APA Transmission Pty Limited

Acid Sulfate Soil Assessment Report

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Glossary and Abbreviations

AGL	AGL Energy Ltd
AHD	Australian Height Datum (the surface that passes through mean sea level as defined by the National Mapping Council)
APA	APA Transmission Pty Limited
ASRIS	Australian Soil Resource Information System
ASS	Acid Sulfate Soil
bgl	Below ground level
CASS	Coastal Acid Sulfate Soils
CEMP	Construction Environmental Management Plan
CoC	Chain of Custody
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEDJTR	Victorian Department of Economic Development, Jobs, Transport and Resources
DER	Western Australia Department of Environment Regulation
EPA	Environment Protection Authority Victoria
GIS	Geographic Information System, a computer based system that allows mapping and management of geographic or spatially based data
GPS	Global Positioning System, a satellite based navigation system
HDD	Horizontal Directional Drill
IB 655.1	EPA Information Bulletin 655.1
IWMP	Industrial Waste Management Policy (Waste Acid Sulfate Soils)
KP	Kilometre Point, being the distance in kilometres along the pipeline from its starting point
PASS	Potential Acid Sulfate Soils
SPOCAS	Suspension Peroxide Oxidation Combined Acidity and Sulfur

Executive Summary

APA Transmission Pty Limited, a wholly owned subsidiary of the APA Group (together referred to as APA) is proposing to construct and operate a 56.2 km high pressure gas pipeline to connect AGL's proposed Gas Import Jetty at Crib Point to the Victorian Transmission System (VTS), east of Pakenham.

This report presents the results of a preliminary Acid Sulfate Soil (ASS) Assessment along the proposed pipeline route. It identifies areas where acidic soils or ASS may be present and discusses the analytical results with a view to identifying the risk that soils excavated along the route will produce free acid and/or adverse environmental impacts when exposed to air.

ASS are naturally occurring soils, sediments and peats that contain iron sulfides, predominantly in the form of pyrite materials, which can form sulphuric acid when exposed to air. These soils are most commonly found in low-lying land bordering the coast, in estuarine and saline wetlands, and in freshwater groundwater-dependent wetlands throughout the state. Other areas where ASS can be found include creeks, rivers and estuaries, and around the coast of Western Port (Coastal ASS).

ASS or Potential Acid Sulfate Soils (PASS) often appear as soft black, dark grey or greenish-grey clays, often with visibly high organic content or pyrite ('fool's gold'). These deposits are often present below or just above high tide level, between - 5 m to + 20 m above Australian Height Datum.

Given the intertidal environment in the southern portion of the route, there is potential for acidic or ASS/PASS to be present in areas characterised as salt marsh/swamp. This is primarily in the area north of Hastings to near the northern edge of the former Koo Wee Rup Swamp (from ~KP26.6 to 48).

To assess the risks that might be posed by ASS/PASS along the pipeline route, 10 survey locations were investigated between KP1.15 and KP39.67. Samples were collected to a depth of 3.5m below ground level (m bgl), 1m deeper than the proposed depth of excavation (unless bedrock was reached first), using either a push-tube sampler or a hand auger.

The soil type found in the samples was predominantly clay, typically stiff rather than soft and plastic, and frequently mottled red or orange, with colour ranging from light brown/orange to blue /grey. No unusual odour, particularly sulphurous odour, was detected anywhere along the proposed pipeline route.

Laboratory results showed that eight of the 10 sampling locations reported pH ≥ 5.8, suggesting that it was unlikely that these were acidogenic soils. Subsequent peroxide oxidation in the laboratory confirmed that it was highly unlikely that these were acidogenic soils. However, soil around CPT006 and CPT008 showed several chemical indicators of being either ASS or PASS, such that exposure to air could ultimately lead to acidification of surface and groundwaters adjacent to the route, with potential adverse effects on fauna and flora. It is also possible that water infiltrating excavations in this sector could become acidic, complicating de-watering measures.

