REPORT

Preliminary Acid Sulfate Soil Hazard Assessment

Submitted to:

Seacombe West Pty Ltd
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Submitted by:

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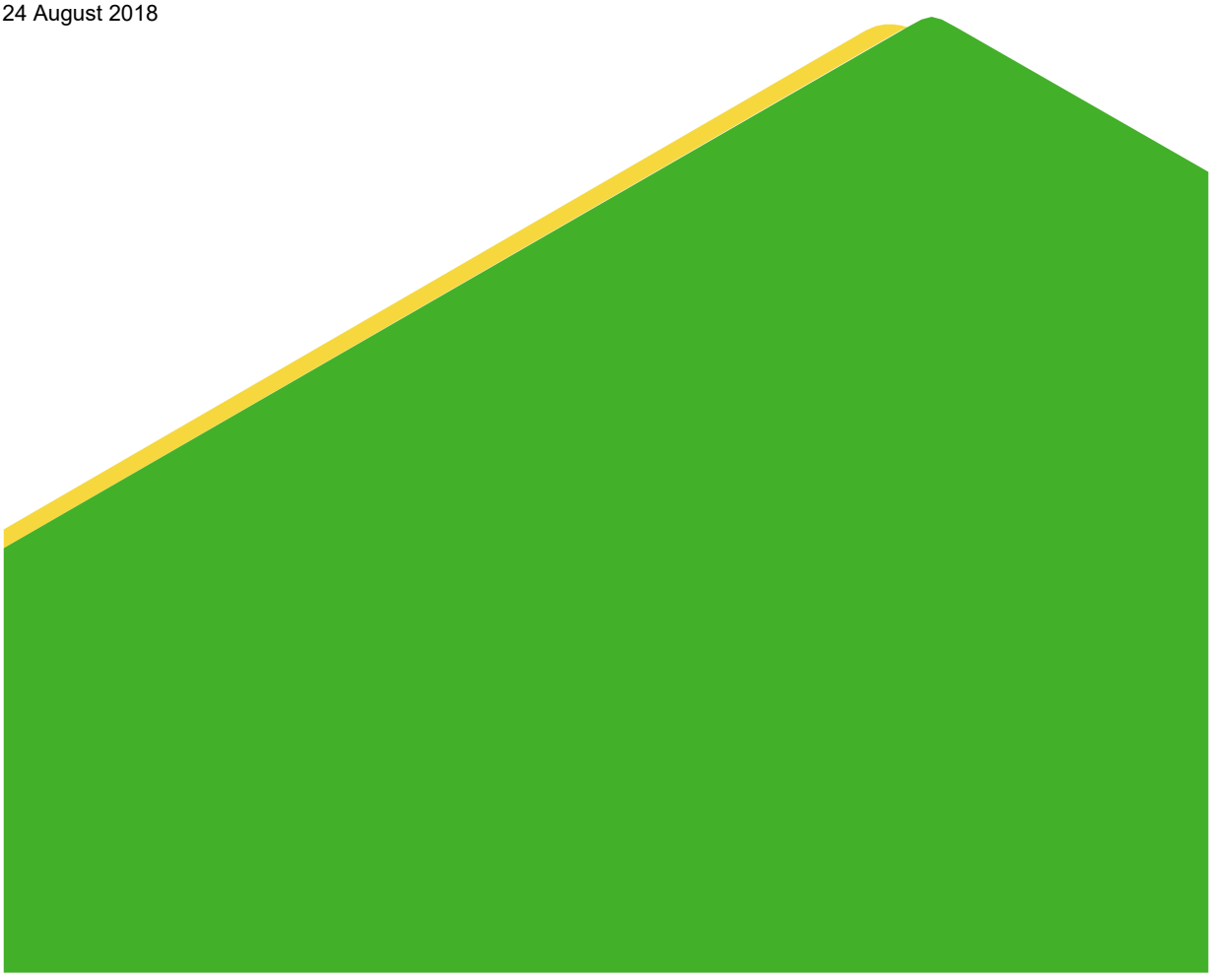

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1.0 INTRODUCTION

Seacombe West Pty Ltd (Seacombe West) proposes to develop the Nunduk Retreat & Spa on the shores of Lake Wellington, located to the east of Sale in Victoria's Gippsland Region.

