CAIRNS SHIPPING DEVELOPMENT PROJECT

Revised Draft Environmental Impact Statement

Supplementary Report

Appendix E: Golder Associates Report 1546223-006

28 October 2016

BASELINE ASSESSMENT - DREDGED MATERIALS

Cairns Shipping Development Project

REPORT

Report Number. 1546223-006-R-Rev2

Distribution:

1 Electronic Copy - Flanagan Consulting Group

Golder Associates

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APPENDICES

1.0 INTRODUCTION

Flanagan Consulting Group (FCG) commissioned Golder Associates Pty Ltd (Golder) to provide geotechnical advice as part of the Revised Draft Environmental Impact Statement for the Cairns Shipping Development (CSD) Project. Geotechnical input related to the assessment of the values and constraints associated with the dredge material includes the following:

- Further assessment of subsurface conditions likely to be encountered in the proposed dredging;
- Further assessment of the geotechnical properties of the dredged materials;
- Further assessment of the ASS properties of the dredged materials.
- Preparation of a 3D model of ground conditions relevant to the proposed dredging.

This report presents the results of the studies.

2.0 PREVIOUS INVESTIGATIONS

2.1 Golder Investigations

Of the documents prepared by Golder for the Draft EIS, the information considered to be most relevant to assessment of the dredged materials is presented in the following reports:

- Golder report reference 117672052-001-Rev0, dated November 2011. This report presented information on subsurface conditions based on a review of available documents from Ports North and information from previous Golder projects in the general area of the port.
- Golder report reference 107672522-008-Rev1, dated June 2012. This report presented information on subsurface conditions based on the results of test pitting at five locations along the channel and subsequent laboratory testing.
- Golder report reference 137632122-001-Rev0, dated September 2013. This report presented further information on subsurface conditions based on the results of drilling at seven locations along the channel and subsequent laboratory testing.

Copies of relevant information from these reports is presented in Appendix A1.

2.2 Other Available Information

Available documents from Ports North containing information relevant to assessment of the dredged materials includes the following:

- Dept of Harbours and Marine Qld - Seven boreholes (BH CA to BH CG) drilled along the channel in 1964.
- Westminster Dredging Australia – Thirty boreholes (WDA1 to WDA30) drilled along the channel in 1965.
- Douglas Partners – Three boreholes drilled for the Marlin Marina in 1993.
- GHD - Two boreholes drilled for the Marlin Marina in 2001.
- BMT WBM – Fifty-five sampling locations for EIS in 2014.

Copies of relevant information from these documents is presented in Appendix A2.

3.0 CURRENT INVESTIGATIONS

3.1 Rationale for Proposed Fieldwork and Laboratory Testing

The rationale for the proposed fieldwork and laboratory testing for the current investigations is summarised below:

- Geotechnical boreholes – Boreholes were proposed at 8 locations within the proposed channel widening, with the aim of recovering “undisturbed” samples for assessment of undrained shear strength (by hand vane/penetrometer) plus geotechnical laboratory testing (i.e. Moisture Content, Bulk Density, Atterberg Limits and Particle Size Distribution). The boreholes were also aimed at recovering soil core for ASS testing (i.e. field screening and Chromium Suite testing). With regard to ASS sampling and testing, it is noted that the main channel widening covers areas of about 4 hectares and 8 sampling locations across these areas provides compliance with QASSIT guidelines.

- Grab sampling (with Ports North dredging equipment) – Grab sampling was proposed at 20 locations to ~0.8m depth in areas proposed for channel deepening (i.e. 16 locations in “sediments”), channel widening/deepening (i.e. 2 locations in “stiff clays”), and channel widening (i.e. 2 locations in “mud”). The aim of this work was recover “undisturbed” samples for further assessment of undrained shear strength plus for geotechnical laboratory testing (as outlined above), plus to recover additional samples for ASS testing (as outlined above), The grab sampling was also aimed at recovering bulk samples of soils and seawater required for specialised laboratory testing by BMT JFA.

- Geophysics – ~52km of longitudinal lines and traverse lines were proposed with the aim of assessing the depth to the soft clay/stiff clay interface within the areas proposed for dredging, particularly in areas where stiff clays are expected to be encountered within the depth of proposed dredging. The results of the survey were to be calibrated with the ground conditions encountered in previous and proposed boreholes.

The fieldwork and laboratory testing are discussed further in the following sections.

3.2 Geophysics

The geophysical survey was completed between 16 and 17 August 2016 and covered an area approximately 200 m wide and 12 km in length. Four longitudinal lines and 27 transverse lines were carried out totalling about 59 km. The survey methodology and results are presented in Section 4.0

3.3 Boreholes and Grab Sampling

The boreholes (namely BH1 to 3, BH5 and BH7 to 8) were drilled to depths ranging from 2.5 m to 9.5 m. proposed boreholes BH4 and BH6 could not be drilled due to the adverse weather and sea conditions at the time of the drilling programme. The geotechnical samples were recovered using wash boring methods with undisturbed (U75) tubes. The ASS samples were generally recovered using piston tube sampling, however where the depth of water did not allow this type of sampling the samples were recovered using wash boring methods with undisturbed (U75) tubes.

Grab sampling was carried out at twenty locations (namely GS1 to GS20). Additional sampling (namely GS21 and GS22) was carried out at the proposed locations of boreholes BH4 and BH6.

The locations of the boreholes and the grab sampling are shown on Figures F001 and F002, and the reports are presented in Appendix B1 and B2 respectively. Photographs of materials collected during the grab sampling are also presented in Appendix B2.

3.4 ASS Sampling

Soil samples targeting ASS were generally collected at 0.25 m intervals in soft sediments. Where stiff materials were encountered sampling for ASS was generally terminated. ASS samples were labelled and sealed in lock seal plastic bags and placed in a chilled esky for transportation to Golder’s office. Samples were held in a freezer at Golder’s office.

Field screening tests were conducted on all retrieved soil samples at Golder’s office. The results of the field screening tests are presented in Appendix C2.

Following field screening, selected samples were then dispatched to SGS Environmental in Cairns and frozen until laboratory testing was undertaken. All samples collected were sent under Chain of Custody (CoC) procedures.

3.5 Geotechnical Field and Laboratory Testing

Field and laboratory testing was carried out on selected samples of the materials encountered from the boreholes and grab sampling. The laboratory testing included the following:

- Bulk Density & Moisture Content – The bulk density (or wet density) was determined by measurement and weighing of U75 tube samples at the time of drilling and grab sampling. Subsamples were then collected for subsequent determination of moisture content and dry density. During the grab sampling up to 4 tube samples were collected for this testing to reduce the potential for erroneous results. Testing was carried out on 83 no. samples
- Undrained Shear Strength – Hand vane tests were carried out on 83 no. U75 tube samples collected during the drilling and grab sampling.
- Atterberg Limits and Particle Size Distribution – 43 no. plasticity and grading tests were performed to classify samples of materials proposed for dredging. Testing on 7 no. samples proposed for settlement column and consolidometer testing organised by BMT JFA also included hydrometer analyses, particle density and organic content.

The laboratory testing certificates are presented in Appendix C1 and the results of the field and laboratory testing are summarised in a table in Appendix C1.

3.6 ASS Laboratory Testing

Soils samples were selected for laboratory Chromium Suite testing based on the field screening results, soil type, consistency and depth profile.

A total of 71 samples were selected for laboratory testing. The laboratory certificates of analysis are presented in Appendix C2.

Net acidity and lime treatment rates for the 71 samples and previous ASS investigation results were calculated using acid base accounting methods. These calculated results are summarised in a table in Appendix C2.

Due the presence of shell and shell grit in most of the recovered soft sediments, a “fineness factor” of 3 was adopted in calculations to account for possible overstatement of neutralising capacity as a result of laboratory ring grinding of samples. This changed the status of some previous investigation results which had been reported as “self-neutralising”.

4.0 MARINE GEOPHYSICAL SURVEY

4.1 General

As outlined previously the marine geophysical survey was completed over an area measuring approximately 200 m wide by 12 km in length. The survey comprised four longitudinal lines and 27 transverse lines totalling approximately 59 km.

The survey was carried out from the vessel ‘Tribulation’, a pilot vessel supplied by Ports North for the duration of the survey. The survey comprised Sub-bottom Profiling (SBP). A trackplot of the completed SBP lines is shown in Figure 003. Descriptions of the survey methodologies are presented below.

4.2 Survey Datum and Navigation

The horizontal datum used in the survey is the World Geodetic System 1984 (WGS84) Map Grid of Australia (MGA) Zone 55. Derivative sub-seabed data from the SBP survey have been adjusted to Chart Datum (CD) by correcting the depths against the available bathymetry data.

The vessel (and all ancillary locations) positioning was determined with AMSA corrected DGPS positions. This typically has sub-metre accuracy, depending upon horizontal dilution of precision (HDOP) values. This level of accuracy is usually adequate for this type of survey. Lever arm offsets between layback tie points and the GPS antenna centre were determined and checked throughout the survey. The Hypack Survey software was used for pre navigation set up and on board vessel navigation along pre-defined survey lines.

