangetti Trail were reduced from 183mm to 127mm (a 56mm reduction) for the single open channel scenario and from 183mm to 88mm (a reduction of 95mm) for the dual open channel scenario.

6 Flood risk assessment

The Douglas Planning Scheme 2018 does not provide guidance on acceptable levels of afflux in the Defined Flood Event (1%AEP flood event), but rather the purpose of the flood hazard overlay code will be achieved through the following overall outcomes:

a. development siting, layout and access responds to the risk of the natural hazard and minimises risk to personal safety;
b. development achieves an acceptable or tolerable risk level, based on a fit for purpose risk assessment;
c. the development is resilient to natural hazard events by ensuring siting and design accounts for the potential risks of natural hazards to property;
d. the development supports, and does not unduly burden disaster management response or recovery capacity and capabilities;
e. the development directly, indirectly and cumulatively avoids an unacceptable increase in severity of the natural hazards and does not significantly increase the potential for damage on site or to other properties;
f. the development avoids the release of hazardous materials as a result of a natural hazard event;
g. natural processes and the protective function of landforms and/or vegetation are maintained in natural hazard areas;
h. community infrastructure is located and designed to maintain the required level of functionality during and immediately after a hazard event.

The proposed development has demonstrated that the development siting, layout and access is above the 1%AEP flood level and is not anticipated to expose people to flood inundation in the 1%AEP flood event by providing a development footprint above the 1%AEP flood level, thus achieving acceptable flood risk and enabling a resilient design.

The two outcomes that required further analysis were:

- the development directly, indirectly and cumulatively avoids an unacceptable increase in severity of the natural hazards and does not significantly increase the potential for damage on site or to other properties;
- natural processes and the protective function of landforms and/or vegetation are maintained in natural hazard areas;

6.1.1 Development avoids an unacceptable increase in severity of the natural hazards and does not significantly increase the potential for damage on site or to other properties

The State Planning Policy defines 'acceptable risk' as "*a risk that, following an understanding of the likelihood and consequences, is sufficiently low to require no new treatments or actions to reduce risk further. Individuals and society can live with this risk without feeling the necessity to reduce the risk any further.*"[3]

As noted above, the Douglas Planning Scheme does not provide a definition of 'acceptable flood impacts', so a risk assessment in line with ISO31000 has been undertaken to demonstrate the proposed development 'avoids an unacceptable increase in severity'. ISO31000 is the international standard for risk management, and defines risk as the consideration of the likelihood of a hazard occurring and the consequence when an event occurs.

The assessment of the potential for damage to other properties was based on the number of properties exposed to flood hazard given a specified likelihood. In this case, the Defined Flood

3 Natural hazards, risks and resilience - Flood, The State of Queensland, Department of Infrastructure, Local Government and Planning, (2017)

Event of 1%AEP was analysed, with the number of properties at risk external of the development site shown in Table 6-1.

Table 6-1. Summary of at-risk properties by land use

Land Use	Count of properties within the 1%AEP flood extent	
	Existing	Post-development
Conservation	9	9
Environmental Management	1	1
Low Density Residential	1	1
Ocean	1	1
Rural	45*	45
Rural Residential	0	0
Special Purpose	1	1
Total	115	115

*Note: An additional rural property was counted in the existing results on the eastern extremity of the hydraulic model. This was deemed to be an artifact of the flood model itself and was not considered to be a valid inclusion in comparison with post development property exposure.

Table 6-1 shows the existing catchment conditions and post-development catchment conditions result in the same number of properties at risk in the 1%AEP flood event, and as such the proposed development does not significantly increase the potential for damage on the site or other properties.

An analysis of flood hazard, using depth-velocity results from the hydraulic modelling of the proposed development was undertaken to gain an understanding of the severity of flood hazard under pre and post development conditions. A comparison of flood hazard is provided in Figure 6-1, which shows a minor increase in flood hazard within the channel immediately downstream of the Captain Cook Highway and negligible (+/-0.2m2/s) or minor reduction in depth-velocity product on all existing properties. A review of aerial imagery available from Google and NearMap, indicates there are currently no dwellings located within the mapped flood impact area. Figure 6-1. Comparison of existing and post development depth-velocity flood behaviour

