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CAIRNS SHIPPING DEVELOPMENT PROJECT

Acid Sulfate Soil Management Plan

ASSMP

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Golder Associates

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1.0 INTRODUCTION

This Acid Sulfate Soil (ASS) Management Plan (ASSMP) has been developed as part of the Revised Draft Environmental Impact Statement for the Cairns Shipping Development Project (CSDP).

Acid Sulfate Soil (ASS) is a general term applying to both a soil horizon that contains sulfides (i.e. Potential Acid Sulfate Soil - PASS) and an acid soil horizon affected by oxidation of sulfides (i.e. Actual Acid Sulfate Soil - AASS). ASS may be peats, silts, clays, or sands.

The ASSMP has been based on available soils investigations previously completed for CSDP offshore works and the results of soils and water quality investigations at land based Dredged Material Placement Areas. The Procedures contained within this ASSMP should be updated and revised to address conditions encountered that vary from those indicated by investigations or where alternative construction methodologies are adopted.

The ASSMP was prepared with consideration of the following documents:

- *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines V4.0,* 2014. Dear, S-E., Ahern, C. R., O'Brien, L. E., Dobos, S. K., McElnea, A. E., Moore, N. G. & Watling, K. M. Department of Science, Information Technology, Innovation and the Arts, Queensland Government
- *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland*, 1998; Ahern, CR., Ahern, M.R. and Powell
- State Planning Policy, July 2017
- State Planning Policy – state interest guideline, Water quality, April 2016
- Environmental Protection Act 1994
- Environmental Protection Policy (Water) 2009

The purpose of the ASSMP is to mitigate or control potential impacts relating to on-shore placement of dredged material.

2.0 PROJECT OVERVIEW

The revised CSDP involves upgrading the following port infrastructure to enable larger cruise ships up to 300 m in length to berth at the Port of Cairns:

- Marine works to widen and deepen the shipping channel and Crystal swing basin, and establishment of a new shipping swing basin (Smith Creek Swing Basin) upstream of the existing Main Swing Basin involving:
  - Capital dredging works involving removal of up to 1,000,000 m^3 (insitu) of dredge material consisting of up to 900,000m^3 (insitu) of soft clays to be removed by a Trailer Suction Head Dredge (TSHD) and 100,000m^3 (insitu) of stiff clays to be removed by a Back–Hoe Dredge (BHD).
  - Construction of a temporary pump out facility located between 2.7 and 3.7 km offshore from Yorkeys Knob.
- Delivery and placement of dredged material to land based Dredged Material Placement Areas (DMPAs) including:
  - Construction of a temporary dredged material delivery pipeline from the pump out facility to the soft clay DMPA on the Barron Delta.
  - Placement of soft clay dredge material at the Barron Delta DMPA located on Lot 2/RP712954 and Lot 5 on SP245573.

- Placement of stiff clay dredged material at the Tingira St DMPA established on Port Land (Lot 27/SP 218291) located at Tingira St, Portsmith.

- Ancillary infrastructure/services upgrades.

3.0 DREDGED MATERIALS

3.1 Materials Characterisation

A baseline assessment of the geotechnical and ASS properties materials to be dredged was reported in Golder Report 1546223-006-R-Rev2. The assessment was based on a review of all historical information including results from fifty-five sampling locations by BMT-WBM from the original EIS in 2014 and the following supplementary investigations by Golder:

- Boreholes at 8 locations within the proposed channel widening for ASS sampling and testing.
- Grab sampling 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”).
- Geophysics – ~52km of longitudinal lines and traverse lines to assess the depth to the soft clay/stiff clay interface within the areas proposed for dredging, particularly in areas where stiff clays were expected to be encountered within the depth of proposed dredging.

The current and previous investigations indicated that the dredged materials will mainly comprise very soft to firm silty clays, with a relatively smaller quantity of stiff to hard clays and an even smaller quantity of sands. The very soft to firm clays include a quantity of transported sediment materials (recent deposits, mainly in the existing channel) as well as insitu marine clays (Holocene age deposits). The inferred sediment materials generally had significantly lower insitu bulk densities and insitu shear strengths compared to the very soft to firm insitu marine clays (i.e. those from “widening” investigation locations). The stiff to hard clays layers are consolidated Quaternary age deposits.

The following general material types were 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 extents of soft clays (sediments and muds) and stiff clays to be dredged were reported in Golder Report 1546223-008-R-Rev2. Plans and sections from that report are reproduced as Figures 1A-1B and 2A to 2J.

3.2 ASS Characterisation

ASS results from all investigations were compiled and acid base accounting calculations were conducted to evaluate net acidity (refer Appendix C2 in Golder Report 1546223-006-R-Rev2). Whilst large shell fragments were removed from samples submitted for laboratory analysis, shell and fine shell grit were observed in most of the recovered sediments and muds. A “fineness factor” of 3 was applied to account for possible overstatement of neutralising capacity as a result of laboratory ring grinding of samples prior to analysis. This approach is consistent with consideration for self-neutralising soils outlined in the Queensland Acid Sulfate Soil Technical Manual – Soil Management Guidelines V4.0.

The adoption of a more conservative fineness factor also changed the status of some previous BMT-WBM investigation results which had been reported as self-neutralising in the 2014 EIS.

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

- The sediment and mud materials have potential acidity (chromium reducible sulfur) levels which would classify these materials as potential acid sulfate soils (PASS). The total insitu volume of these materials has been conservatively calculated as 900,000 m^3.
- The majority of these PASS materials have sufficient neutralising capacity to classify them as self-neutralising PASS (SNP). The volume of these SNP materials has been calculated as 580,000 m^3.
- Locations where PASS materials (without sufficient neutralising capacity) have been identified are shown on Figures 3A and 3B along with their interpreted extents. The interpreted extents have been conservatively derived by assuming that:
  - PASS materials are present in all sediments and muds across the full width of channel sections at investigation locations where PASS materials were identified.
  - PASS extends up and down the channel in all sediments and muds from identified locations to the next investigation location where only SNP was identified.

  The calculated insitu volumes of sediments and muds to be dredged from identified PASS areas, as described above, comprise:
  - Main Swing Basin – 55,000 m^3
  - Crystal Swing Basin – 11,000 m^3
  - CH14750-CH15250 – 40,000 m^3
  - CH15250-CH16250 - 118,000 m^3
  - CH17500-CH18000 - 96,000 m^3
- The Quaternary aged stiff clays by definition were not expected to be acid sulfate soils. All tests conducted on the stiff clays confirmed them to be non-ASS.

The combined historical and supplementary investigations conducted do not meet spatial requirements of the QASSIT *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland* across the entire project area. However, dredging will not occur over the entire project areas (refer Figures 1A-1B). Elements such as the channel widening over an area of about 4 hectares have been sampled at a frequency compliant with the QASSIT guidelines (2 boreholes per hectare). Overall the findings are considered to be suitable to develop an ASSMP for onshore placement of PASS and SNP.

3.3 Marine Considerations

When left undisturbed and submerged in an anoxic environment, pyrite (in acid sulfate soil) is chemically inert. Pyrite oxidizes in the presence of oxygen and hydrogen to form sulfuric acid. There are a number of variables affecting the oxidation of pyrite, and the reactions are complex although predominantly limited by the rate of supply of oxygen:

- When ASS is excavated and allowed to dry, an almost infinite supply of atmospheric oxygen at relatively high concentrations (21 %) is available to exposed surfaces and within pore spaces between the soil particles. The oxygen is delivered to the soil via advection and diffusion. Under this scenario there is a high potential to generate acid.
- When ASS is saturated, the available supply of oxygen is significantly lower (typically 9 ppm). In still water, the oxygen is delivered to the soil surface via diffusion at a very slow rate and the risk of acid generation is very low. In dynamic, open water bodies, the oxygen is principally delivered via advection to suspended soil particles and oxygen delivery via diffusion to bottom sediments is negligible. The risk of acid generation is variable and dependent upon the rate and duration of suspension.

In open marine environments, the alkaline and relatively stable pH of seawater results in a slow rate of pyrite oxidation in suspended or resuspended sediments. The majority of the dredged or disturbed material not delivered to the Hopper will settle to the sea bed and return to an anoxic, reducing state.

Seawater contains the major buffering constituents - bicarbonate and carbonate in solution. When acid is generated, the neutralising reaction occurs instantaneously. In an open marine environment, the available buffering capacity is immense and surrounds the suspended soil particles.

In summary, the potential to generate acid underwater following disturbance of PASS material during dredging is very low and, if acid is generated it would be immediately neutralised. Therefore, from an ASS perspective, the dredging process does not pose a risk to the surrounding environment.

3.4 Transportation Considerations

During maintenance dredging of the Cairns Channel over the past 15 years using the *Brisbane* THSD, free water has been observed over dredged sediments within the hopper during loading and the 20-30 minute transit time to the placement area.

Dredged material collected during the capital dredging within the hopper of the dredge vessel will effectively remain saturated during transport to the pump out point. Under normal operating activities there is little opportunity for these materials to oxidise and generate acid. Contingency measures for equipment breakdown of longer than 24 hours are required to address the potential for dredged material oxidisation in the hopper.

On land spillage and/or pipeline breakages could result in PASS slurry release. Initially the slurry will have a very high water content and materials will be saturated with little opportunity for oxidisation. Contingency measures are required to address the potential for dredged material oxidisation in the event of a PASS slurry release.

4.0 BARRON DELTA DMPA SITE

4.1 Existing Site

The Northern Sands site is an operating sand extraction site with an existing Environmental Authority for acceptance and disposal of inert waste and potential acid sulfate soils within the water filled void resulting from sand extraction.

The Northern Sands void holds permanent water, consisting primarily of groundwater and seasonally influenced stormwater runoff. Monitoring since about 2005 indicates that the lowest seasonal water level across the site is approximately 0.0 m AHD.

The existing void at Northern Sands is being progressively enlarged to the north as part of ‘business as usual’ sand extraction operations. The sand extraction will provide a void of sufficient capacity below natural ground level to accommodate the settled soft clay after extraction of excess water used for material transport (pumping) and supernatant as a consequence of material consolidation. During dredging the 900,000 m^3 of insitu soft clay material will ‘bulk up’ to a larger volume. Concept design of the Barron Delta DMPA has been based on a Bulking Factor of 2.6. The adopted Bulking Factor (2.6) indicates a pre-consolidation volume of approximately 2,340,000 m^3 will be required to accommodate the soft clay material at the end of the dredging campaign. In order to provide sufficient containment capacity, the capacity of sand extraction void that will be provided to accept the placed material will be augmented through the construction of surrounding earth bunds of suitable height to accommodate the pre-consolidation volume and an initial water cover.

4.2 DMPA Operations

All dredged materials will be delivered into the Barron Delta DMPA as a slurry through a pipeline. Slurry will typically be delivered at a rate of approximately 3.9 m^3/sec over a period of about 1 hour every 4 hours during the dredging program. Multiple spigot points will be utilised along with diffusers and spreader devices to assist in spreading the material evenly and to minimise disturbance of placed material. This also allows, the placement locations within the DMPA to be varied with time to enhance overall settlement rates (e.g.

following placement of PASS in the deepest portion of the DMPA, the placement location can be changed to the far end of the DMPA to allow PASS to settlement and consolidate for several days prior to commencing placement of SNP over the PASS). Bed levelling equipment will also be employed, where required, to ensure all PASS is placement to the required level.

The weir boxes will be used to control the water depth through which the slurry is deposited and to control draw off water to achieve the required tailwater quality. Tailwater will be discharged via pumping to an outfall in the Barron River under the Captain Cook Highway Bridge in accordance with approval conditions.

About 40,000 m^3 of seawater will be delivered as part of the pumped slurry into the DMPA every day during the dredging program. The seepage rate out of the DMPA has been modelled and is significantly lower than the delivery rate. Water levels in the DMPA will be allowed to rise to ensure that at least 1 m of water cover is maintained over placed PASS and SNP to prevent exposure to the air and the potential for oxidation of these materials. The water cover will be maintained until characterisation/validation testing of all SNP materials placed above -1.0m AHD has confirmed that they are self-neutralising or that they have been suitably treated to confirm there is negligible risk of acid generation from these materials when drained.

The identified areas of PASS in the channel (about 320,000 m^3 insitu or 832,000 m^3 bulked), will be dredged from the start of the dredging campaign and deposited in deeper sections of the void. The DMPA has capacity to accommodate all of the identified PASS, at the time of placement, below the lowest seasonal water level (0m AHD), without consideration of settlement and consolidation. Consolidation modelling by BMT-JFA suggests that PASS placed to 0 m AHD will settle to below -1.0 AHD within in about 2 to 15 days of placement to provide a long term minimum of coverage of 1m of groundwater over the PASS (in line with acceptable measures for internment of PASS described in Queensland Acid Sulfate Soil Technical Manual – Soil Management Guidelines V4.0). Following completion of the dredging of the PASS material, the SNP materials will then be dredged and placed on the PASS to form a permanent cap to further ensure PASS is not remobilised or exposed to the air (removing the possibility of future oxidation).

SNP materials placed elsewhere in the DMPA and over PASS above -1.0m AHD will be progressively sampled from predetermined volumetric “lots” within the DMPA (these lots will be spatially derived and are not physically separated) to confirm that:

- Remixing (during dredging and pumping) and placement of SNP has not resulted in particle size segregation and formation of fines “hotspots”. (The risk of such hotspots generating acid, should PASS be present, under saturated conditions during placement is very low as the presence of sufficient oxygen is required to result in acid generation).
- The SNP materials remain self-neutralising (again adopting a fineness factor of 3 for conservatism).

Should insufficient neutralising capacity be detected within a “lot”, materials forming the lot will be removed (by small dredge), treated (using in-line lime dosing), replaced in another identifiable volumetric lot within the DMPA and resampled/analysed to confirm suitable treatment.

The deposition of wastes or other fill materials over placed dredged spoil within the DMPA will be prohibited until such time as the spoil has obtained a suitable strength gain. Once suitable strength gain (or equivalent settled level) has been verified, controlled placement methods will be adopted to minimise displacement of placed SNP and to prevent displacement of PASS above -1m AHD.

5.0 TINGIRA STREET DMPA SITE

The stiff clays to be placed at the Tingira Street DMPA have been confirmed as non-ASS materials. Therefore these materials do not require specific ASS management measures.

Contingency measures are required to address the potential for material oxidisation should the presence of soft, darker hued materials be observed in these excavated materials. These measures may require segregation and possible treatment of these materials if confirmed as PASS.

6.0 MITIGATION STRATEGIES AND CONTINGENCY OPTIONS

Potential environmental considerations associated with ASS disturbance and onshore placement of dredged material are summarised in Table 1 below. Also included are proposed management strategies and contingency options that may be used individually or in combination to mitigate potential impacts if required.

Table 1: Summary of mitigation strategies and contingency options based on expected behaviour of ASS Material

Activity	Issue	Expected Behaviour of ASS Material	Perceived Level of Impact to the Environment	Mitigation Strategies	Contingency Options
Dredging of marine sediments	Aeration of ASS materials during dredging operations.	The majority of marine sediments which are disturbed during the dredging activities but not recovered for onshore disposal will settle to the ocean floor and return to an anoxic, reducing state. These residual materials will not generate acid and do not represent a risk to the marine environment. Prior to settling, aerated sediment in suspension may partially oxidise and generate acid. The available oxygen in saturated conditions is significantly smaller than in air and therefore the potential for acid generation is similarly smaller. In the open marine environment the available buffering capacity is immense and surrounds the suspended soil particles to immediately neutralise the generated acidity. Therefore suspended sediments do not represent a risk to the marine environment.	**Negligible to low potential for environmental impact.**	Water quality monitoring and management as outlined in separate Dredge Management Plan.	Addressed in Dredge Management Plan,
Transport and placement of stiff clays at Tingira Street DMPA	Accidental excavation and comingling of PASS with stiff clays.	PASS materials are typically dark grey and soft whilst the stiff clays are typically yellow to orange hued. The presence of PASS in the excavated stiff clays would be easily discerned by visual inspection. Very little oxidisation of comingled PASS will occur during transportation to Tingira Street DMPA.	**Negligible to low potential for environmental impact.**	Stiff clays are to be placed in bunded cells at the DMPA. If present in significant amounts, pockets of PASS can be segregated from stiff clays and treated with lime at the DMPA.	Lime can be added to stiff clays with comingled PASS materials as it is being spread and compacted.
Transport of dredged marine sediments to Barron Delta DMPA	Oxidisation of ASS materials in dredge hopper during transport.	Dredged material collected within the hopper of the dredge vessel will effectively remain saturated during transport to the pump out point near Yorkeys Knob. Under normal operating activities there is little opportunity for these materials to oxidise and generate acid.	**Negligible to low potential for environmental impact.**	Dredged materials will not be stored in hoppers for more than 24 hrs (Dredge Management Plan requirement).	Contingency measures for equipment breakdown are addressed in the Dredge Management Plan.