4.3 Sub-Bottom Profiling

4.3.1 Field Methods

The Sub-Bottom Profiling (SBP) survey was completed using an Innomar SES-2000 portable profiling system. The high ping rate, small footprint and the possibility of transmitting sound pulses over a wide frequency range ensures that the SES-2000 images the sub-seafloor with excellent resolution and has very good sediment penetration. The transducer was pole mounted to the vessel at 1.5 and 2.1 m below the water line. The acquisition settings utilised combined 4, 10, and 15 kHz operating frequencies, with one pulse rate. The vessel speed for the SBP survey was maintained at 4 to 5 knots.

The SBP equipment was interfaced to a computer system through the SeisWin software, which enabled navigation data to be appended to the seismic digital record and depth window control. The seismic data were recorded in RAW and SES formats, and were later converted to the industry standard SEGY format in accordance with typically accepted practice.

4.3.2 Data Processing

The SEGY data files were imported into ReflexW v 8.1 software for processing and interpretation. During data processing filtering, trace interpolation and normalisation, and gain enhancements were considered to optimise the output of the seismic records. Interpretation of the SBP data involved bottom tracking and identifying the soft to stiff clay interface through correlation with available borehole data.

4.4 Survey Results

The SBP data was successfully acquired over the entire area proposed for dredging along a total of 31 transects, comprising four longitudinal lines and 27 transverse cross lines. The main features of the sub-bottom profiling results are summarised below.

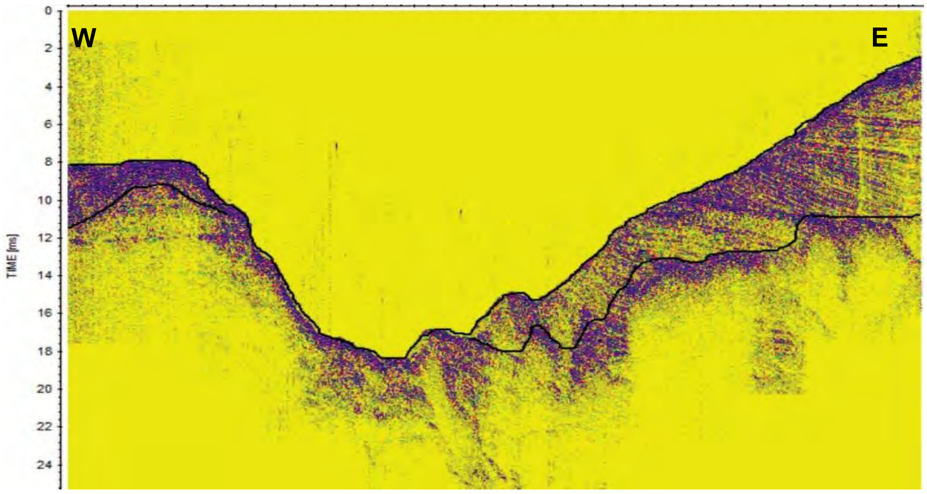
The SBP data is generally of good quality and adequate depth penetration to image the soft to stiff clay interface was achieved along the majority of the transects. Depth penetration ranged from 1 m to 8 m below the seabed.

There were a few isolated areas where the vessel engine noise impacted resolution of the data. The effect of heavy swells can be seen on the lines at the outer end of the survey area, but they are not enough to negatively impact the detection of the soft to stiff clay interface reflector. Following post-processing several acoustic artifacts were recognisable in the data, especially seabed ‘multiples’ in shallow water. These require to be identified and isolated during interpretation for sub-bottom features.

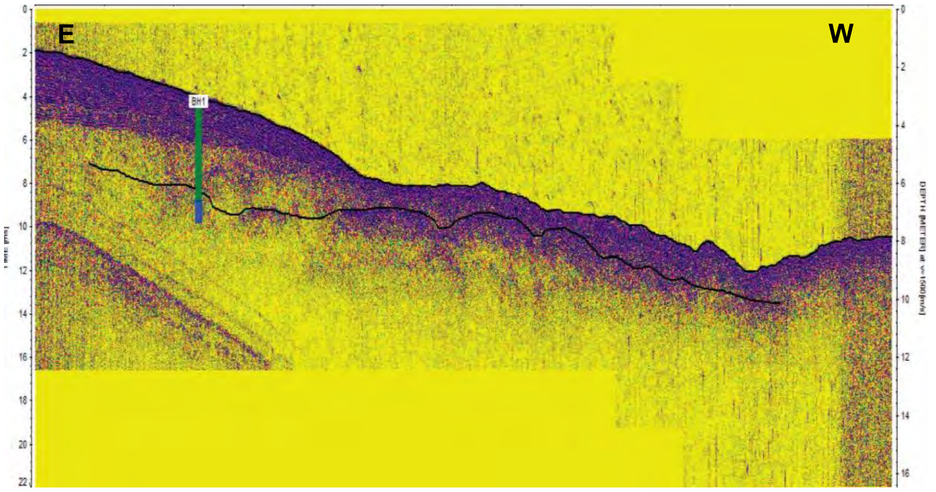
Correlation with borehole data revealed that the soft to stiff clay interface is defined by a prominent sub-bottom reflector and is referred to in this report as “R1”.

Insets 1 to 6 below show some example SBP sections across the survey area, with available borehole information overlain and the interpreted seafloor and R1 reflectors marked with a continuous black line. Blue segments of the overlain borehole data represent the stiff clay layers.

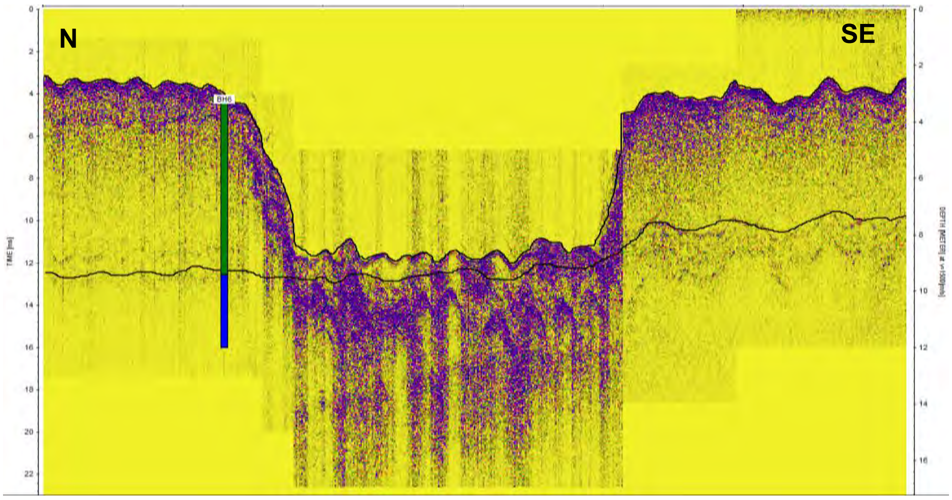
This reflector is variously defined on the basis of geometrical changes in internal reflections, contact relationships and amplitude changes. The R1 reflector is generally more undulating in the inner part of the survey area adjacent to the wharfs and marina, where there is evidence of incisions (e.g. Inset 1 and 2). It becomes more regular and continuous in the outer part of the survey area where there appears to have been more uniform deposition (e.g. Inset 3 and 5). The soft clay unit, above the R1 reflector, often shows higher amplitude internal reflections (e.g. Inset 4 and 6) and cross bedding (e.g. Inset 1) which may be indicative of coarser sediment layers such as sand and shells as encountered in some boreholes.



***Inset 1:** Example SBP section at the inner-channel area, showing the undulating R1 reflector and cross bedding in the soft unit above. Presented in a west to east orientation.*



***Inset 2:** Example SBP section at the inner-channel area (near wharf), showing the undulating R1 reflector, correlated against borehole BH1. Presented in an east to west orientation.*



***Inset 3:** Example SBP section at the mid-channel area, correlated against borehole BH6 (offset approximately 230 m north-east). Presented in a north-west to south-east orientation.*