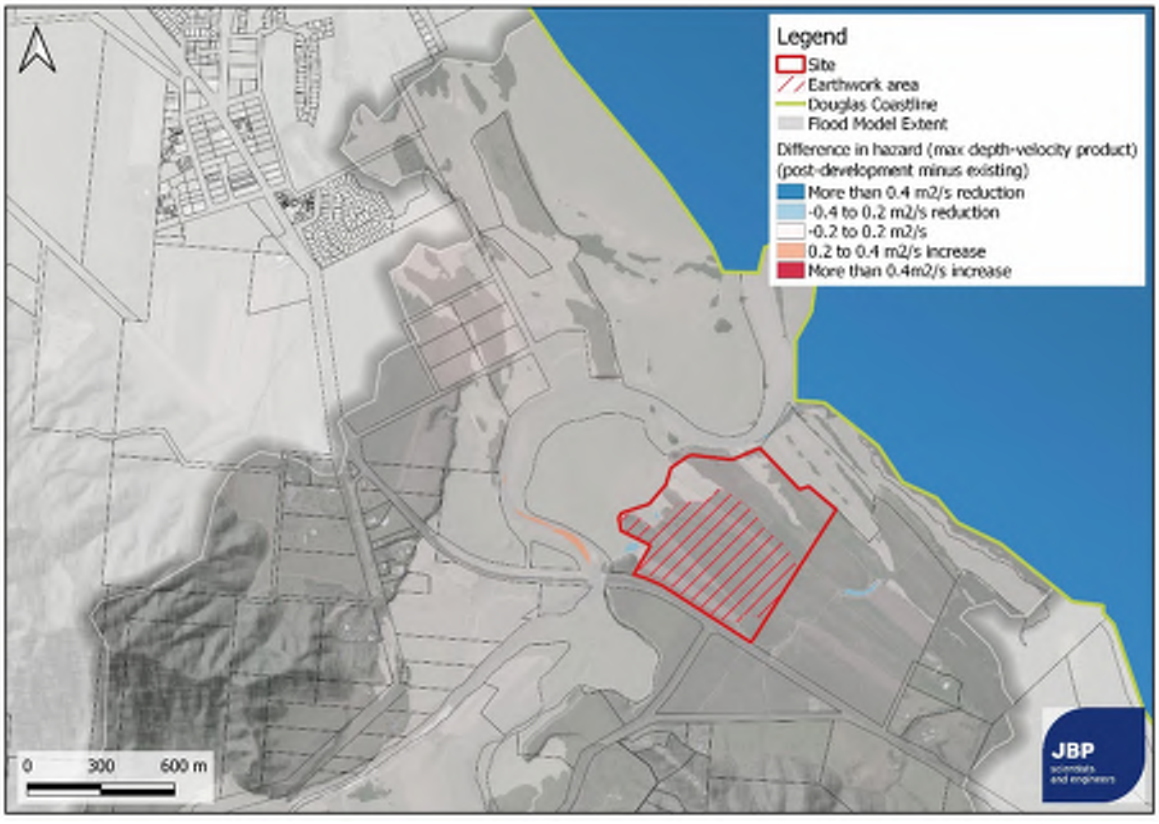

Figure 6-1. Comparison of existing and post development depth-velocity flood behaviour

The assessment of potential exposure to flooding and severity of flood hazards analysed using a risk-based approach consistent with ISO31000, which considers the likelihood of flooding and

consequence of flooding hazard, has demonstrated the proposed development does not increase existing flood risk in an unacceptable manner.

6.1.2 Natural processes and the protective function of landforms and/or vegetation are maintained in natural hazard areas

The natural flood behaviour has been described throughout this report. It has been shown there is a 13% increase in nett fill (as a proportion of proposed fill) on the site, which will result in a small decrease of floodplain storage.

The placement of the fill has the most significant impact on modelled post-development flood behaviour, specifically in the vicinity of the cabin/camping area, which impacts the out-of-channel flood conveyance in the 1%AEP flood event. This has been demonstrated to have an impact on existing peak flood levels of up to 183mm on conservation land, and up to 18mm on residential-zoned land, currently undeveloped to the north of the site.

A flood risk assessment was undertaken to investigate the implication of the modelled flood impacts, which has shown the proposed development:

- will not increase the number of properties at risk of flood inundation in the 1%AEP
- will not significantly impact flood hazard
- will not adversely impact existing dwellings.

Further modelling was undertaken to investigate if the addition of open channels through the cabin/camping grounds would improve floodplain conveyance. Whilst the design iterations were shown to improve floodplain conveyance and reduce flood level impacts in the post-development scenario, given the initial proposed design has been demonstrated to achieve acceptable flood risk outcomes outlined by the Douglas Planning Scheme, and the need for additional excavation and removal of vegetation to construct the channels, these design options may be contrary to the desired outcomes of the Planning Scheme in maintaining the protective function of existing vegetation.

7 Conclusion

JBPacific were commissioned by Hunt Design to deliver hydrological and hydraulic modelling within the Mowbray River catchment, to support the proposed integrated development of a recreational 'wave park', at Lot 123 on SR687, located 5km south of Port Douglas on the Captain Cook Highway.

An URBS hydrological model was developed estimate rainfall-runoff and streamflow in the Mowbray River catchment. Design flood estimation for the 1% Annual Exceedance Probability (AEP) flood event was completed to provide inflow hydrograph information to the hydraulic modelling.

The hydrodynamic modelling software TUFLOW using its 'Classic' engine was adopted as the basis of the hydraulic analysis. An existing TUFLOW model, developed for Douglas Shire Council as part of the draft Storm Tide Inundation Methodologies Study (JBPacific, 2020) project, was available as basis for modelling the proposed development. The TUFLOW model was modified to ensure that it appropriately simulated river flooding in the vicinity of the proposed development.

The hydraulic modelling was run to simulate both the existing catchment conditions and the post-development scenario. The results of the hydraulic modelling indicate flood impacts are restricted to the portion of the floodplain downstream of the Captain Cook Highway, Mowbray.

Results of the flood study demonstrate:

- The largest flood level impacts are evident to the west (upstream) side of the site between the proponents land and the Highway. The maximum afflux in this location is 183mm, however this is on State-owned conservation land and as such, the flood impacts are not anticipated to result in adverse impacts to people or property.
- There is only a minor increase in inundation extent, to the north of the site on the opposite bank to the proposed development. The minor increase in flood liable land is generally restricted to property zoned for rural uses and a review of available aerial imagery does not indicate the increase in flooded area will impact any existing dwellings in the lower catchment.
- The maximum impact on residential property is 18mm. It should be noted that whilst this land is zoned as low density residential in the Douglas Planning Scheme 2018, aerial imagery indicates it is currently vegetated, undeveloped land. Additionally, flood impacts are limited to an existing low-laying area of lot, which represents approximately 2% of the total lot area.
- Maximum flood impacts on rural land external of the proponents land is 37mm, which is located opposite the proposed development on agricultural land. An increase of 37mm is not expected to adversely affect the existing land owners ability to farm the land.
- Analysis of velocity afflux was conducted to demonstrate the impact the proposed development has on the flood velocity compare to the existing case. There are some increases in flood velocity within the proposed development site (up to 0.5 m/s); however, the maximum velocity change external of the site is less than 0.2 m/s.
- The supplied concept earthwork plan shows the total cut and fill volumes of 165,200m^3 and 190,700 m^3 respectively, resulting in a nett fill of 25,500 m^3. If flood impacts are considered undesirable, reducing the nett fill volume, through further compensatory cut on the western side of the earthworks area will likely reduce post development peak flood levels.

The proposed development has been shown to result in localised increases to 1%AEP peak flood levels external of the site. The maximum afflux of 183mm is located to the south-west of the site immediately adjacent to the proposed development between the site and the Captain Cook Highway. The flood impacts at the location are not considered to result in material nuisance as the lot is State-owned conservation land. The maximum impact to 1%AEP flood event peak water levels on existing residential lots is 18mm.

A 13% increase in nett fill (as a proportion of total proposed fill) on the site is proposed, which will result in a decrease of floodplain storage. The placement (rather than nett volume) of the fill has the most significant impact on modelled post-development flood behaviour, specifically in the vicinity of the cabin/camping area. Filling in this location impacts the out-of-channel flood conveyance in the 1%AEP flood event.