Activity	Issue	Expected Behaviour of ASS Material	Perceived Level of Impact to the Environment	Mitigation Strategies	Contingency Options
	Onshore spillage/pipeline breakage allowing oxidisation of ASS materials	Saturated and predominantly clay materials have a low potential to oxidise and generate acid over a short period of time.	**Negligible to low potential for environmental impact.**	Containment of spillage or discharges to the ground surface. Excavation and removal/treatment within 42 hours (based on short term stockpiling of ASS – Table 11.1 Queensland Acid Sulfate Soil Technical Manual – Soil Management Guidelines V4.0).	Contingency measures for equipment breakdown are addressed in the Dredge Management Plan.
Dredged Material Placement in the Barron Delta DMPA	Acid generation from dredged PASS material and release to groundwater.	Dredged PASS materials will remain saturated during placement and internment below the groundwater table. These saturated conditions represent a low potential for acid generation.	**Negligible to low potential for environmental impact.**	PASS to be placed below the lowest recorded groundwater level. Long term internment will be at least 1m below the permanent groundwater level (as per Section 10.1 of Queensland Acid Sulfate Soil Technical Manual – Soil Management Guidelines V4.0). PASS to be capped with SNP to prevent remobilisation. Groundwater quality monitoring surrounding the DMPA as outlined in the Dredge Management Plan.	Lime dosing during placement or lime treatment post placement.
	Future filling on placed dredge materials causing displacement of PASS above -1m AHD	PASS could only be disturbed if uncontrolled filling over placed dredged materials occurred prior to adequate consolidation of the dredged material, or if large scale instability occurred as a result of an excessively high filling face resulting in PASS being displaced upwards.	There is a low potential for PASS materials to generate acid during the placement works whilst they remain saturated and below -1m AHD. **Low potential for environmental impact**	The placement of wastes or other materials over placed dredged spoil within the DMPA will be prohibited until such time as the spoil has obtained a suitable strength gain. Once suitable strength gain (or equivalent settled level) has been verified, controlled placement methods will be adopted to minimise displacement of placed SNP and prevent displacement of deeper PASS materials.	A separation layer of high strength geotextile over the top of the dredged materials prior to placement of waste.
	Acid generation from dredged SNP material and release to groundwater.	Finer particles may be segregated from coarser particles during pumping and placement of SNP. This may result in placed SNP having neutralising capacities which vary from that indicated from offshore sampling and create the potential to	There is a low to moderate potential for the SNP materials to generate excess acidity.	Maintenance of water cover over (and saturated conditions within) placed SNP until the presence of suitable neutralising capacity is confirmed.	Lime dosing during placement or lime treatment post placement.

Activity	Issue	Expected Behaviour of ASS Material	Perceived Level of Impact to the Environment	Mitigation Strategies	Contingency Options
		produce "pockets" of PASS that may generate future unbuffered acidity when dried. If pockets of PASS are present in surface materials, this could result in acid formation in these exposed materials (following draining of the water cover) which may be mobilised by rainfall and require surface runoff to be treated. Deeper materials (at least those 2m below the surface) are expected to remain saturated for at least several years following draining of water cover. If pockets of PASS were present in these materials, they are unlikely to generate acid within this time frame. If these deeper pockets of PASS were allowed to drain over time, they may oxidise and generate acid. This acid may leach through the soil, strip heavy metals from the soils and could result in groundwater impacts. It is not intended that saltwater and/or groundwater buffering capacities would be relied upon as the primary neutralisation mechanisms.	There is a low potential for PASS materials to generate acid during the placement works whilst they remain saturated with a water cover in place. **Low to moderate potential for environmental impact**	Progressive characterisation/verification testing as SNP materials are placed. Strategies to be reviewed and updated if a higher level of risk is indicated. Removal of identified zones with insufficient neutralising capacity, treatment and reinternment. Groundwater quality monitoring surrounding the DMPA as outlined in the Dredge Management Plan.	
	Release of acidic and/or metals impacted water to groundwater or through tailwater outflow.	Dredged materials will remain saturated during placement. These saturated conditions represent a low potential for acid generation.	**Negligible to low potential for environmental impact.**	Groundwater quality monitoring surrounding the DMPA as outlined in the Dredge Management Plan. Tailwater monitoring and management as outlined in the Dredge Management Plan.	Treatment of return water prior to discharge.

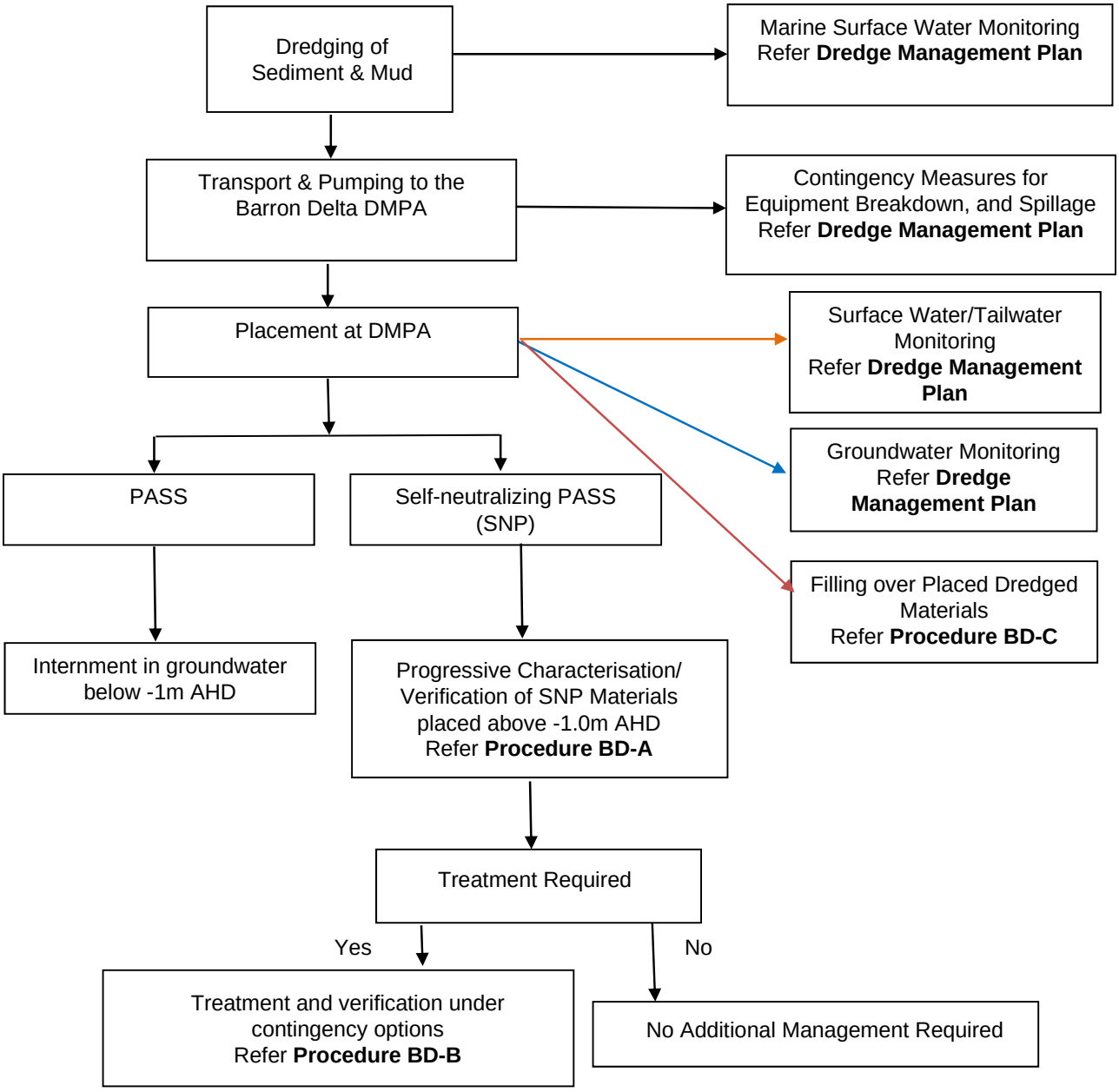
7.0 MANAGEMENT PROCEDURES

The following provides representative management procedures related to phases of activity by use of a visual summary of the mitigation strategies and contingency options identified for the ASS materials in the DMPAs. These procedures will be reviewed and revised as the project matures and additional information becomes available.

7.1 Sediment & Mud Dredged Materials

Flow Chart 1 summarises the mitigation strategies, including contingency options, for dredged materials to be placed at the Barron Delta DMPA.

Flow Chart 1: Summary of Sediment and Mud Dredged Materials ASS Management

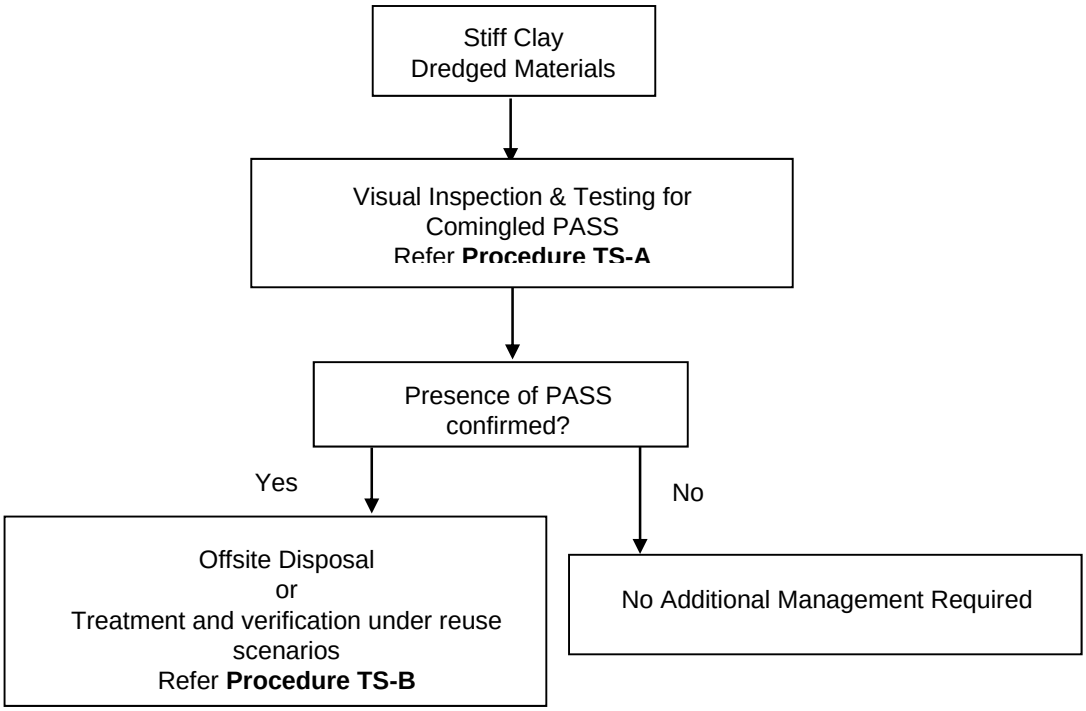


The management procedures and contingency options for the Barron Delta DMPA, including characterisation / verification of placed SNP are presented in APPENDIX A.

7.2 Stiff Clay Dredged Materials

Flow Chart 2 summarises the mitigation strategies, including contingency options, for dredged materials to be placed at the Tingira Street DMPA, if necessary.

Flow Chart 2: Summary of Stiff Clay Material Placement Management



The management procedures and contingency options for the Tingira Street DMPA are presented in APPENDIX B.

8.0 RESPONSIBILITIES

This section outlines the responsibilities to manage, document and report on ASS issues for the project.

- The *Site Manager* is responsible for ensuring that all requirements of the ASSMP are met during the project.
- The *Site Foreman* is responsible for ensuring the strategies and procedures prescribed in the ASSMP are implemented at the site in accordance with the specified performance criteria.
- The *Environmental Manager* is responsible for reviewing compliance with the ASSMP and development of actions to address non-conformance.
- All other site personnel are responsible for implementing strategies and procedures prescribed in the ASSMP, as applicable to their work activities.

9.0 NON-CONFORMANCE AND CORRECTIVE ACTION

Any non-conformance to the ASSMP must be addressed as soon as is practical. The personnel responsible for the non-conformance must be notified immediately for purposes of issuing rectification instructions.

10.0 AUDITING

The Environmental Manager will be responsible for ensuring that an auditing program is implemented for construction and treatment works. The audit program shall aim to ensure compliance with the ASSMP and relevant statutory requirements.

The Environmental Manager shall appoint an experienced ASS practitioner to conduct regular auditing of activities and ASS management measures. Given the expected construction period a weekly, auditing schedule is recommended. The frequency of these audits may gradually decrease if a high level of compliance with the ASSMP is evident.

The audit shall take the form of a visual inspection of the works and treatment sites and associated control measures and a review of monitoring data. A written record of auditing undertaken shall be maintained, including details on the date of the audit, activities undertaken, observations made and any non-conformances identified. A copy of the audit report shall be forwarded to the Environmental Manager within 2 days of the audit.

11.0 COMMUNITY RELATIONS

Concerns or complaints raised by the community (or other parties) in relation to ASS will be directed to the Environmental Manager for action.

The Environmental Manager shall maintain a concern register recording the following information:

1) Details: Name, address and phone number of party raising the concern.
2) Nature of concern: Detail of issue, date of incident, people involved, and location.
3) Action taken or required: Any action proposed or undertaken to address the concern, including time and date.
4) Response to action: Was the complainant satisfied with the outcome of the actions taken, if not, what else needs to be done, or is it outside the scope of the development works.
5) Prevention or re-occurrence: What action has been taken by the nominated responsible person to ensure the problem will not re-occur.

12.0 TRAINING

All equipment operators, supervisors and subcontractors engaged in DMPA works shall participate in induction training for ASS. This training will include basic recognition and identification of ASS, plus an outline of the requirements of the ASSMP. The Site Foreman shall verify attendance at induction training prior to commencement of site works.

Report Signature Page

GOLDER ASSOCIATES PTY LTD

Paul Scells
Principal Environmental Engineer

PKS/MSC/ps

A.B.N. 64 006 107 857

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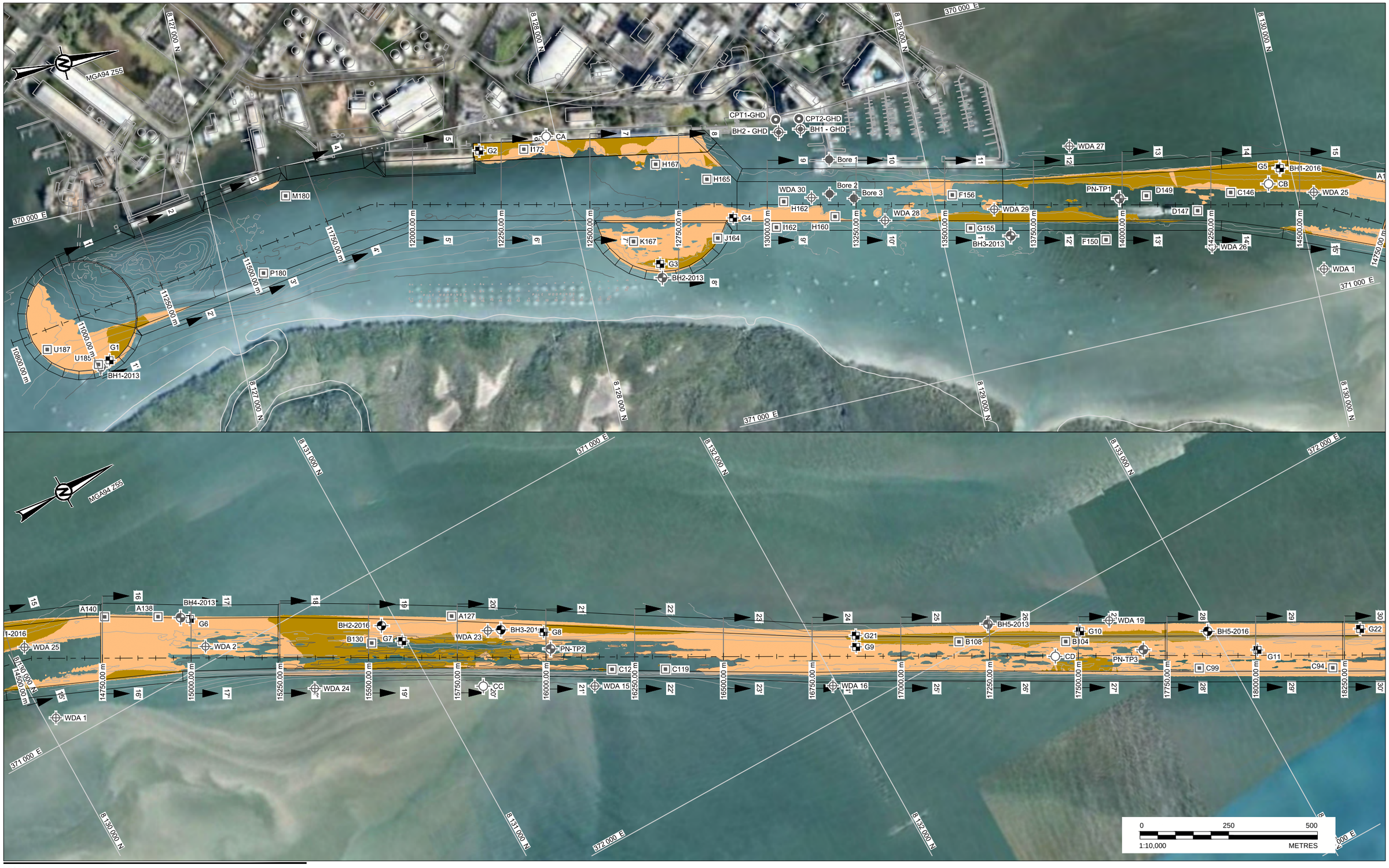

LEGEND

- BORE HOLE GOLDER ASSOCIATES (CURRENT INVESTIGATION)
- GRAB SAMPLE GOLDER ASSOCIATES (CURRENT INVESTIGATION)
- BORE HOLE GOLDER ASSOCIATES (PREVIOUS INVESTIGATION)
- 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)
- SOFT CLAY (CAPITAL DREDGING)
- STIFF CLAY (CAPITAL DREDGING)