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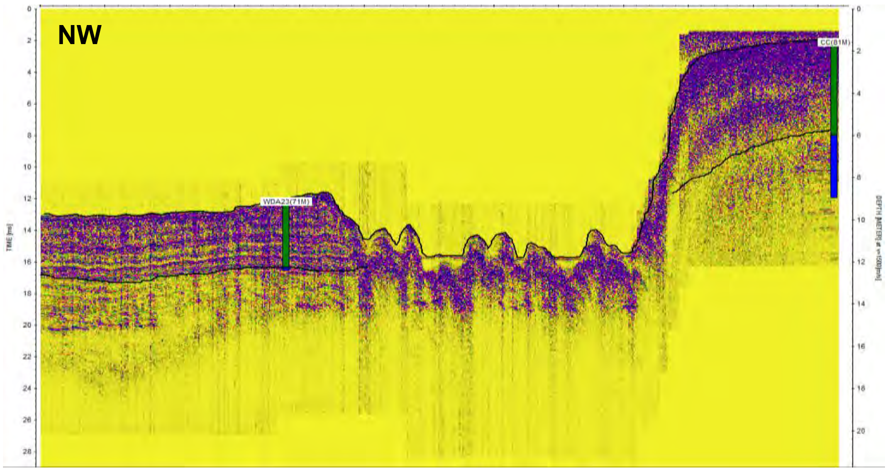
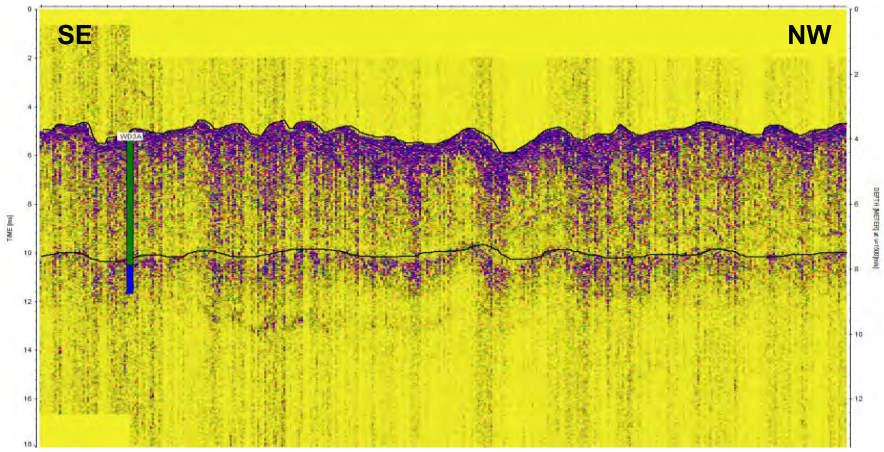
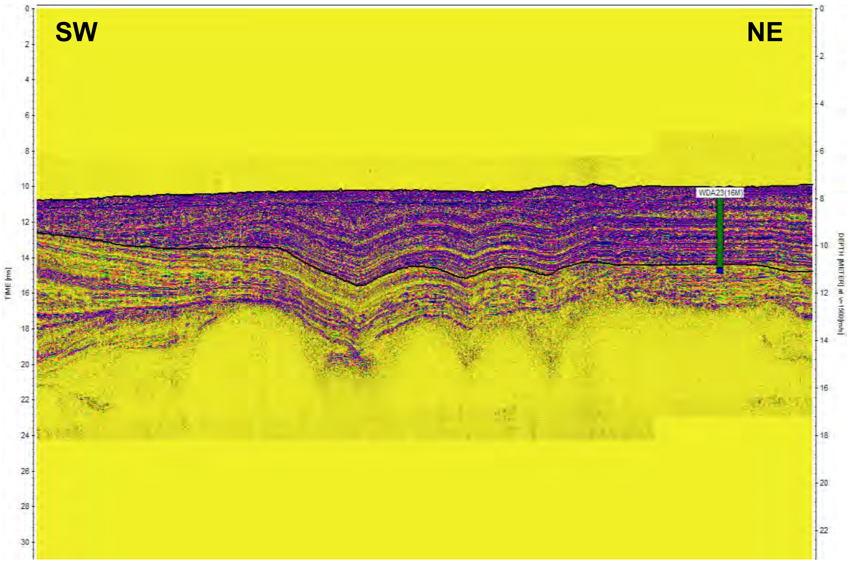


Inset 4: *Example SBP section at the lower-channel area, correlated against boreholes WDA23 (offset approximately 70 m north-east) and CC (offset approximately 81 m north-east). Presented in a north-west to south-east orientation.*



Inset 5: *Example SBP section at the northern end of the outer channel, correlated against borehole WDA3. Presented in a south-east to north-west orientation.*



Inset 6: *Example SBP section at the lower-channel area, correlated against borehole BH6 (offset approximately 15 m south-east). Presented in a south-west to north-east orientation.*

An interval velocity of 1500 m/s and 1700 m/s was used to convert ‘two-way times’ seismic data into an interpreted depth for the seabed and the R1 reflectors respectively. These were used to estimate the thickness of the soft clay layer above the R1 reflector. The thickness of this layer was then subtracted from pre-existing bathymetry data extracted along each of the SBP lines, to derive the top of stiff clay surface layer relative to CD.

This approach to the data reduction assumes that the seafloor levels were the same at the time of the bathymetry data and SBP data acquisition. Due to ongoing dredging works at the time of the SBP survey, it should be noted that the seafloor may not be consistent in a few places between the surveys.

The interpreted top of stiff clays surface has been used to prepare a 3D model of the subsurface relevant to the proposed dredging.

5.0 GROUND MODEL

An interpreted 3-dimensional (3D) triangulated surface model of ground conditions has been developed using the VulcanTM geological modelling software. The main feature of the model is the top of stiff clay, with this boundary surface being equivalent to the base of soft clay where a soft clay layer is present or, where stiff clay occurs at sea bed level, is coincident with the sea bed.

The modelled surface of the stiff clay has been used in combination with the bathymetric survey and channel design information provided to estimate the expected dredging volumes of the different material types within the maintenance and capital channel designs.

The following information was used in the development of the model and calculation of estimated material volumes:

- Bathymetric survey – “Composite survey data.dxf” provided by email to Golder by BMT JFA on 2 August 2016 (file size 62.017 MB);
- Capital Channel design – “Rev B Revised Draft EIS Channel design Model.dxf” provided by email to Golder by BMT JFA on 2 August 2016 (file size 6.918 MB);
- Maintenance Channel design – “Existing channel design 2016-08-02.dxf” provided to Golder by BMT JFA on 2 August 2016 (file size 1.869 MB);
- The results of previous site investigations outlined in Section 2.0;
- The results of 2016 investigation drilling and grab sampling outlined in Section 3.0; and
- The results of the 2016 geophysical surveys discussed in Section 4.0.

Prior to incorporating the geophysics results into the Vulcan model, the inferred top of stiff clay level defined by the geophysics was calibrated against the available investigation points located along the traverse lines. The resultant stiff clay levels along the traverse lines were then imported into Vulcan and used as the primary basis for the modelled surface developed in Vulcan.

Along each geophysical traverse line, a smoothed line of best fit was drawn through the geophysics points, with minor local variations in level being generally disregarded / smoothed in an effort to simplify the model.

The modelled surface was extrapolated between and outside the limits of the geophysical traverse lines by using the available investigation points as a guide. Wherever there was an apparent discrepancy between the information, the geophysics data was favoured on the basis that its surveyed (by GPS) plan location was considered to be more accurate.

Volumetric calculations within Vulcan are based on a comparison of the relative vertical positions of two triangulated surfaces, within the area of overlap between the two surfaces. The total volume of capital dredge material has been taken as the volume between maintenance dredge level and capital dredge level. Calculated volumes of dredge materials are as follows:

- Total volume of capital dredge material - 824,242m^3
- Volume of “soft” clays in capital dredge volume - 697,346m^3
- Volume of “stiff” clays in capital dredge volume - 126,896m3

Cross sections generated from the ground model are presented as Figures F004 to F006. It is noted that in some cases the existing seabed is already below the maintenance dredge level.

6.0 DREDGED MATERIAL PROPERTIES

6.1 General

The current and previous investigations have indicated that in general terms the dredged materials will mainly comprise very soft to firm silty clays, with a relatively small quantity of stiff to hard clays and an even smaller quantity of sands. Golder had previously indicated that the very soft to firm clays include a quantity of transported sediment materials as well as insitu marine clays. The inferred presence of the transported sediment materials had been based on the following:

- A layer of silty material was noted above the soft to firm silty clays in most of the 2012 test pits by Golder. Although the results of laboratory classification testing indicate that these materials were clays their properties were different from the underlying soft to firm silty clays. These test pits were located within the existing channel.

The results of current investigations appear to confirm the above (at least in some aspects) and also provide additional information to support the above, namely:

- The insitu bulk densities of materials inferred to be sediments (i.e. those from “deepening” investigation locations) are generally significantly lower than other very soft to soft materials (i.e. those from “widening” investigation locations;
- The insitu shear strengths of materials inferred to be sediments (i.e. those from “deepening” investigation locations) are generally significantly lower than other very soft to soft materials (i.e. those from “widening” investigation locations).

Based on the above the following general material types have been adopted for the purposes of reporting:

- Very soft to soft transported materials – “sediments”.
- Very soft to soft insitu materials – “mud”.
- Stiff to hard insitu materials – “stiff clays”.

In addition to these general materials indications are that relatively isolated layers or zones of sandy and/or gravelly materials are also likely to be present.

The location and/or extent of each of the mud and sediments has not been quantified, however based on the information available our comments on the properties of these materials and other dredge materials are presented in the following sections.

6.2 Sediments

The sediments appear to be mainly confined to the existing dredged channel and are inferred to generally range in thickness from 0.2 – 1 m. The sediments comprise predominantly silt and clay size material. Available information indicates insitu dry densities around 0.7 t/m^3 (range 0.43 to 1.12 t/m^3).

6.3 Mud

The mud generally underlies the sediment in the existing dredged channel and is expected to be present in most areas where channel widening is proposed, particularly Ch 17,000 to 20,000. The mud comprises predominantly silt and clay size material. Available information indicates insitu dry densities around 0.9 t/m^3 (range 0.55 to 1.24 t/m$^{3)}$.

6.4 Stiff Clays

The stiff clays generally underlie the mud in the existing dredged channel and in areas where channel widening is proposed. Stiff clays are expected to be encountered within the channel widening and deepening from Ch 13,500 to 15,000. Available information indicates insitu dry densities around 1.6 t/m^3 (range 1.42 to 1.72 t/m$^{3)}$.

6.5 Sands

Sands were encountered at number of inner harbour investigation locations – namely GS1, GS3, GS4, GS5, GS21, and GS10 at Ch. 17500 to depths ranging from 0.2 to 0.75 m. This unit is typically underlain by very soft to soft silt/ clay at depth. Shell contents are inferred to range from about 20 to 40 % of the total mass based on visual observations.

