CAIRNS SHIPPING DEVELOPMENT PROJECT

Revised Draft Environmental Impact Statement

APPENDIX X: Soils and Groundwater Impact Assessment: Tingara Street DMPA Report (2017)

2 June 2017

SOILS AND GROUNDWATER IMPACT ASSESSMENT TINGIRA STREET DMPA

Cairns Shipping Development Project

REPORT

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Executive Summary

The CSDP will require the land based placement of up to 100,000m^3 stiff clay material at a DMPA at Port North's Tingira Street property.

The stiff clays will be transferred to shore by barges for loading to trucks and delivery to either of two proposed DMPAs on the Tingira Street site. The total area of the DMPAs is about 53,000 m^2 indicating that with about 100,000m^3 of dredged material filling to an average thickness of about 2 m could be accommodated. The Tingira Street site has been progressively filled since the 1980s with the aim of creating land suitable for commercial/industrial development. Proposed filling operations in the DMPAs are to be carried out with the same aim.

Historical information for the overall Tingira Street site indicates from the early 1990's imported fills including demolition wastes (e.g. concrete rubble and soils) were placed at the site. Hydrocarbon impacted soils from various locations were also remediated on portions of the site from 1994 to 1996. The land parcels forming the overall site are listed on the Environmental Management Register and more recently this has enabled placement of contaminated soil from other areas of the Port. Only soils with contaminant concentrations below current health investigation thresholds for commercial/industrial land use have been accepted from the other Port sites.

The overall Tingira Street site is surrounded by mangrove wetlands to the south and west, developed land to the north and Smiths Creek to the east. Ground surface levels across the site typically range from about RL 2m around the boundaries of the site to about RL 4 m in the south central part of the site.

Subsurface conditions at the Tingira Street site generally comprise fill materials typically extending from the surface to about RL 0 m, overlying soft marine clays typically extending from about RL 0 m to between about RL -4 m and RL -9 m, over stiff to hard clays. The soft marine clays are ASS.

Groundwater is generally encountered within about 2m to 3m below the surface of the overall site. The groundwater is saline to brackish and use of the groundwater in developed areas to the north and west of the overall Tingira Street site is uncommon. Groundwater levels are known to fluctuate on a tidal and seasonal basis. The direction of groundwater flow is expected to be east towards Smiths Creek.

Relatively minor site preparation will be required at the DMPAs prior to placement of dredged stiff clays. This is expected to involve trimming of the surface to remove the existing grass/vegetation and then formation of bunds (estimated to be <0.5 m high) around the perimeter of the placement areas using insitu clay materials. Placement of dredged stiff clay will create a source of material suitable for filling to design levels where required, plus for surcharging parts of the site.

The following potential impacts related to soils and groundwater have been identified.

- Instability within or around the perimeter of the DMPAs during placement results in disturbance of PASS or contaminated materials;
- Instability along Smiths Creek during placement results in displacement of insitu and placed materials into the waterway;
- Breach of perimeter bunds results in discharge of sediment/water to the adjacent mangrove areas;
- Raising or lowering of groundwater levels within PASS materials

Impacts related to instability are likely to be able to be mitigated by appropriate geotechnical input during detailed design and implementation of the proposed works.

The potential impacts related to soils and groundwater are assessed to be short term and reversible, irrespective of whether they are predictable or unpredictable. The risks associated with potential impacts related to soils and groundwater are assessed to be low

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Acronyms

AHD: Australian Height Datum

ASS: Acid Sulfate Soil

AASS: Actual Acid Sulfate Soil.

PASS: Potential Acid Sulfate Soil

DMPA: Dredged Material Placement Area

CSDP: Cairns Shipping Development Project

1.0 INTRODUCTION

Flanagan Consulting Group (FCG) commissioned Golder Associates Pty Ltd (Golder) to provide advice related to soils and groundwater issues as part of the Revised Draft Environmental Impact Statement for the Cairns Shipping Development Project (CSDP).

The CSDP will require the land based placement of up to 900,000m^3 soft clays and up to 100,000m^3 stiff clay material at separate Dredge Material Placement Areas (DMPA).

The soft clays are proposed for placement in the Northern Sands void DMPA. The stiff clays are proposed to be placed at Port North's Tingira Street property (Lot 27 SP218291). The site locality is shown on Figure 1.

For the Tingira Street DMPA it is proposed that the stiff clays will be transferred to shore in split hopper barges via a temporarily moored barge mounted excavator loading heavy haulage vehicles at the two barge ramps. Minor earthworks including temporary piles may be necessary at the ramps to facilitate unloading. After unloading the dredged materials would be trucked to either of two proposed DMPAs on the Tingira St site. The proposed placement areas at Tingira St are shown on Figure 2 and are designated DMPA 1 and DMPA 2 for the purposes of this report.

The aims of the geotechnical assessment were to describe the existing soil and groundwater conditions at the Tingira Street DMPA and to identify:

- Key soils and groundwater related constraints (and opportunities) for the design and construction of the facilities required for placement of the dredged material; and
- Potential soils and groundwater related environmental impacts and mitigation/management measures.

The assessment is to also address the following aspects:

- Geotechnical characteristics of insitu soils at the site;
- Assessment of suitable placement landform specifications and recommended batter configuration; and
- Soil management recommendations including erosion and sediment control and post placement landuse suitability.

A stormwater management plan to manage on and off site impacts will be prepared for the site (by others). This will be incorporated into Part C of the EIS addressing water quality management, ASS management and other issues.

2.0 DREDGED MATERIAL PLACEMENT OPERATIONS

2.1 Reclamation Filling and Surcharging

As outlined in Section 1.0, it is proposed that the dredged stiff clays will be transferred to shore in split hopper barges via a temporarily moored barge mounted excavator loading heavy haulage vehicles at two barge ramps. Minor construction works including temporary piles may be necessary at the ramps to facilitate unloading. After unloading the dredged materials would be trucked to either of two proposed DMPAs.

The total area of the DMPAs is about 53,000 m^2 indicating that with about 100,000m^3 of dredged material filling to an average thickness of about 2.0 m could be accomodated, if the material is evenly spread across these areas. Given that the Tingira Street site has been progressively filled since the 1980s with the aim of creating land suitable for commercial/industrial development, proposed filling operations in the DMPAs are expected to be carried out with the same aim. On this basis initial fill placement is expected to be carried out to achieve design levels, with the balance of filling expected to be used for surcharging targeted areas.

It is expected that relatively minor site preparation will be required at the DMPAs prior to placement of dredged stiff clays. This is expected to involve trimming of the surface to remove the existing grass/vegetation and then formation of bunds (estimated to be <0.5 m high) around the perimeter of the placement areas using insitu clay materials.

The results of available laboratory testing on samples of the stiff clays proposed for dredging indicate that the clays are typically of high plasticity with <10% sand content. The stiff clays are not ASS.

Dredging of these clays is likely to generate “chunks” of material and relatively small amounts of seawater. Even with relatively small amounts of seawater these materials are likely to be “sticky” and potentially difficult to handle until drying occurs.

Placement operations are expected to comprise unloading of trucks into stockpiles along a “working face” for subsequent spreading, drying as required and compaction. Spreading is expected to require tracked plant (i.e. dozers) rather than wheeled plant (i.e. graders) and should aim to achieve layers of about 0.3 m maximum thickness. Each layer is to be compacted prior to placing subsequent layers. If the filling is being placed to achieve a design level (i.e. reclamation filling) then the material should be placed as controlled fill targeting a density ratio of at least 95% Standard Compaction. If the filling is being placed as surcharge then only nominal compaction would be required. Conventional erosion and sediment control (ESC) measures would need to be implemented during the works (e.g. in accordance with FNQROC requirements).

2.2 Surcharging

The height of surcharge required depends on several factors including:

- The thickness of fill required to achieve the design surface level - design surface levels around RL 3 m are expected to be targeted requiring up to about 1.3 m of filling;
- The thickness of the highly compressible layer – the thickness of soft clays is generally about 6 m to 8 m in the proposed DMPA areas;
- The proposed development load – generally assumed to be 10 to 20 kPa;
- Targeted post construction settlements – generally assumed to be up to 50 mm; and
- Time available for surcharging – generally minimum of 12 months.

Previous studies by Golder for the Common Users Barge Facility (CUBF) site adjacent to DMPA 1 indicated that a surcharge of about 2 m was required for 12 months for a design surface level of ~RL 3.0 m and a proposed development load of 20 kPa. These guidelines can be adopted for surcharging at DMPA 1 and 2.

2.3 Stability

As a general guide an overall filling profile of about 1V:4H is required to achieve adequate factors of safety against instability for up to 4 m of filling on the boundaries of the Tingira Street site (i.e. adjacent to the mangroves or Smiths Creek). If steeper profiles are proposed then either geotextile reinforced filling and/or staged filling may need to be adopted depending on the height of filling required. Location specific analyses would need to be carried out to confirm the stability of proposed profiles with surcharge levels in excess of RL 5 m.