Further modelling was undertaken to investigate if the addition of open channels through the cabin/camping grounds would improve floodplain conveyance and assess the potential benefit of adding a trapezoidal open channel in this location. The objective of testing these design iterations was to determine if one or two channels - with an indicative 20 metre base, 1:4 sides and 500mm

depth - would provide sufficient additional conveyance to compensate for the loss of floodplain conveyance arising from the proposed earthworks. The two design iterations were successful in reducing the maximum peak flood impacts, however they did not show material benefit in flood risk outcomes.

Whilst the design iterations were shown to improve floodplain conveyance and reduce flood level impacts in the post-development scenario, given the initial proposed design has been demonstrated to achieve acceptable flood risk outcomes outlined by the Douglas Planning Scheme, and the need for additional excavation and removal of vegetation to construct the channels, these design options may be contrary to the desired outcomes of the Planning Scheme in maintaining the protective function of existing vegetation.

The Douglas Planning Scheme does not provide a definition of 'acceptable flood impacts', so a risk assessment in line with ISO31000 has been undertaken to demonstrate the proposed development 'avoids an unacceptable increase in severity'. ISO31000 is the international standard for risk management, and defines risk as the consideration of the likelihood of a hazard occurring and the consequence when an event occurs.

The assessment of the potential for damage to other properties was based on the number of properties exposed to flood hazard given a specified likelihood. In this case, the Defined Flood Event of 1%AEP was analysed, with the number of properties at risk external of the development site shown in Table 7-1.

Table 7-1. Summary of at-risk properties by land use

Land Use	Count of properties within the 1%AEP flood extent	
	Existing	Post-development
Conservation	9	9
Environmental Management	1	1
Low Density Residential	1	1
Ocean	1	1
Rural	45*	45
Rural Residential	0	0
Special Purpose	1	1
Total	115	115

*Note: An additional rural property was counted in the existing conditions model on the eastern extremity of the hydraulic model. This was deemed to be an artifact of the flood model itself and was not considered to be a valid inclusion in comparison with post development property exposure.

The exposure analysis shows the existing catchment conditions and post-development catchment conditions result in the same number of properties at risk in the 1%AEP flood event, and as such the proposed development does not significantly increase the potential for damage on the site or other properties.

An analysis of flood hazard, using depth-velocity results from hydraulic modelling of the proposed development was undertaken to gain an understanding of the severity of flood hazard under pre and post development conditions. A comparison of existing and post-development flood hazard based on depth-velocity flood information, shows a minor increase in flood hazard within the channel immediately downstream of the Captain Cook Highway and negligible (+/-0.2m2/s) or minor reduction in depth-velocity product on all existing properties. A review of aerial imagery available from Google and NearMap, indicates there are currently no dwellings located within the mapped flood impact area. Figure 6-1. Comparison of existing and post development depth-velocity flood behaviour

The assessment of potential exposure to flooding and severity of flood hazards analysed using a risk-based approach consistent with ISO31000, which considers the likelihood of flooding and consequence of flooding hazard, has demonstrated the proposed development does not increase existing flood risk in an unacceptable manner.

Appendices

A Appendix – Base Case Flood Model Results

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477 Boundary Street
Spring Hill
QLD 4004

Scale

0 0.5 1 km

Date
18/03/2021

Legend

Earthwork_hatch
Site

Peak Flood Level (mAHD)

- <= 1.9
- 1.9 - 2
- 2 - 2.1
- 2.1 - 2.2
- 2.2 - 2.3
- 2.3 - 2.4
- 2.4 - 2.5
- 2.5 - 2.6
- 2.6 - 2.7
- > 2.7

Title
Existing - 1%AEP Peak Water Level

Project
2021s0206 - Mowbray Wave Park Flood Study

Client
Hunt Design

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477 Boundary Street
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QLD 4004

Scale

0 0.5 1 km

Date
18/03/2021

Legend

Earthwork_hatch
Site

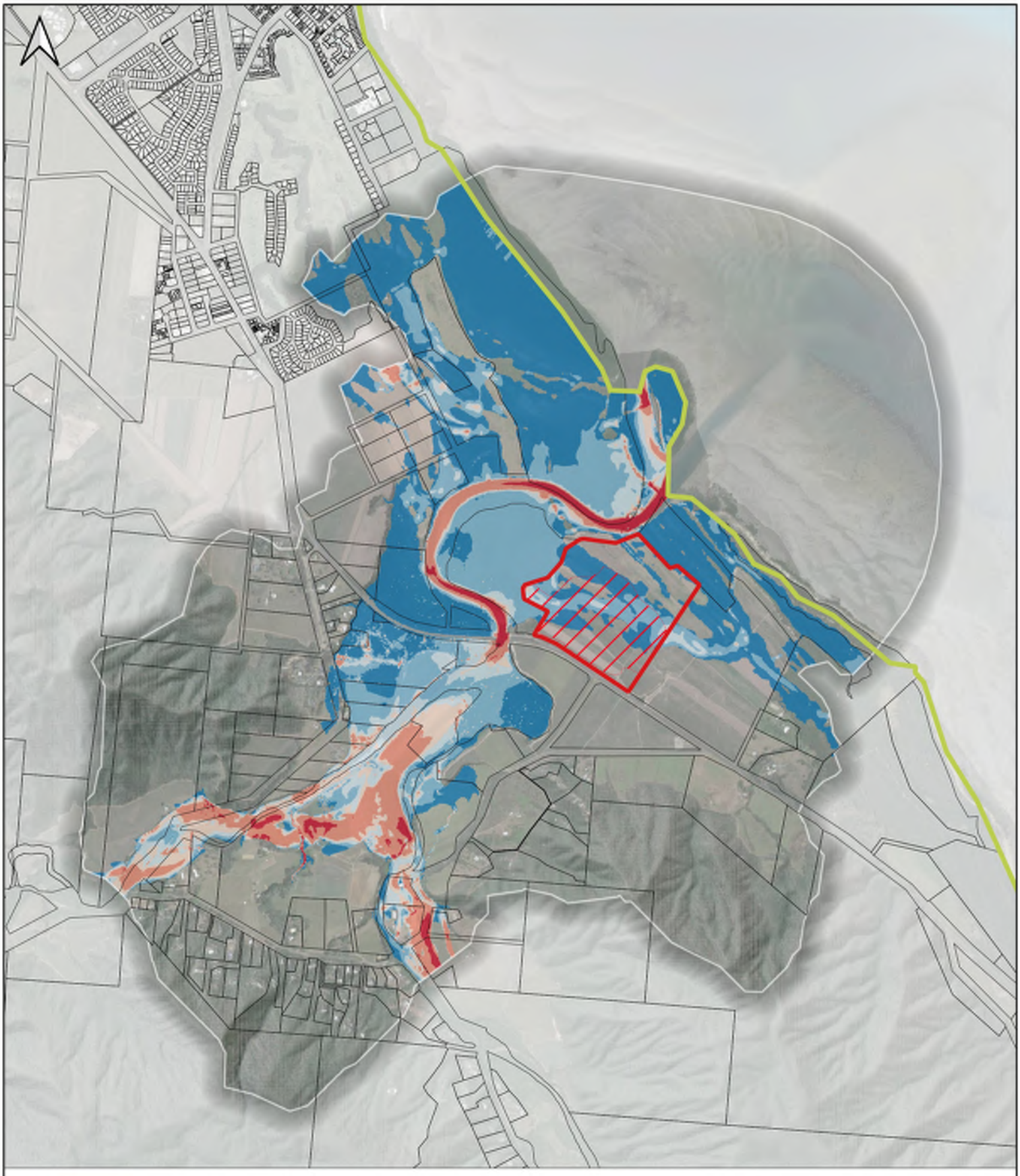
Peak flood depth (m)