The project will comprise the development of luxury accommodation, geothermally heated pools and a wellness spa on a construction footprint of about 9 hectares. The accommodation villas will be connected to the main building via elevated walkways 3.3 m above ground level. The main building will have a vegetated roof which is connected to the area behind the main building which will be built up using placed imported clean fill. The development will be constructed using driven piles to elevate the buildings and structures above predicted flood levels. There are no existing structures at the site which require demolition as part of the proposed development.

Seacombe West is seeking planning approval for the project. As part of the planning approvals process, EPA Victoria has requested an assessment of Coastal Acid Sulfate Soils (CASS) in accordance with the *Victorian Best Practice Guidelines for Assessing and Managing Coastal Acid Sulfate Soils* (BPMG) (Department of Sustainability and Environment, 2010). The BPMG is discussed in further detail in Section 2.0. This report presents the findings of an assessment in accordance with Stage A of the BPMG.

1.1 Objective

The objective was to assess the potential for acid sulfate soil (ASS) impacts due to the proposed development.

1.2 Scope

The scope of work undertaken was as follows:

- Review client supplied background information (as made available to Golder);
- Identify development activities which may trigger acid sulfate soil conditions;
- Assess the likelihood of occurrence of each identified activity;
- Undertake preliminary geotechnical modelling of the potential movement of underlying soils due to construction activities for the project; and
- Provide an overall assessment of the risk associated with acid sulfate soil impacts arising from construction of the proposed development.

2.0 FRAMEWORK FOR ASSESSING ACID SULFATE SOILS

Coastal acid sulfate soils (CASS) occur naturally and can contain metal sulfide minerals which, if drained, excavated or exposed to air, can react with oxygen and water to form sulfuric acid. Disturbance of CASS is likely to result in acid production, which has associated environmental, health, engineering and other impacts.

2.1 Victorian Guidelines

The BPMG sets out a risk identification approach that can be used to make decisions about the assessment and management of CASS. The BPMG is applicable to the potential development of new sites and not to the rehabilitation of existing sites.

2.2 CASS Risk Identification and Assessment Process

In accordance with the BPMG, there are four stages to the CASS risk identification and assessment process:

- Stage A: Preliminary CASS hazard assessment
- Stage B: Detailed site soil sampling program and assessment
- Stage C: Surface/groundwater sampling program and assessment
- Stage D: CASS hazard assessment

It is the responsibility of the owner of the site to initiate investigations to determine whether CASS is present and whether it will not be disturbed at the site and/or in areas beyond the boundaries of the site.

Stage A may be undertaken by a person with limited ASS experience and training. Stages B, C and D should be undertaken by an appropriately qualified and experience practitioner, such as an accredited soil scientist or a person with five or more years recognised experience in ASS assessment and management.

2.3 Stage A: Preliminary CASS Hazard Assessment

Stage A of the CASS risk identification process determines the likelihood of CASS being present at a site (CASS risk area) and whether CASS will be disturbed (high risk activity).

The BPMG defines five high risk activities that may disturb CASS as follows:

- Excavating soil/sediment (>1,000 m^3)
- Extracting or lowering groundwater
- Filling land or stockpiling soil (more than 100 m^3 with an average depth of 0.5 m) over in situ potential acid sulfate soils (PASS); these activities can force the underlying ASS above the water table at the margins of the added soil or fill
- Planting of vegetation (crops or plantations) that may potentially lower the water table
- Coastal or inshore dredging

A CASS risk area is defined in the BPMG as:

- An area where acid sulfate soils have been previously identified at or near the site; or
- An area identified by mapping as prospective land that has the potential to contain CASS and:
  - Displaying geomorphic indicators for CASS; and/or
  - Displaying soil and water indicators for CASS.