6.6 ASS Assessment

Interpretation of the results of current and previous sampling and testing is summarised below:

- Sediment and mud materials have potential acidity (chromium reducible sulfur) levels which would classify these materials as PASS. The total volume of these materials was calculated as 697,346 m^3.
- The majority of these PASS materials have sufficient neutralising capacity to classify them as self-neutralising PASS. The volume of these materials was calculated as 467,633 m^3.
- Locations where PASS materials (without sufficient neutralising capacity) have been identified are shown on Figures F007 and F008. The volume of these materials was calculated as 229,713 m^3 made up as follows:
  - Main Swing Basin – 33,379 m^3 with an indicative treatment rate of 85 kg lime/m^3
  - Crystal Swing Basin – 1,463 m^3 with an indicative treatment rate of 40 kg lime/m^3
  - CH14750-CH15250 - 19,943 m^3 with an indicative treatment rate of 85 kg lime/m^3
  - CH15250-CH16250 - 105,699 m^3 with an indicative treatment rate of 30 kg lime/m^3
  - CH17500-CH18000 - 69,229 m^3 with an indicative treatment rate of 70 kg lime/m^3
  - PASS was also detected at isolated investigation locations beyond CH19250 but at depths of 2m to 3m below the base of the channel. These results have not been considered further.
- Stiff clays have been confirmed as non-ASS.

7.0 IMPORTANT INFORMATION

Golder’s geophysical services are conducted in a manner consistent with the level of care and skill ordinarily exercised by other members of the geophysical community currently practicing under similar conditions and subject to the time limits, financial and physical constraints applicable to the services. The Sub-Bottom Profiling technique used in the work is a remote sensing geophysical method that may not detect all subsurface features. Depth of penetration is dependent on the nature of the subsurface. Furthermore, it is possible that interpreted features such as stratigraphic boundaries, top of bedrock, fills, faults, voids, other geologic characteristics and also buried features/ utilities may, upon intrusive sampling, prove to have been misinterpreted. Accurate interpretation of remote sensing data benefits form and to some extent can rely on the site specific correlation of information with that obtained from direct observation, possibly borehole drilling, in situ testing or digging methods.

Your attention is drawn to the document – “Important information relating to this report” which is included as an Appendix to this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing. We would be pleased to answer any questions about this important information from the reader of this report.

GOLDER ASSOCIATES PTY LTD

Malcolm Cook

Malcolm Cook
Principal Geotechnical Engineer

MSC/PKS/ow

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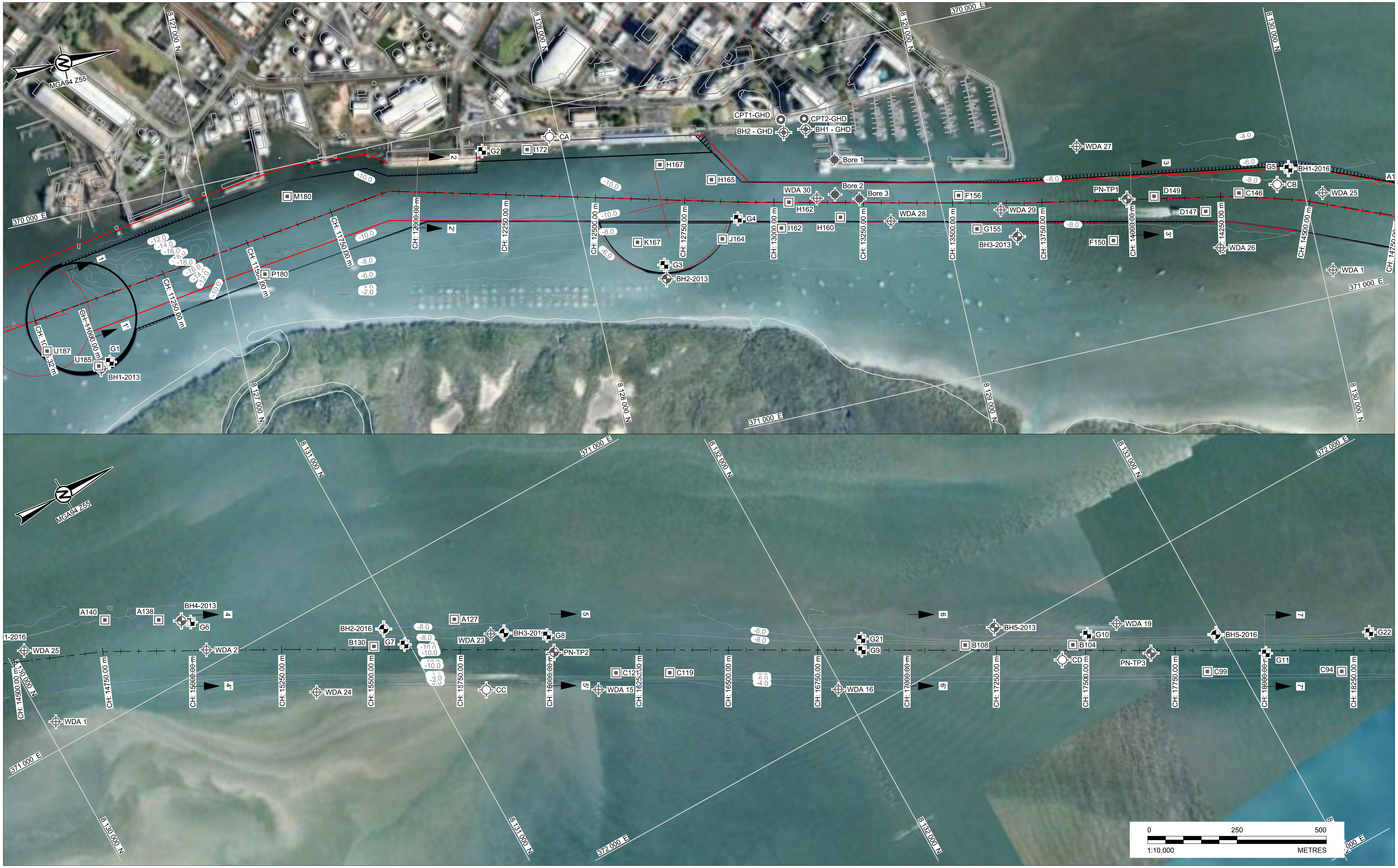
FIGURES



LEGEND

●	BORE HOLE GOLDER ASSOCIATES (CURRENT INVESTIGATION)
▪	GRAB SAMPLE GOLDER ASSOCIATES (CURRENT INVESTIGATION)
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⊕	BORE HOLE GHD (PREVIOUS INVESTIGATION)
●	BORE HOLE DOUGLAS PARTNERS (PREVIOUS INVESTIGATION)
⊕	BORE HOLE WDA (PREVIOUS INVESTIGATION)
○	BORE HOLE CH (PREVIOUS INVESTIGATION)
▣	BORE HOLE BMT-WBM (PREVIOUS INVESTIGATION)
◉	CPT GHD (PREVIOUS INVESTIGATION)

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

CONSULTANT
Golder Associates

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PREPARED	GPG
REVIEWED	MC
APPROVED	MC

TITLE
INVESTIGATION LOCATION PLAN - SHEET 1

PROJECT NO.	DOCUMENT No	REV.	FIGURE
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CONSULTANT
Golder Associates

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INVESTIGATION LOCATION PLAN - SHEET 2

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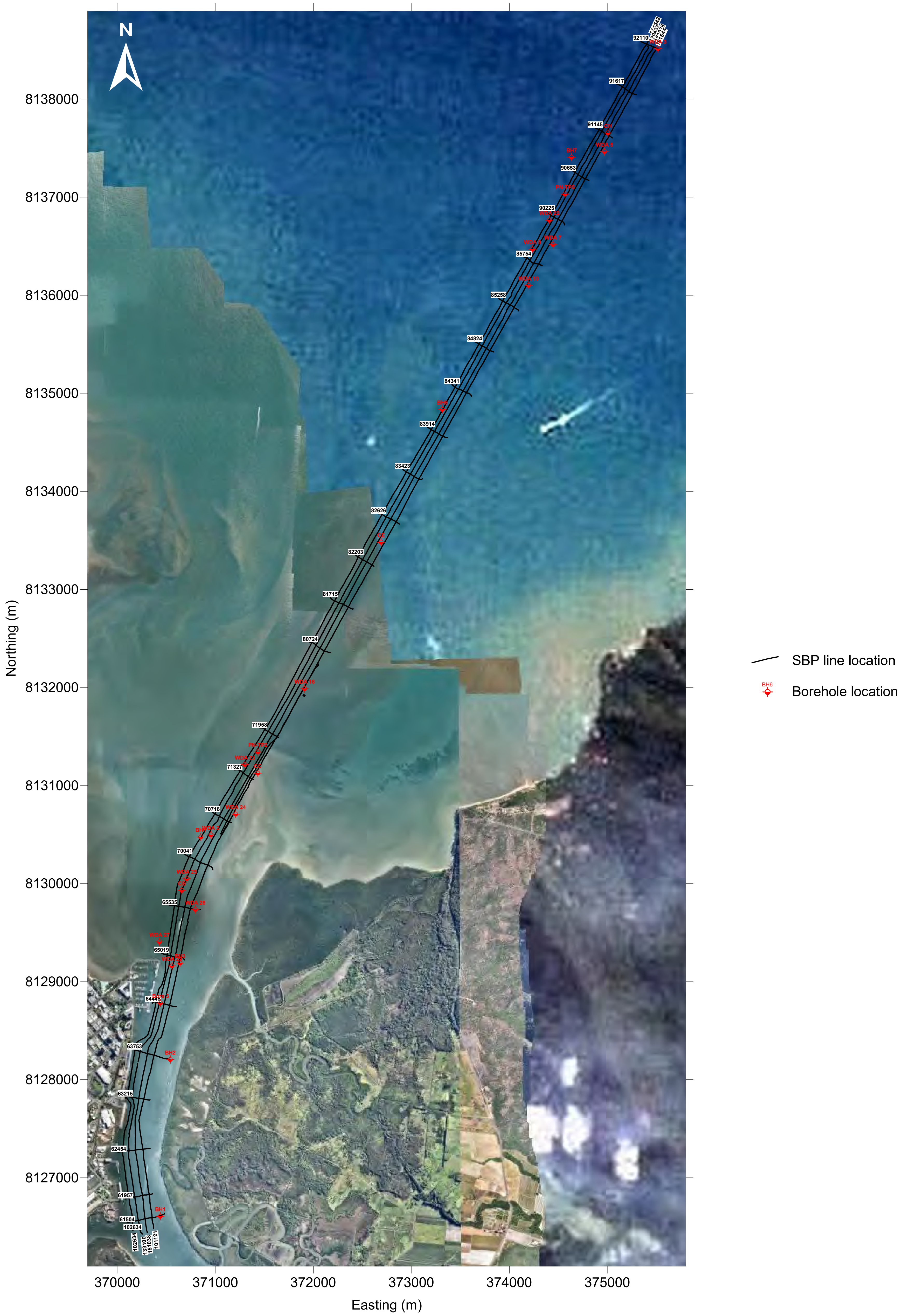