Possible mitigation measures to limit acidogenesis and for managing potentially acidic excavation water are discussed in the Report, including the use of alternative construction methods around CPT006 to CPT008 to minimise soil disturbance, lime neutralisation, and the development of an ASS management strategy for the southern part of the pipeline route and neutralisation and filtering of water infiltrating excavations prior to discharge.

1 Introduction

1.1 Project Overview

APA Transmission Pty Limited, a wholly owned subsidiary of the APA Group (together referred to as APA) is proposing to construct and operate a 56.2 km in length high pressure gas pipeline which will connect AGL's proposed Gas Import Jetty at Crib Point to the Victorian Transmission System (VTS), east of Pakenham.

Upon completion, APA transmission pipeline and AGL's Gas Import Jetty will increase energy security and supply stability to Victoria. In addition, the pipeline will present other long term opportunities for the supply of gas to residential and industrial growth areas along the pipeline route and the potential for future power generation opportunities across the design life of the pipeline. The pipeline will also be designed in manner that will enable reverse flow from the main VTS connection at Pakenham to future customers connected to the pipeline.

The proposed AGL gas importing jetty project will consist of a Floating Storage and Regasification Unit (FSRU) continuously moored at the existing Crib Point Jetty. The FSRU will vapourise the natural gas from a visiting Liquefied Natural Gas (LNG) carrier that will moor directly adjacent to the FSRU. The natural gas will then be transferred to APA's Crib Point Receiving Facility via a marine loading arm and jetty piping. The high pressure gas pipeline will transfer the generated gas from the Crib Point Receiving Facility to the APA Pakenham Delivery Facility where it is conditioned to maintain the operating parameters of the VTS before injection.

Construction is currently scheduled to commence at the Receiving and Delivering Facilities in June – July 2019. The pipeline construction is scheduled to commence in October 2019 with the pipeline system planned to be operational by March 2020. The exact timing is dependent on a number of factors including timing of the required approvals, access agreements with relevant stakeholders and weather conditions.

The construction schedule is driven by the Project objective to receive and transport gas from AGL's first LNG cargo scheduled for first quarter of 2020.

1.2 Project Description

The Crib Point Pakenham Pipeline project (the project) consist of the following components:

- 56.2km of high pressure gas transmission pipeline with a diameter of 600mm with a minimum cover of 1.2 m from ground level.
- Crib Point Receiving Facility situated at landside of the Crib Point Jetty managed by Port of Hastings Development Authority (PoHDA) and include metering, pigging facility, nitrogen storage and injection, odourant plant, gas analysers and a vent stack.
- Pakenham Delivery Facility situated adjacent to the Pakenham East Rail Depot, which is within land owned by Public Transport Victoria and include a scraper station, filtration, metering, heating, pigging facility and a vent stack.
- Two mainline valves (MLVs) will be situated along the pipeline at kilometre point (KP)12 and KP40. MLVs are provided as a means to isolate the pipeline in segments for maintenance, repair, operation, and for the minimisation of gas loss in the event that pipeline integrity is lost. Once isolated, the gas from the relevant pipeline section may be vented prior maintenance taking place. A typical MLV site comprises of 10 m x 10 m fenced compound.
- Cathodic protection (CP) is to be provided via a combination of crossbonds to existing CP system and the installation of an impressed current system at either of the MLVs which will be determined during detailed design. The pipeline primary corrosion protection system shall be its external coating.

The Crib Point Pakenham pipeline has a design life of 60 years. The design life of other pipeline equipment and sub-systems ranges from 15 to 25 years, but with ongoing integrity management, and subject to appropriate commercial drivers, the operational life is expected to be longer.

1.3 Pipeline Route

The preferred pipeline route has been selected after more than 6 months of consultation with affected landowners and Government Stakeholders, and the completion of detailed environmental investigations that inform the construction methodology for avoidance and minimisation of impacts. A map showing the preferred route is presented in **Figure 1**.