2.4 Post Placement Land Use

Following placement of the dredged material it is expected that design surface levels will have been achieved in the DMPAs, with “excess” material being used as surcharging in selected areas. The surface of filled areas will need to be profiled to provide drainage and to be vegetated or otherwise protected against erosion. Trafficability of the clay fill may be difficult in wet conditions, particularly if water is allowed to pond on the surface.

Post placement land use could include barge operations similar to those currently operating to the north of DMPA 2 or storage operations similar to those currently operating on the opposite side of Tingira Street to the north of DMPA 2. It is noted that these uses do not include settlement sensitive buildings or pavements. Surcharged areas of the DMPAs should be suitable for settlement sensitive development similar to the Great Barrier Reef International Marine College to the north of DMPA 2.

3.0 DESKTOP ASSESSMENT - SOILS

3.1 Available Information

Information available to Golder considered relevant to the assessment includes the following:

- Investigation for Proposed No.2 Commercial Fisherman's Wharf, Smith's Creek (Hollingsworth Consultants, 1985);
- Geotechnical Investigation Tingira Street Land Development Portsmith, Queensland (Golder Associates, February 1998);
- Geotechnical Assessment – Bund Wall Stability, Tingira Street, Portsmith (Golder Associates, June 2002);
- Geotechnical Studies – Redevelopment of Cairns Ports Land at Tingira Street, Portsmith (Golder Associates, October 2008); and
- Geotechnical Investigation Common User Barge Facility Stage 1 and Smiths Creek Revetment, Tingira Street, Portsmith (Golder Associates, March 2013).

The above reports have not been reproduced in this report, however the information from these reports forms the basis of this report.

3.2 Site History

Available historical information for the overall Tingira Street site indicates the following:

- Prior to 1982 the overall Tingira Street site was mangrove wetland.
- In 1982 Reclamation Order was approved under the *Harbours Act*, and a bund was constructed around the portion of the site west of the present Tingira Street alignment. After construction of the bund some mangroves were cleared and about 0.5m of dredged material from Commercial Fisherman's Base No 2 was hydraulically placed within the bunded area.
- In the late 1980's the remainder of the site was cleared of mangroves and imported quarry fill was placed to form and surcharge the proposed alignment of Tingira Street and the area of the proposed Harbours and Marine Base. Excess material from the surcharge was later used as fill in adjacent areas of the site.
- From the early 1990's the Cairns Port Authority began to accept small amounts of soil and pavement materials at the site from the Cairns City Council and building contractors. The Port Authority is also understood to have entered into agreements with several demolition contractors to accept demolition wastes (e.g. concrete rubble and soils). The majority of filling at the site is understood to have occurred between 1994 and 1996.
- From around 2008 various parts of the site were surcharged, with some areas subsequently being developed.

3.3 Topography

The overall Tingira Street site is surrounded by mangrove wetlands to the south and west, developed land to the north and Smiths Creek to the east (refer Figure 1)

As outlined in Section 3.2, the overall Tingira Street site has been formed by reclamation filling. Ground surface levels across the site typically range from about RL 2m around the boundaries of the site to about RL 4 m in the south central part of the site. Localised lower lying areas with surface levels of about RL 1.7 m exist within proposed DMPA 2. It is noted that surcharge material for the proposed Common Users Barge Facility (CUBF) remains in place adjacent to proposed DMPA 1.

DMPA 1 is bordered by mangroves to the west and south, Smiths Creek to the east and vacant land to the north. A bund has been constructed along Smiths Creek on the eastern boundary. Surface levels within the mangrove areas are typically around RL 1 m. The area of DMPA 1 is shown below.

DMPA 2 is bordered by Tingira Street to the west, an access road and carpark to the south, the basin for Commercial Fisherman's Base No 2 to the east and barge loading facilities to the north. This site has settled since reclamation and is subject to partial periodic inundation and accumulation of surface water in lower lying areas. The area of DMPA 2 is shown below.

3.4 Geology

Published geological information from *State of Queensland (Department of Employment, Economic Development and Innovation) 2011* indicates that the Tingira Street site is underlain by Holocene aged coastal mangrove flats comprising mud, silt and sand. The Holocene aged deposits are underlain by older Pleistocene age consolidated alluvial deposits comprising clays and sands. An extract from the geology mapping showing the surface geology of the Tingira Street area is reproduced as Figure 3.

3.5 Soils

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) Soils of Babinda - Cairns Area 2016 soils map indicates that detailed mapping of soil units has not been carried out in the area of the Tingira Street site.

3.6 Acid Sulfate Soils

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).

The *State of Queensland (Department of Natural Resources and Mines) 2016* ASS mapping shows the areas to the west and south of the site to have PASS starting in the top 0.5 m. An extract from the ASS mapping covering the site area and showing the interpreted distribution of PASS is reproduced as Figure 4. It is noted that the soft clays underlying the reclamation filling at the site are also PASS.

3.7 Contaminated Land Issues

The Golder 1998 report included a preliminary evaluation of the contamination status of the site. The results of this preliminary evaluation are summarised below:

- Prior to 1982 the site was mangrove wetland. A bunded area was constructed around the portion of the site west of the present Tingira Street alignment and the mangroves were cleared after this time. About 0.5m of dredged spoil was then hydraulically placed within the bunded area.
- From the early 1990’s small amounts of soil and pavement materials from Cairns City Council and building contractors were accepted at the site. Cairns Port Authority (the predecessor of Ports North) also entered into agreements with several demolition contractors to accept demolition wastes (e.g. concrete rubble and soils) from about 1994 to 1996.
- Hydrocarbon impacted soils from various locations were remediated on portions of the site from 1994 to 1996. The remediation works were conducted in a controlled manner and the soil was validated on completion of these works.
- From early 1997 to 1998, the site accepted only “good quality” fill material, although a thin layer of concrete rubble was understood to have been placed in the south west corner of the site during this time.
- Limited sampling and analysis of the site fill materials indicated that the human health risks associated with residual chemicals in the fill materials were considered to be acceptable for a commercial/industrial development.
- Given that a large proportion of the site is likely to be covered by buildings and pavements, and that additional clean fill will be placed over landscape areas, the potential for impacts upon ecological receptors and associated environmental risks was considered to be acceptably low.
- The potential for migration of the residual concentrations of chemicals to groundwater was also considered to be low given that generally low concentrations of contaminants were observed in the fill and given that buildings and pavements are likely to cover the majority of the site and prevent infiltration of rainwater.

Since the 1998 report was written, the guidelines for the assessment and management of contaminated land have been updated. A review of the 1998 report with respect to the more recent guidelines indicates the following:

- The land parcels forming the site remain listed on the Environmental Management Register and this enables Disposal Permits to be granted for placement of soil from sites listed on the EMR in other areas of the Port undergoing earthworks or remediation. Such activities have been conducted under Site Management Plans which are also required to prevent removal and/or exposure to residual contaminants identified under portions of the site. Only soils with contaminant concentrations below current health investigation thresholds for commercial/industrial land use have been accepted from the other Port sites.

- From a contamination perspective, the Tingira Street site is still considered to be suitable for future commercial/industrial land use as a “managed” site.

3.8 Geotechnical Conditions

Previous subsurface investigations have been carried out across the Tingira Street site over the past 30 years. These include the following:

- Investigations for Proposed Harbours and Marine Base and Commercial Fishing Base No.2, Portsmith (Hollingsworth Consultants, 1987);
- Geotechnical Investigation Tingira Street Land Development Portsmith, Queensland (Golder Associates, February 1998);
- Geotechnical Studies – Redevelopment of Cairns Ports Land at Tingira Street, Portsmith (Golder Associates, October 2008); and
- Geotechnical Investigation Common User Barge Facility Stage 1 and Smiths Creek Revetment, Tingira Street, Portsmith (Golder Associates, 2013).

Investigation locations from these previous studies are shown on Figure 5 and inferred geotechnical sections for DMPA 1 and 2 are presented on Figure 6.

The results of previous investigations indicated that subsurface conditions at the Tingira Street site generally comprise the following units:

- Unit 1 – Fill materials generally comprising gravelly sandy silts/clays with variable amounts of pavement and building materials. Typically extending from the surface to about RL 0 m; overlying
- Unit 2 – Hydraulic fill materials comprising sand and clayey sand (these materials may not be present in the areas of proposed DMPA 1 and 2);
- Unit 3 – Soft marine clays. Typically extending from about RL 0 m to between about RL -4 m and RL -9 m (note the upper parts of this unit may also include some hydraulically placed soft clay); overlying
- Units 4 and 5 – Stiff to hard silty/sandy clays and medium dense to dense silty/clayey sands. Typically extending from about RL -4 m and RL -9 m to greater than RL -20 m.