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

TITLE
EXTENT OF MATERIALS TO BE DREDGED - SHEET 1

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	1	1A

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0 25 mm

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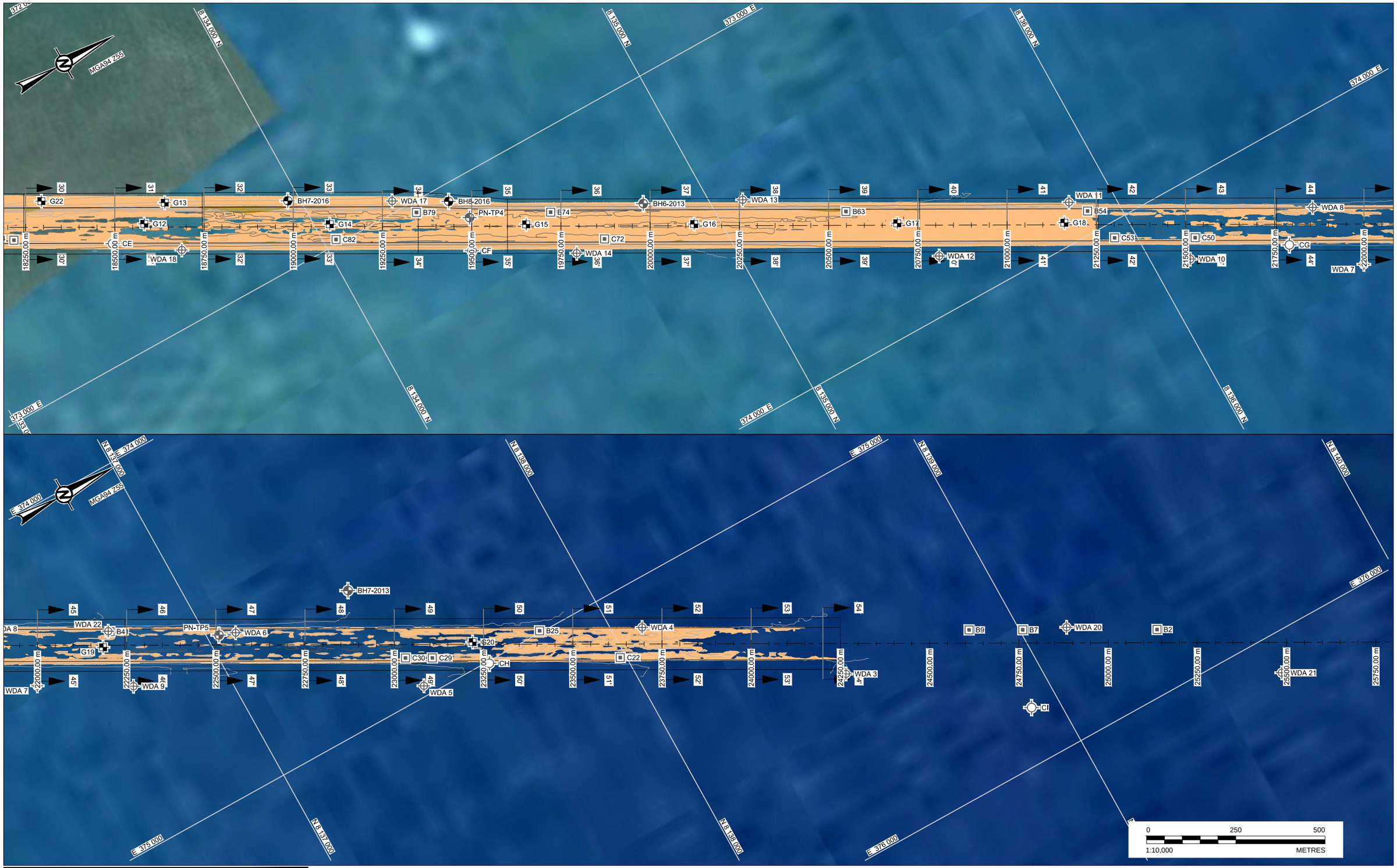

LEGEND

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- CPT GHD (PREVIOUS INVESTIGATION)
- SOFT CLAY (CAPITAL DREDGING)
- STIFF CLAY (CAPITAL DREDGING)

CLIENT
FLANAGAN CONSULTING GROUP

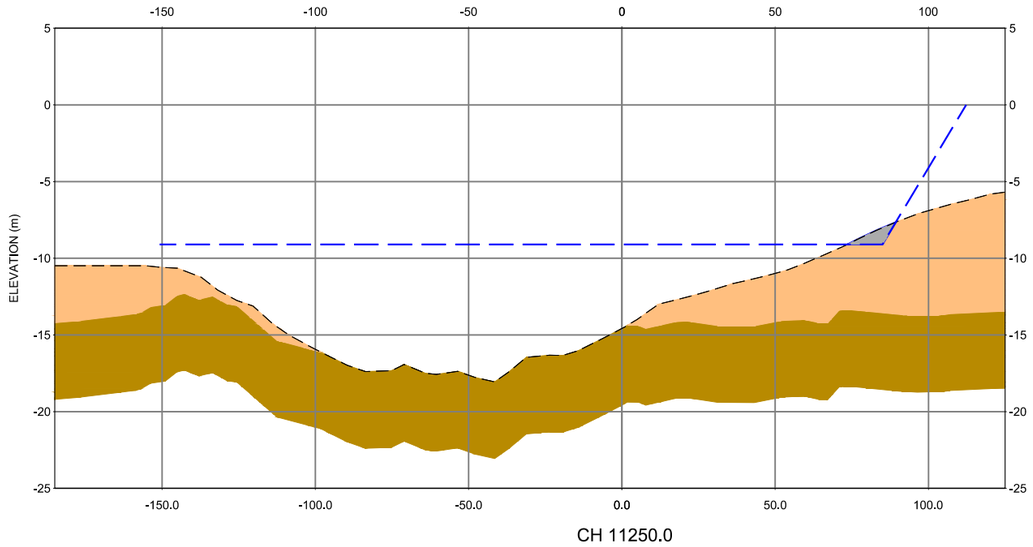
PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

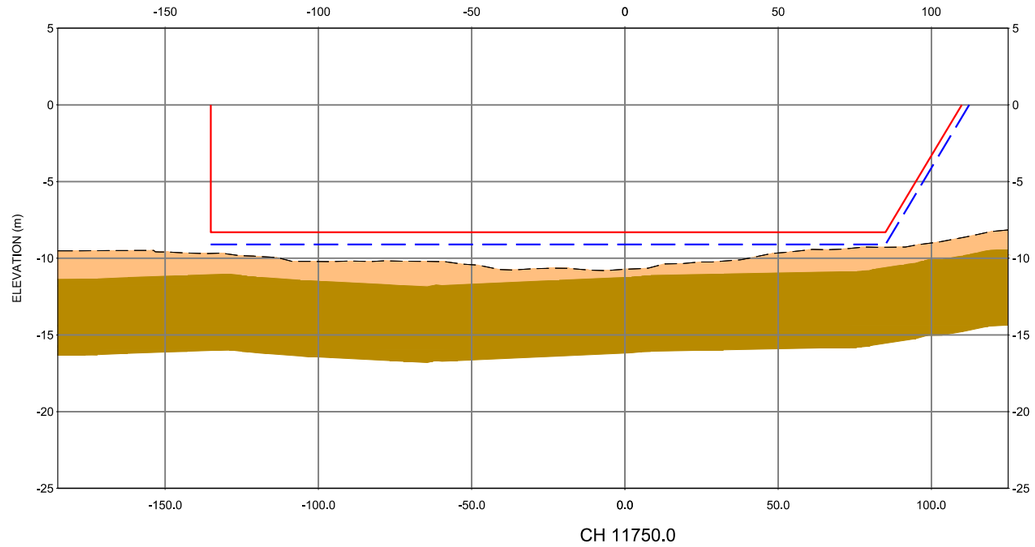
CONSULTANT
Golder Associates

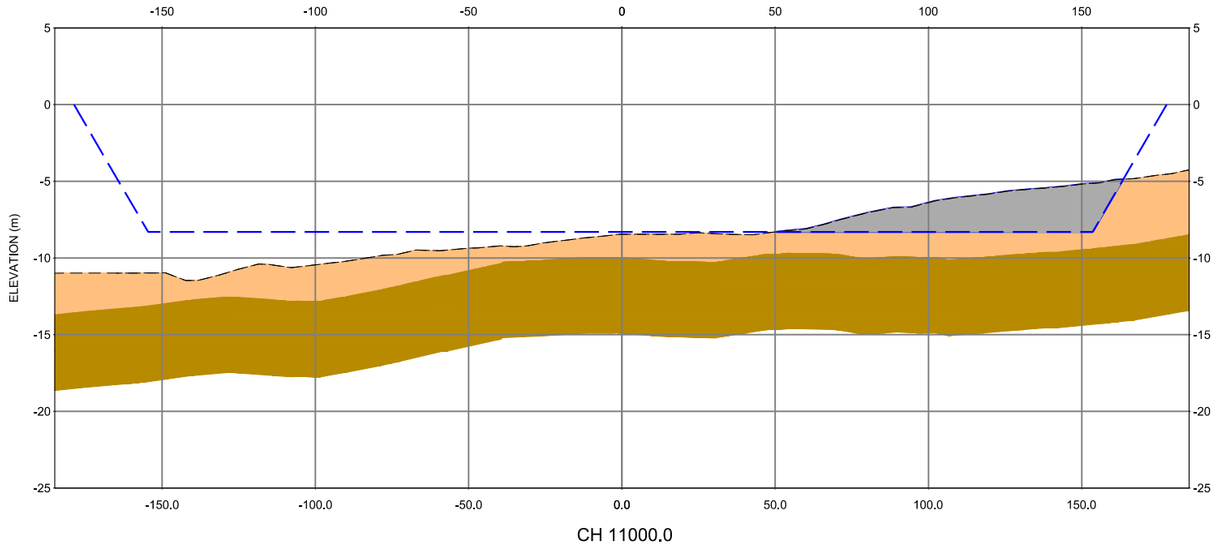
YYYY-MM-DD	2017-10-30
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

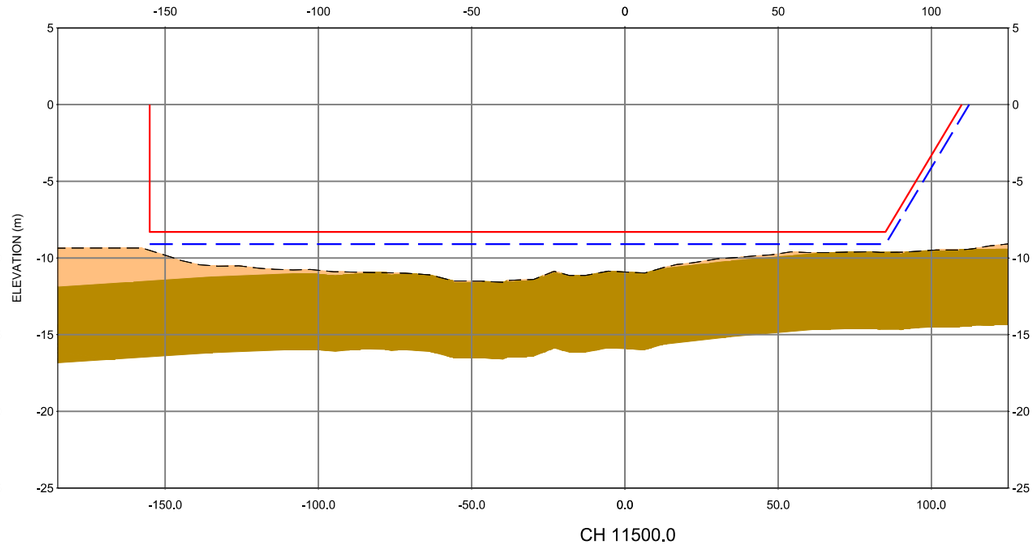
TITLE
EXTENT OF MATERIALS TO BE DREDGED - SHEET 2

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	1	1B









LEGEND

- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 METRES 1:400

HORIZ. 0 50 100 METRES 1:2,000

CLIENT
FLANAGAN CONSULTING GROUP

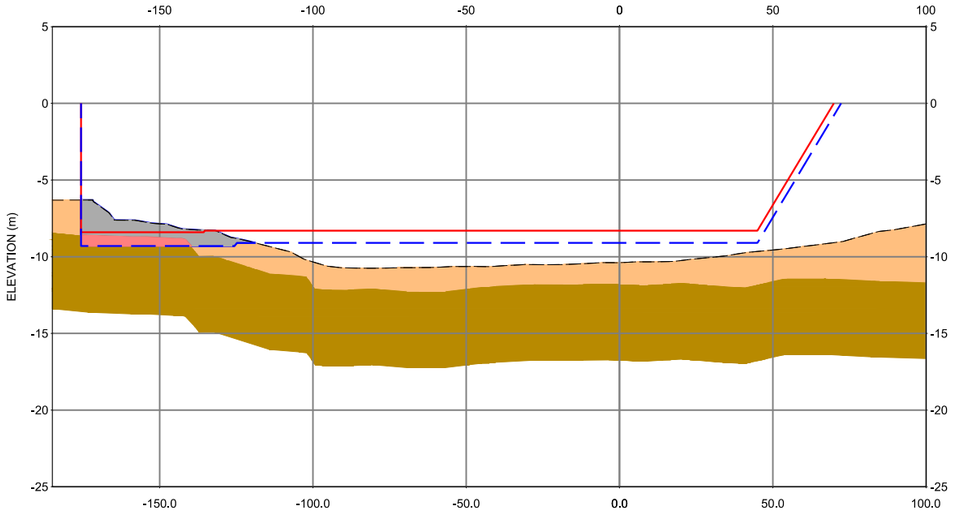
PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

CONSULTANT
Golder Associates

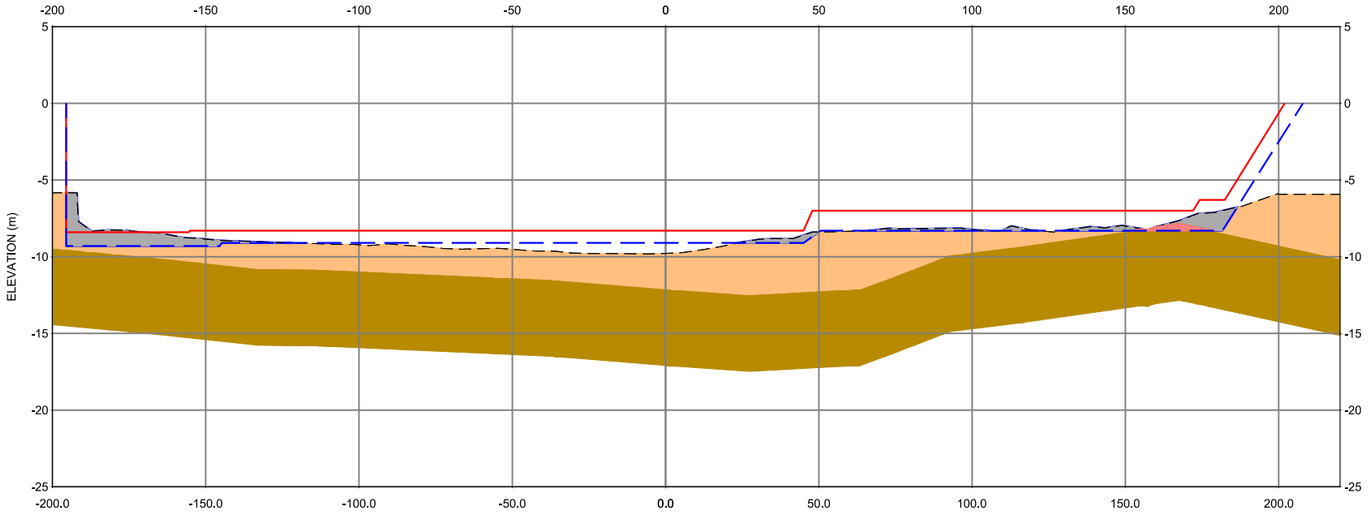
YYYY-MM-DD	2017-10-30
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

TITLE
CHANNEL CROSS SECTIONS SHEET 1

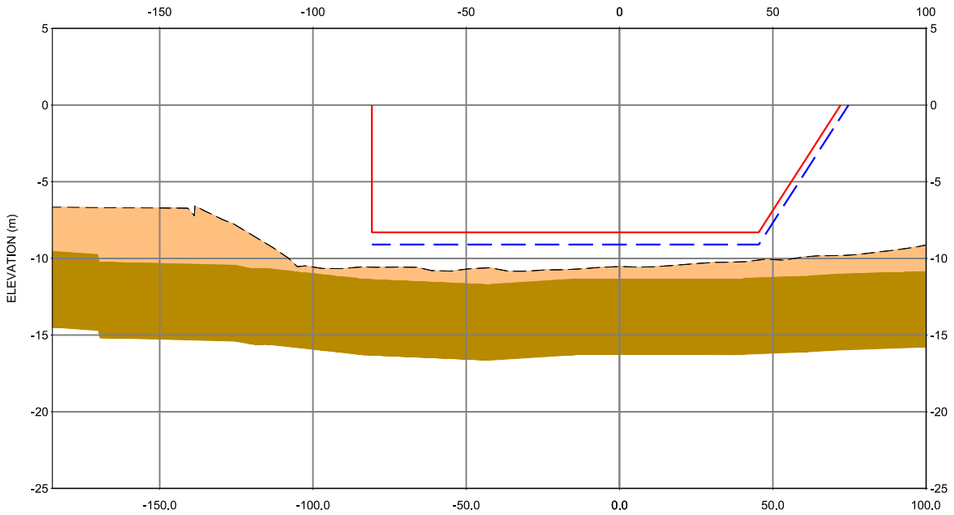
PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	1	2A