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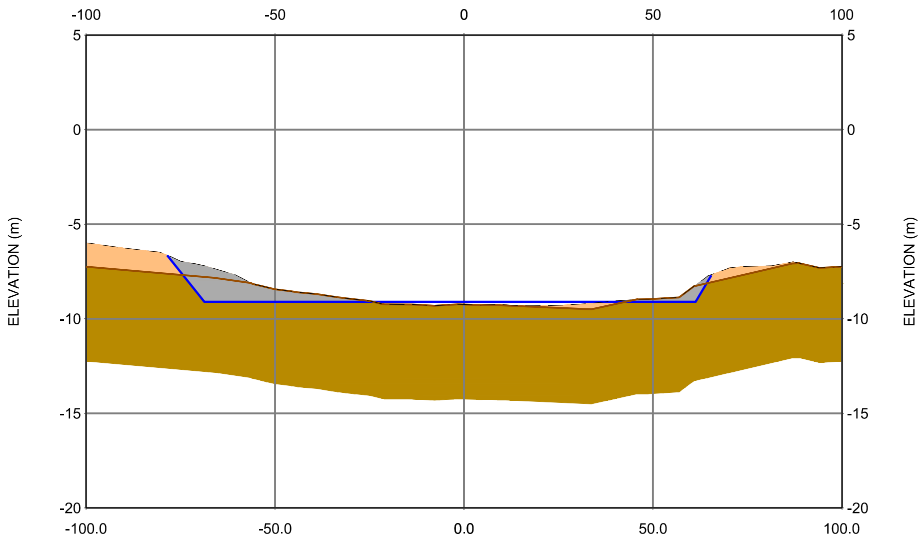

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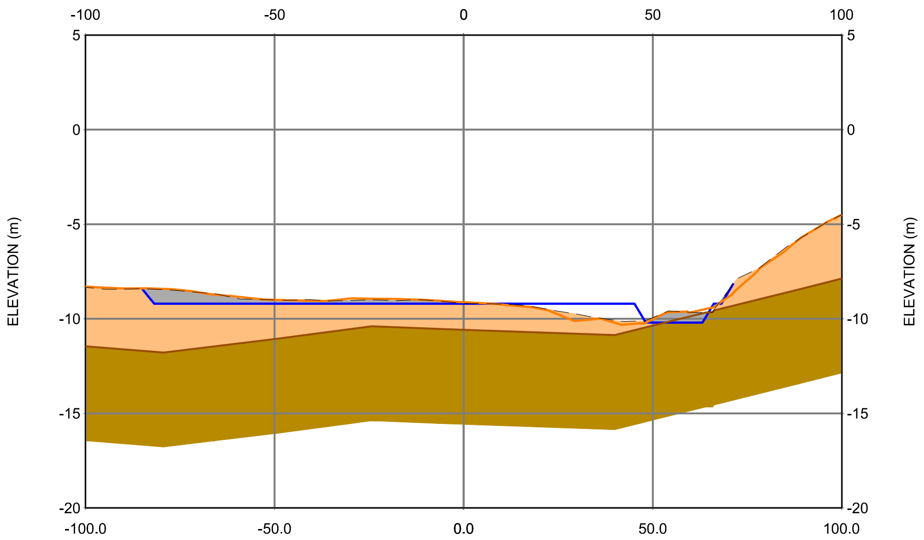

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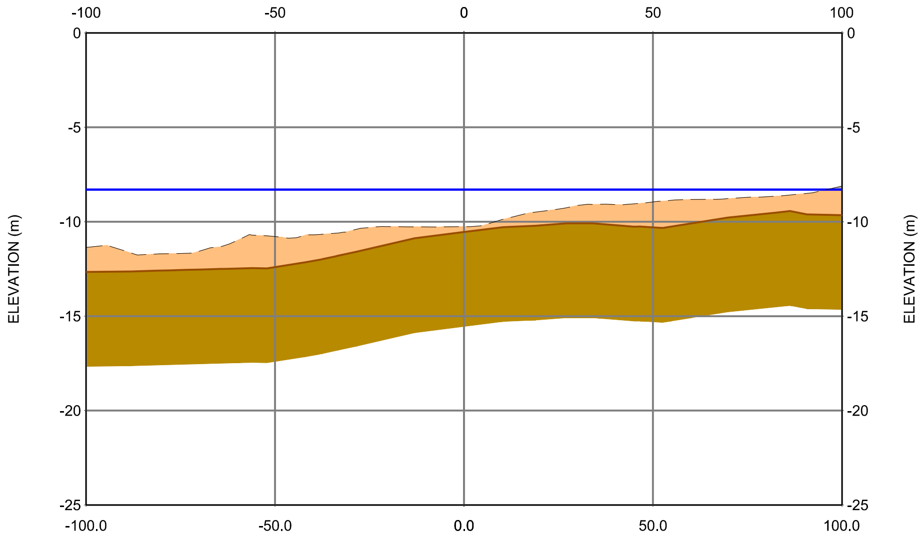

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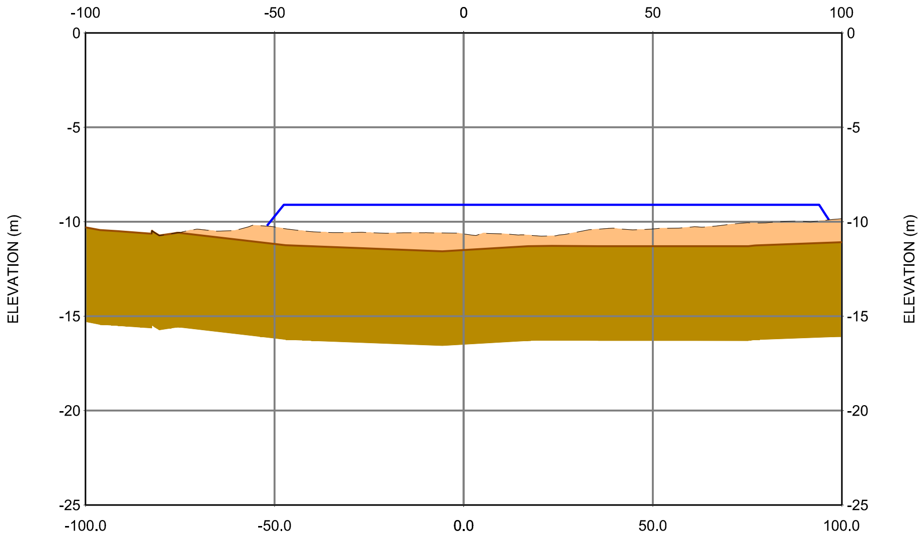

CH 12000.0

LEGEND

▨	PROPOSED DREDGE SPOIL	– – – – –	CHANNEL SURVEY 160825
▨	SOFT CLAY	———	REV B REVISED DRAFT EIS CHANNEL DESIGN MODEL
▨	STIFF CLAY	———	SOFT CLAY - STIFF CLAY INTERFACE

VERT. 0 50 100
1:2,000 METRES

HORIZ. 0 50 100
1:2,000 METRES

CLIENT
FLANAGAN CONSULTING GROUP

CONSULTANT

YYYY-MM-DD	2016-08-25
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
CHANNEL CROSS SECTIONS SHEET 1