From the APA Crib Point Receiving Facility immediately north of the existing jetty facilities (KP0), the pipeline generally follows existing oil and gas pipeline infrastructure corridors to the south of Hastings. These infrastructure corridors are followed for the first 5km of the pipeline route to Reid Parade, Hastings including a 1.7km crossing of Warringine Park, a local conservation reserve managed by the Mornington Peninsula Shire Council. Through Hastings, the pipeline route generally follows Frankston-Flinders Road, with the exception of where the Stony Point Rail Line corridor is wide enough to accommodate the pipeline for approximately 500m. Within Hastings where the pipeline is co-located with Frankston-Flinders Road, the pipeline route has been located within the adjacent service road of the main carriageway where possible.

From Graydens Road to the north of Hastings, the pipeline is generally located within private property following the crossing of the Stony Point Rail Line and Frankston-Flinders Road (KP9.8). Between KP10.1 and KP29.9 the pipeline is generally co-located adjacent to the Esso Australia oil and gas pipeline corridor. In a number of instances, the pipeline route diverges from this existing linear infrastructure corridor to avoid social and environmental constraints or to facilitate the proposed construction methodology. The pipeline route is located to the south of the Western Port Highway and the townships of Tyabb and Pearcedale, with the crossing of Baxter-Tooradin Road at KP25.3. Through the area between KP13 to 25, the pipeline route is close to Westernport and the associated Ramsar Wetland and the Yaringa Marine National Park.

Following the crossing of Baxter-Tooradin Road (KP25.1), the pipeline is generally located in more open agricultural land and the pipeline diverges from the Esso Australia oil and gas pipeline corridor prior to the crossing of the South Gippsland Highway (KP30.4) to take a more direct route to the east of Pakenham. The pipeline crosses the dis-used Leongatha Rail Line at KP33.7. Between the South Gippsland Highway (KP30.4) and Pakenham South (approximately KP50), the pipeline traverses the low lying Koo Wee Rup swamp area and a number of significant drainage features that are maintained by Melbourne Water. Western Contour Drain (KP31), Cardinia Creek (KP40.2), Deep and Toomuc Creeks (KP41.5) are three of the most significant drainage features that the pipeline crosses in between South Gippsland Highway and Pakenham South.

Towards Pakenham, the pipeline crosses the Gippsland Rail Line (KP54.2), prior to reaching the proposed Pakenham Delivery Facility. From this facility, the pipeline then follows Oakview Lane and Mt Ararat Road to reach the terminal point on the Longford-Dandenong Pipeline on the northern side of the Princes Highway. In order for this to occur there are two significant road crossings of both the Princes Freeway (KP54.9) and the Princes Highway (KP55.9).

1.4 Purpose of this Report

Monarc Environmental (Monarc) has been engaged by APA to provide ecological and environmental services to support the regulatory approval process for the Crib Point Pakenham Pipeline Project.

This report presents the results of the preliminary Acid Sulfate Soil (ASS) Assessment, identifies areas where acidic soils or ASS may be present and discusses the analytical results with a view to identifying the risk that soils excavated along the proposed pipeline route will produce free acid when exposed to air.

1.5 Study Area

Based on preliminary assessment, ASS is expected to occur primarily in two areas:

- near coastal areas in the southern half of the alignment, and
- in the former Koo Wee Rup Swamp (north of South Gippsland Hwy).

Monarc proposed 10 sampling locations to provide a preliminary understanding of the potential that ASS could occur within the construction footprint. These were spaced to target the areas considered most likely to harbour acidogenic soils.

After further discussions and securing access to the properties, the locations presented in **Table 1** below have been investigated, on the dates shown. All 10 sample locations are presented in **Figure 2**. Each sampling location is presented in detail in **Figures 3-10**.