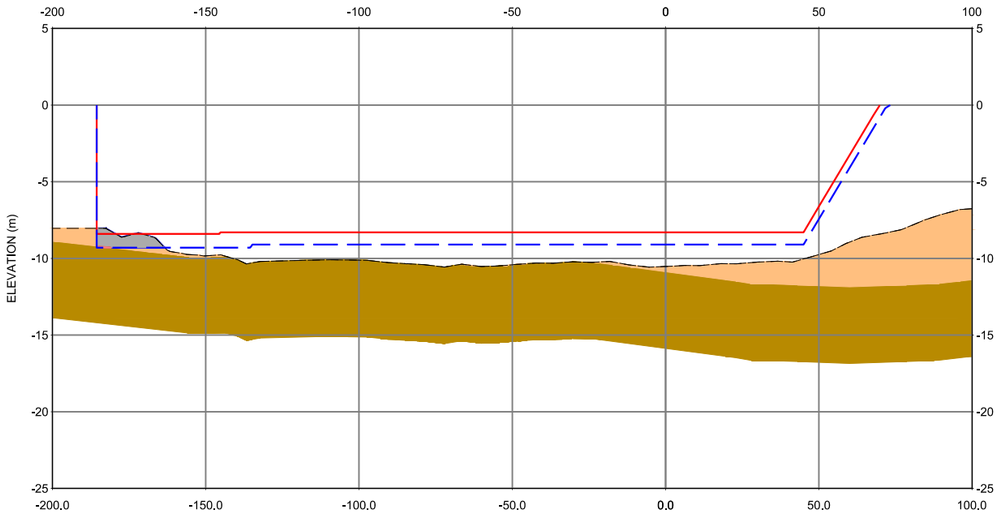
CH 12250.0



CH 12750.0



CH 12000.0



CH 12500.0

LEGEND

- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 METRES 1:400

HORIZ. 0 50 100 METRES 1:2,000

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

TITLE
CHANNEL CROSS SECTIONS SHEET 2

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	1	2B

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

25 mm

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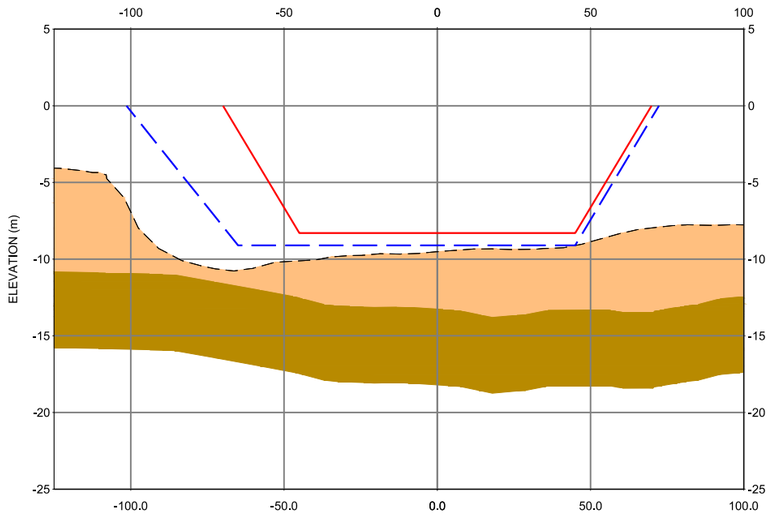
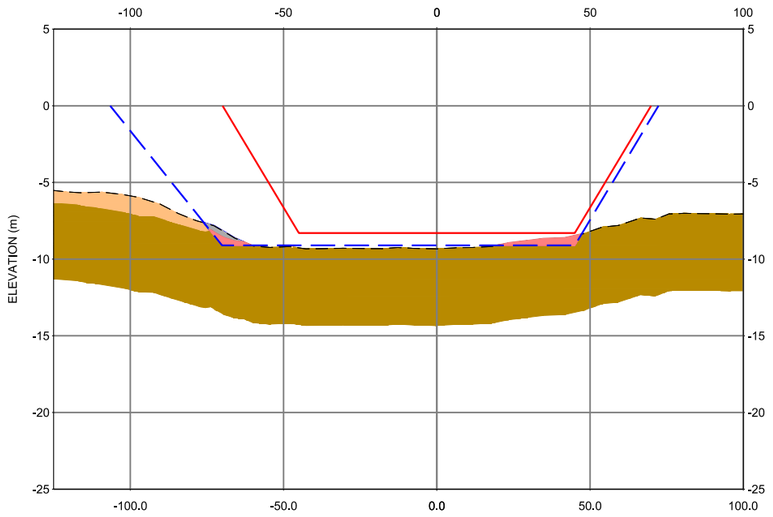
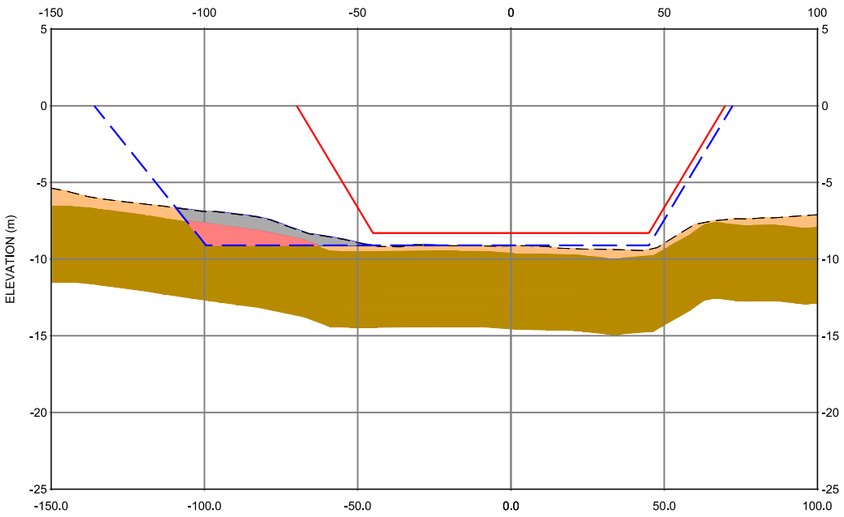


CH 13250.0



CH 13750.0



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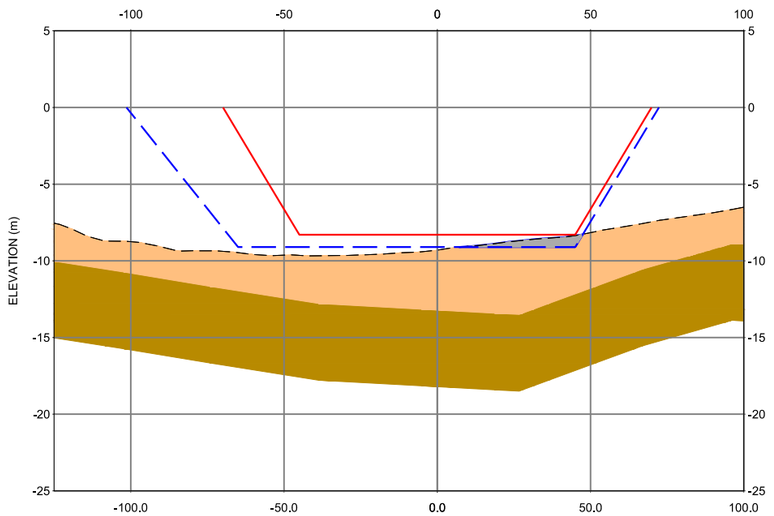
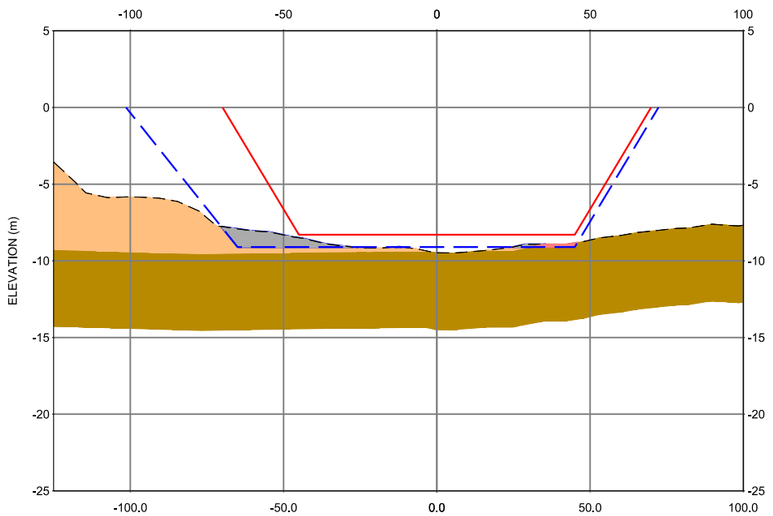
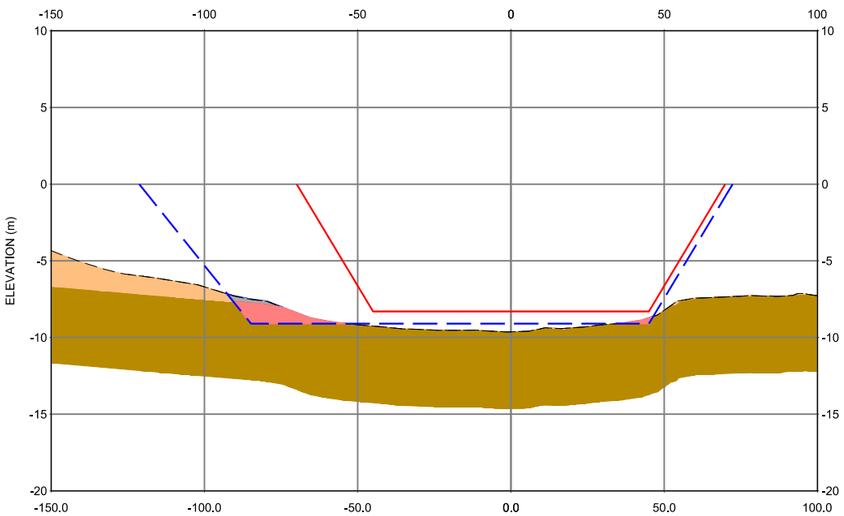


CH 13000.0



CH 13500.0



CH 14000.0

LEGEND

- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 METRES 1:400

HORIZ. 0 50 100 METRES 1:2,000

CLIENT
FLANAGAN CONSULTING GROUP

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
CHANNEL CROSS SECTIONS SHEET 3

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	1	2C

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

25 mm

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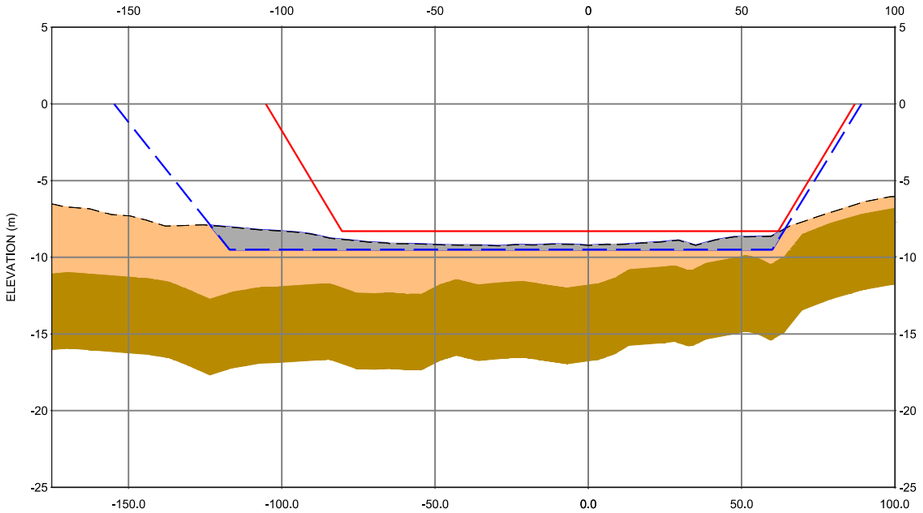
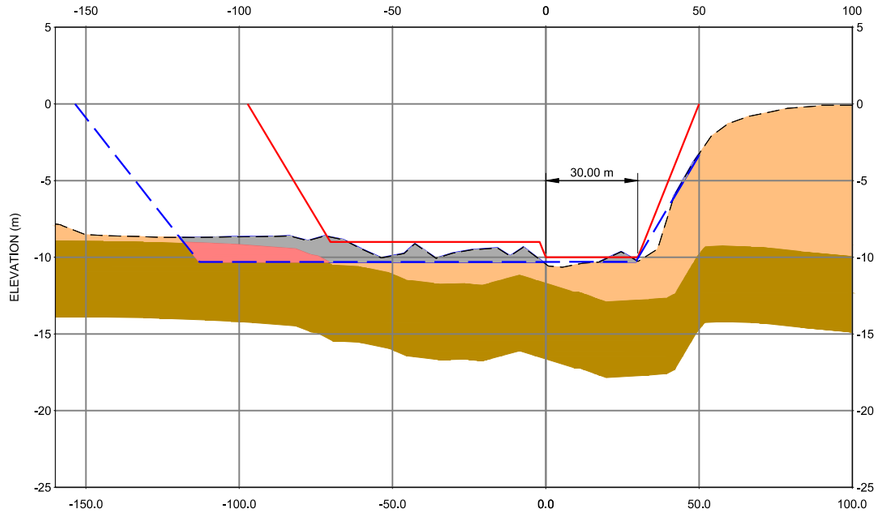


CH 14750.0



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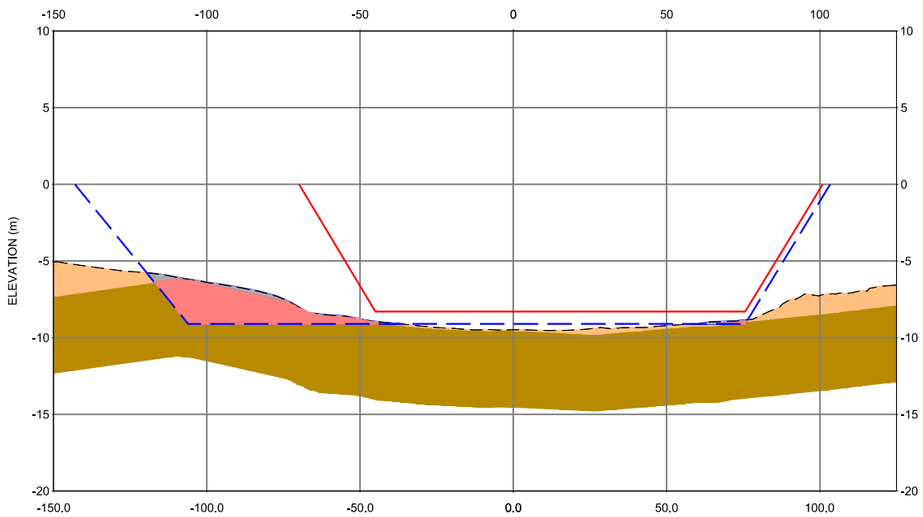
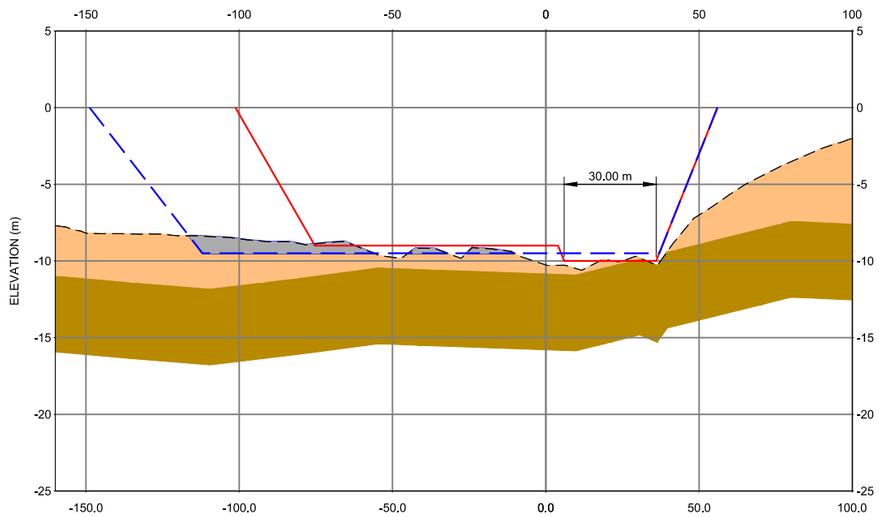