- <= 0
- 0 - 0.3
- 0.3 - 0.6
- 0.6 - 0.9
- 0.9 - 1.2
- 1.2 - 2
- > 2

Title
Existing - 1%AEP Peak flood depth

Project
2021s0206 - Mowbray Wave Park Flood Study

Client
Hunt Design



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477 Boundary Street
Spring Hill
QLD 4004

Scale

0 0.5 1 km

Date
18/03/2021

Legend

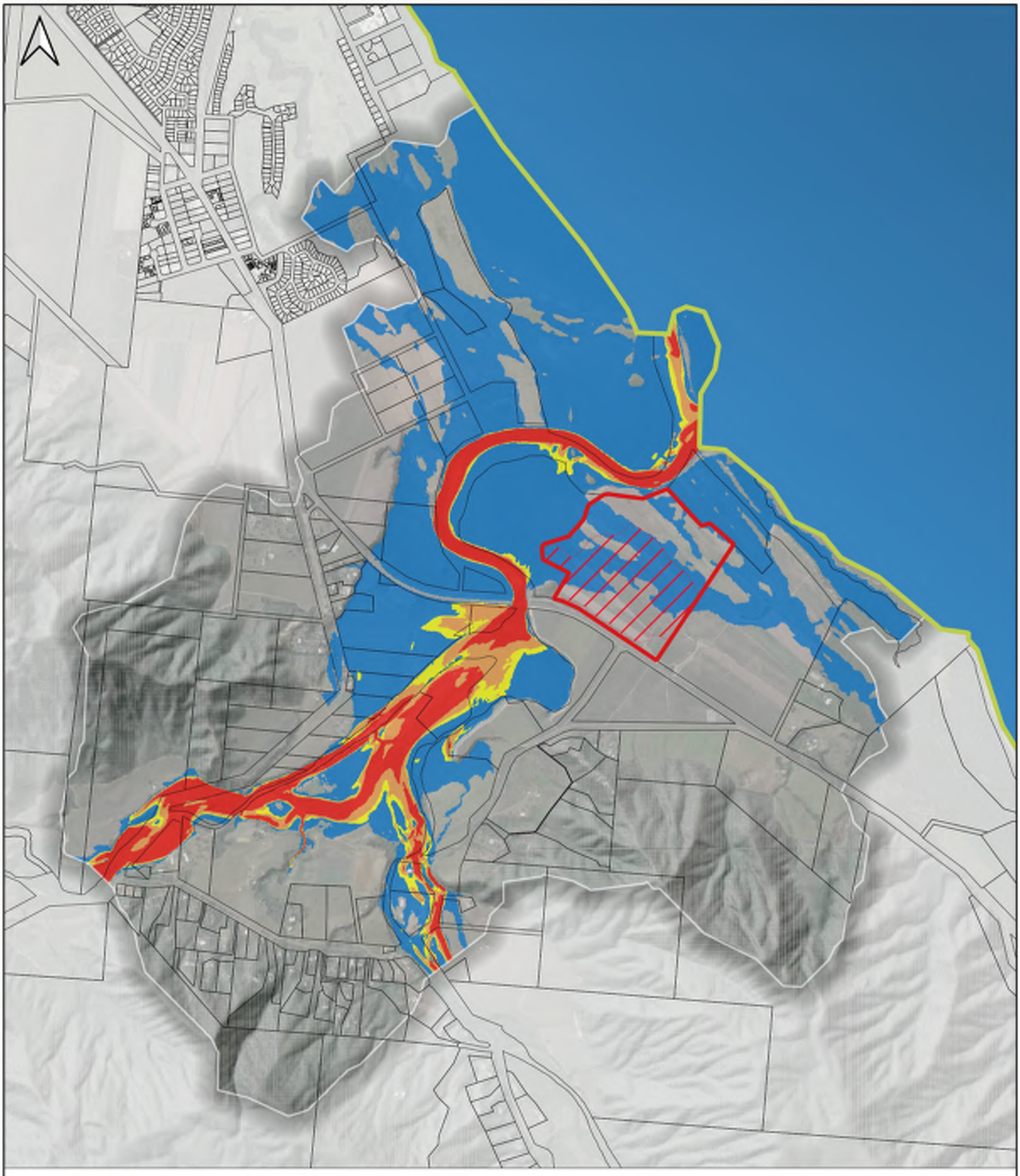
Earthwork_hatch
Site

Peak velocity (m/s)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 2.5
> 2.5