Table 1: Acid Sulfate Soil Assessment Sampling Location

Property Reference No.	KP	Location	Remarks
CPT006	1.15	Crib Point Terminal, Hastings	Samples collected 04 July
CPT008	1.84	Crib Point Terminal, Hastings	Samples collected 04 July
CPT012	4.44	Warringine Park, Hastings	Sample collected 20 June
CPT051	19.1	Pearcedale	Sample collected 09 July
CPT057	20.41	Pearcedale	Sample collected 20 June
CPTP6 01	21.05	Pearcedale	Sample collected 20 June
CPT067	25.48	Devon Meadows	Sample collected 21 June
CPT073	28.85	Devon Meadows	Sample collected 21 June
CPT084	33.41	Clyde	Sample collected 21 June
CPT104	39.67	Cardinia	Sample collected 21 June

1.6 Scope of Works

This report presents the results of the Acid Sulfate Soil Assessment, identifies areas where ASS was found to be present and discusses the soil sample analytical results including extent and severity of ASS.

The specific sampling locations have been determined onsite after the underground services have been identified and properly marked out.

To minimise site disturbance, a 4WD-mounted rig (Eziprobe 1700) equipped with a push tube (with a 38mm core) was used for soil sampling.

In areas where vehicle access or landholder restrictions apply, a hand auger was used to collect soil samples.

Samples were collected from each distinct soil horizon (typically three) at each location.

A total of 10 locations were sampled using push tube or hand auger for ASS analysis.

Twelve samples, comprising at least one from each location in the natural soil at depth, were analysed for acidogenic potential using the SPOCAS suite of tests. CPT006 and CPT008 were sampled at two depths as they were sampled in conjunction with a separate soil contamination assessment.

1.7 Limitations

LogiCamms Consulting Pty Ltd t/a Monarc Environmental (Monarc) has prepared this report on behalf of APA for the proposed route options regarding the construction of a gas transmission line between Crib Point and Pakenham.

The report includes a review of certain information that was obtained from the sources and contacts noted by methods described in the report, including information obtained from APA.

Monarc has exercised care in checking and interpreting the data and information referred to in this report. The report program has been designed and managed in good faith and in a manner that seeks to confirm the information available and test its accuracy and completeness. However, Monarc cannot guarantee the accuracy or completeness of that data and information. Accordingly, while our conclusions are based on the information available to us during our assessment of the work area, some of those conclusions could be different if the information upon which they are based is determined to be inaccurate or incomplete.

This report has been prepared specifically for APA for the purpose of pipeline route planning. Any other persons seeking to rely upon this report should only do so after seeking approval from APA. The extent of any environmental, health and safety or financial risks associated with this report may vary significantly according to its proposed use.

Therefore, any representation, statement, opinion or advice expressed or implied in this report is made in good faith but on the basis that Monarc, its agents and employees are not liable to any other person for any damage or loss whatsoever which has occurred or may occur in relation to that person taking or not taking (as the case may be) action in respect of any representation, statement or advice referred to above.

Monarc disclaims any obligation to update the report for events taking place or information becoming available or known to us, after the preparation of this report.

2 Methodology

2.1 Desktop Assessment

Acid Sulfate Soils (ASS) are naturally occurring soils, sediments and peats that contain iron sulfides, predominantly in the form of pyrite materials (EPA 2009). These soils are most commonly found in low-lying land bordering the coast, in estuarine and saline wetlands, and in freshwater groundwater-dependent wetlands throughout the state.

In an anoxic state, these materials remain benign and do not pose a significant risk to human health or the environment. However, the disturbance of ASS, and its exposure to oxygen, has the potential to cause significant environmental and economic impacts, including:

- fish kills and loss of biodiversity in wetlands and waterways;
- contamination of groundwater resources by acid, arsenic, heavy metals and other contaminants;
- loss of agricultural productivity; and
- corrosion of concrete and steel infrastructure by acidic soil and water.