CH 14500.0



CH 15000.0

LEGEND

- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 METRES 1:400

HORIZ. 0 50 100 METRES 1:2,000

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

TITLE
CHANNEL CROSS SECTIONS SHEET 4

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	1	2D

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

25 mm

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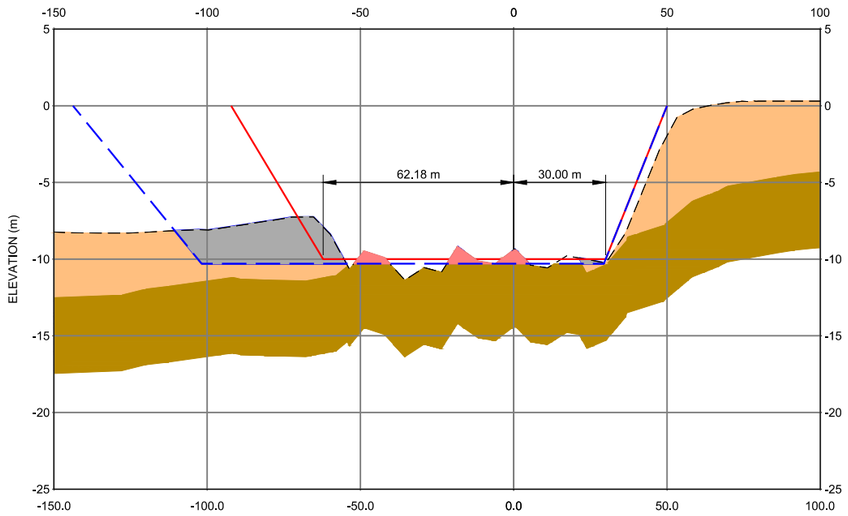
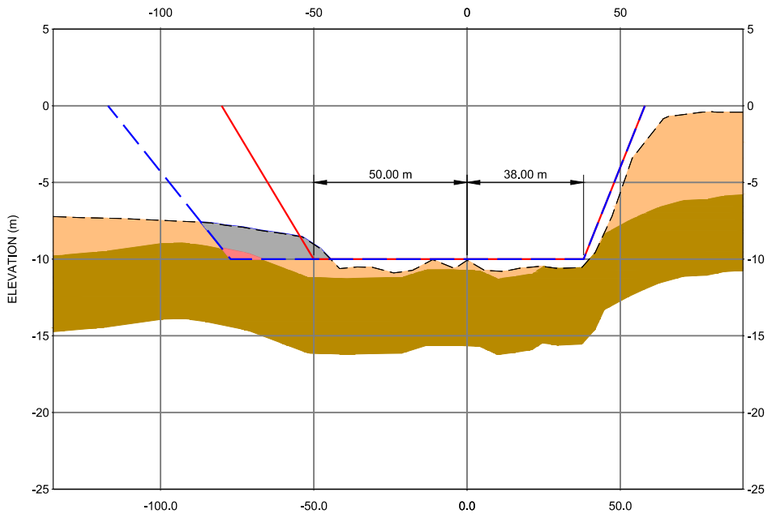
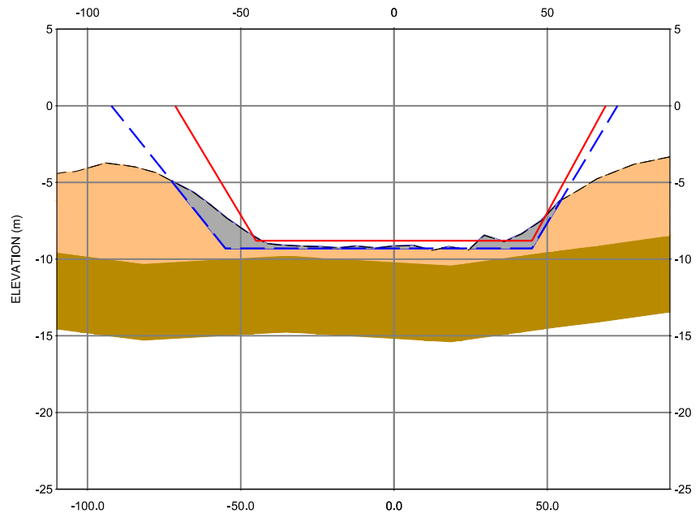


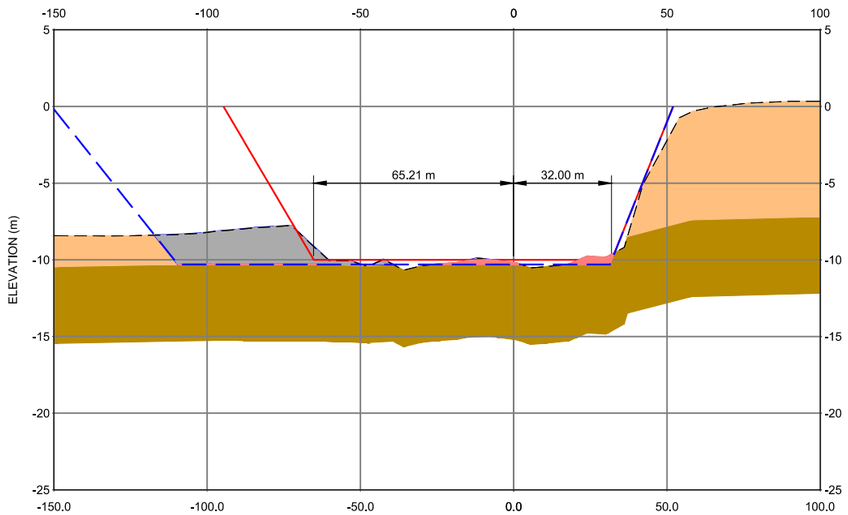
CH 15750.0



CH 16250.0



CH 16750.0



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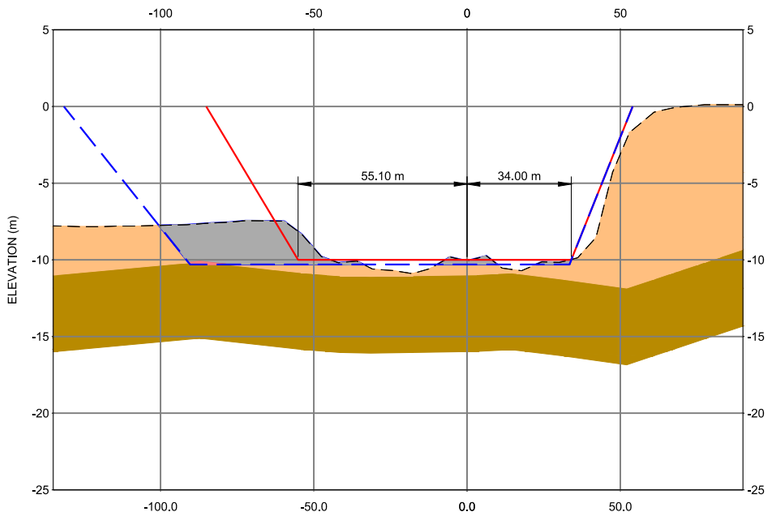

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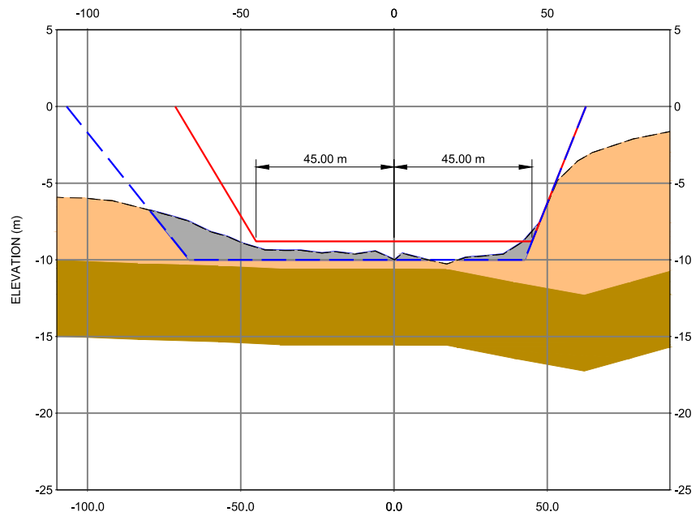

CH 16500.0

LEGEND

- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 — 1:400 METRES

HORIZ. 0 50 100 — 1:2,000 METRES

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

TITLE
CHANNEL CROSS SECTIONS SHEET 5

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	1	2E

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

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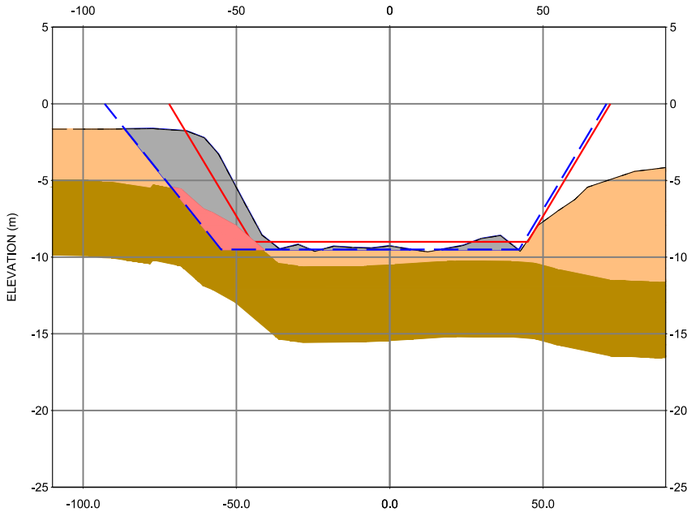
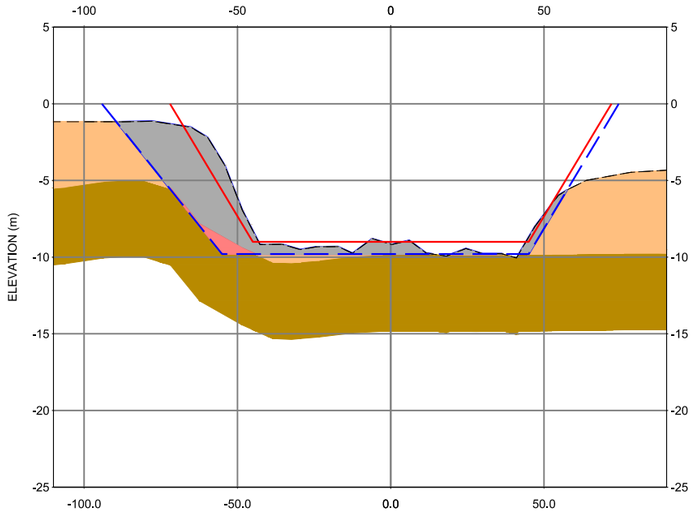
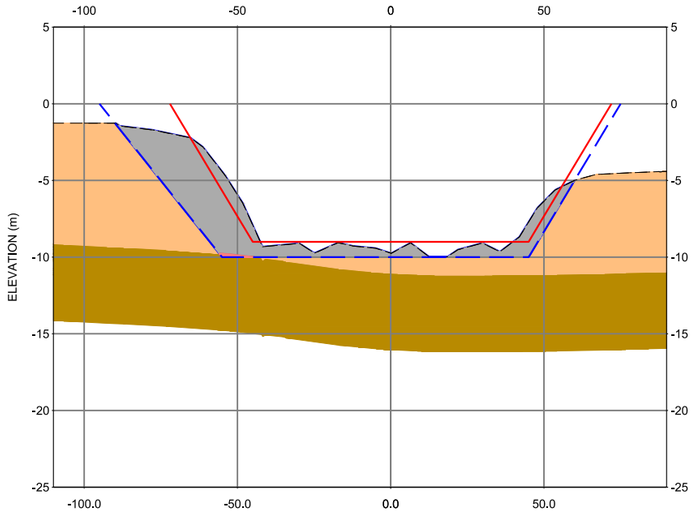


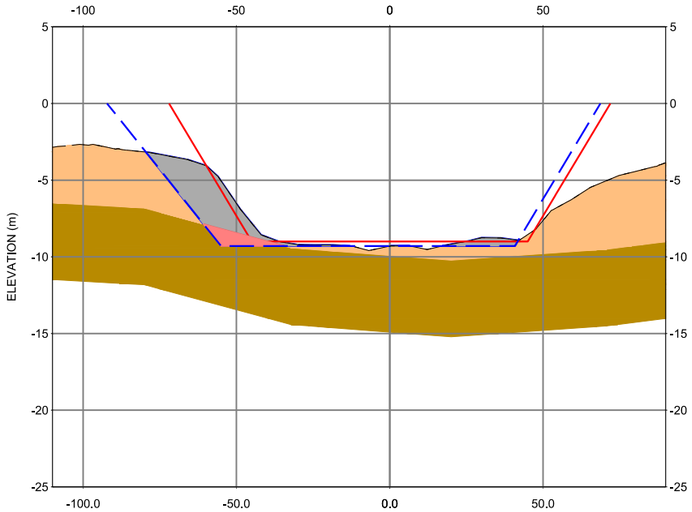
CH 17250.0



CH 17750.0



CH 18250.0



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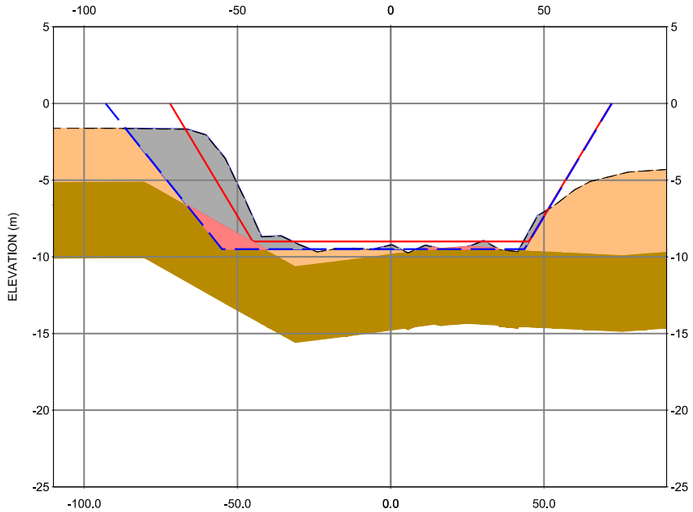

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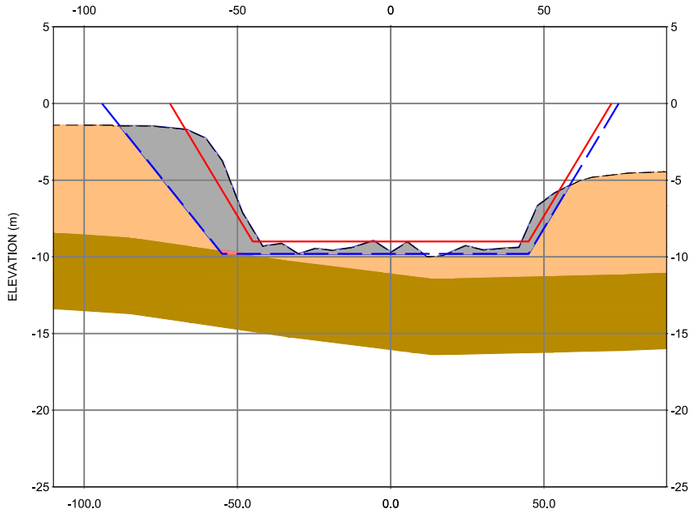

CH 18000.0

LEGEND

- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 — 1:400 METRES

HORIZ. 0 50 100 — 1:2,000 METRES

CLIENT
FLANAGAN CONSULTING GROUP

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
CHANNEL CROSS SECTIONS SHEET 6

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	1	2F

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

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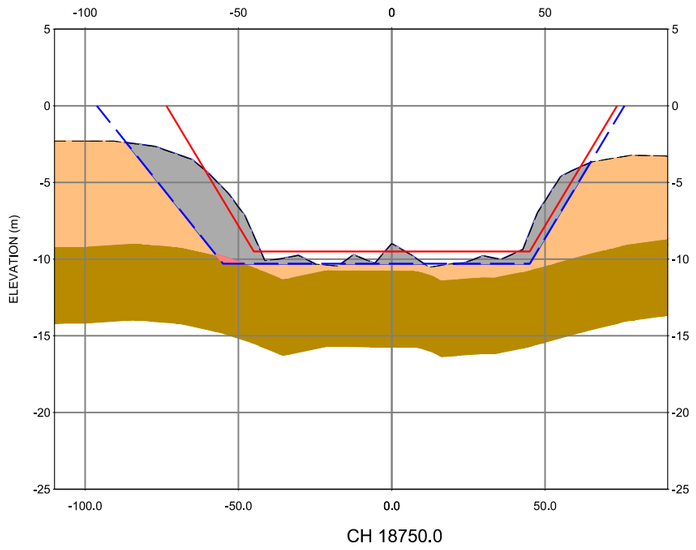
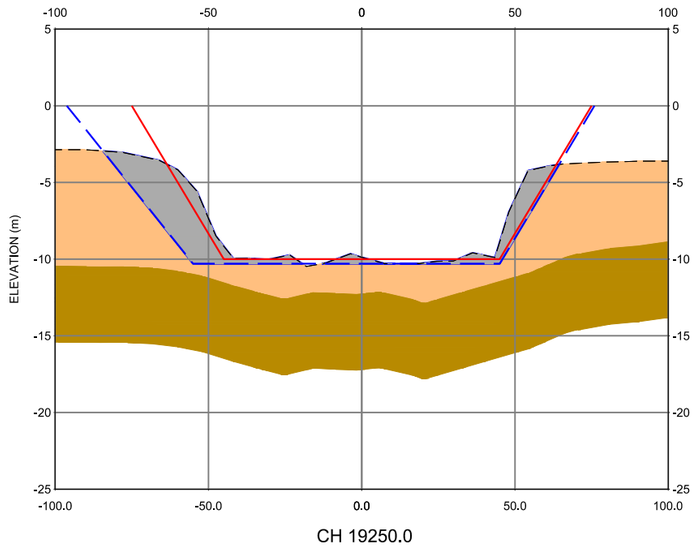
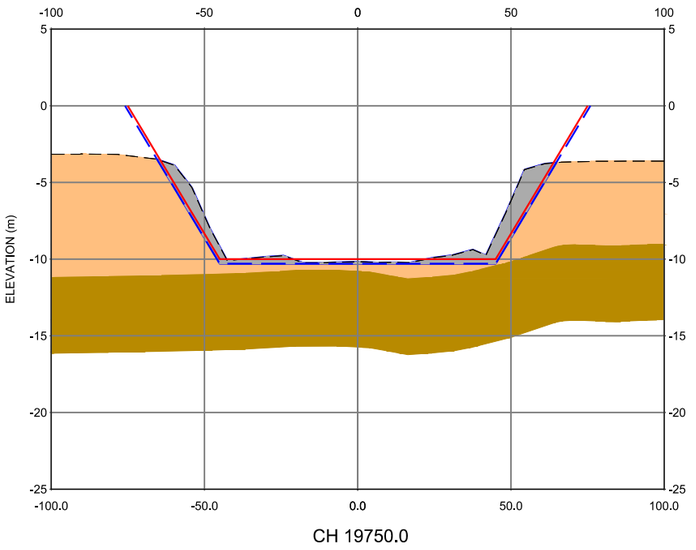