Title
Existing - 1%AEP Peak flood velocity

Project
2021s0206 - Mowbray Wave Park Flood Study

Client
Hunt Design



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Scale

0 0.5 1 km

Date
14/04/2021

Legend

- Earthwork_hatch
- Site
- Flood model extent
- Coastline

Depth-velocity hazard

- Low
- Significant
- High
- Extreme

Title
Existing case: 1%AEP flood depth-velocity hazard

Project
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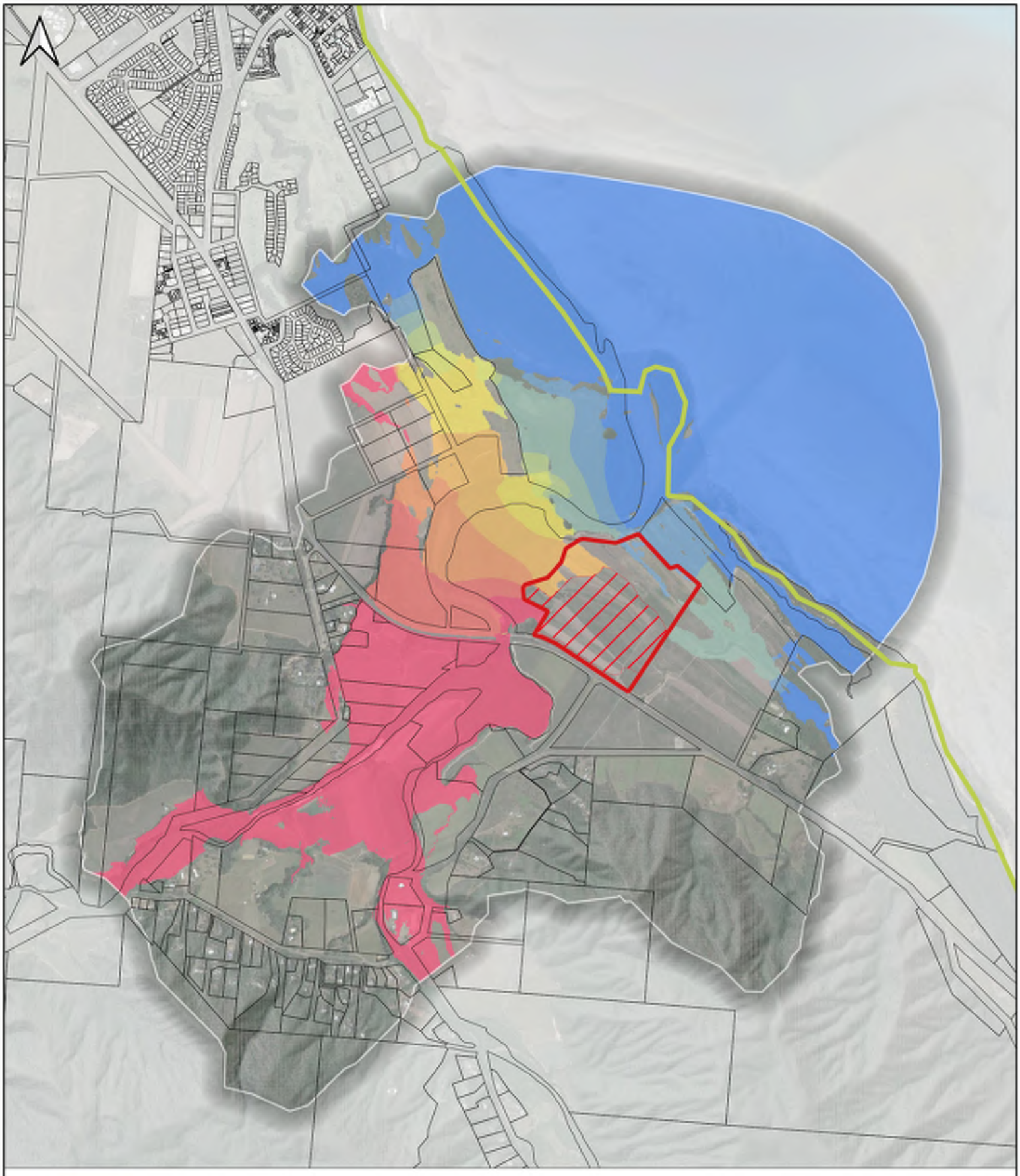
Hunt Design

B Appendix – Design Case Flood Model Results



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QLD 4004

Scale

0 0.5 1 km

Date
18/03/2021

Legend

Earthwork_hatch
Site

Peak flood level (mAHD)

- <= 1.9
- 1.9 - 2
- 2 - 2.1
- 2.1 - 2.2
- 2.2 - 2.3
- 2.3 - 2.4
- 2.4 - 2.5
- 2.5 - 2.6
- 2.6 - 2.7
- > 2.7

Title
Post development - 1%AEP Peak flood level

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Legend

Earthwork_hatch
Site

Peak flood depth (m)

- <= 0
- 0 - 0.3
- 0.3 - 0.6
- 0.6 - 0.9
- 0.9 - 1.2
- 1.2 - 2
- > 2

Title
Post development - 1%AEP Peak flood depth

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Date
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Legend

Earthwork_hatch
Site

Peak velocity (m/s)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 2.5
> 2.5