There are three possible outcomes of a Stage A Preliminary CASS Hazard Assessment:

1) The development is in a CASS risk area and includes a high risk activity. Stage B is required.

2) The development is in a CASS risk area but the proposed activities will not disturb CASS or impact on the water table. There appears to be low risk of CASS disturbance. Evidence that the proposed activity will not disturb CASS should be submitted along with an approval application for the proposed development.

3) The development is not in a CASS risk area. Works can proceed in accordance with all necessary approvals.

3.0 DESKTOP REVIEW OF AVAILABLE REPORTS

Golder has reviewed the available reports provided by Seacombe West in relation to the assessment of acid sulfate soils at the site. A summary of the key findings from each report is presented in the sections below.

Acid Sulfate Soil Assessment Wellington Waters Canal Estate Lake Wellington, Victoria – Meinhardt (December 2002)

Meinhardt (Vic) Pty Ltd (Meinhardt) was commissioned by Wellington Waters to undertake an acid sulfate soil assessment of the proposed residential development located along the southern shores of Lake Wellington (area formerly known as Pelican Cove). Field tests indicated no Actual Acid Sulfate Soils (AASS) within the six locations sampled, however all six locations indicated positive results for Potential Acid Sulfate Soils (PASS). Reaction strengths were medium to high, with strong effervescing in most samples. Laboratory results (SPOCAS testing) confirmed the presence of PASS, with three samples exceeding the sulfur trail and four samples exceeded the acid trail soil criteria. Meinhardt concluded that the sediments are considered PASS and if exposed to oxygen may oxidise producing acid leachate.

Nunduk Retreat & Spa Environmental Management Plan - AECOM (March 2018)

AECOM Australia Pty Ltd (AECOM) prepared an Environmental Management Plan (EMP) outlining the proposed management measures to be undertaken at the site in order to reduce the potential for acid sulfate soil impacts during the construction and operation of the Nunduk Retreat. The EMP recognised that design and construction methods had been adopted by Seacombe West to avoid exposure or dewatering these soils and hence limit the risk of disturbance of CASS. These design choices included but are not limited to the majority of built infrastructure being elevated and supported by driven piles (rather than excavated foundations) as well as the suspension of services from raised walkways to avoid the need for excavation via trenching.

Geotechnical Investigation for Nunduk Retreat and Spa - Cardno (April 2018)

Cardno Victoria Pty Ltd (Cardno) undertook a preliminary geotechnical investigation in 2017 which included the excavation of three test pits, pocket penetrometer testing of cohesive soils and a preliminary acid sulfate soil assessment comprising the field testing of 15 samples and he laboratory testing of 5 samples for chromium reducible sulfur.

The key findings from the geotechnical report were as follows:

- The geological map of the area (Sale 1:100,000 sheet) indicates that the site is underlain by Aeolian and Paludal swamp and lake deposits of silt, clay and peat and dune deposits of silt, sand and clay of the Quaternary Age.
- The groundwater level measured at the site varied from 0.5 m below ground level (bgl) to 3.5 m bgl.
- The site is approximately 0.4 m above sea level on average and is susceptible to periodical flooding.
- The ground conditions typically consisted of up to approximately 0.4 m of silty clay overlying dense to very dense SAND / Clayey SAND.
- Traces of peat were encountered in the test pits. Peat is typically associated with high compressibility and therefore settlement when subjected to loading.
- A field moisture content of 131% was encountered in test pit 01. This is consistent with the presence of peat.
- The silty clay is not suitable as a subgrade due to its softened and organic nature and should be stripped from site (unless stabilised with lime and / or cement).

- Field testing and laboratory testing of the silty clay soils observed from 0.1 m to 0.4 m below surface level was inconclusive as to whether these soils were either actual or potential acid sulfate soils.
- Field testing and laboratory testing of the unsaturated sandy soils observed at depths of greater than 0.5 m (i.e. underlying the surficial silty clay soils) indicated that these soils were an actual acid sulfate soil (AASS) and present a high risk of acid generation should they be disturbed or exposed.