Based on the above, the subsurface conditions in the site area are considered to be consistent with the site history, published geology and ASS mapping.

4.0 CONSTRAINTS AND OPPORTUNITIES - SOILS

4.1 Opportunities

Opportunities related to the placement of dredged spoil at Tingira Street are as follows:

- Relatively minor site preparation will be require prior to placement of dredged stiff clays. This is expected to involve trimming of the surface to remove the existing grass and other vegetation plus standard erosion and sediment control measures (i.e. bunding around the perimeter of the placement areas).
- Placement of dredged stiff clay at DMPA 1 and 2 will create a source of material suitable for filling to design levels where required, plus for surcharging parts of the site. On completion of surcharging the balance of the surcharge material would be available for surcharging other sites as required.

4.2 Constraints

4.2.1 Construction Works

Constraints related to construction works that may be required prior to and during placement of dredged clay are as follows:

- Due to the presence of low strength clays underlying the site area, earthworks prior to placement and during disposal will need to be managed such that instability does not occur into the mangroves around the perimeter of DMPA 1.
- Again due to the presence of low strength clays, earthworks prior to disposal and during disposal will need to be managed such that instability does not occur into Smiths Creek adjacent to DMPA 1 or into the basin of Commercial Fishing Base No 2 adjacent to DMPA 2.

It is noted that procedures for minimising the potential for instability during reclamation filling and surcharging operations are well established for the Tingira Street site. Such procedures include adopting appropriate set-backs and flattening batter profiles, and/or installing geotextile reinforcement.

4.2.2 Insitu ASS & Contaminated Materials

Constraints related to insitu ASS and contaminated materials are as follows:

- Filling operations need to be managed (as outlined above) such that instability with the potential to disturb the PASS materials present in the adjacent mangroves or along Smiths Creek does not occur.
- Although unlikely, if excavations into the existing fill at the DMPA sites were required to be carried out then contaminated materials may be disturbed.
- Although unlikely, if excavations beyond the depth of fill at the DMPA sites were required to be carried out then ASS materials may be disturbed.

It is noted that excavation into the existing fill materials can be controlled under management plans for the works. As noted above, procedures for minimising the potential for instability during reclamation filling and surcharging operations are well established for the Tingira Street site.

4.2.3 Dredged Materials

Constraints related to dredged clay materials are as follows:

- Dredging of the stiff clays is likely to generate “chunks” of material with relatively small amounts of seawater. Run-off of seawater will need to be managed during the unloading, transporting and placement operations.
- Even with relatively small amounts of seawater the dredged clays are likely to be “sticky” and potentially difficult to handle until drying occurs.

5.0 POTENTIAL IMPACTS - SOILS

Potential impacts relating to soils resulting from construction and operation of the dredged material placement area include the following:

- Instability around the perimeter of the DMPAs during placement resulting in disturbance of adjacent mangrove areas (including PASS materials);
- Instability along Smiths Creek during placement resulting in disturbance into the waterway (including PASS materials);
- Instability within the DMPA areas during placement resulting in disturbance of insitu fill materials and underlying soft clays (including PASS materials); and
- Breach of perimeter bunds, possibly resulting in discharge of water to the adjacent mangrove areas. It is noted that the material is unlikely to contain much free water by the time it is placed at the DMPA. Management of drainage water from loading and haulage will be covered in the Site Preparation and

Post Placement EMP. An ESCP will be in place during the works and is likely to include control measures inclusive of a perimeter sediment fence, and sediment traps commensurate with the final detailed design for the site.

In relation to PASS materials it is important to note that when PASS is exposed to oxygen by disturbance (via excavation or displacement) or by drainage (via dewatering or other means of lowering the water table), pyrite can oxidise and form sulfuric acid when combined with water. Sulfuric acid can leach out of these affected soils and strip metals (including iron, aluminum and heavy metals) from the surrounding soils. Acidic and metals impacted water can migrate into surface waters and groundwater.

These processes can lead to degradation of terrestrial vegetation through:

- Stunting of root growth;
- Increased toxicity from higher concentrations of aluminum, iron and manganese;
- Reduced plant minerals and nutrients; and
- Reduced resistance to pathogen attack.

Longer term impacts may include species die off and changes to vegetation cover (domination by more acid tolerant species).

The discharge of acidic water to estuarine environments such as those surrounding the Tingira Street site may cause the following impacts:

- Increased acidity and increased iron and aluminum concentrations may be toxic to some aquatic organisms and may cause fish diseases (eg. red spot).
- Iron and aluminum precipitates can affect water quality and coat stream banks, benthic (sediment-dwelling) organisms and aquatic vegetation.
- Aquatic vegetation communities may change to become dominated by acid tolerant species.
- Deoxygenated water may also result from the secondary oxidation of the Fe_{2+} consuming oxygen and lowering the level of dissolved oxygen in surface waters.

Acidic waters can also weaken concrete and steel infrastructure such as culverts, pipes and piles.

Further assessment of soils related impacts is presented in Section 10.0

6.0 DESKTOP ASSESSMENT - GROUNDWATER

6.1 Climate

The climate of the Cairns region and that of the Tingira Street area is tropical with weather patterns consisting of a wet season (typically December to April) and a dry season (typically May to November. Key climatological and weather data obtained from the nearest weather station, located at the Cairns Airport (Bureau of Meteorology Station Number 031011) is summarised below:

- Mean annual rainfall is 1999.7 mm with highest rainfall in January through March.
- Mean number of days of rain greater than or equal to 1 mm is 119.6 days per year.
- Mean annual 9 am humidity is 72%; with February, March, and April having highest humidity.
- Mean annual 3 pm humidity is 62% with February having highest humidity.

Mean monthly rainfall and mean monthly evaporation are reported in Table 1. This data is from the Cairns Airport (Weather Station Number 031011). Source: Bureau of Meteorology (2016).

Table 1: Mean rainfall and evaporation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Mean rainfall (mm) (1942 to 2016)	390	448	419	195	92	48	30	27	33	46	94	178
Mean evaporation (mm) (1965 to 2016)	198	164	180	162	152	141	155	174	201	233	225	223

Note: data is rounded to the nearest millimetre

The annual rainfall from 2005 to 2015 is reported in**Error! Not a valid bookmark self-reference.**. This data is from the Cairns Airport (Weather Station Number 031011). Source: Bureau of Meteorology (2016).

Table 2: Annual rainfall between 2005 and 2015

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015*
Rainfall (mm)	1471	2289	1813	2215	2199	2660	2623	2003	1269	1826	1897

Note: data is rounded to the nearest millimetre

*Not quality controlled by BOM (2016)

During the wet season (November to April), the Cairns region may experiences cyclonic storms and extreme rainfall on a regular basis, with such events occurring every two to eight years. Rainfalls of 100 mm/day or greater and high intensity runoff can be expected in such periods. Due to the proximity of the site to Trinity Inlet, storm surges from the sea would also be expected in the event of a cyclonic event impacting Cairns. Such extreme weather does not occur during the dry season in which the placement of dredged material is proposed, however design and management of the site needs to accommodate such an event in the months immediately after the works.

6.2 Topography

The overall Tingira Street site has been formed by reclamation filling in low lying mangrove areas adjacent to Smiths Creek, which is tidal and flows into Trinity Inlet about 1.5 km to the north of the site (refer Figure 1).

6.3 Hydrogeology

In general terms the hydrogeology of the Tingira Street area is characterised by shallow groundwater systems in the Holocene sediments, and deeper aquifers within the Pleistocene age sediments. The deeper aquifers are isolated from surface waters and shallow aquifers and likely discharge well out into Trinity Bay.

7.0 GROUNDWATER CONDITIONS ON SITE

7.1 Stratigraphy

Inferred geotechnical sections for DMPA 1 and 2 are presented on Figure 6 and indicate the following stratigraphy.

- Reclamation fill materials - Generally comprising gravelly sandy silts/clays with variable amounts of pavement and building materials. Typically extending from the surface to about RL 0 m; overlying
- Holocene sediments - Generally comprising soft marine clays. Typically extending from about RL 0 m to between about RL -4 m and RL -9 m (note the upper parts of this unit may also include some hydraulically placed soft clay); overlying
- Pleistocene sediments - Generally comprising stiff to hard silty/sandy clays and medium dense to dense silty/clayey sands. Typically extending from about RL -4 m and RL -9 m to greater than RL -20 m.