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	006	2	F004

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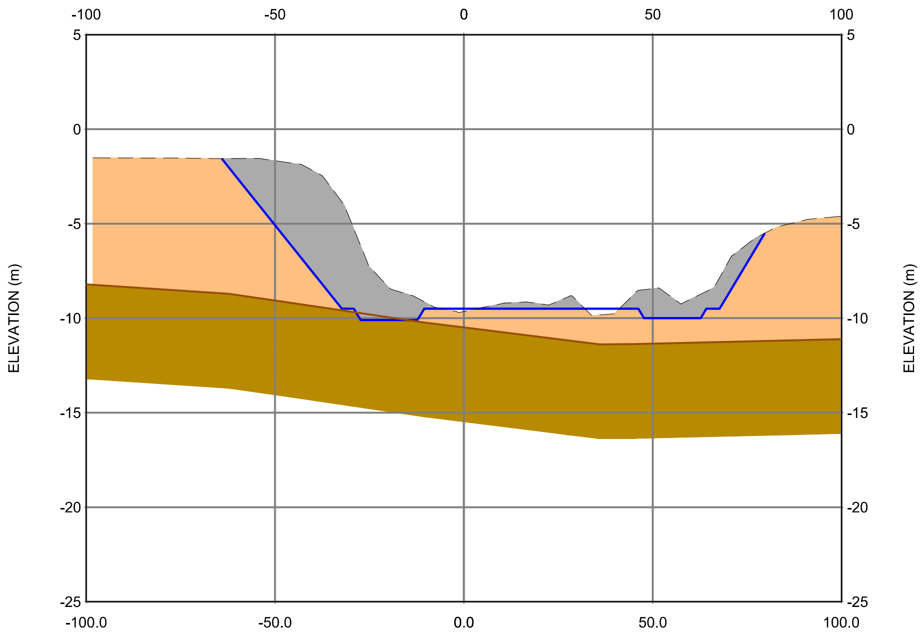

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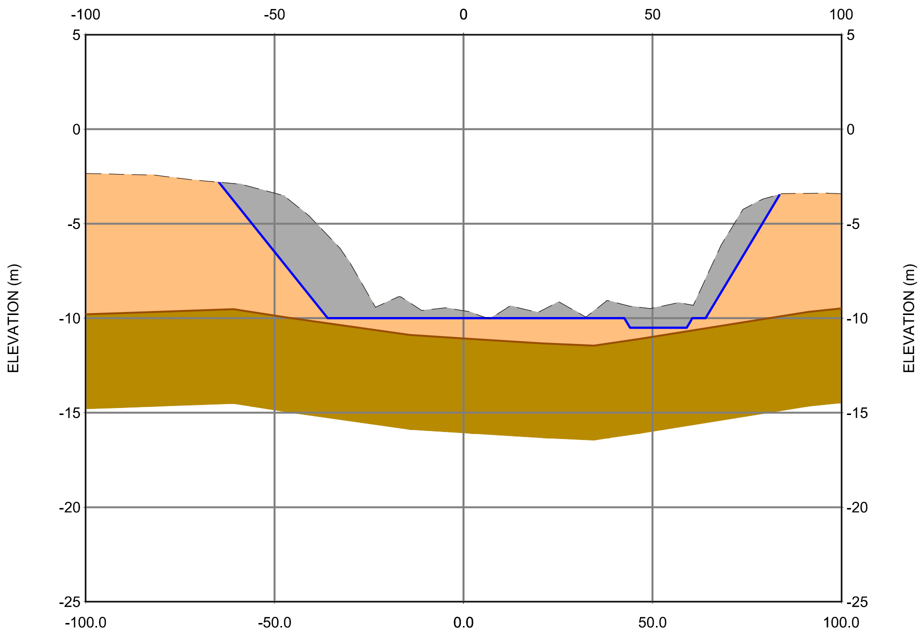

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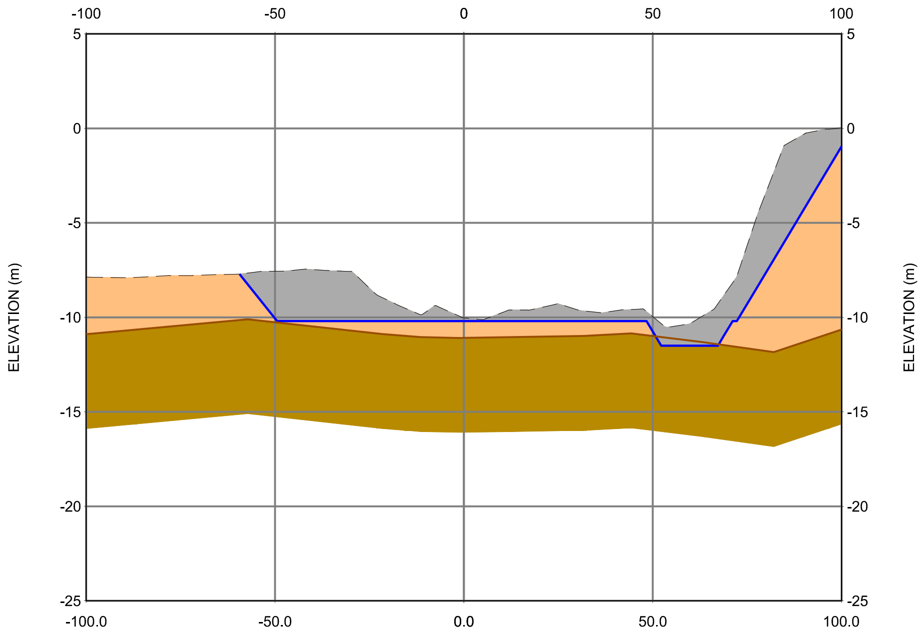

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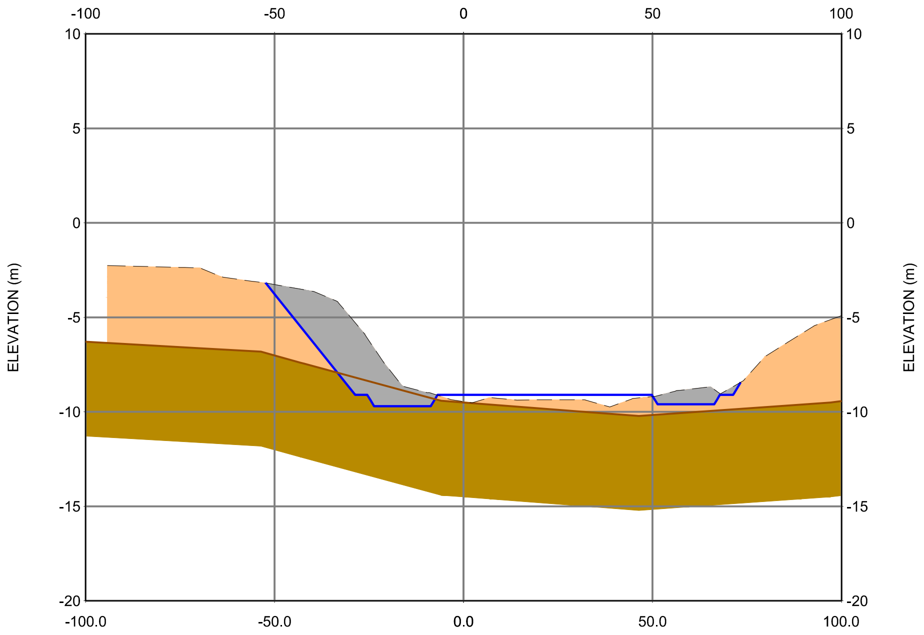

CH 17000.0

LEGEND

▨	PROPOSED DREDGE SPOIL	— — — — —	CHANNEL SURVEY 160825
▨	SOFT CLAY	——	REV B REVISED DRAFT EIS CHANNEL DESIGN MODEL
▨	STIFF CLAY	——	SOFT CLAY - STIFF CLAY INTERFACE

VERT. 0 50 100
1:2,000 METRES

HORIZ. 0 50 100
1:2,000 METRES

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

CONSULTANT

YYYY-MM-DD	2016-08-25
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

TITLE
CHANNEL CROSS SECTIONS SHEET 2

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	006	2	F005

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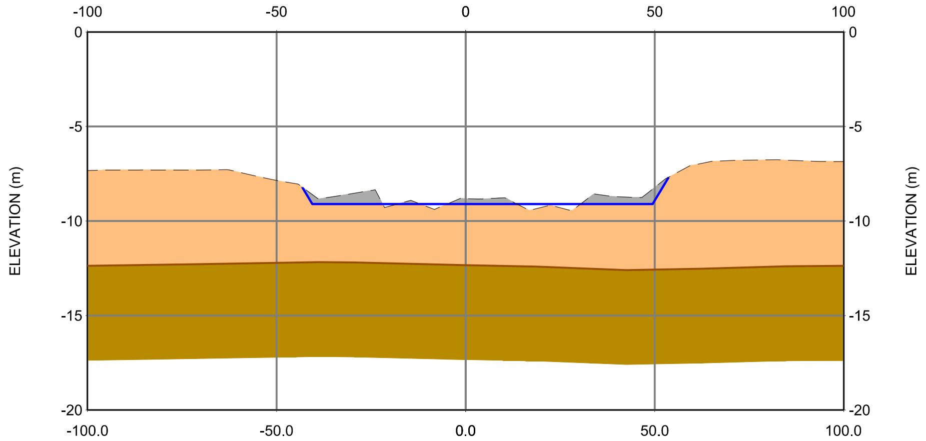
0 25 mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3