Structure Concept Design Report - Felicetti (April 2018)

Felicetti Pty Ltd prepared a preliminary structural concept design for the project in 2018. The key information in relation to potential impacts to acid sulfate soils from the concept design report was as follows:

- The structures will need to be supported on piles and driven piles are proposed.
- A large embankment of up to 10 m height will be located behind the main building for the development.

Civil Engineering Report - Cardno (March 2018)

Cardno Pty Ltd prepared a civil engineering report for the project in 2018. The key information in relation to potential impacts from acid sulfate soils within the concept design report was as follows:

- A minimum floor level of RL 3.2 m has been adopted for the buildings in the development to accommodate potential flood levels in a 1 in 100-year storm event and potential sea level rise.
- Access roads will be set at a minimum level of RL 0.5 m when at grade and will be supported on piles when above RL 0.5 m.
- The eastern access road has been designed for flood conditions and will be supported on piles at a minimum level of RL 2.2 m.
- The earth mound behind the main building will require a volume of 112,500 m^3 of engineered fill.
- Before placement of engineered fill, unsuitable material will be stripped to an average depth of 0.5 m.

4.0 PRELIMINARY CONCEPTUAL SITE MODEL

The preliminary conceptual site model is based on limited soil data and further field investigations would be required to confirm the inferences made in this section. Figure 1 shows the test pit locations described below relative to the geological map information.

Groundwater has been encountered beneath the site at depths of between 0.5 to 3.0 m bgl. These measurements were recorded during June 2017 and no data is available on the potential for seasonal variation in the water table. It is estimated that the seasonal variation in the level of the water table may be in the order of 1 m but further investigations would be needed to confirm this preliminary estimate.

The shallowest soil horizon in each test pit location comprises silty clay which is inferred to represent a non-acid sulfate alluvial topsoil.

Underlying the silty clay are sands and clayey sands. At TP01 and TP02, these are inferred to represent the youngest geological formation (Qrm) and at TP03 these are inferred to represent the slightly older geological formation (Qrd).

Unsaturated soils at TP01 and TP02 (i.e. above the water table) are inferred to represent actual acid sulfate soils (AASS). Saturated soils at TP01 and TP02 are inferred to represent potential acid sulfate soils (PASS).

Unsaturated soils at TP03 are inferred to represent non-acid sulfate soils. Saturated soils at TP03 are inferred to represent potential acid sulfate soils (PASS).

In general, the Qrm geological formation is considered to have the highest risk of ASS, with AASS typically present above the water table and PASS typically present below the water table. In general, the Qrd geological formation is considered to have a lower risk of ASS, with AASS not necessarily present above the water table but PASS typically present below the water table.

5.0 PRELIMINARY HAZARD ASSESSMENT FOR CASS

5.1 CASS Risk Area Assessment

Given that acid sulfate soils have been identified at or near the site and that field indicators for CASS have been identified at the site, the proposed development is considered to be located within a CASS risk area (as defined in the BPMG).

5.2 High Risk Activity Assessment

An assessment of whether the proposed development includes a high risk activity that may disturb CASS (as defined in the BPMG) is presented in Table 1 below.

Table 1: Consideration of High Risk Activities

High Risk Activity	Discussion
Excavating soil/sediment (>1000 m^3)	Excavations proposed for this project will not exceed a volume of >1000 m^3. Driven piles will be used for the retreat development rather than bored piles. (*Cardno, 2018).* Driven piles will displace material in situ and have a low risk of disturbing CASS.
Extracting or lowering groundwater	No changes will be made to the water table during construction for the project. (*Cardno, 2018*).
Filling land or stockpiling soil (> 100 m^3 with an average depth of 0.5 m) over *in situ* PASS	A volume of approximately 112,500 m^3 of imported clean fill will be placed as engineered fill over *in situ* PASS (located beneath the water table) within a large embankment behind the main building. The average depth of the engineered fill will be greater than 0.5 m. (*Cardno, 2018*).
Planting of vegetation (crops or plantation) that may potentially lower the water table	No crops or plantation vegetation will be planted during the development. (*Cardno, 2018*).
Coastal or inshore dredging	No dredging will be undertaken as part of the project. (*Cardno, 2018*).