Title
Post development - 1%AEP Peak flood velocity

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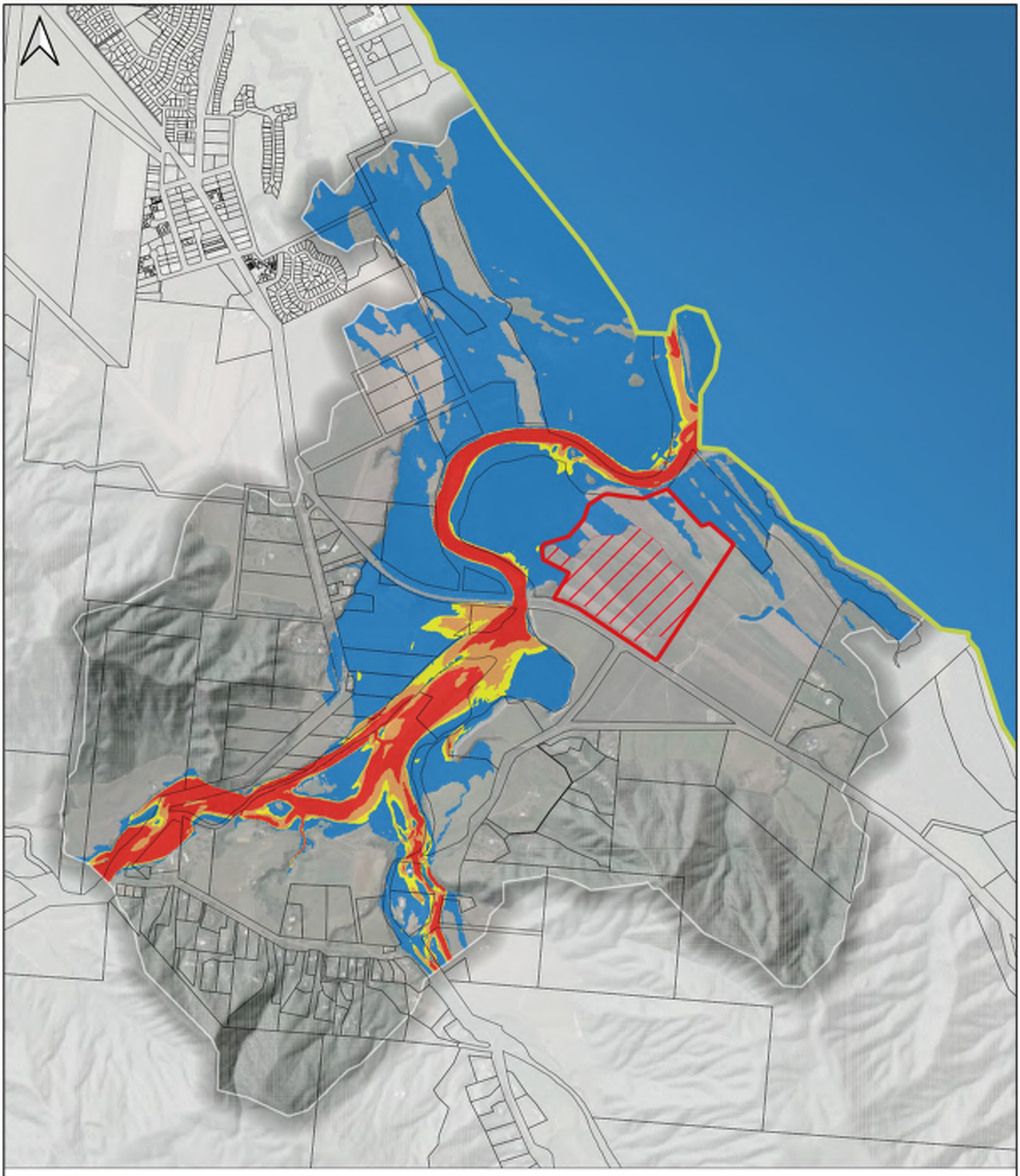

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Date
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Legend

- Earthwork_hatch
- Site
- Flood model extent
- Coastline

Depth-velocity hazard

- Low
- Significant
- High
- Extreme

Title
Post-development case: 1%AEP flood depth-velocity hazard

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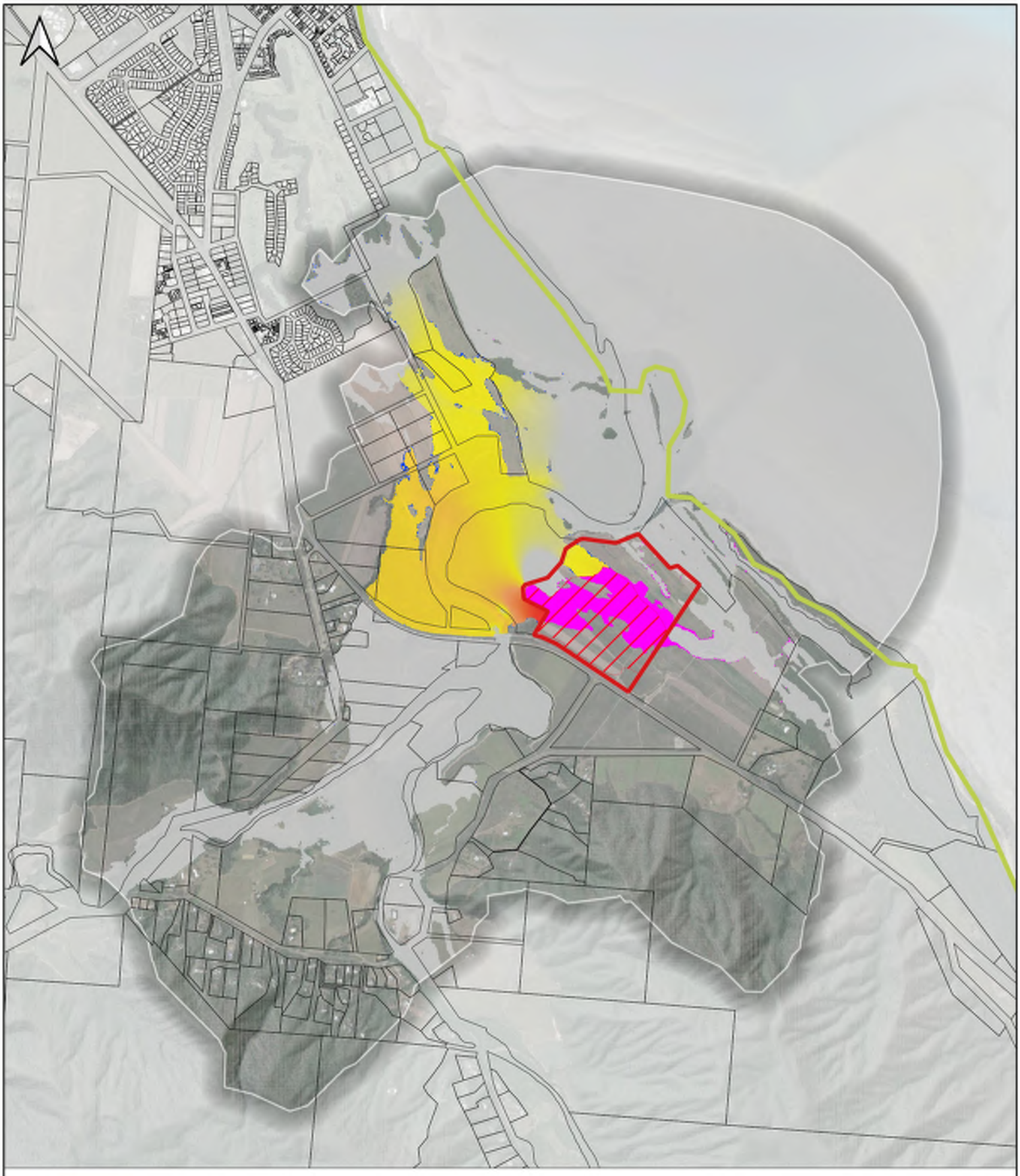
C Appendix - Flood Impact maps