Disturbance of acid sulphate soils can adversely affect land use and development and can adversely impact land, water and ecosystems in the following ways (EPA 2009):

- Environmental quality – affecting soil quality, surface and groundwater quality, and aquatic habitats.
- Agricultural practices – loss of rural productivity, loss of commercial and recreational fisheries, the cost of additional lime and fertilizer requirements and degradation of drainage systems.
- Engineering and landscaping works –- the corrosion of concrete and steel and the design of transport structures (i.e. road or rail), buildings, embankments and drainage systems to avoid impacted areas.
- Human health – skin and eye irritation, contamination of drinking water and occupational health and safety risks.

The potential environmental impact of acid sulphate soils depends on a number of factors, including the following:

- Exposure to oxidising conditions – ASS cannot commence generating acidic discharges unless exposed to oxygen and water.
- The volume, texture and sulfidic characteristics of the soil being disturbed – higher volumes of disturbance, greater porosity (i.e. sands), or higher percentages of sulfide often result in higher rates of acid generation and greater impacts.
- Capacity for self-neutralisation – acidic discharges may be neutralised as they occur, depending on the content and nature of neutralising material present in the soil, including organic material and/or carbonates (e.g. fine-grained shell matter or lime).
- The acid buffering capacity of the receiving environment – for example, some water environments. Acid buffering capacity of soil and water is often limited, so may not provide neutralising capacity in the long term.

- The concentrations of aluminium, iron and other metals in soils or rock and the potential for acidic discharges to dissolve these metals.

2.1.1 Geology

According to the GeoVic modelled website (DEDJTR 2016) the route passes through several lithology types from Sedimentary for most of the project corridor to Igneous near the termination point east of Pakenham. Several lithology types cover the southern part of the project corridor from Crib Point to Tooradin comprising marine, swamp deposits and sandstone to Swamp and Lake Deposits (Qm1) and Alluvium (Qa1) dominating the northern half.

Table 2 provides a broad summary of geological conditions expected along the project corridor.

The common lithology appears to be generally swamp/marsh environments around Western Port and the former Koo Wee Rup swamp areas. The tidal environment in the vicinity of Western Port and particularly past Watson Creek is likely to result in wet ground conditions. Wet and low-lying conditions are also likely to be found to the east of the Western Outfall Drain (KP31.5) which is reclaimed land.

A study for Esso's Longford Liquids Pipeline Replacement Project (Worley Parsons 2014) stated that Baxter Sandstone have been found around Melbourne to be acidic and also ASS. It is noted that Baxter Sandstone has been superseded and renamed as Red Bluff Sandstone in 2009 and more recently replaced by Sandringham Sandstone (Geoscience Australia 2018).