7.2 Surface Drainage

Surface levels across the overall site are shown on Figure 5. Surface levels across DMPA 1 range from about RL 2.0 m to 2.2 m around the eastern, southern and western boundaries, and from about RL 2.0 to 4.0 m along the northern boundary. DMPA 1 is bordered by mangroves to the west and south, Smiths Creek to the east and vacant land to the north. A bund has been constructed along Smiths Creek on the eastern boundary. Surcharge material for the proposed Common Users Barge Facility is located in the south east corner of the overall site adjacent to DPMA 1. The surface of DMPA 1 is generally grassed. Surface runoff is generally directed towards the eastern, southern and western boundaries.

Surface levels across DMPA 2 are generally about RL 2 m around the eastern, northern and western boundaries, and range to about RL 2.5 m along the northern boundary. The central part of the area drops to about RL 1.7 m. DMPA 2 is bordered by Tingira Street to the west, an access road and carpark to the south, Smiths Creek to the east and barge facilities to the north. The surface of DMPA 2 is generally covered with long grass, although the lower lying area is bare. Surface water tends to pond in the lower lying areas.

7.3 Groundwater Levels and Quality

Groundwater is generally encountered within about 2m to 3m below the surface of the overall site. The groundwater is brackish to saline, although a layer of freshwater is sometimes present on top of the brackish water (particularly during the wet season). Use of the groundwater in developed areas to the north and west of the overall Tingira Street site is uncommon. Groundwater levels are known to fluctuate on a tidal and seasonal basis. The direction of groundwater flow is expected to be east towards Smiths Creek.

8.0 CONSTRAINTS AND OPPORTUNITIES - GROUNDWATER

8.1 Opportunities

As outlined in Section 3.7, the potential for migration of the residual concentrations of chemicals within the existing site fill to groundwater is considered to be low given that generally low concentrations of contaminants were observed in the fill and given that buildings and pavements are likely to cover the majority of the site and prevent infiltration of rainwater. The proposed placement of dredged clays at the site will provide a layer of clean, low permeability fill over the surface which will also reduce or prevent infiltration of rainwater.

8.2 Constraints

As outlined in Section 4.2.2 filling operations will need to be managed such that instability disturbing the PASS materials present in the adjacent mangroves or along Smiths Creek does not occur. Should such instability occur and not be appropriately managed there is a potential for acidic water to be generated and although this is more likely to impact surface water, groundwater may also be impacted.

9.0 POTENTIAL IMPACTS - GROUNDWATER

Groundwater in the site area is generally saline and is not a viable potable water supply source.

Proposed dredged material placement operations are not likely to result in a lowering of groundwater levels within PASS materials such that acidic groundwater would be generated. Similarly proposed operations are not likely to increase groundwater levels surrounding the site and hence impacts on terrestrial vegetation with high salt tolerance is not likely.

Surface water flows from the bunded areas are only likely to occur as a result of rainfall (as opposed to seawater associated with the deposition process). Such flows are not likely to impact groundwater levels or quality.

There is a potential for acidic water to be generated if instability occurs and disturbs PASS materials. Although this is more likely to impact surface water, groundwater may also be impacted.

10.0 IMPACT ASSESSMENT – SOILS AND GROUNDWATER

10.1 Methodology

In order to address the terms of reference, guidelines and other requirements for the currently defined project the following methodology was adopted:

- Assess impacts (based on the risk assessment format outlined below);
- Provide recommendations for mitigation by design changes; and
- Provide recommendations for mitigation by management.

Flanagan Consulting Group has extracted relevant items from the Queensland Government Terms of Reference and the Commonwealth Government Guidelines for soils and groundwater studies. These items and relevant details are presented in Appendix A.

The initial assessment of impacts utilises a significance table based on that shown in Table 3.

Table 3: Significance Criteria

Impact Significance / Consequence	Description of Significance (examples)
Very High	The impact is considered critical to the decision-making process. Impacts tend to be permanent or irreversible or otherwise long term and can occur over large scale areas.
High	The impact is considered likely to be important to decision-making. Impacts tend to be permanent or irreversible or otherwise long to medium term. Impacts can occur over large or medium scale areas.
Moderate	The effects of the impact are relevant to decision making including the development of environmental mitigation measures Impacts can range from long term to short term in duration Impacts can occur over medium scale areas or otherwise represents a significant impact at the local scale
Minor	Impacts are recognisable/detectable but acceptable. These impacts are unlikely to be of importance in the decision making process. Nevertheless, they are relevant in the consideration of standard mitigation measures. Impacts tend to be short term or temporary and/or occur at local scale.
Negligible	Minimal change to the existing situation. This could include, for example, impacts which are beneath levels of detection, impacts that are within the normal bounds of variation, or impacts that are within the margin of forecasting error.

It is noted that some impacts can have a positive outcome on the existing situation.

The approach to classifying the duration of identified impacts is presented in Table 4.

Table 4: Classifications of the duration of identified impacts

Relative Duration Of Impacts	
Temporary	Days to months
Short Term	Up to one year
Medium Term	From one to five years
Long Term	From five to 50 years
Permanent/Irreversible	In excess of 50 years

The likelihood of an impact occurring is assessed as per Table 5.

Table 5: Likelihood of Impact

Likelihood of Impacts	Risk Probability Categories
Highly Unlikely	Highly unlikely to occur but theoretically possible
Unlikely	May occur during construction of the project but probability well below 50%; unlikely, but not negligible
Possible	Less likely than not but still appreciable; probability of about 50%
Likely	Likely to occur during construction or during a 12 month timeframe; probability greater than 50%
Almost Certain	Very likely to occur as a result of the proposed project construction and/or operations; could occur multiple times during relevant impacting period

An impact risk rating is assigned by assessing impact significance (consequence) versus likelihood within a risk matrix. Risk is described as the product of likelihood and significance (consequence) as shown in Table 6.

Table 6: Risk Matrix

Likelihood			Significance		
	Negligible	Minor	Moderate	High	Very high
Highly Unlikely/ Rare	Negligible	Negligible	Low	Medium	High
Unlikely	Negligible	Low	Low	Medium	High
Possible	Negligible	Low	Medium	Medium	High
Likely	Negligible	Medium	Medium	High	Extreme
Almost Certain	Low	Medium	High	Extreme	Extreme

The rating of risk assessed in the risk matrix is presented in Table 7.

Table 7: Risk Rating Legend

Extreme Risk	An issue requiring change in project scope; almost certain to result in a 'significant' impact on the environment
High Risk	An issue requiring further detailed investigation and planning to manage and reduce risk; likely to result in a 'significant' impact on the environment
Medium Risk	An issue requiring project specific controls and procedures to manage
Low Risk	Manageable by standard mitigation and similar operating procedures
Negligible Risk	No additional management required

After assessing the nature and severity of impacts they are summarised under the following categories:

- Adverse/beneficial;
- Consequential;
- Cumulative;
- Short-term/long term;
- Reversible/irreversible; and
- Predictable/unpredictable.

10.2 Results of Impact Assessment

As outlined in Sections 5.0 and 9.0 the following potential impacts related to soils and groundwater have been identified. All of the potential impacts are assessed as being temporary or short term.

- Instability around the perimeter of the DMPAs during placement results in disturbance of PASS materials;
- Instability along Smiths Creek during placement results in displacement of insitu and placed materials into the waterway;
- Instability within the DMPA areas during placement results in disturbance of contaminated fill materials and/or PASS materials;
- Breach of perimeter bunds results in discharge of sediment/water to the adjacent mangrove areas;
- Lowering of groundwater levels within PASS materials such that acidic groundwater would be generated;
- Increase in saline groundwater levels surrounding the site;
- Groundwater adversely impacted by surface water run-off from site; and
- Acidic water generated following disturbance of PASS as a result of instability.

It is noted that impacts related to instability are likely to be able to be mitigated by appropriate geotechnical input during detailed design and implementation of the proposed works. Comments relating to instability mitigation measures are presented in Table 8.

Table 8: Mitigation Measures for Instability Impacts

Impacting Processes	Proposed Mitigation Measures
Instability around the perimeter of the DMPAs during placement resulting in disturbance of PASS materials;	Adopt a minimum setback from the perimeter of DMPA and a batter profile to achieve the required factor of safety against instability of proposed profile. If minimum setback cannot be achieved place appropriate high strength geotextile reinforcement to achieve required factor of safety against instability of proposed profile.
Instability along Smiths Creek during placement resulting in displacement of insitu and placed materials into the waterway	Adopt a minimum setback from the perimeter of DMPA and a batter profile to achieve the required factor of safety against instability of proposed profile. If minimum setback cannot be achieved place appropriate high strength geotextile reinforcement to achieve required factor of safety against instability of proposed profile.
Instability within the DMPA areas during placement resulting in disturbance of contaminated fill materials and/or PASS materials	Assess minimum thickness of existing fill required within DMPA to achieve required factor of safety against instability. If minimum thickness cannot be achieved place appropriate high strength geotextile reinforcement to achieve required factor of safety against instability of proposed profile.