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Legend

Earthwork_hatch
Site

Afflux (mm)
Was Wet, Now Dry
<-10mm
-10mm
10mm
20mm
50mm
100mm
200mm
>200mm
Was Dry, Now Wet

Title
Post development - 1%AEP Peak flood afflux

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Earthwork_hatch
Site

Velocity change (m/s)
<= -0.4
-0.4 - -0.1
-0.1 - 0.1
0.1 - 0.4
> 0.4

Title
Post development - 1%AEP Peak flood velocity impacts

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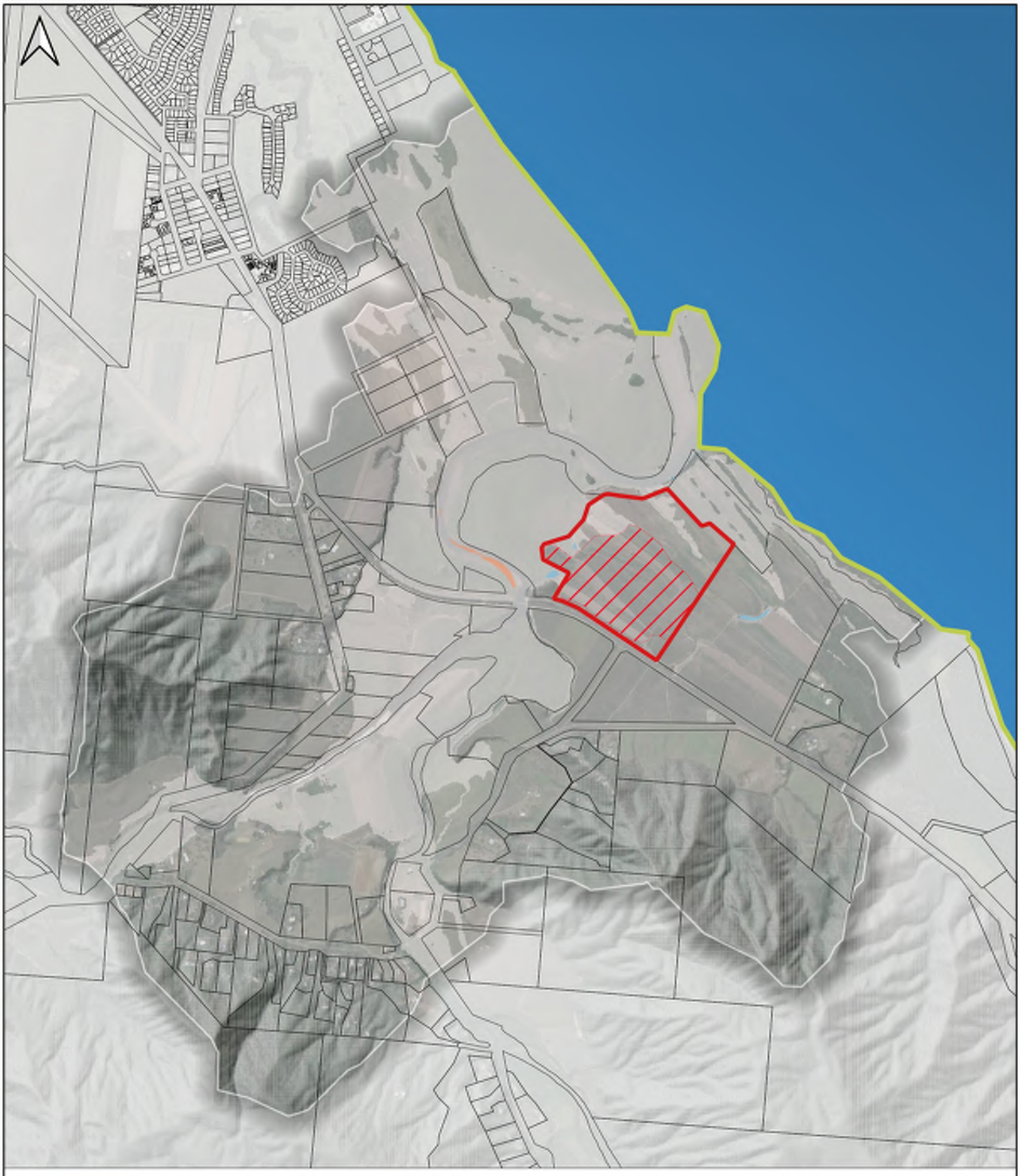

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Change in depth-velocity

- More than 0.4 m2/s reduction
- -0.4 to 0.2 m2/s reduction
- -0.2 to 0.2 m2/s
- 0.2 to 0.4 m2/s increase
- More than 0.4m2/s increase

Title
Change in 1%AEP flood depth-velocity (post-development minus existing case)