Table 2: Overview of Geology along the project corridor

KP	Element	Description	Lithological Description
0 - 0.9, 1.25 - 2.1, 7.9 - 9.9, 10.9 - 14.4, 21.7 - 22.1, 22.3 - 22.5, 22.6 - 22.8, 23.1 - 25.5, 25.8 - 25.9,	Nbr	Red Bluff Sandstone	Sandstone, conglomerate: pale yellow and brown; fine to coarse-grained, massive to well bedded; cross-bedded; local ironstone.
1 - 1.2, 2.1 - 5.45	Sm	Murrindindi Supergroup	Siltstone, shale, sandstone, rare conglomerate and limestone; sandstone typically quartz-rich in the lower part and lithic in the upper part; siltstone commonly bioturbated; marine to fluvial.
1.2 - 1.25	Qg	Coastal lagoon deposits	Silt, clay: dark grey to black; variably consolidated.
9.9 - 10.9, 14.4 - 14.9, 45.2 - 46.5, 46.7 - 47.3, 49 - 53.3, 53.8 - 55	Qa1	Alluvium	Gravel, sand, silt: variably sorted and rounded; generally unconsolidated; includes deposits of low terraces; alluvial floodplain deposits.
5.45 - 7.9, 14.9 - 17.2, 17.45 - 17.65, 17.85 - 20.1,	Qdl1	Coastal dune deposits	Sand, silt, clay: well sorted, poorly consolidated; coastal dune and beach deposits, some swamp deposits.
22.1 - 22.3, 22.5 - 22.6, 22.8 - 23.1, 25.9 - 26.2, 26.5 - 27.2, 27.5 - 28.2, 28.5 - 28.8, 42.5 - 42.7, 46.5 - 46.7,	Qd1	Inland dune deposits	Sand, silt, clay: friable to consolidated; well sorted; includes both lunette deposits and deposits of longitudinal dunes.
20.1 - 21.1, 21.2 - 21.7, 26.2 - 26.5, 27.2 - 27.5,	Qb	Alluvium and colluvium	Sand, silt, clay, gravel, diamictite; alluvial and colluvial deposits.
17.2 - 17.45, 17.65 - 17.85, 21.1 - 21.2,	Nb	Brighton Group	Gravel, sand, silt: variably calcareous to ferruginous sandstones and coquinas; marine to non-marine.
25.5 - 25.8, 28.2 - 28.5, 28.8 - 42.5, 42.7 - 45.2, 47.3 - 49	Qm1	Swamp and lake deposits	Former Koo Wee Rup Swamp. Grey to black carbonaceous mud, silt, clay, minor peat: generally unconsolidated; rare dolomite.
53.3 - 53.8, 55 - 55.2	-Put	Thorpdale Volcanic Group	Extrusive basalt. Tholeiitic and alkalic basalt; minor nephelinite, basanite, nepheline hawaiite, hawaiite, mugearite, nepheline mugearite, tuff, interbedded sandstone and silcrete.

2.1.2 Soil Type

The project corridor passes through several soil types which are summarised in **Table 3** below.

Much of the area around the northern end of Western Port is low lying and wet with poor soil structure, making it susceptible to erosion, which is characteristic of the soil type around Western Port. The waterways around Western Port are tidally influenced and some of this land is reclaimed, especially to the east of the Western Outfall Drain.

Table 3: Overview of soil type along the project corridor.*

KP	Element	Description	Occurrence
0 - 22.5, 23.7 - 32.5, 47.7 - 51.6	PO	Podosol soils are dominated by accumulation of organic matter, aluminium and iron rich and are highly sandy and acidic. These soils have high permeability and poorly drained.	Podosols occur in areas of high rainfall and in poorly drained areas on foot slopes and flats. Found around the coast from Crib Point to Devon Meadows and the lower part of Pakenham.
22.5 – 23.7	RU	Rudosol soils are have negligible pedological development and mainly comprise unconsolidated mineral materials that are slightly gravelly.	Generally found in the north-east region near Pakenham. Concentrated around Western Port, Cannons Creek to Blind Bight.
32.5 – 47.7	HY	Hydrosols are a range of soils that are seasonally or permanently saturated for a minimum of 2-3 months in a year.	Hydrosol soils occur in low lying areas and in swamps. Located in the former Koo Wee Rup swamp area.
51.6 – 53.4	SO	Sodosols have a strong texture contrast between the loamy surface (A) horizons and sodic clayey subsoils (B) horizon.	Commonly found in the poorly drained areas with very low agricultural potential, high sodicity, high erodibility, poor structure and low permeability. These soils can be associated with soil salinity and may be dispersive. Located north of Nar Nar Goon.

* Estimate only, based on mapping as provided by CSIRO's ASRIS database (CSIRO 2014)

Given the intertidal environment in the southern portion of the route, there is potential for acidic or ASS to be present in areas characterised as salt marsh/swamp. This is primarily in the area north of Hastings to near the northern edge of the former Koo Wee Rup Swamp (from ~KP26.6 to 48). These materials often appear as soft black, dark grey or greenish clays, often with visibly high organic content or pyrite ('fool's gold'). These deposits are often present below or just above high tide level, between 5 m to 20 m above Australian Height Datum (AHD).