An assessment of the risk associated with potential impacts to soils and groundwater is presented in Table 9. The assessment has been conducted on the basis of standard construction measures and with the application of the mitigation measures listed in Table 8.

Table 9: Assessment of Impacts

Primary Impacting Processes	Initial Assessment with Standard (Statutory) Mitigation Measures in Place			Residual Assessment with Additional (Proposed) Mitigation in Place		
	Significance of Impact	Likelihood of Impact	Risk Rating	Significance of Impact	Likelihood of Impact	Risk Rating
Instability around the perimeter of the DMPAs during placement results in disturbance of PASS materials;	Moderate	Possible	Medium	Moderate	Unlikely	Low
Instability along Smiths Creek during placement results in displacement of insitu and placed materials into the	Moderate	Possible	Medium	Moderate	Unlikely	Low
Instability within the DMPA areas during placement results in disturbance of contaminated fill materials and/or PASS materials	Moderate	Possible	Medium	Moderate	Unlikely	Low

Primary Impacting Processes	Initial Assessment with Standard (Statutory) Mitigation Measures in Place			Residual Assessment with Additional (Proposed) Mitigation in Place		
	Significance of Impact	Likelihood of Impact	Risk Rating	Significance of Impact	Likelihood of Impact	Risk Rating
Breach of perimeter bunds results in discharge of water to the adjacent mangrove areas	Minor	Possible	Low	Minor	Possible	Low
Lowering of groundwater levels within PASS materials such that acidic groundwater would be generated	Moderate	Unlikely	Low	Moderate	Unlikely	Low
Increase in saline groundwater levels surrounding the site	Moderate	Unlikely	Low	Moderate	Unlikely	Low
Groundwater adversely impacted by surface water run-off from site	Minor	Possible	Low	Minor	Possible	Low
Acidic water generated following disturbance of PASS as a result of instability	Moderate	Unlikely	Low	Moderate	Unlikely	Low

Based on the above, the risks associated with potential impacts related to soils and groundwater are assessed to be low. A summary of assessed impacts is presented in Table 10.

Table 10: Summary of Assessed Impacts

Element	Adverse Impact	Beneficial Impact	Consequential Impact	Cumulative Impact	Short Term	Long Term	Reversible	Irreversible	Predictable	Unpredictable
Soils - General		Dredged materials provide a source of fill for reclamation and surcharging	Creates land suitable for commercial or industrial development			X			X	
Soils - ASS	Instability into the mangroves. PASS could be disturbed. Acidic waters could be generated		Minimal impact as risk can be mitigated in design, even if instability does occur risk can be readily mitigated with appropriate remedial works (e.g. excavation and lime treatment) during construction		X		X			X
Soils - ASS	Instability into Smiths Creek PASS could be disturbed. Acidic waters could be generated		Minimal impact as risk can be mitigated in design, even if instability does occur risk can be readily mitigated with appropriate remedial works (e.g. excavation and lime treatment) during construction		X		X			X
Soils - ASS	Instability within DMPA. PASS could be disturbed. Acidic waters could be generated		Minimal impact as risk can be mitigated in design, even if instability does occur risk can be readily be mitigated with appropriate remedial works (e.g. excavation and lime treatment) during construction		X		X			X
Soils - Contamination	Instability within DMPA. Contaminated soils could be disturbed.		Minimal impact as risk can be mitigated in design, even if instability does occur risk can be readily mitigated		X		X			X

Element	Adverse Impact	Beneficial Impact	Consequential Impact	Cumulative Impact	Short Term	Long Term	Reversible	Irreversible	Predictable	Unpredictable
	Contaminant migration could occur		with appropriate remedial works (e.g. excavation and replacement) during construction							
Groundwater	Decrease in groundwater levels. PASS could be exposed. Acidic waters could be generated		Minimal impact as risk can be mitigated with appropriate, monitoring, management and/or treatment during construction		X		X		X	
Groundwater	Increase in groundwater levels with increase in saline groundwater surrounding the site		Minimal impact as risk can be mitigated with appropriate monitoring, management and/or treatment during construction		X		X		X	
Groundwater	Sediment & surface water run-off from site with impact on groundwater quality		Minimal impact as risk can be mitigated with appropriate remedial works (e.g. excavation and treatment) during construction		X		X		X	

Based on the above, the potential impacts related to soils and groundwater are assessed to be short term and reversible irrespective of whether they are predictable or unpredictable.

11.0 REFERENCES

Commonwealth Scientific and Industrial Research Organisation (CSIRO) 2013 *Soils of Babinda -Cairns Area, North QLD 1996 (1:50,000 scale)*. Sourced from QGIS 9/2013 (DP_QLD_LAN_BBC_50K)

Manders J.A. O'Brien L.E. Morrison DW (2009). *Acid Sulfate Soils of Cairns, North Queensland* Department of Environment and Resource Management, Indooroopilly, Queensland, Australia.

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

12.0 IMPORTANT INFORMATION

Your attention is drawn to the document - "Important Information", which is included as an attachment 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.

GOLDER ASSOCIATES PTY LTD

Malcolm Cook
Principal Geotechnical Engineer

Paul Scells
Principal Geo-environmental Engineer

MSC/PKS/ow

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- Localities
- Main Roads
- Major Waterways
- Study Area

NOTE(S)
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REFERENCE(S)
Cadastre, Roads: © State of Queensland (Department of Natural Resources and Mines) 2017.
Localities: © State of Queensland (Department of Natural Resources and Mines) 2016.
Watercourses: © State of Queensland (Department of Environment and Resource Management) 2010.

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
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CLIENT
FLANAGAN CONSULTING GROUP PTY LTD

PROJECT
CSDP - TINGIRA STREET DMPA

CONSULTANT
Golder Associates

YYYY-MM-DD	21/03/2017
DESIGNED	DP
PREPARED	DP
REVIEWED	MC
APPROVED	MC

TITLE
LOCALITY PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
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- Localities
- Watercourses (1:25k)
- Clay Placement Areas

Cadastre

- Property Boundaries
- Easements
- Study Area

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REFERENCE(S)
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CONSULTANT
Golder Associates

YYYY-MM-DD	28/03/2017
DESIGNED	DP
PREPARED	DP
REVIEWED	MC
APPROVED	MC

TITLE
DREDGED MATERIAL PLACEMENT AREAS

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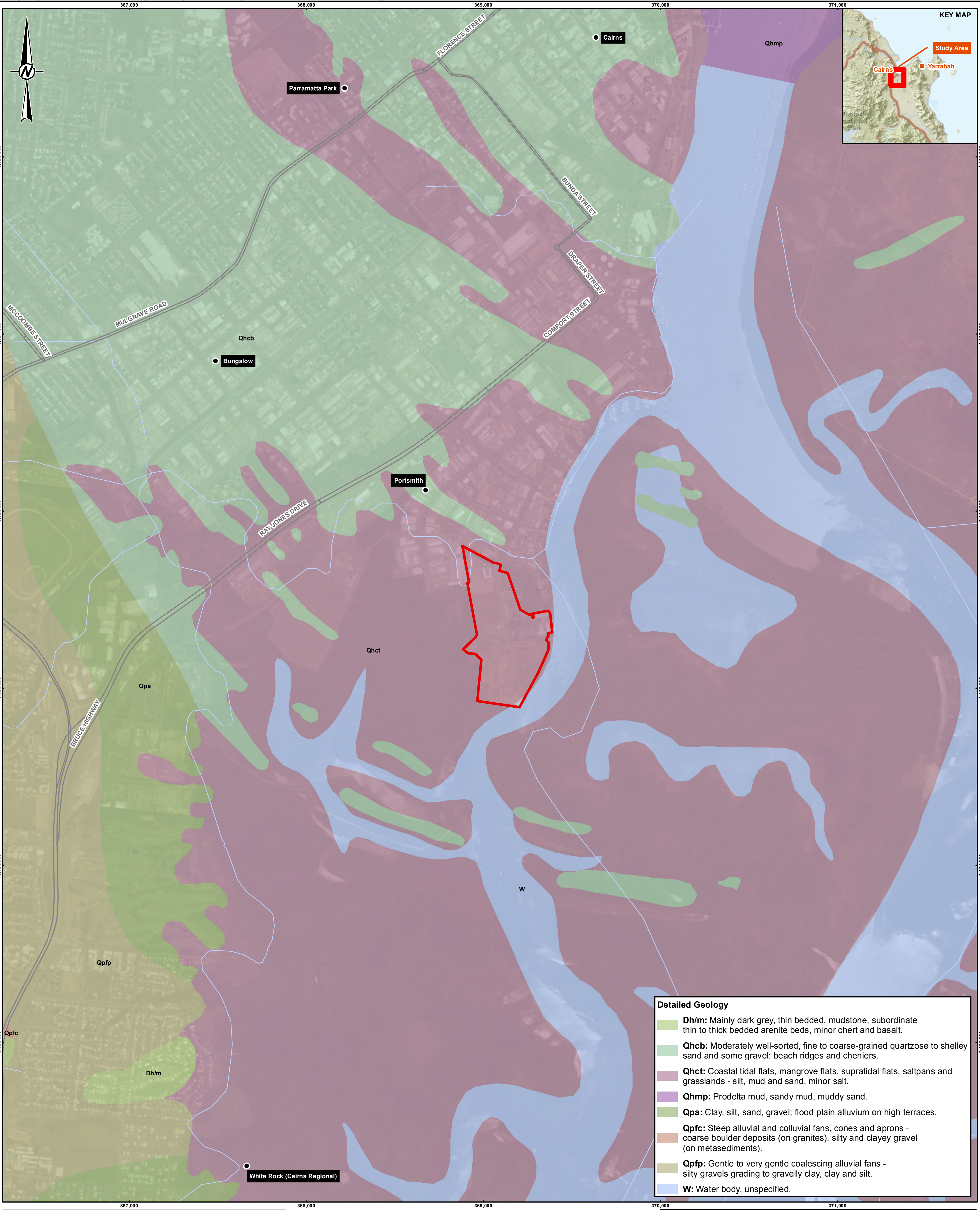