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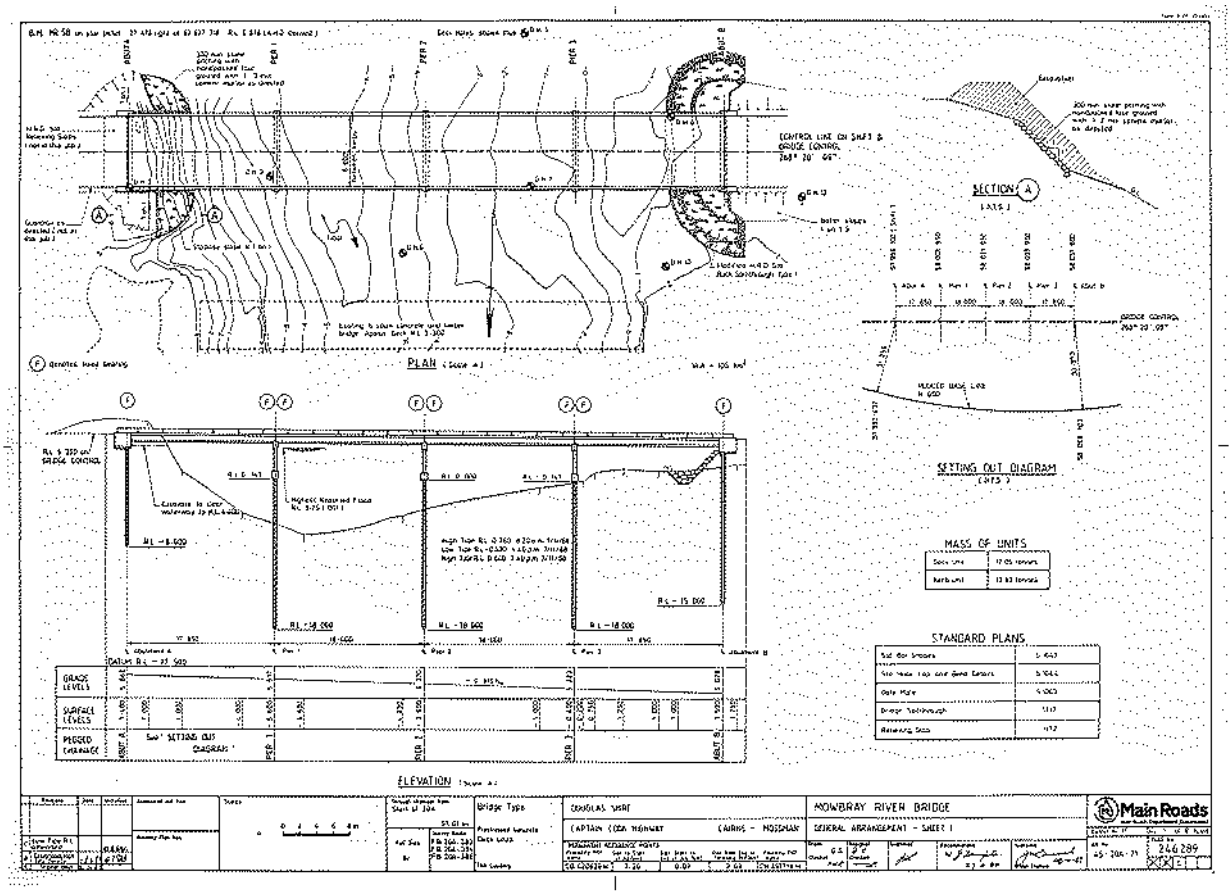
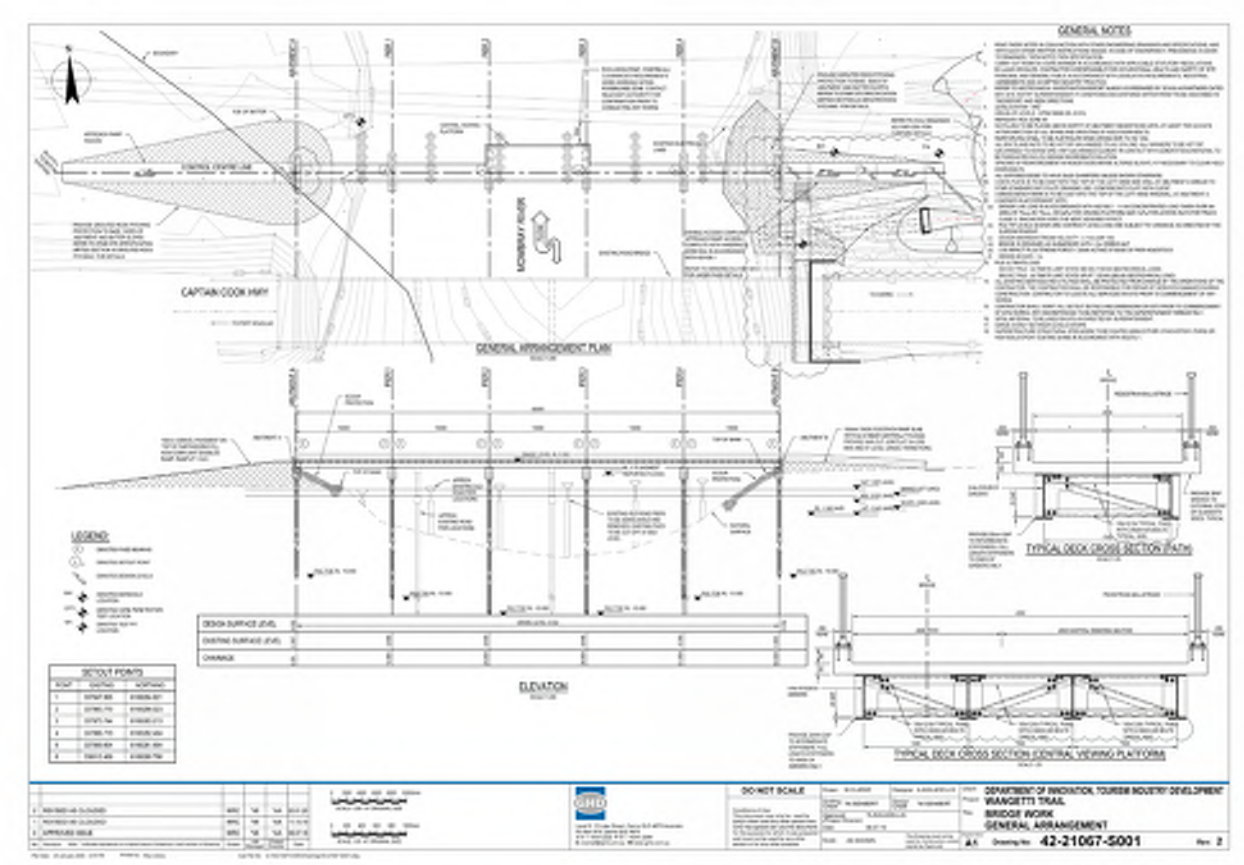
D Appendix – As Constructed Drawings





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Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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