Other areas where the likelihood of ASS can be increased include rivers and estuaries, creeks and the coast of Western Port (Coastal ASS).

CSIRO's Australian Soil Resource Information System (ASRIS) soil database (CSIRO 2014) has been reviewed to assess the likelihood of ASS being present in the project area. This map of ASS potential has been overlaid on the pipeline alignment and presented as **Figure 2**.

In general, this review has found that the alignment traverses areas with the following soil acid sulfate ratings:

- *Low* to *Extremely Low Probability / Very Low Confidence* in the southern portion of the route (Crib Point to Tooradin ~KP0 to KP26.6). This indicates there is an extremely low probability of occurrence based on mapped soil types and geological formations but with little actual data to support this (very low confidence in the data).
- *High Probability / Low to High Confidence* in the north end (Tooradin to Officer South ~KP26.6 to KP48). This indicates there is a high probability of occurrence based on mapped soil types and geological formations and some with data to support this.

The probability of ASS being present along the route is summarised in **Table 4** below.

Table 4: Overview of potential acid sulfate soils along the project corridor.

KP	Class	Description
0 - 32.5, 33.8 - 36.1, 36.8 - 37, 50 - 53.4	Cq(p4)	Extremely Low Probability / Very Low Confidence
53.4 - 55.2	Bn(p4)	Low Probability / Very Low Confidence
32.5 - 33.8, 36.1 - 36.8	Ac(p1)	High Probability / High Confidence
37 - 50	Am(p4)	High Probability / Very Low Confidence

Previously reported investigations into ASS along the project corridor were reviewed and summarised below:

- The alignment runs parallel to the existing Esso easement which was considered to potentially traverse areas of ASS from northwest of Cannons Creek to Koo Wee Rup and is therefore relevant for consideration of implications to the proposed pipeline corridor between about KP 11 to 30.3. The ASS characterisation investigation prepared for the Esso easement concluded that, in general, the soils were considered to be acidic (low pH) but not acid sulfate producing (relatively low sulfur content). The soils were, however, considered to be subject to oxidation which required management and discussion in the Construction Environment Management Plan (Worley Parsons 2014).
- A study undertaken by Monarc for APA's Koo Wee Rup Supply Main project in February 2015 reported soils with potential ASS characteristics (even if acidity was not directly attributable to sulfide or sulfur-based acidity) at all of the locations tested (Monarc Environmental 2015). Although the supply main route only parallels the project corridor for a relatively short distance (~KP48-49), both the supply main and the project corridor pass through a similar area described as *High Probability / Low to High Confidence* for ASS.

It is noted that where the project corridor diverts from the Esso easement it crosses areas of the former Koo Wee Rup swamp, where potential for ASS exists. For this reason, the survey to determine presence or absence of ASS in these areas has been undertaken with a view to determining whether acidogenic soils are present and if a management plan is required in accordance with EPA Publication 680 - *Managing Waste Acid Sulfate Soils*.

2.1.3 Sample Collection

A suitably qualified and experienced Monarc environmental scientist was present to confirm the final sampling locations and to collect the samples for laboratory analysis. The sampling and testing were undertaken in accordance with methods outlined in Victorian EPA information bulletin IB-655.1 – *Acid Sulfate Soil and Rock* (EPA 2009).

Each location was sampled to a depth of 3.5 metres below ground level (m bgl) - 1m deeper than the proposed depth of excavation at 2.5 m bgl (unless bedrock was reached first). In accordance with IB-665.1 and the WA Department of Environment Regulation's guidelines for assessing CASS (DER 2013), samples were collected at 0.5 m intervals to maximum depth. (Please refer to **Figure 11** for site photos)

Sample bores were reinstated with original spoil and topped up with bentonite pellets.