CH 18750.0



CH 19250.0



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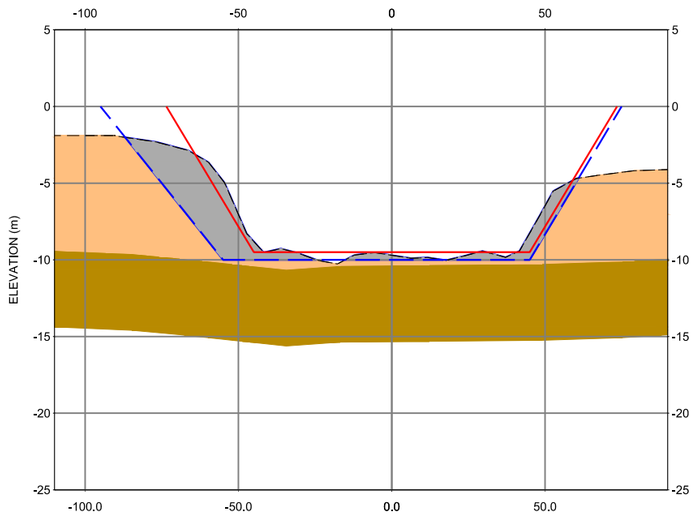

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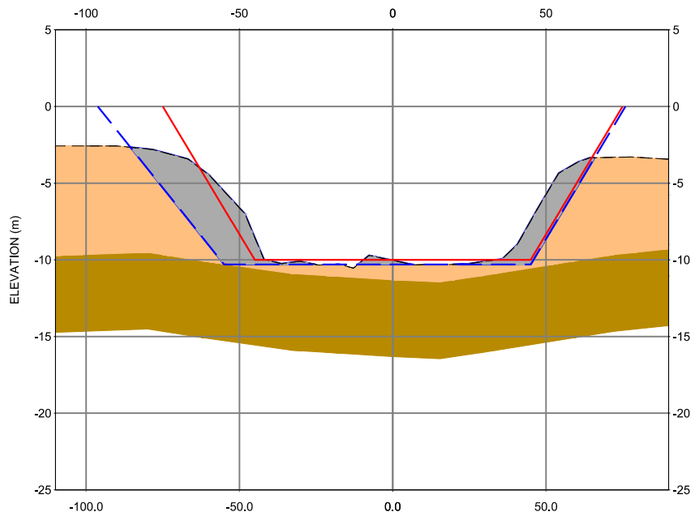

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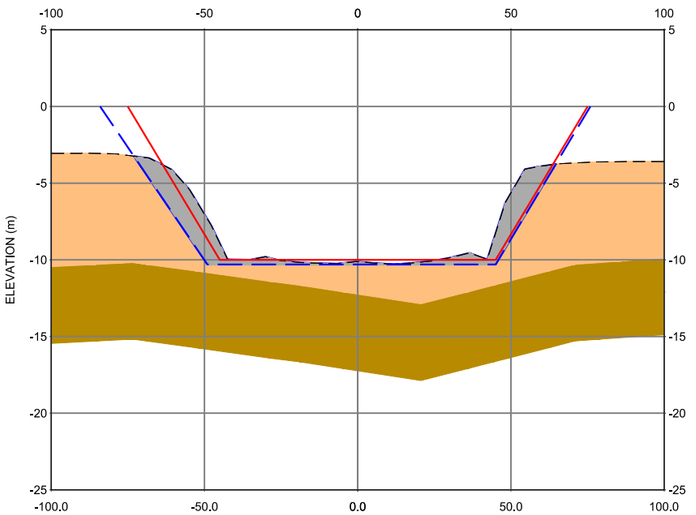

CH 19500.0

LEGEND

- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 METRES 1:400

HORIZ. 0 50 100 METRES 1:2,000

CLIENT
FLANAGAN CONSULTING GROUP

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
CHANNEL CROSS SECTIONS SHEET 7

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	1	2G

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

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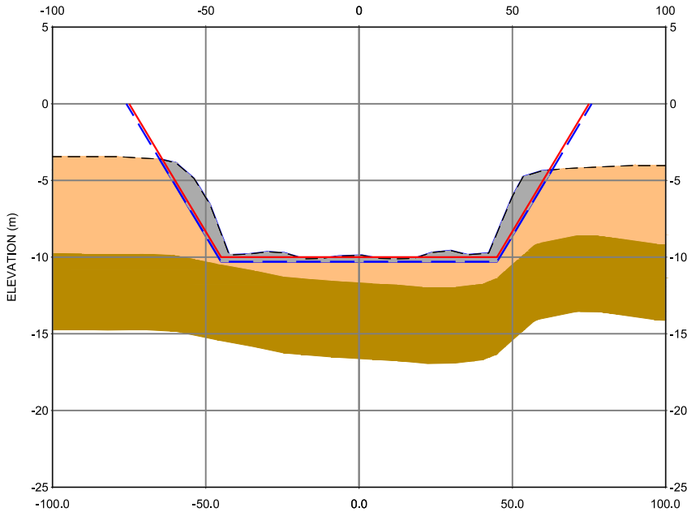
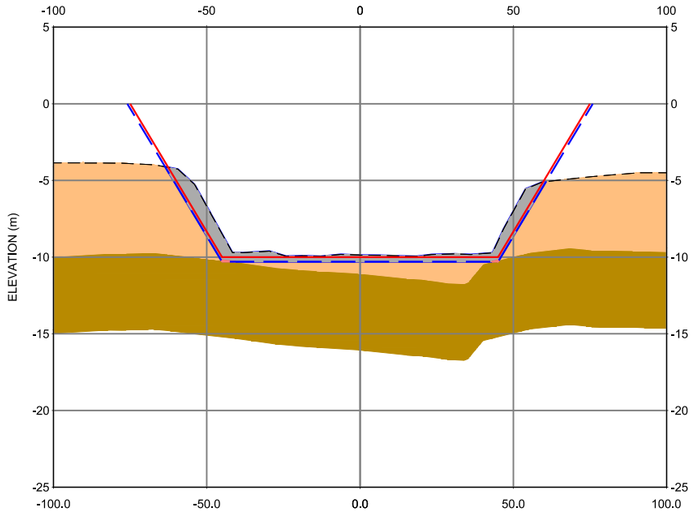
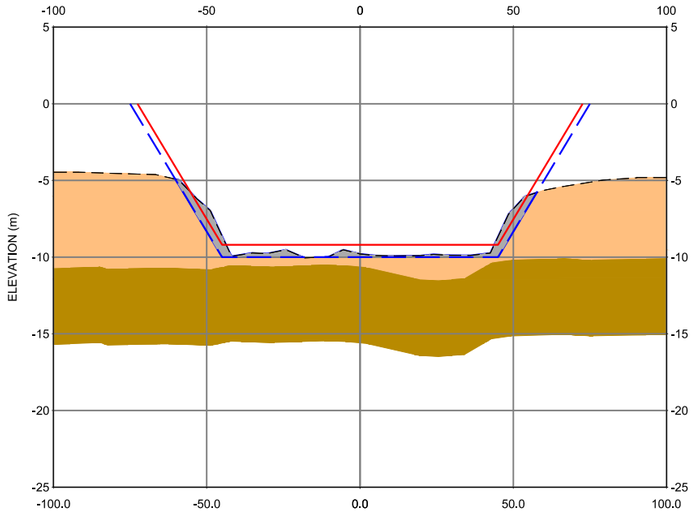


CH 20250.0



CH 20750.0



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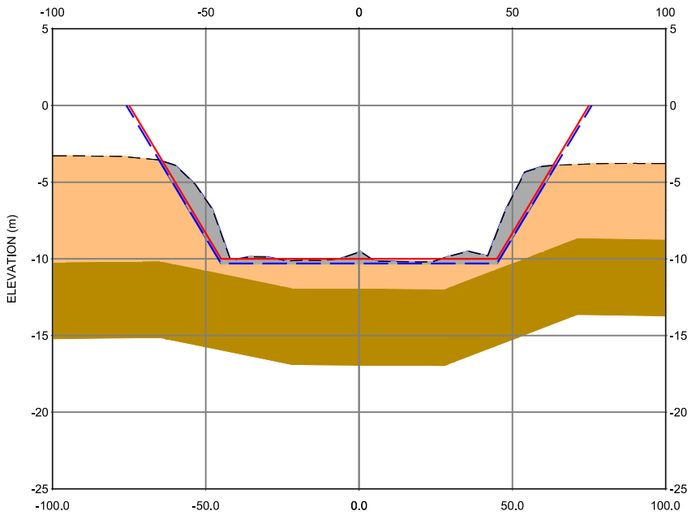

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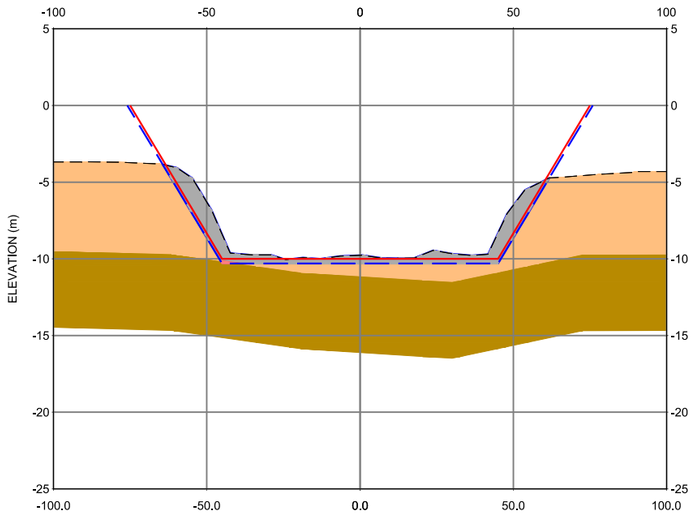

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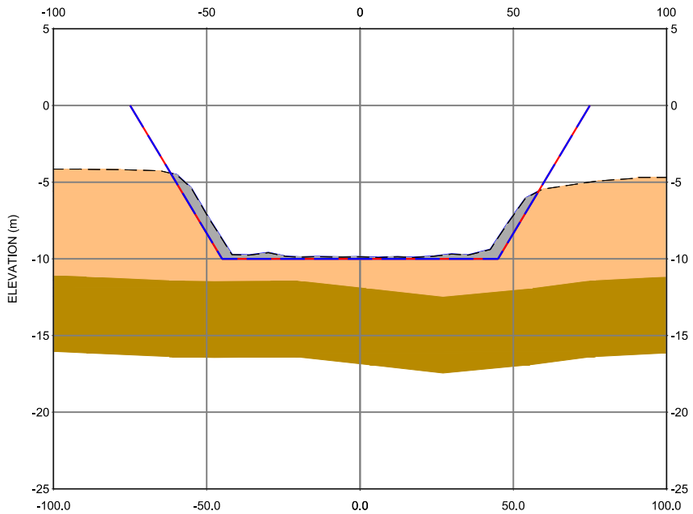

CH 21000.0

LEGEND

- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 METRES 1:400

HORIZ. 0 50 100 METRES 1:2,000

CLIENT
FLANAGAN CONSULTING GROUP

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
DESIGNED	PB
PREPARED	GPG
REVIEWED	MC
APPROVED	MC

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
CHANNEL CROSS SECTIONS SHEET 8

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	1	2H

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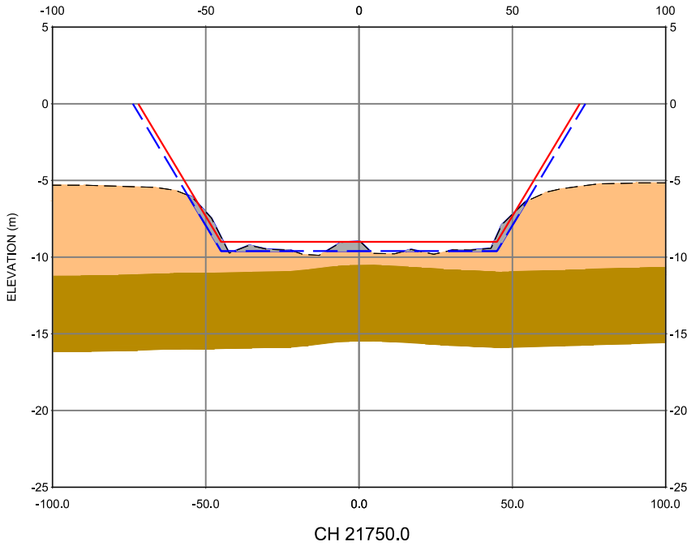

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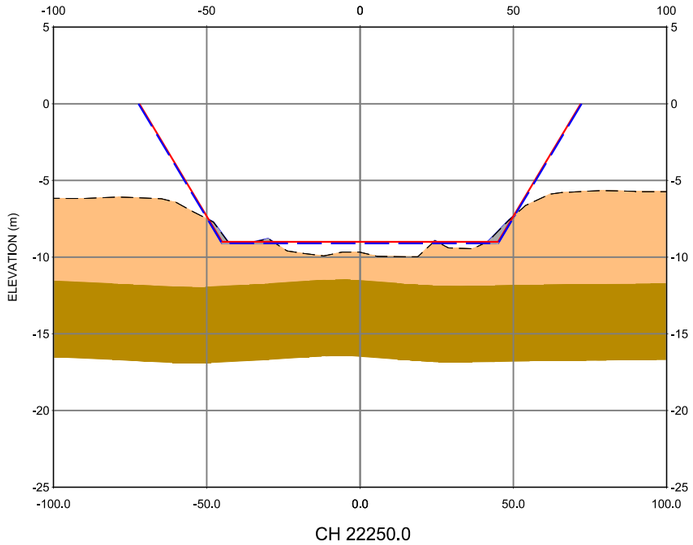

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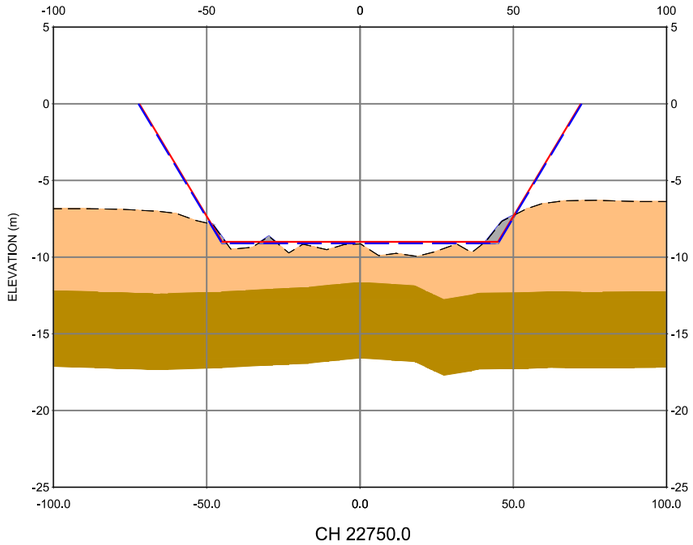

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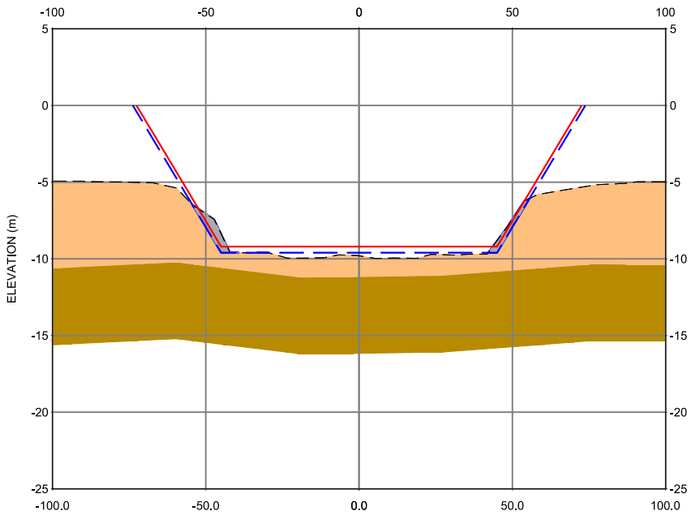

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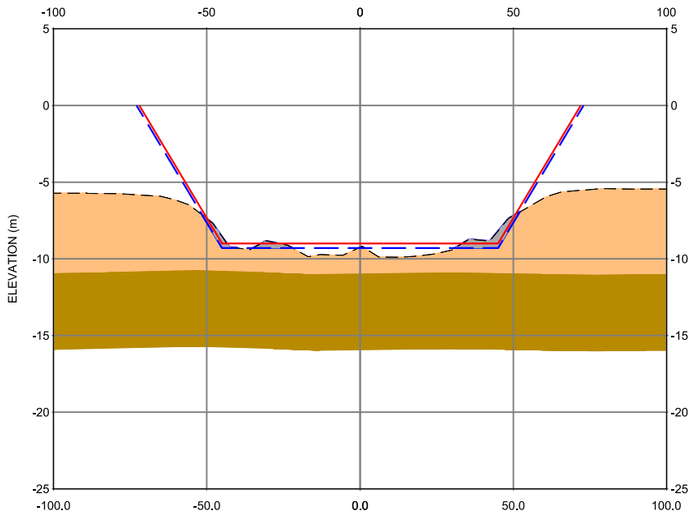

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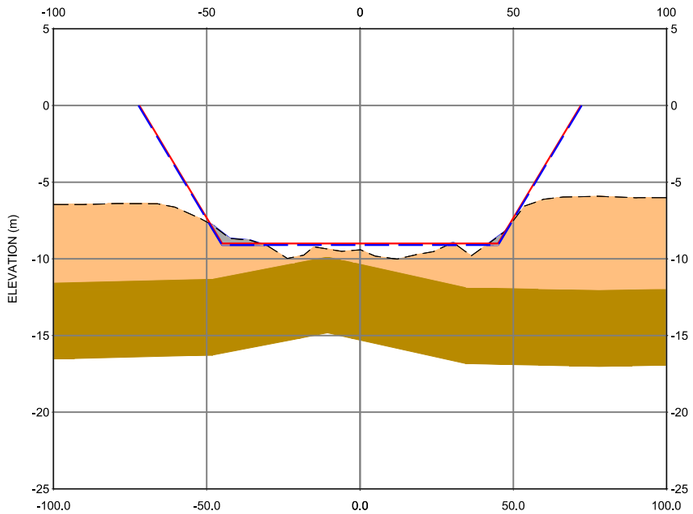