LEGEND

- Localities
- Main Roads
- Major Waterways
- Study Area

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REFERENCE(S)
Geology: © State of Queensland (Department of Employment, Economic Development and Innovation), 2011.
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DESIGNED	DP
PREPARED	DP
REVIEWED	MC
APPROVED	MC

TITLE
SURFACE GEOLOGY

PROJECT NO.	CONTROL	REV.	FIGURE
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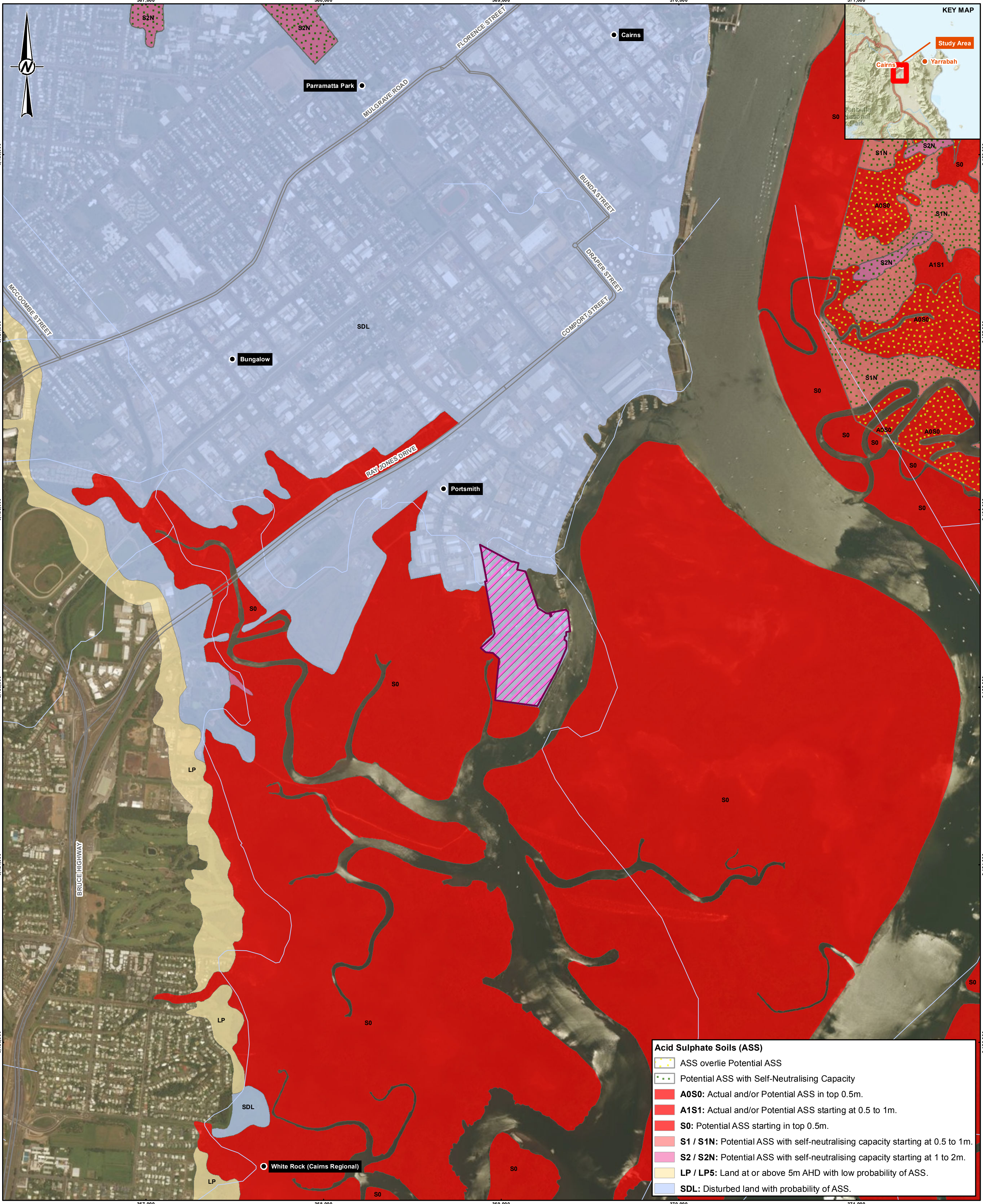

LEGEND

- Localities
- Main Roads
- Major Waterways
- Study Area

Coordinate System: GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Datum: GDA 1994

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NOTE(S)
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REFERENCE(S)
ASS: © State of Queensland (Department of Natural Resources and Mines), 2016.
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Localities: © State of Queensland (Department of Natural Resources and Mines) 2016.
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YYYY-MM-DD	29/03/2017
DESIGNED	DP
PREPARED	DP
REVIEWED	MC
APPROVED	MC

TITLE
ACID SULPHATE SOILS

PROJECT NO.	CONTROL	REV.	FIGURE
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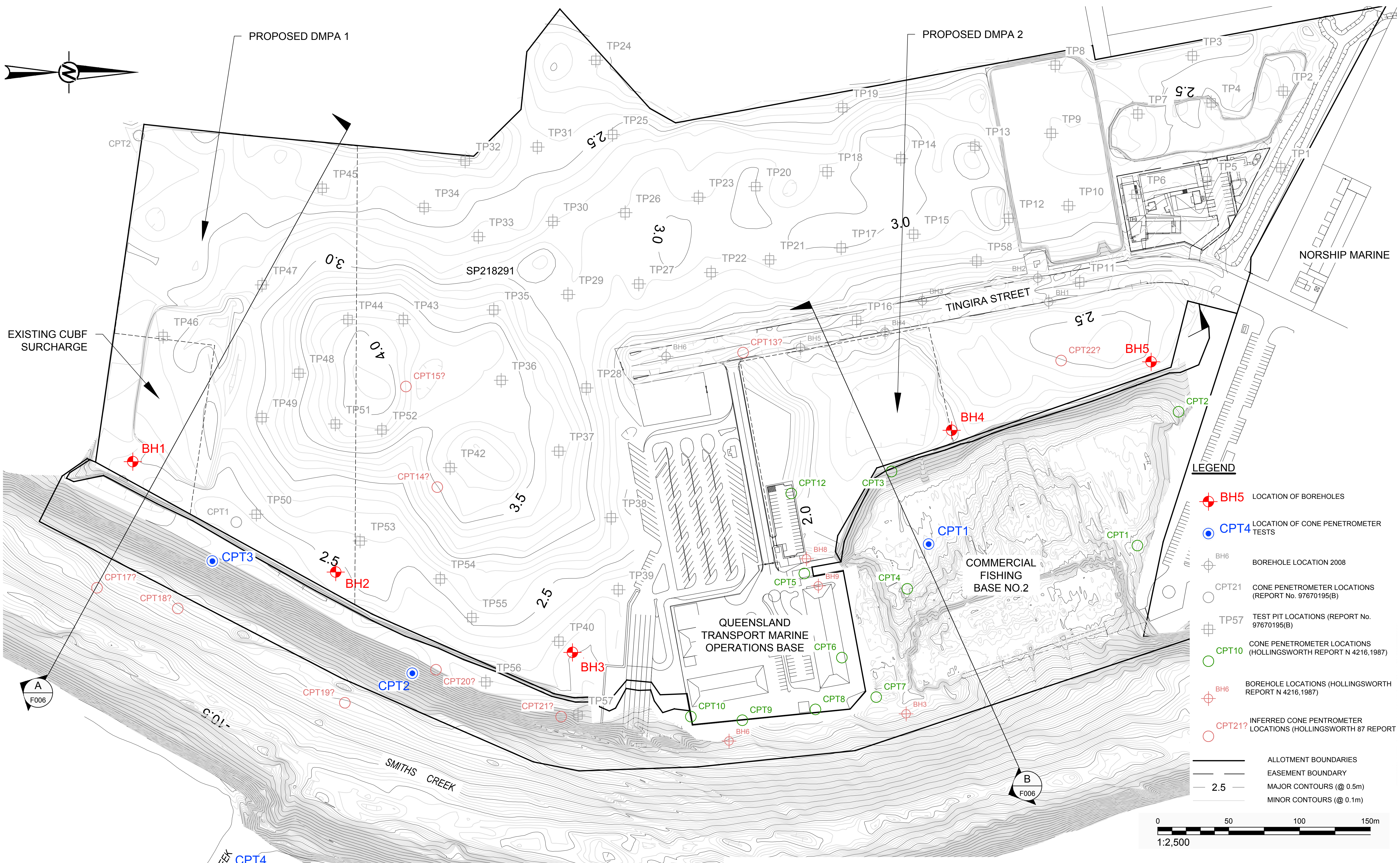