In summary, the proposed placement of an embankment of engineered fill behind the main building as part of the proposed development may represent a high risk activity, whereby this process could potentially force the underlying PASS above the water table at the margins of the added soil. No further activities to be undertaken during the development have been identified which meet the definition of a high risk activity (as set out in the BPMG).

Golder has undertaken a preliminary geotechnical assessment to further consider whether the proposed placement of engineered fill behind the main building will displace PASS from below to above the groundwater table. The geotechnical assessment is presented in Section 5.3 below.

5.3 Preliminary Geotechnical Assessment

To address concerns regarding the disturbance of PASS, we have undertaken a geotechnical assessment which included reviewing the Cardno geotechnical report, estimating the vertical settlement due to the proposed placement of fill and assessing the likelihood of the underlying PASS moving from below to above the groundwater table.

Seacombe West proposes to place a substantial amount of fill (maximum height of approximately 8.6 m) immediately adjacent to the south side of the proposed retreat section of the development (refer Figure 1).

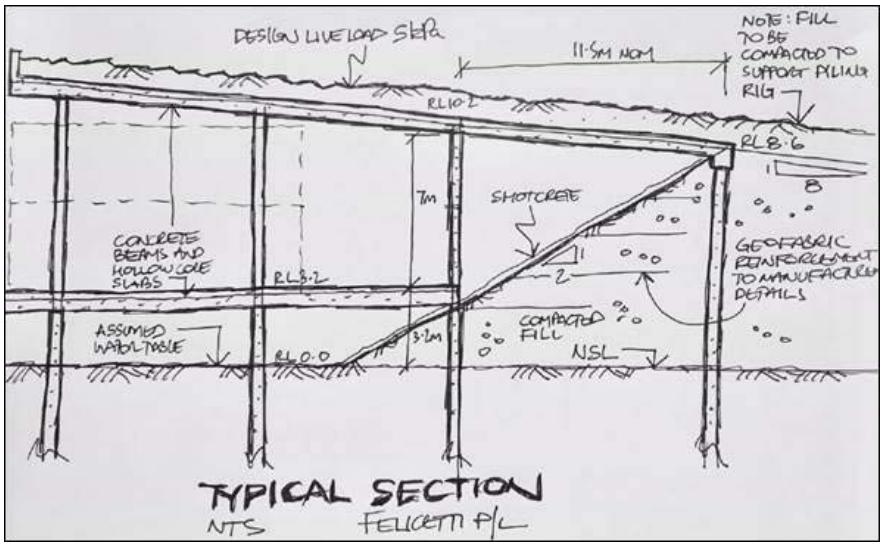

Figure 1: Depth of proposed fill placement (from Felicetti, 2018)

Estimation of Vertical Settlement

Based on the information presented in the Cardno geotechnical report, we have estimated the vertical settlement due to the proposed placement of up to 8.6 m of fill. For our assessment we have assumed that the surficial silty clay will be stripped from the site, that the engineered fill will be placed on the sand layer, and that the unit weight of the fill is 19 kN/m^3.

We have considered two cases:

1) The sand layer has a stiffness of 40 MPa (i.e. little peat material present); and

2) The sand layer has a stiffness of 20 MPa (i.e. some peat material present).

The estimated vertical settlement for Cases 1 and 2 is up to 100 mm and 150 mm, respectively. The estimated vertical settlement values should be considered to be preliminary only. A review of the magnitude of settlement should be undertaken following completion of additional geotechnical investigations at the site.