CH 22500.0

LEGEND

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- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 METRES 1:400

HORIZ. 0 50 100 METRES 1:2,000

CLIENT
FLANAGAN CONSULTING GROUP

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
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PREPARED	GPG
REVIEWED	MC
APPROVED	MC

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
CHANNEL CROSS SECTIONS SHEET 9

PROJECT NO.	DOCUMENT No	REV.	FIGURE
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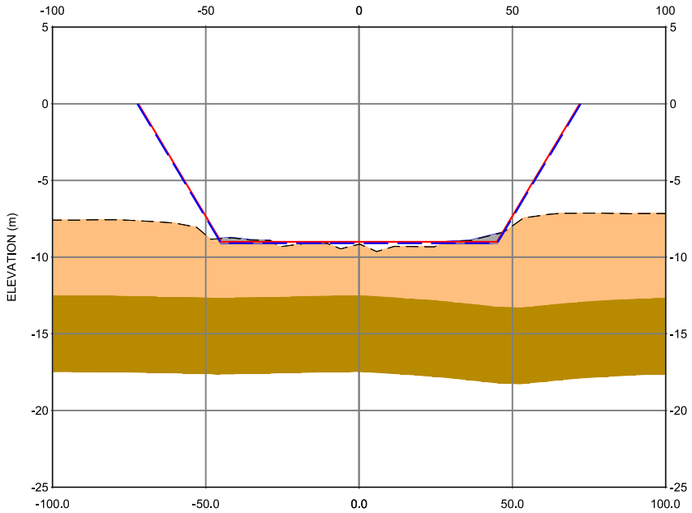

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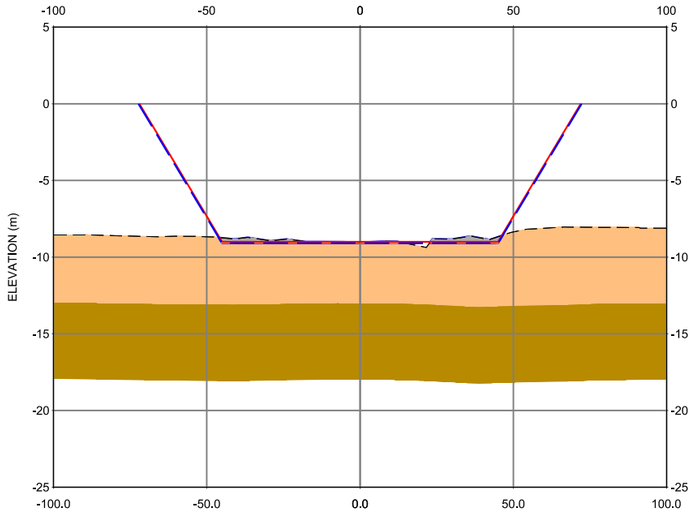

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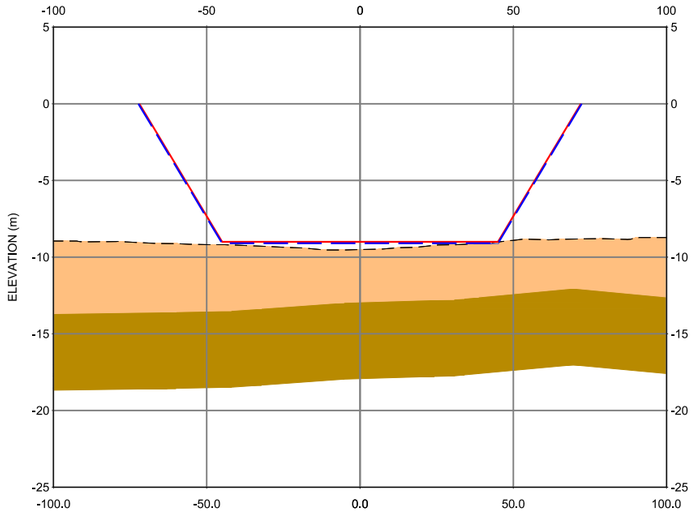

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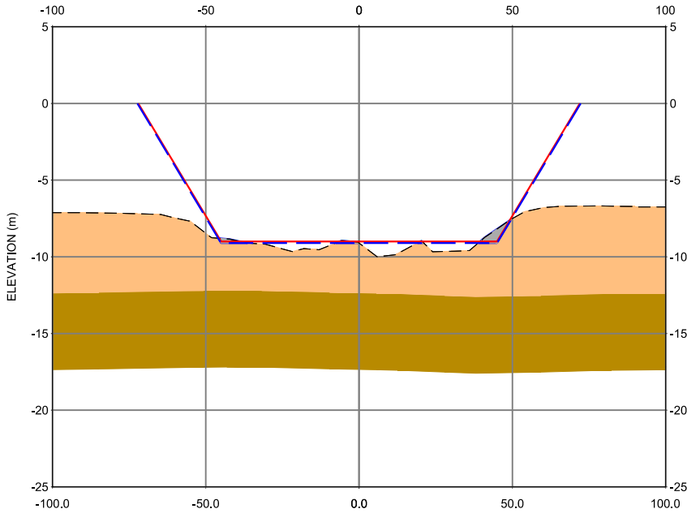

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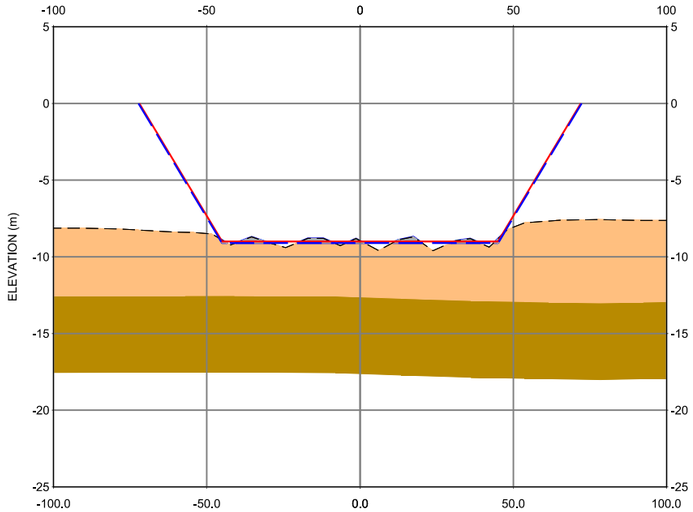

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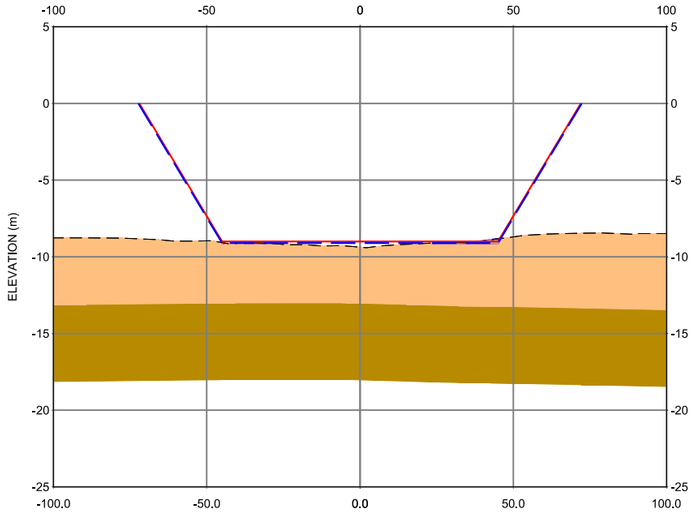

CH 24000.0

LEGEND

- PROPOSED DREDGE SPOIL (SOFT) (MAINTENANCE & CAPITAL)
- PROPOSED DREDGE SPOIL (STIFF) (MAINTENANCE & CAPITAL)
- SOFT CLAY
- STIFF CLAY
- EXISTING CHANNEL DESIGN
- 2016 COMPOSITE POST DREDGE DATA POINTS 21-10-16
- PROPOSED CHANNEL DESIGN

VERT. 0 10 20 METRES 1:400

HORIZ. 0 50 100 METRES 1:2,000

CLIENT
FLANAGAN CONSULTING GROUP

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-30
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REVIEWED	MC
APPROVED	MC

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

TITLE
CHANNEL CROSS SECTIONS SHEET 10

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	1	2J

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

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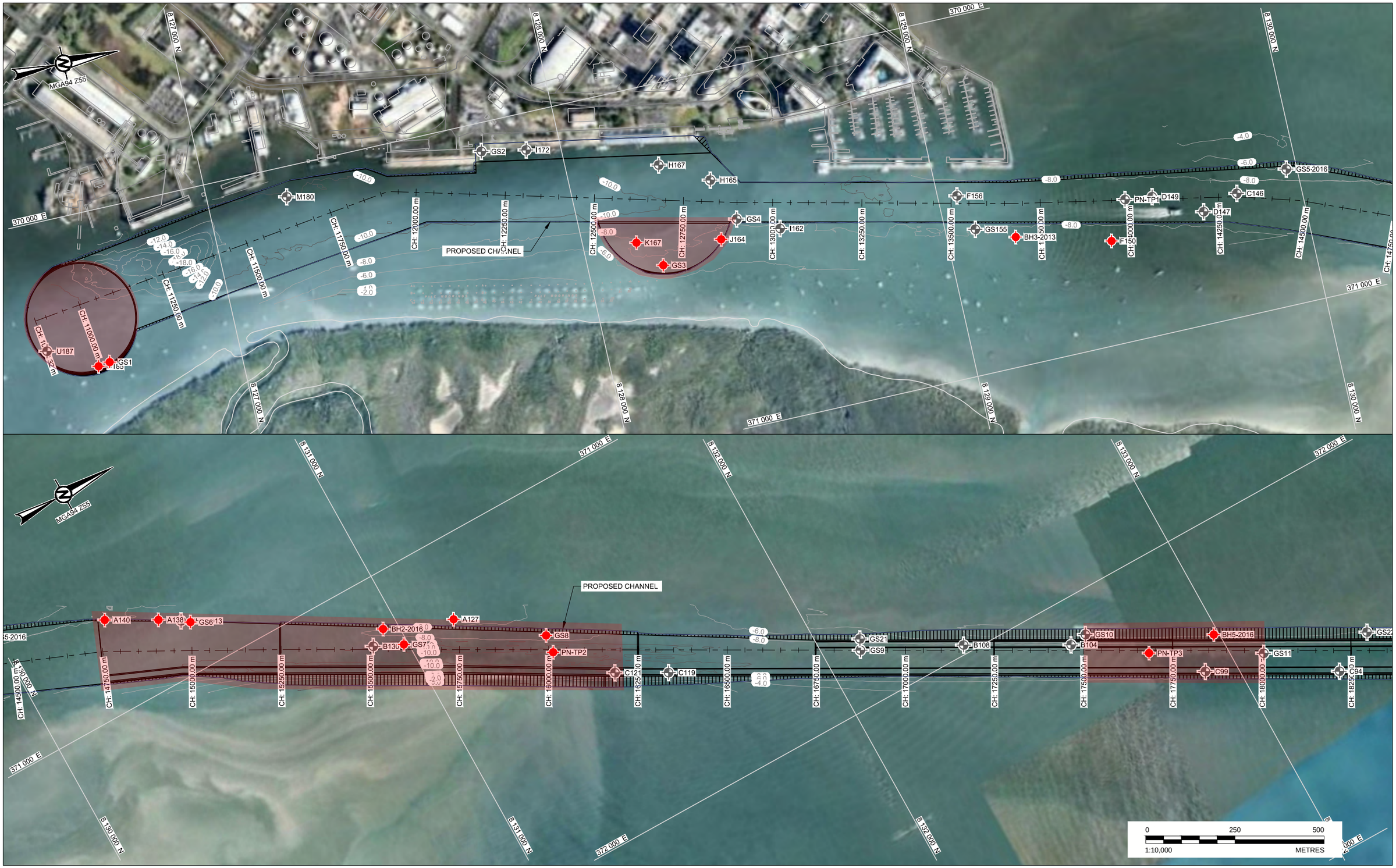

LEGEND

- BH Borehole Location with Identified PASS
- BH Borehole Location with Self-neutralising PASS
- Interpreted Extent of PASS Area (without sufficent neutralising capacity)

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-25
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PREPARED	GPG
REVIEWED	PS
APPROVED	MC

TITLE
EXTENTS OF POTENTIAL ACID SULFATE SOILS - SHEET 1

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	0	1A

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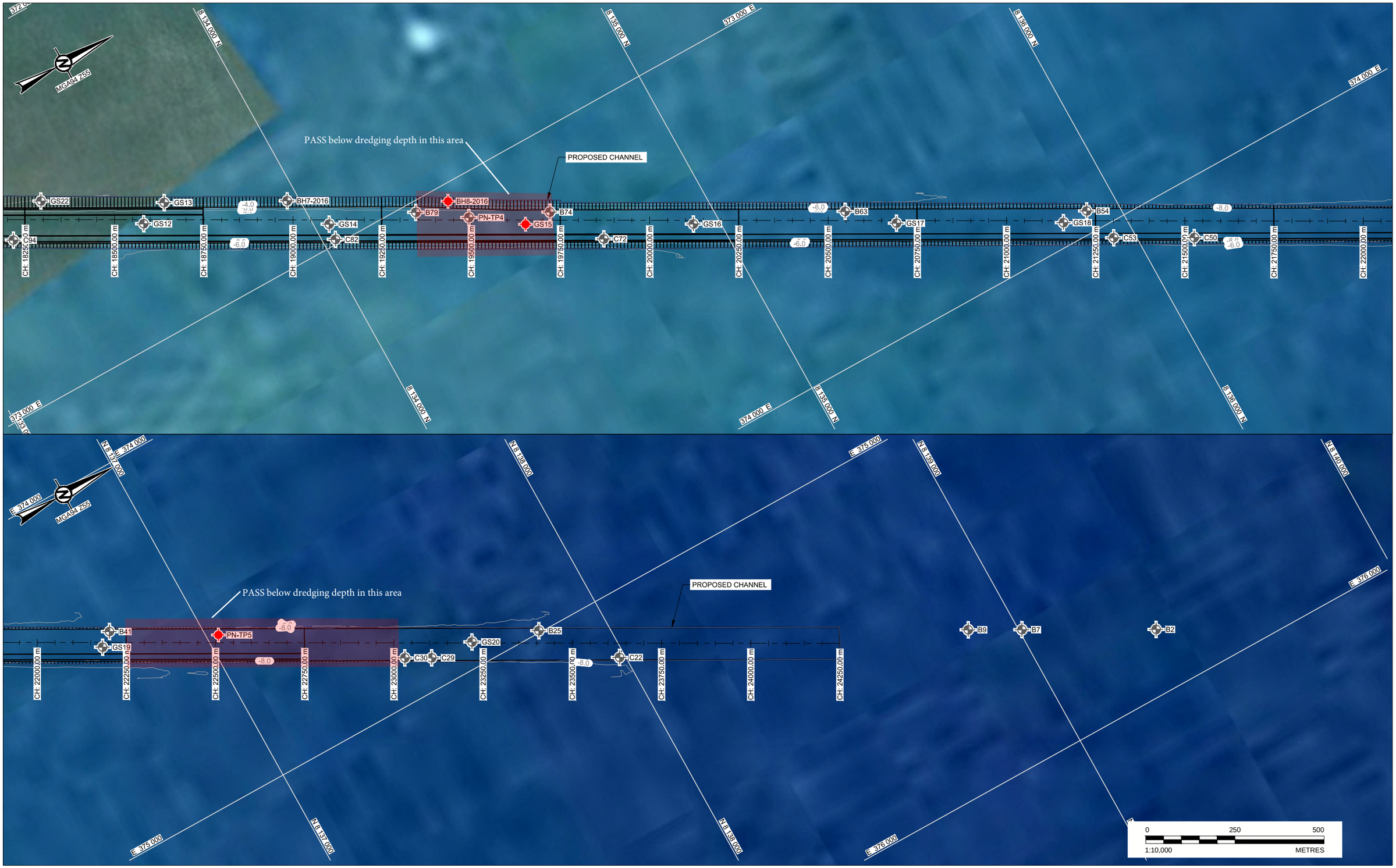

LEGEND

- BH Borehole Location with Identified PASS
- BH Borehole Location with Self-neutralising PASS
- Interpreted Extent of PASS Area (without sufficent neutralising capacity)

CLIENT
FLANAGAN CONSULTING GROUP

PROJECT
CAIRNS SHIPPING DEVELOPMENT PROJECT

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-25
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PREPARED	GPG
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APPROVED	MC

TITLE
EXTENTS OF POTENTIAL ACID SULFATE SOILS - SHEET 2

PROJECT NO.	DOCUMENT No	REV.	FIGURE
1546223	025	0	1B

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

25 mm

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APPENDIX A

Acid Sulfate Soil Management Procedures – Barron Delta DMPA

Procedure BD-A: Characterisation and Verification of SNP Dredged Materials

Procedure BD-B: Treatment and Verification of Dredged PASS

Procedure BD-C: Future Filling over Placed Dredged Materials

BD-A1. GENERAL

The procedure outlined below is provided to further characterise self-neutralizing PASS (SNP) placed in the Barron Delta DMPA to confirm the materials are self-neutralising.

BD-A2. OBJECTIVES

1) Appropriately characterise SNP materials placed above -1m AHD (i.e. 1m below the lowest recorded permanent water table) to confirm whether treatment is required or whether the material is self-neutralising.

2) Comply with conditions of licences, permits or other approvals issued for the project.