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DRAWN BY: GZL	DATE: 28.03.2017	DRAWING TITLE: PREVIOUS INVESTIGATION - LOCATION PLAN
CHECKED BY: MSC	DATE: 28.03.2017	

SCALE	SHEET SIZE	PROJECT No	DOC No	DOC TYPE	FIGURE No	REVISION	
AS SHOWN	A3	1546223	019	R	F005	2	FIGURE 5

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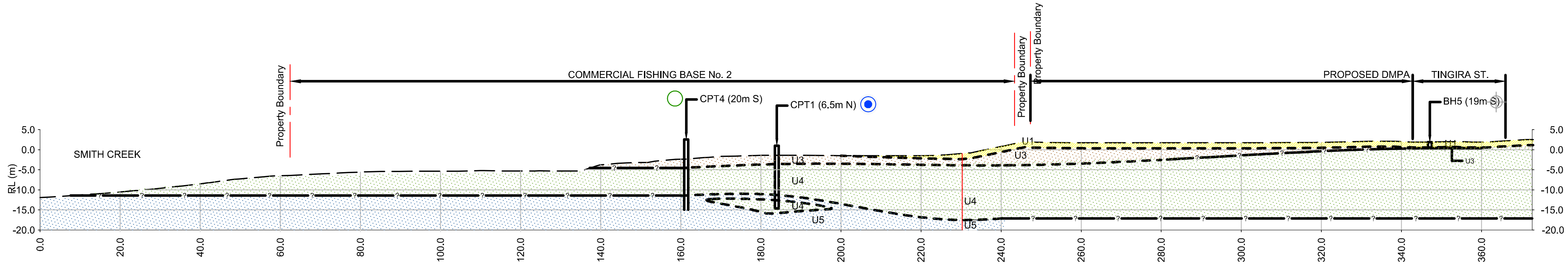

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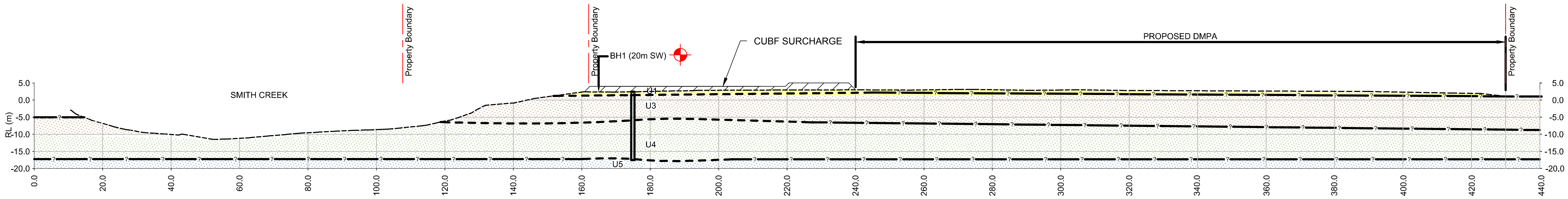

SCALE 1:1250 A SECTION F005

LEGEND

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	UNIT 2:	SAND/ Sandy Clayey SAND	VL-L	Hydraulic Fill (Inferred):DREDGE MATERIAL
	UNIT 3:	Silty CLAY/Marine organic CLAY	VS-S	NATURAL
	UNIT 4:	Silty CLAY/CLAY	St-H	NATURAL
	UNIT 5:	Silty SAND/ SAND/Silty Clayey SAND	MD-D	NATURAL

BH5	LOCATION OF BOREHOLES
CPT4	LOCATION OF CONE PENETROMETER TESTS
BH6	BOREHOLE LOCATION 2008
CPT21	CONE PENETROMETER LOCATIONS (REPORT No. 97670195(B)
TP57	TEST PIT LOCATIONS (REPORT No. 97670195(B)
CPT10	CONE PENETROMETER LOCATIONS (HOLLINGSWORTH REPORT N 4216,1987)
BH6	BOREHOLE LOCATIONS (HOLLINGSWORTH REPORT N 4216,1987)
CPT21?	INFERRED CONE PENTROMETER LOCATIONS (HOLLINGSWORTH 87 REPORT)

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1:2,500

Golder Associates	CLIENT: FLANAGAN CONSULTING GROUP			PROJECT: CSDP - TINGIRA STREET DMPA				
	DRAWN BY: GZL	DATE: 28.03.2017		DRAWING TITLE: SECTIONS A & B				
	CHECKED BY: MSC	DATE: 28.03.2017						
www.golder.com GOLDER ASSOCIATES PTY. LTD.	SCALE: AS SHOWN	SHEET SIZE: A3	PROJECT No: 1546223	DOC No: 019	DOC TYPE: R	FIGURE No: F006	REVISION: 2	FIGURE 6

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APPENDIX A

Queensland Government Terms of Reference

Commonwealth Guidelines

Queensland Government Terms of Reference

Flanagan Consulting Group has extracted relevant items from the Queensland Government Terms of Reference for soils and groundwater studies. These items and relevant details are presented below. Items that are not in scope are shaded grey in the table. The section of this report where each item is discussed is also shown in the table.

Relevant Queensland Government ToR - Soils

ToR	Title	Details	Comments
4.1.2	Dredge spoil disposal	Bore logs at a frequency and depth, and with material characterisation sufficient to determine potential displacement of material and/or the need for excavation	Refer Section 3.8, Figs 5 & 6
		Contaminant assessment of material potential displaced or excavated consistent with the NAGD	Refer Section 3.7 & 4.2.2
		Acid sulfate soil survey of material potentially displaced or excavated consistent with the Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland 1998 (Ahern et al. 1998)	Refer Section 3.6 & 4.2.2
4.2	Location	Location of natural features including intertidal sand and mud banks, wetland areas including Port of Cairns and Trinity Inlet Wetland	Refer Fig 1
5.2.3	Topography, geology and soils	Provide a description, map and a series of cross-sections of the geology of the project area relevant to the project components.	Refer Fig 1, 5 & 6
		Assess the potential for acid sulfate soils in accordance with:	
		• Queensland Acid Sulfate Soil Technical Manual	Refer Section 3.6 & 4.2.2
		• Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland 1998 (Ahern et al. 1998)	Refer Section 3.6 & 4.2.2
		• State Planning Policy 2/02: Planning and Managing Development Involving Acid Sulfate Soils (Department of Natural Resources and Mines & Department of Local Government and Planning 2002a)	Refer Section 3.6 & 4.2.2
		• State Planning Policy 2/02 Guideline: Acid Sulfate Soils (Department of Natural Resources and Mines & Department of Local Government and Planning 2002b).	Refer Section 3.6 & 4.2.2
		Provide geotechnical information on the soils' stability and suitability for construction of project facilities.	Refer Section 2.0
		Identify any erosion management techniques to be used. Provide details of an erosion monitoring program (including rehabilitation measures for erosion problems identified during construction), and detail acceptable mitigation strategies. Summarise methods proposed to prevent or control erosion with regard to:	