Potential for Movement of Underlying Material from Below to Above the Groundwater Table

The likely magnitude of heave of the in situ material adjacent to the area over which the fill will be placed is considered to be minimal. In our experience, the shape of the settlement profile will reflect the shape of the placed fill, i.e. minimal settlement at the edge of the fill zone and maximum settlement beneath the highest sections of fill. We consider the only plausible mechanism by which in situ material below the groundwater table would be forced above the groundwater table is a slip failure of the fill embankment through the in situ material. We consider the risk of such a slip failure to be minimal, assuming that:

- The fill embankment is appropriately designed by a suitably qualified and experienced geotechnical engineer based on the results of an appropriate geotechnical investigation at the site; and
- The fill embankment is constructed by a suitably qualified and experienced contractor.

Based on these assumptions, it is concluded that the potential for movement of the underlying PASS from below to above the groundwater table due to the placing of the fill will be insignificant.

6.0 OUTCOME OF PRELIMINARY HAZARD ASSESSMENT FOR CASS

The outcome of the Stage A Preliminary Hazard Assessment for CASS has been evaluated in accordance with the decision-making flow chart provided in the BPMG, as shown below.

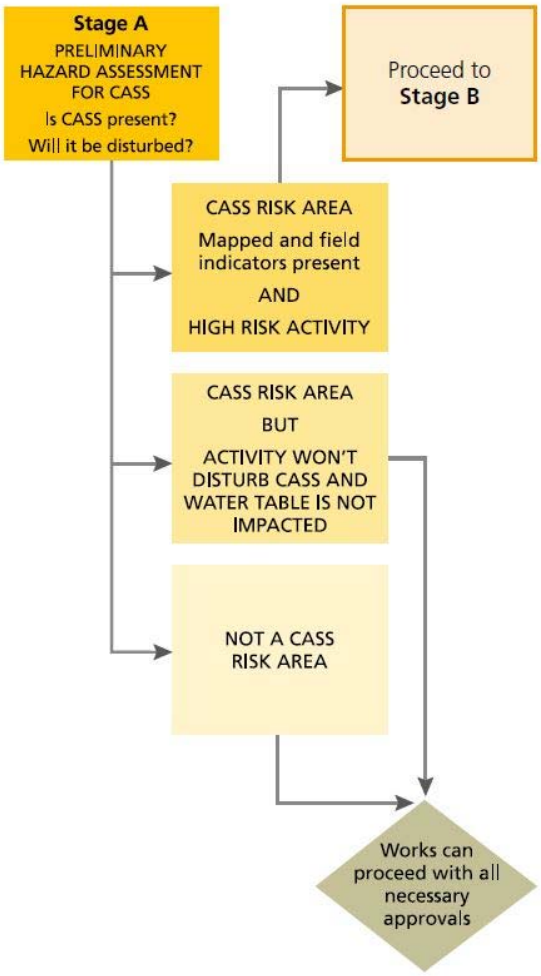

Figure 2: Stage A Decision Making Flow Chart (from BPMG)

In summary, given that the site is (a) located in a CASS Risk Area but (b) the activities to be undertaken during development will not disturb CASS and the water table will not be impacted, it is concluded that work can proceed with all other necessary approvals. In accordance with the decision-making process set out in the BPMG, a detailed site soil sampling program (i.e. Stage B) is not considered to be required at this time to support the approvals process.

Based on the proposed environmental management measures for the project (Cardno, 2018), the potential for ancillary site preparation works such as levelling, stripping of near-surface vegetation and/or soils or the movement of plant and equipment along access tracks to potentially result in exposure of CASS to oxidising conditions is low but cannot be ruled out. However, it is noted that the BPMG does not require detailed characterisation of these risks at the planning approvals stage of a project. Rather, management of these potential risks (if required) could typically be addressed via the preparation and implementation of a CASS management plan prior to the construction phase of the project.

7.0 CONCLUSIONS

Based on the outcomes of the Stage A Preliminary Hazard Assessment for CASS and in accordance with the *Best Practice Guidelines for Assessing and Managing Coastal Acid Sulfate Soils* (BPMG), the Nunduk Retreat and Spa falls within a CASS risk area but the proposed activities will not disturb CASS or impact on the water table. Therefore, there appears to be low risk of CASS disturbance. It is Golder's opinion that the Nunduk Retreat and Spa works can proceed with all other necessary approvals.