BD-A3. STATUTORY REQUIREMENTS AND GUIDELINES

1) Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines V4.0, 2014. Dear, S-E., Ahern, C. R., O'Brien, L. E., Dobos, S. K., McElnea, A. E., Moore, N. G. & Watling, K. M. Department of Science, Information Technology, Innovation and the Arts, Queensland Government;

2) Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland, 1998; Ahern, CR., Ahern, M.R. and Powell;

3) Environmental Protection Act 1994;

4) Environmental Protection Policy (Water) 2009

BD-A4. MANAGEMENT MEASURES

- During placement of SNP, a water cover of at least 1m shall be maintained to prevent draining/drying of these materials, prior to characterisation/verification.
- An earthworks strategy shall be developed to spatially define volumetric "lots" of 2,500 m^3 of materials deposited above -1m AHD. The height of each lot shall not be more than 1m. Placed heights shall be confirmed by sonar or other surveying measures.
- Positions of sample locations will be located by differential GPS and sample depths will be predetermined based on the water level in the DMPA.
- Samples of the SNP material shall be collected on a 1 per lot basis. Samples shall be collected across the full lot depth.
- Samples shall be collected from a punt/boat using a sampler or other suitable method.
- Sampling of each volumetric lot shall be conducted progressively and before filling of the overlying volumetric lot has been completed.
- Characterisation/verification samples will be analysed using the Chromium Suite of tests, following removal of shells and shell fragments larger than 2mm.

BD-A5. PERFORMANCE CRITERIA

To be confirmed as SNP materials, laboratory testing must demonstrate one of the following:

- Sum of existing plus potential acidity (excluding neutralising capacity) of less than 18 mol H+/tonne (0.03% S); or
- A neutralising capacity of more than 3 times the sum of existing plus potential acidity, all measured in the same units (and using a minimum safety factor of 3).

Some individual samples may vary from these criteria, as outlined below:

- No single sample shall exceed a net acidity of 18 mol H+/tonne (0.03% S); **and**
- If any single sample has a net acidity between 0 and 18 mol H+/tonne (0.00 to 0.03% S), then the average of any four spatially adjacent samples (including the exceeding sample) shall have an average net acidity of zero or less.

BD-A6. CONTINGENGY MEASURES

Where the performance criterion is exceeded, the lot represented by the sample (and any material placed above the lot) shall be lime treated as outlined in Procedure BD-B.

BD-A7. MONITORING AND REPORTING

Records shall be kept by the Site Manager or their delegated representative to verify volumes of sampling. Specific records of volumes, origin, material type and placement, including photos, shall be maintained by the Site Manager or their delegated representative.

The Site Manager or their delegated representative shall develop the materials tracking register plan and maintain a register of test results.

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BD-B1. GENERAL

The procedures outlined below are provided as contingency measures for on-site treatment and verification of dredged materials placed above -1m AHD, if confirmed to be not self-neutralising. This procedure should be reviewed and revised should other treatment options be considered.

BD-B2. OBJECTIVES

- Appropriately treat and manage PASS materials (detected in SNP) so as to minimise adverse effects on the natural and built environment (including infrastructure).
- Comply with conditions of licences, permits or other approvals issued for the project.

BD-B3. STATUTORY REQUIREMENTS AND GUIDELINES

1) *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines V4.0, 2014. Dear, S-E., Ahern, C. R., O'Brien, L. E., Dobos, S. K., McElnea, A. E., Moore, N. G. & Watling, K. M. Department of Science, Information Technology, Innovation and the Arts, Queensland Government;*
2) *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland, 1998; Ahern, CR., Ahern, M.R. and Powell;*
3) *Environmental Protection Act 1994;*
4) *Environmental Protection Policy (Water) 2009*

BD-B4. TREATMENT MEASURES

BD-B4 (a) In-line Dosing

Should initial testing of SNP (Procedure BD-A) consistently indicate PASS with insufficient self-neutralising capacity, in-line application of additional neutralising agents may be trialled to negate the need for other insitu treatments. A low soluble neutralising agent will need to be adopted.

BD-B4 (b) Earthworks Strategy

An earthworks strategy shall be developed to plan and track movement, treatment and verification of each volumetric lot (as defined in Procedure BD-A), where self-neutralisation performance criteria are not met.

BD-B4 (c) Insitu Treatment

Treatment of identified lots of PASS materials will occur within the DMPA as placement continues in other portions of the DMPA.

Identified PASS lots (and any overlying material) may be reworked using a small slurry pump (example below) or other small dredge to re-dredge the material and incorporate lime/neutralising agent via inline dosing. This treated material will be discharged into a new volumetric lot.

Alternatively, neutralising agent injection and soil mixing may be undertaken with mechanical mixing methods (e.g. jet grouting and shallow soil mixing equipment, cutter soil mixer, etc).

BD-B4 (e) Neutralisation Rates

Neutralisation rates for each treatment lot shall be determined from the initial characterisation result.

The neutralising rate required to neutralise the Net Acidity (Existing Acidity + Potential Acidity) shall be calculated by:

- Multiplying Net Acidity by a safety factor of 3 to allow for mixing deficiencies and poor reactivity of the lime;
- Multiplying the above result by the bulk density of the soil to arrive at the liming rate (kg/m^3).
- Multiplying the above result by the neutralising value of the neutralising agent.

BD-B4 (f) Verification Testing

Verification samples shall be collected for each treated lot. The samples shall be formed by compositing materials from three randomly selected locations across the lot. Samples shall be collected over the full thickness of the treated lot.

The Chromium Suite of tests shall be conducted on each sample to confirm net acidity by Acid Base Accounting.

BD-B5. PERFORMANCE CRITERIA

To confirm adequate treatment, laboratory testing must demonstrate the following:

- A neutralising capacity of more than 3 times the sum of existing plus potential acidity, all measured in the same units (and using a minimum safety factor of 3).

BD-B6. CONTINGENGY MEASURES

Additional treatment and further verification testing shall be conducted where adequate neutralisation is not initially indicated.

BD-B7. PERFORMANCE INDICATORS

Item	Performance Indicator
Earthworks strategy	■ An appropriate earthworks strategy has been prepared to track the treatment of PASS (appended to the ASSMP)
PASS treatment	■ Treatment procedures employed
Neutralising rates	■ Correct neutralising rates are applied for each treatment lot.
Treatment verification	■ Verification of treatment on each lot of treated material. ■ Correct verification laboratory analysis used. ■ If verification shows performance criteria in section BD-B5 are not met, additional treatment has been employed.
Non conformance	■ All non-conformances are reported and rectified.

BD-B8. MONITORING AND REPORTING

Records shall be kept by the Site Foreman to verify volumes of soils treated.

The Site Foreman shall be responsible for ensuring neutralisation and verification tests are completed for each lot of PASS.

The Site Foreman shall maintain a register of testing results and a record of inspections.

A summary report of all test results and inspections shall be complied by the Site Foreman each week and submitted to the Environmental Manager.

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BD-C1. GENERAL

The procedures outlined below are provided to control future filling activities over placed dredged materials to minimise displacement of placed SNP and prevent displacement of deeper PASS materials.

BD-C2. OBJECTIVES

- Provide measures to prevent PASS materials being displaced above -1m AHD.
- Comply with conditions of licences, permits or other approvals issued for the project.

BD-C3. STATUTORY REQUIREMENTS AND GUIDELINES

1) *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines V4.0, 2014. Dear, S-E., Ahern, C. R., O'Brien, L. E., Dobos, S. K., McElnea, A. E., Moore, N. G. & Watling, K. M. Department of Science, Information Technology, Innovation and the Arts, Queensland Government;*
2) *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland, 1998; Ahern, CR., Ahern, M.R. and Powell;*
3) *Environmental Protection Act 1994;*
4) *Environmental Protection Policy (Water) 2009*

BD-C4. MANAGEMENT MEASURES

- The deposition of wastes or other fill materials over placed dredged spoil within the DMPA will be prohibited until such time as the spoil has obtained a suitable strength gain (or equivalent settled density). At this time, a shear strength of at least 20kPa in this top 1m should be the target strength. This requirement could be reviewed by geotechnical engineer should contingency measures in BD-C6 be adopted.
- Once suitable strength gain (or equivalent settled level) has been verified, controlled placement of new fills shall be conducted. This shall include:
  - No end dumping on to dredged materials.
  - No creation of an excessively high (greater than 1m) face of fill material on the side slopes of the DMPA.
  - The initial layer of fill placed over the dredged material should distributed by excavator bucket and shall not exceed 0.5m in height.
  - At least a week shall pass before the next layer is placed in a similar manner. New layers must not extend closer than 2m from the edge of the underlying layer.
  - Fill layer stability should be confirmed by a geotechnical engineer, prior to any equipment access on to placed fills.
- Filling shall cease immediately if a “mud wave” is observed extending greater than 0.5m above the original surface of the placed dredged spoil. Where this occurs, a review of filling methods shall be conducted by a geotechnical engineer and the method shall be altered to mitigate further mud wave formation.

BD-C5. PERFORMANCE CRITERIA

- No large scale instability within the placed dredge materials.
- No mud wave greater than 0.5m above the original surface of the placed dredged spoil.

BD-C6. CONTINGENGY MEASURES

A layer of high strength geotextile and geogrid could be placed over the top of the dredged materials prior to placement of fill to act as a separation layer and to mitigate mud wave formation.

BD-C8. MONITORING AND REPORTING

Records shall be kept by the Site Manager or their delegated representative to verify target strength in the dredged spoil prior to filling. Specific records of fill material type and placement, including photos, shall be maintained by the Site Manager or their delegated representative.

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APPENDIX B

Acid Sulfate Soil Management Procedures – Tingira Street DMPA

Procedure TS-A: Identification and Characterisation of Possible ASS

Procedure TS-B: Treatment and Verification of Identified ASS

TS-A1. GENERAL

The procedure outlined below is provided for the visual inspection and characterisation of possible ASS materials within stiff clay materials arriving at the Tingira Street DMPA.

TS-A2. OBJECTIVES

- Visual inspection for the presence of ASS materials.
- Comply with conditions of licences, permits or other approvals issued for the project.

TS-A3. STATUTORY REQUIREMENTS AND GUIDELINES

1) *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines V4.0, 2014. Dear, S-E., Ahern, C. R., O'Brien, L. E., Dobos, S. K., McElnea, A. E., Moore, N. G. & Watling, K. M. Department of Science, Information Technology, Innovation and the Arts, Queensland Government;*
2) *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland, 1998; Ahern, CR., Ahern, M.R. and Powell;*
3) *Environmental Protection Act 1994;*
4) *Environmental Protection Policy (Water) 2009*

TS-A4. INSPECTION FOR ASS

Each load of stiff clay arriving at the Tingira Street DMPA will be inspected by an experienced ASS practitioner for the presence of soft, dark coloured (particularly grey hued soils) clays mixed or comingled with the stiff, yellow/orange hued clays. Visual examples of each of these materials are presented in Plates 1 and 2.

Plate 1 – Soft Clays - Possible Acid Sulfate Soils

Plate 2 – Stiff Clays – non Acid Sulfate Soil

TS-A5. MANAGEMENT MEASURES

Training – Equipment operators and supervisors at the Tingira Street DMPA shall be trained in the basic recognition of ASS as part of a site induction presentation. An experienced ASS practitioner shall be appointed to conduct site inspections and assist in the identification of ASS.

Soil Handling – Material arriving at the Tingira Street DMPA shall be placed in bunded areas where drying and then placement and compaction will occur. Where possible ASS is observed during the inspection, this material should be segregated from non-ASS materials where this is feasible/practical. Segregated materials should be directly be removed for disposal at a licenced PASS disposal site or characterised and treated at the DMPA as per Procedure TS-B.

Where, it is not practical to segregate the non-ASS from possible ASS materials. A sample of the possible material shall be collected for characterisation and that load of comingled material shall be treated at the liming rate indicated by the characterisation test.

Characterisation – Where suspected ASS is observed a samples shall be collected for analysis by the Chromium Suite of tests. Materials returning net acidity less than 0.03%S shall be reused at the DMPA without further acid sulfate management. Where net acidity greater than 0.03%S is found, the materials shall be transported directly to a treatment area and measures described in Procedure TS-B shall be followed.

TS-A6. MONITORING AND REPORTING

The Site Foreman or their delegated representative shall keep a record of all equipment operators and supervisors who are trained in the basic recognition of ASS as part of induction training.

The Site Foreman shall maintain a register of inspections of each load received at the DMPA and records of any test results on samples of suspected ASS.

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TS-B1. GENERAL

The procedures outlined below are provided as a **contingency measure** for the on-site treatment and verification of ASS materials, if identified commingled with stiff clays at the Tingira Street DMPA.

TS-B2. OBJECTIVES

- Appropriately treat and manage confirmed ASS materials so as to minimise adverse effects on the natural and built environment (including infrastructure).
- Comply with conditions of licences, permits or other approvals issued for the project.

TS-B3. STATUTORY REQUIREMENTS AND GUIDELINES

1) *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines V4.0, 2014. Dear, S-E., Ahern, C. R., O'Brien, L. E., Dobos, S. K., McElnea, A. E., Moore, N. G. & Watling, K. M. Department of Science, Information Technology, Innovation and the Arts, Queensland Government;*
2) *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland, 1998; Ahern, CR., Ahern, M.R. and Powell;*
3) *Environmental Protection Act 1994;*
4) *Environmental Protection Policy (Water) 2009*

TS-B4. TREATMENT MEASURES

TS-B4 (a) Stockpiling of Identified ASS

Stockpiling and treatment of identified ASS materials shall only be conducted within a bunded area on the DMPA.

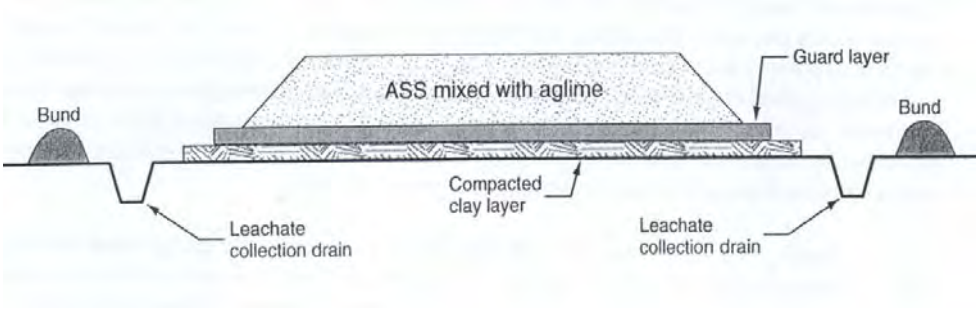
TS-B4 (b) Treatment Facility

A treatment facility shall be constructed within the DMPA area in general accordance with the requirement detailed in *Soil Management Guidelines, 2014* (refer Figure TS-B1) and the following additional requirement:

- A guard layer of fine ground agricultural lime shall be applied to the treatment areas prior to placement of soils at a rate 5 kg/m^2 for each 1m height of soil to be treated.

The treatment facility shall be inspected on a daily basis and maintained to prevent escape of soils or water from the facility.

Figure TS-B1: Schematic cross-section of a treatment pad, including a compacted clay layer, guard layer, leachate collection system and containment with bund



Identified ASS materials shall be placed into appropriately identified treatment lots at the treatment facility where the material shall be spread in layers and allowed to dry (if required).

The overall layer thickness shall not exceed 250 mm thickness unless effective treatment over a greater thickness can be demonstrated. Where required, drying shall be enhanced by mechanical methods (rotary hoe, disc plough, etc) to create a relatively homogenous, friable material prior to addition of lime for neutralisation.

Fine ground agricultural lime (or other approved neutralising agent) shall be applied to the ASS surface in each treatment lot using a spreader truck or other approved method. Following lime application, the lime shall be mixed into the ASS layer using mechanical methods (disc plough, rotary hoe, etc).

TS-B4 (c) Liming Rates

The liming rates shall be determined from Chromium Suite testing. The highest indicated rate shall apply to a treatment lot.

TS-B4 (d) Verification Testing

Verification samples shall be collected for each treated lot (1 per lot). The samples shall be formed by compositing materials from three randomly selected locations across the allotment. Samples shall be collected over the full thickness of the treated lot. Chromium Suite testing shall be conducted on each sample to confirm net acidity by Acid Base Accounting.

TS-B5. PERFORMANCE CRITERIA

To confirm adequate lime treatment, laboratory testing must demonstrate the following:

- A neutralising capacity of more than 1.5 times the sum of existing plus potential acidity, all measured in the same units (and using a minimum safety factor of 1.5).

Some individual samples may vary from these criteria, as outlined below:

- No single sample shall exceed a net acidity of 18 mol H+/tonne (0.03% S); **and**
- If any single sample has a net acidity between 0 and 18 mol H+/tonne (0.00 to 0.03% S), then the average of any four spatially adjacent samples (including the exceeding sample) shall have an average net acidity of zero or less.

TS-B6. CONTINGENGY MEASURES

Additional lime treatment and further verification testing shall be conducted where adequate neutralisation is not initially indicated.

TS-B7. PERFORMANCE INDICATORS

Item	Performance Indicator
Earthworks strategy	■ An appropriate earthworks strategy has been prepared to track the treatment of ASS (appended to the ASSMP)
Liming rates	■ Correct liming rates are applied for each treatment lot.
Treatment verification	■ Verification of treatment on each of treated material. ■ Correct verification laboratory analysis used. ■ If verification shows performance criteria in section TS-B5 are not met, additional treatment has been employed.
Non conformance	■ All non-conformances are reported and rectified.

TS-B8. MONITORING AND REPORTING

Records shall be kept to track identified ASS materials, volumes transported to the treatment facility, treatment rates applied. The Site Foreman shall conduct an inspection of the treatment areas including bunds and sumps on a weekly basis.

The Site Foreman shall be responsible for ensuring lime neutralisation and verification tests are completed for each lot of excavated ASS.

The Site Foreman shall maintain a register of testing results and a record of inspections.

A summary report of all test results and inspections shall be complied by the Site Foreman each week and submitted to the Environmental Manager.

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