ToR	Title	Details	Comments
		• the Soil Erosion and Sediment Control—Engineering Guidelines for Queensland Construction Sites (Institution of Engineers Australia 1996)	Refer Section 2.1
		• the Guideline: EPA Best Practice Urban Stormwater Management—Erosion and Sediment Control (Environmental Protection Agency 2008a)	Refer Section 2.1
		• preventing soil loss in order to maintain land capability/suitability	Refer Section 2.1
		• preventing degradation of local waterways.	Refer Section 2.1
		Discuss the potential for acid generation from disturbance of acid sulfate soils during earthworks and construction, and propose measures to manage soils and mitigate impacts for all site earthworks and construction activities. Should action criteria be triggered by acid generating potential as a result of testing, provide a site-specific acid sulfate soils management plan prepared in accordance with: Queensland Acid Sulfate Soil Technical Manual)	Refer Section 2.1, 2.3, 3.6 & 4.2.2
		• State Planning Policy 2/02: Planning and Managing Development Involving Acid Sulfate Soils (Department of Natural Resources and Mines & Department of Local Government and Planning 2002a)	Refer Section 2.1, 2.3, 3.6, 4.2.1 & 4.2.2
		Provide details of any potential impacts to the topography or geomorphology associated with the project and proposed mitigation measures, including: - a discussion of the project in the context of major topographic features and any measures taken to avoid or minimise impact to such. - relevant coastal geomorphology, characterised and supported by illustrative mapping	Refer Section 2.1, 2.4, 3.3, 4.2.1 & 4.2.2
5.2.3	Topography, geology and soils	Provide details of any potential impacts to the topography or geomorphology associated with the project and proposed mitigation measures, including:	Refer Section 2.1, 2.4, 3.3, 4.2.1 & 4.2.2
5.2.3	Topography, geology and soils	Discussion of the project in the context of major topographic features and any measures taken to avoid or minimise impact to such.	Refer Section 2.1, 2.4, 3.3, 4.2.1 & 4.2.2

Relevant Queensland Government ToR - Groundwater

ToR	Title	Details	Comments
5.2	Land	Detail the existing land environment values for all areas associated with the project.	Refer Section 2.1, 2.3, 3.2, 3.6, 3.7, & 7.3
5.2.1	Land use and tenure	· declared water storage catchments	
5.3.2	Water quality	groundwater quality for likely discharge, runoff or seepage waters from any dredge spoil structures using the ANZECC Guidelines (Australian and New Zealand	Refer Section 7.3
5.5.1	Water resources	Provide an overview of the quality and quantity of any water resources in the vicinity of the project area and the relevance to the project.	Refer Section 7.3
5.5.2	Water resources	potential impacts on the flow and the quality of surface and groundwater from all phases of the project, with reference to their suitability for the current and potential downstream uses and discharge licences	Refer Section 7.3 &9.0
5.5.2	Water resources	an assessment of all likely impacts on groundwater depletion or recharge regimes	Refer Section 7.3 & 9.0
5.5.2	Water resources	where disposal of dredge spoil to land is being considered, the use of the ANZECC Guidelines methodology is required to derive water quality trigger values and investigate surface and groundwater quality of the receiving environment that are likely to receive discharge, runoff or seepage waters from any dredge spoil	Refer Section 7.3
5.5.2	Water resources	an assessment of the potential to contaminate surface and groundwater resources and measures to prevent, mitigate and remediate such contamination	Refer Section 7.3 & 9.0
5.5.2	Water resources	details of a monitoring program for the groundwater resources, using existing deep bores, to establish the base line yield and water quality of the supply from those bores	Refer Section 7.3

Commonwealth Guidelines

Flanagan Consulting Group has extracted relevant items from the Commonwealth Guidelines for soils and groundwater studies. These items and relevant details are presented below. Items that are not in scope are shaded grey in the table. The section of this report where each item is discussed is also shown in the table.

Relevant Commonwealth Government Guidelines

Guideline	Title	Details	Comments
5.9	The Existing Environment	This section must provide a description of the project area including baseline condition and trends of coastal, terrestrial and marine environments, including hydrology, sediment characteristics, sediment flows, geography, flora and fauna, cultural and heritage values, and all relevant socio-economic considerations. This section must link to the proposal description, potential impacts, and proposed avoidance, mitigation, adaptive management framework and/or offset measures throughout the life of the project including pre-construction, construction, operation, and any decommissioning. This section is to also identify and reference any relevant (published and unpublished) studies undertaken in the area which will assist in describing patterns and trends in the environment. Acute and chronic) from geotechnical activities (such as blasting (such as blasting (such as blasting (such as blasting pile driving), impacts of increased marine underwater marine species, including the impacts from noise at varying from each project component (considering the variables e.g. depth, wave height, bottom profile); impacts from proposal on air quality impacts; dredged material and impacts from increased shipping	Refer Sections 3.0 and 6.0
5.9	The Existing Environment	The section must include a description of the environment of the proposal site and the surrounding areas that may be affected by the action. This must include the following information:	Refer Sections 3.0 and 6.0
5.9	The Existing Environment	b) A detailed assessment of the nature, extent, likelihood and consequence of the likely short-term and long-term impacts including but not limited to: description of the risks and potential impacts disposal impacts	Refer Section 10.0
5.9	The Existing Environment	e) Any technical data, including modelling, and other information used or needed to make a detailed assessment of the relevant impacts;	Refer Sections 3.0 & 6.0
5.9	The Existing Environment	h) Consideration of potential impacts throughout the life of the proposal – from preconstruction, construction through to operation and any decommissioning;	Refer Sections 5.0, 9.0 &10.0

Guideline	Title	Details	Comments
5.9	The Existing Environment	l) Impacts on the existing use of the area and nearby areas that may be affected by the proposed action;	Refer Sections 5.0, 9.0 &10.0
5.10	Relevant Impact of the Proposed Action	The EIS must include a description of all of the relevant impacts of the action. Relevant impacts (both direct and indirect) are impacts that the action will have or is likely to have on a matter protected by a controlling provision (as listed in the preamble of this document). This section must provide clear linkages with the existing environmental values described in section 5.9 and proposed avoidance, safeguards, management and mitigation measures described in section 5.11. Impacts during all phases of the project must be addressed. This section must include:	Refer Sections 5.0 and 9.0
5.10	Relevant Impact of the Proposed Action	a) A description of the framework used to assess impacts, including risk assessment processes based on an approved standard;	Refer Section 10.0
5.10	Relevant Impact of the Proposed Action	b) A detailed assessment of the nature, extent, likelihood and consequence of the likely short-term and long-term impacts including but not limited to: description of the risks and potential impacts (acute and chronic) from geotechnical activities (such as blasting and pile driving), impacts of increased marine underwater noise on marine species, including the impacts from noise at varying distances from each project component (considering the environmental variables e.g. depth, wave height, bottom profile); impacts from the proposal on air quality impacts; dredging and dredged material disposal impacts and impacts from increased shipping;	Refer Section 10.0
5.10	Relevant Impact of the Proposed Action	c) A statement whether any relevant impacts are likely to be unknown, unpredictable, irreversible or sub-lethal (reversible over time) and what confidence level is placed on the predictions of relevant impacts;	Refer Section 10.0
5.10	Relevant Impact of the Proposed Action	d) Analysis of the significance of the impacts;	Refer Section 10.0
5.10	Relevant Impact of the Proposed Action	e) Any technical data, including modelling, and other information used or needed to make a detailed assessment of the relevant impacts;	Refer Sections 3.0 & 6.0
5.10	Relevant Impact of the Proposed Action	f) Consideration of potential impacts throughout the life of the proposal – from preconstruction, construction through to operation and any decommissioning;	Refer Sections 5.0, 9.0 &10.0
5.10.9	Dredging and Dredged Material	h) Assessment of the risk and potential impacts of acid sulfate soils (ASS) and potential acid sulfate soils (PASS);	Refer Section 2.1

Guideline	Title	Details	Comments
5.11	Proposed avoidance, safeguards, management and mitigation measures	The EIS must provide information on proposed avoidance, safeguards and mitigation measures to deal with the impacts of the action. Specific and detailed descriptions of proposed measures must be provided and substantiated, based on best available practices/standards and must include the following elements.	Refer Section 10.0
5.11	Proposed avoidance, safeguards, management and mitigation measures	a) Identify the level of risk associated with potential impacts already identified and those that require mitigation, monitoring or management to avoid or reduce impacts to an acceptable level;	Refer Section 10.0
5.11	Proposed avoidance, safeguards, management and mitigation measures	b) A consolidated list of measures proposed to be undertaken to avoid, prevent, minimise or compensate (in priority order) for the impacts of the action (as specified in section 5.10), including: i. A description of proposed avoidance, safeguards and mitigation measures to deal with impacts of the action, including measures proposed to be taken by State governments, local governments or the proponent; ii. Assessment of the expected or predicted effectiveness of the measures; iii. Any statutory or policy basis for the mitigation measures; iv. The cost of the mitigation measures; and v. The resulting risk level for that impact post- avoidance, mitigation and/or management.	Refer Section 10.0
5.11	Proposed avoidance, safeguards, management and mitigation	c) Particular focus must be given to: i. Determining factors in the planning of the proposal so as to avoid damage to the environment;	Refer Section 10.0

APPENDIX B

Important Information

IMPORTANT INFORMATION RELATING TO THIS REPORT

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

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

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

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

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

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

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

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

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

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

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

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

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