There is currently limited data available for the site, however for the purpose of this preliminary assessment, the available information is sufficient to support the conclusions presented herein.

Based on the proposed environmental management measures for the project, the potential for ancillary site preparation works such as levelling, stripping of near-surface vegetation and/or soils or the movement of plant and equipment along access tracks to potentially result in exposure of AASS to oxidising conditions is low but cannot be ruled out. However, it is noted that the BPMG does not require detailed characterisation of these risks at the planning approvals stage of a project. Rather, management of these potential risks (if required) could typically be addressed via the preparation and implementation of a CASS management plan prior to the construction phase of the project.

8.0 RECOMMENDATIONS

This report should be presented to the relevant planning authority as evidence that the proposed development activities considered in this preliminary assessment will not disturb CASS.

Further assessment of the potential for CASS issues related to ancillary construction activities such as site preparation works during the construction phase of the project is recommended to be undertaken after the planning approvals phase has been completed.

If further site characterisation of CASS conditions at the site indicates that ancillary construction activities such as site preparation works could lead to the potential generation of acidity in near-surface soils, a CASS management plan should be developed and implemented prior to the commencement of the construction phase of the project.

9.0 IMPORTANT INFORMATION RELATING TO THIS REPORT

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

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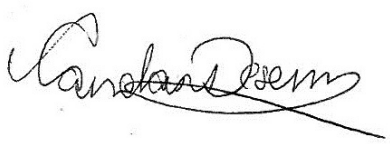