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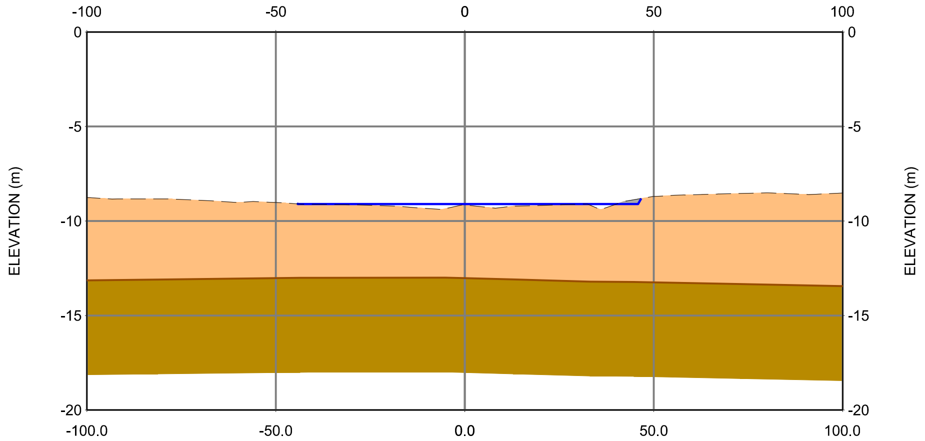

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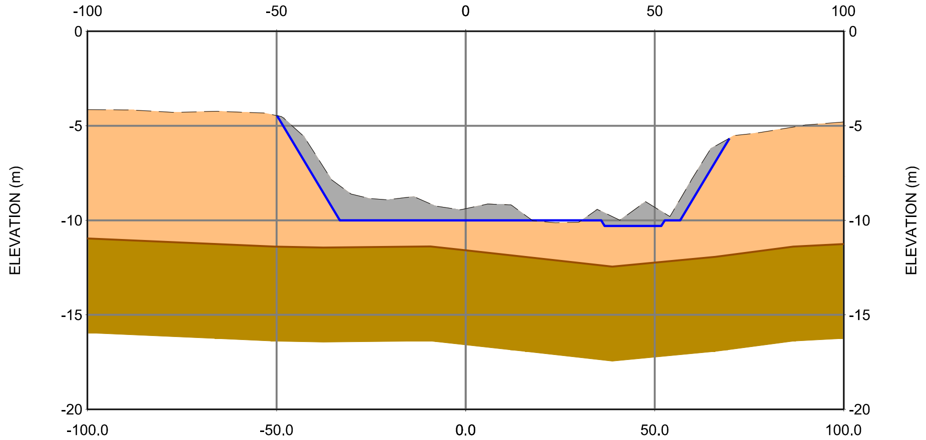

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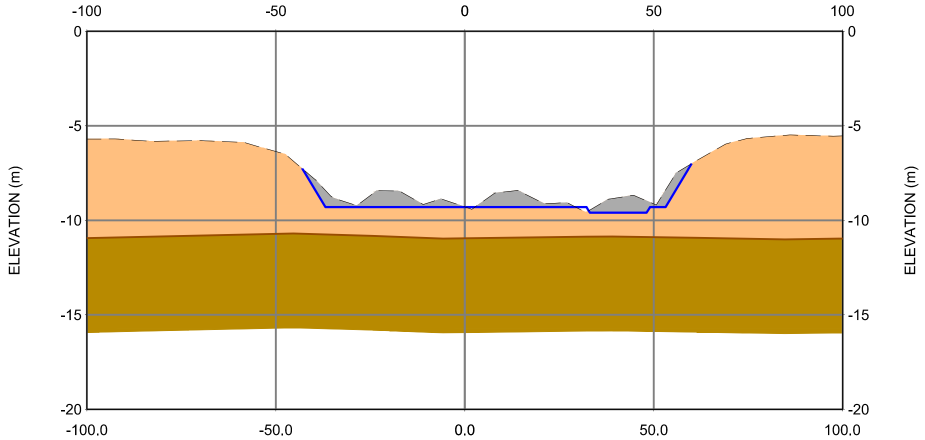

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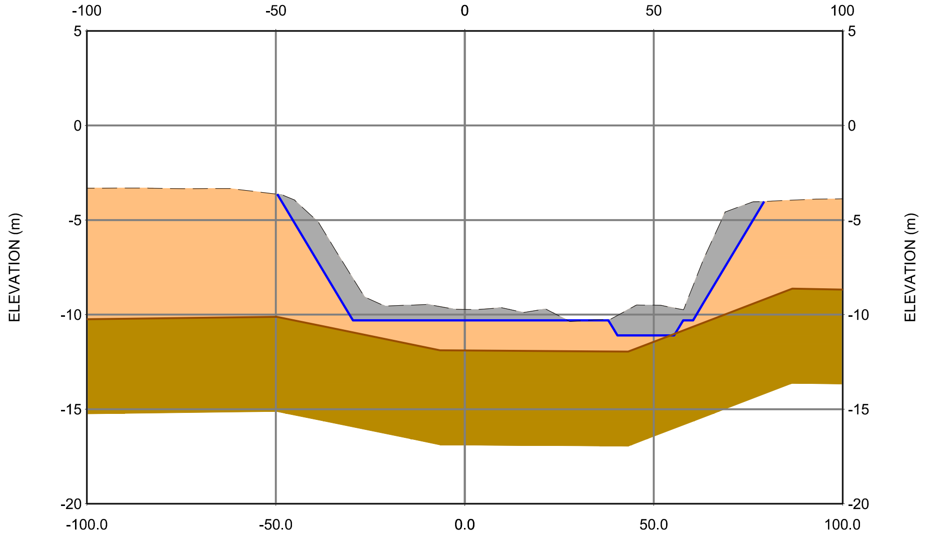

CH 20000.0

LEGEND

▨	PROPOSED DREDGE SPOIL	– – – –	CHANNEL SURVEY 160825
▨	SOFT CLAY	―	REV B REVISED DRAFT EIS CHANNEL DESIGN MODEL
▨	STIFF CLAY	―	SOFT CLAY - STIFF CLAY INTERFACE

VERT. 0 50 100
1:2,000 METRES

HORIZ. 0 50 100
1:2,000 METRES

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-25
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

TITLE
CHANNEL CROSS SECTIONS SHEET 3

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	006	2	F006

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LEGEND

🟥	BH	BORE HOLE PASS REQUIRING TREATMENT
⊕	BH	BOREHOLE NO TREATMENT REQUIRED

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-08-25
DESIGNED	DS
PREPARED	GPG
REVIEWED	PS
APPROVED	MC

TITLE
ACID SULFATE SOILS BOREHOLE LOCATIONS - SHEET 1

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	006	2	F007

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

25 mm

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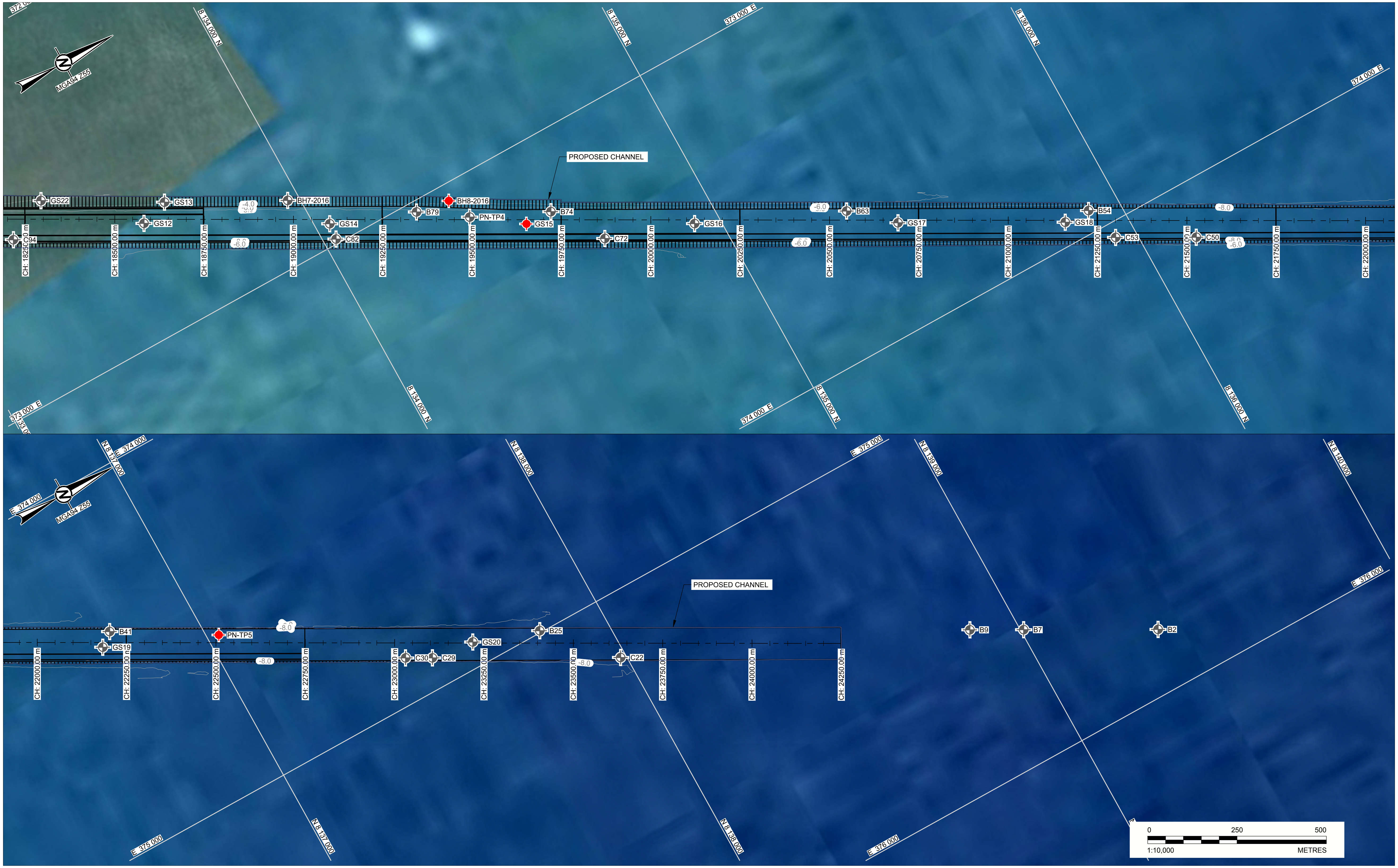