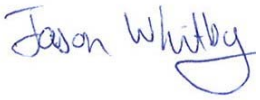

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APPENDIX A

Figures

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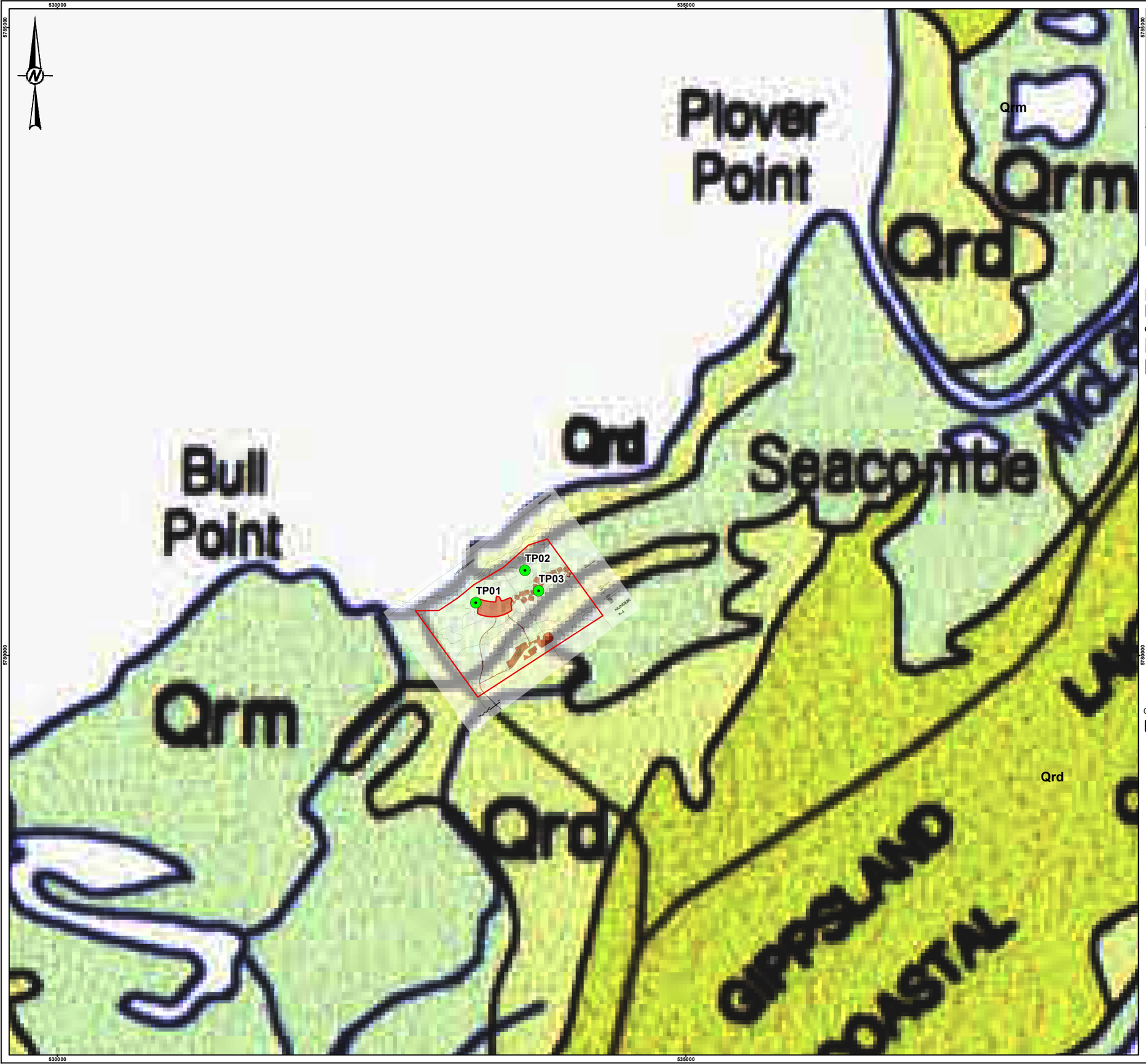
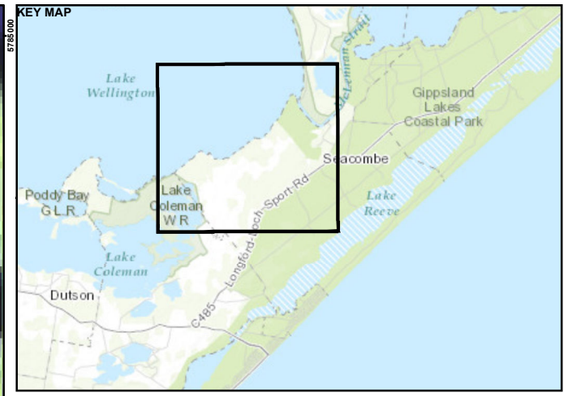


KEY MAP



LEGEND

- Sampling Locations (Cardno)
- Site Boundary
- Property Boundary

Geology

- Qrm — Paludal: Lagoon and swamp deposits: silt clay
- Qrd — Aeolian: Coastal and unland dunes: dune sand, some swamp deposits

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NOTE(S)

1. PROJECTION: GDA 1994 MGA ZONE 55
2. ROAD, WATER, PROPERTY AND RAIL INFORMATION, SOURCED FROM VICMAP 14/05/2016
3. LOCATION MAP SOURCED FROM ESRI ONLINE BASEMAPS.
4. APPROXIMATE DATA USED FOR GEOREFERECED
5. SAMPLING LOCATIONS SOURCED FROM CARDNO

REFERENCE(S)

ROAD, PROPERTY AND RAIL DATA © THE STATE OF VICTORIA, DEPARTMENT OF ENVIRONMENT, WATER LAND AND PLANNING, 2015.

CLIENT
SEACOMBE WEST PTY LTD

PROJECT
NUNDUK RETREAT
ACID SULFATE SOIL IMPACT ASSESSMENT

TITLE
SURFACE GEOLOGY

CONSULTANT
GOLDER

YYYY-MM-DD	16/08/2018
DESIGNED	–
PREPARED	FS
REVIEWED	JW
APPROVED	JW

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APPENDIX B

Important Information

IMPORTANT INFORMATION RELATING TO THIS REPORT

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