LEGEND

🟥	BH	BORE HOLE PASS REQUIRING TREATMENT
●	BH	BOREHOLE NO TREATMENT REQUIRED

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-25
DESIGNED	DS
PREPARED	GPG
REVIEWED	PS
APPROVED	MC

TITLE
ACID SULFATE SOILS BOREHOLE LOCATIONS - SHEET 2

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	006	2	F008

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APPENDIX A

Appendix A1 – Historical Information - Golder
Appendix A2 – Historical Information - Others

Appendix A1 – Historical Information - Golder

Golder Test Pit 2012

PRELIMINARY REPORT OF TEST PIT: PN-TP1

Golder Associates

CLIENT: Ports North	COORDS: 370607.0 m E 8129511.0 m N MGA94 55	SHEET: 1 OF 1	
PROJECT: CITYPORT STH FORESHORE	SURFACE RL: -9.60 m DATUM: LAT	MACHINE: Hitachi CX550 Crane	
LOCATION: CH13988	DIRECTION: 000°	CONTRACTOR: Ports North	
JOB NO: 107672522	PIT DEPTH: 0.05 m	LOGGED: JJP	DATE: 2/3/12
	BUCKET TYPE: Clamshell	CHECKED: WB	DATE: 6/3/12

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
CT	H		0.0	-9.65	BDS 0.00-0.05 m PN-TP1-001 0.05 m PP @ 0.05m = 1.10kg/cm^2	■	■	CI-CH	CLAY medium to high plasticity, pale grey with pale orange layers, with some silt, occasional shell fragments. TEST PIT DISCONTINUED @ 0.05 m TARGET DEPTH DRILLED OVER WATER	M	F - St	
			0.5									
			1.0									
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Golder Associates

PRELIMINARY REPORT OF TEST PIT: PN-TP2

CLIENT: Ports North
PROJECT: CITYPORT STH FORESHORE
LOCATION: CH13988
JOB NO: 107672522

COORDS: 371434.0 m E 8131343.0 m N MGA94 55
SURFACE RL: -10.20 m DATUM: LAT
DIRECTION: 000°
PIT DEPTH: 2.70 m
BUCKET TYPE: Clamshell

SHEET: 1 OF 1
MACHINE: Hitachi CX550 Crane
CONTRACTOR: Ports North
LOGGED: JJP DATE: 7/3/12
CHECKED: WB DATE: 6/3/12

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
CT	L		0.0	-10.20	BDS 0.00-0.70 m PN-TP2-001			MH	SILT high liquid limit, grey, with some clay, trace fine grained sand, Trace oranics.	W	VS	
			0.5									
	M-H			0.70 -10.90	PP @ 0.7m = 0.2kg/cm² U50 0.70-1.60 m Rec = 0.25m PN-TP2-002			CH	Silty CLAY high plasticity, grey to pale brown, trace fine sands, with some organics			
			1.0							M - W	F	
			1.5									
	H			1.60 -11.80	PP @ 1.6m = 0.85kg/cm² BDS 1.60-2.70 m PN-TP2-003				pale grey with pale organse, with some sand	M	St - VSt	
			2.0									
				2.10 -12.30	PP @ 2.1m = 1.3kg/cm²				grey more prominent			
			2.5									
				-12.90					TEST PIT DISCONTINUED @ 2.70 m DRILLED OVER WATER			
			3.0									
			3.5									
			4.0									
			4.5									
			5.0									

Golder Associates

PRELIMINARY REPORT OF TEST PIT: PN-TP3

CLIENT: Ports North	COORDS: 372247.0 m E 8132802.0 m N MGA94 55	SHEET: 1 OF 1
PROJECT: CITYPORT STH FORESHORE	SURFACE RL: -9.10 m DATUM: LAT	MACHINE: Hitachi CX550 Crane
LOCATION: CH13988	DIRECTION: 000°	CONTRACTOR: Ports North
JOB NO: 107672522	PIT DEPTH: 3.20 m	LOGGED: JJP DATE: 2/3/12
	BUCKET TYPE: Clamshell	CHECKED: WB DATE: 6/3/12

Excavation					Sampling	Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
CT	L		0.0 0.5 1.0	-9.10				MH	Sandy Clayey SILT high liquid limit, grey, fine to coarse grained sand, trace shell fragments and organics, trace fine to medium grained gravel	W	VS	
			1.5 2.0 2.5	1.50 -10.60	PP @ 1.5m = 0.3kg/cm^2 BDS 1.50-2.80 m PN-TP3-001 U50 1.50-2.80 m Rec = 0.25m PN-TP3-002 PP @ 1.8m = 0.4kg/cm^2	■		CH	Silty CLAY high plasticity, grey, trace organics and shell fragments	M	S	
	M		3.0	2.80 -11.90	PP @ 2.8m = 0.4kg/cm^2 BDS 2.80-3.20 m PN-TP3-003 U50 2.80-3.20 m Rec = 0.25m PN-TP3-004	■			with some interbedded organic zones <200mm thickness, trace interbedded shell fragment seams		S - F	
			3.5 4.0 4.5 5.0	-12.30	PP @ 3.1m = 0.5kg/cm^2				TEST PIT DISCONTINUED @ 3.20 m TARGET DEPTH DRILLED OVER WATER			

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.

Golder Associates

PRELIMINARY REPORT OF TEST PIT: PN-TP4

CLIENT: Ports North
PROJECT: CITYPORT STH FORESHORE
LOCATION: CH13988
JOB NO: 107672522

COORDS: 373115.0 m E 8134391.0 m N MGA94 55
SURFACE RL: -9.20 m DATUM: LAT
DIRECTION: 000°
PIT DEPTH: 3.40 m
BUCKET TYPE: Clamshell

SHEET: 1 OF 1
MACHINE: Hitachi CX550 Crane
CONTRACTOR: Ports North
LOGGED: JJP DATE: 1/3/12
CHECKED: DATE: 6/3/12

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
CT	L		0.0 0.5 1.0 1.5 2.0 2.5 3.0	-9.20			▨	MH	Sandy SILT medium to high liquid limit, grey, fine to medium grained sand, with some clay high plasticity clay, interbedded layers of fine to coarse grained sand, trace shells fragments and organics	W	VS	
				3.30 -12.50	PP @ 3.3m = 0.05kg/cm^2 BDS 3.30-3.40 m PN-TP4-001	■	▨	MH	Clayey SILT high liquid limit, grey, trace fine to medium grained sand			
			3.5 4.0 4.5 5.0	-12.60					TEST PIT DISCONTINUED @ 3.40 m TARGET DEPTH DRILLED OVER WATER Did not encounter soft/ stiff clay layer to investigation depth. Max investigation depth greater than proposed depth of dredging.			

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.

Golder Associates

PRELIMINARY REPORT OF TEST PIT: PN-TP5

CLIENT: Ports North	COORDS: 374569.0 m E 8137032.0 m N MGA94 55	SHEET: 1 OF 1	
PROJECT: CITYPORT STH FORESHORE	SURFACE RL: -9.90 m DATUM: LAT	MACHINE: Hitachi CX550 Crane	
LOCATION: CH13988	DIRECTION: 000°	CONTRACTOR: Ports North	
	PIT DEPTH: 3.60 m	LOGGED: JJP	DATE: 1/3/12
JOB NO: 107672522	BUCKET TYPE: Clamshell	CHECKED:	DATE: 6/3/12

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
CT	L		0.0 0.5 1.0 1.5 2.0	-9.90			🟨	MH	Sandy Clayey SILT medium to high liquid limit, grey, fine to medium grained sand, trace shell fragments and organics	W	VS	
			2.5	2.50 -12.40	PP @ 2.5m = 0.10kg/cm^2 BDS 2.50-2.90 m PN-TP5-001 U5050 2.50-2.90 m Rec = 0.25m PN-TP5-002	■	🟫	CI-CH	Silty CLAY medium to high plasticity, grey, trace sand, fine grained, trace shell fragments and organics	M - W	VS - S	
	M		3.0 3.5	2.90 -12.80	PP @ 2.9m = 0.95kg/cm^2 BDS 2.90-3.60 m PN-TP5-003 U50 2.90-3.60 m Rec = 0.25m PN-TP5-004	■	🟫	CH	Silty CLAY high plasticity, pale brown with orange brown and grey pockets, trace organics	M	F	
			4.0 4.5 5.0	-13.50					TEST PIT DISCONTINUED @ 3.60 m TARGET DEPTH DRILLED OVER WATER			