Each sample was analysed for the *SPOCAS* suite (Suspension Peroxide Oxidation Combined Acidity and Sulfur) to give detailed acid-base accounting to allow a determination of the acidification potential of soils (if any) and treatment rates for acidic soils (if required).

2.1.4 Detailed Acid-Base Accounting (SPOCAS)

The pH_{KCl} test is used to determine soil pH in a 1:40 1 M KCl suspension, and is designed as a screening tool to determine the presence of actual or existing (readily available/generated) acidity contained within the soil. This pH value is affected by the amount of acid buffering or acid neutralising capacity ('ANC') contained within the soil (e.g. alkaline or high pH calcareous soils, dissolution of calcium and/or magnesium carbonates from limestone or shell-grit which would contribute to any buffering of acidity) (see DER 2013). In combination with the Titratable Peroxide Acidity (TPA), ANC is used to calculate Titratable Sulfidic Acidity (TSA) (Ahern et al. 2004).

The pH_{OX} test is pH of a known volume of soil following oxidation with 30% hydrogen peroxide (H_2O_2). It is used as a screening tool to determine the presence of potential or stored acidity. Hydrogen Peroxide is a caustic oxidant which is used to simulate the effects of oxidation of soils and releases any potential or stored acidity contained within the soil that would be released after oxidation of the soils via exposure to air and water (DER 2013). pH_{ox} is also used to measure Titratable Peroxide Acidity (TPA), which represents the amount of acid released from the complete oxidation of sulfides (and organic matter) (combined with any pre-existing TAA), balanced against any buffering provided by acid-neutralising components in the soil.

In some soils, buffering supplied by acid neutralising components may exceed acid generated by oxidation of sulfides, resulting in an 'excess' acid neutralising capacity (ANCE) result (Ahern et al. 2004).

The Suspension Peroxide Oxidation Combined Acidity and Sulfur (SPOCAS) test is a self-contained suite allowing a detailed acid-base accounting in soil. SPOCAS compares the pH, titratable acidity, sulphur and cations on two sub-samples of a soil, where one sub-sample is oxidised with hydrogen peroxide and the other is not.

The differences between the two sub-samples for the various SPOCAS parameters are then calculated, providing twelve (12) individual analytes plus five (5) calculated parameters, "*enabling the quantification of some key fractions in the soil sample, leading to better prediction of its likely acid-*

generating potential" (DER 2013 - for more details regarding the SPOCAS test, please refer to pages 32-33 of this publication).

The pH_{KCl} and pH_{OX} tests are components of the SPOCAS suite.

2.1.5 Assessment Criteria

Analytical results were assessed against relevant ASS guidelines as contained in IB-655.1 (EPA 2009) and in the Victorian Industrial Waste Management Policy (IWMP) No. S125: *Waste Acid Sulfate Soils* declared under the Environmental Protection Act (EP Act, 1970) (Victorian Government 1999).

Analytical results from the SPOCAS test were assessed against criteria outlined in Appendix 3 of IB-655.1 (EPA 2009), which presents texture-based Net Acidity action criteria for classification of Acid Sulphate Soil.

The criteria differ as a function of soil texture. For the purpose of classifying ASS, three soil textures are recognised:

- Sands to loamy clays.
- Sandy loams to light clays.
- Medium to heavy clays and silty clays.

As IB-655.1 states:

> *"the criteria relate to soil texture. The clay content of soil influences the amount of sulphuric acid generated after soil disturbance. Clay rich soils generally have a higher natural pH buffering capacity [Acid Neutralising Capacity or ANC] than clay-poor soils. This means they can neutralise more acid than clay-poor soils."*

Assessment criteria presented in IB-655.1 (EPA 2009) are also based on the quantity of soil likely to be displaced (see **Table 4**, below). In this project, the volume likely to be displaced is not yet known.

The most important analytical parameter for determining acid sulphate soil status is Net Acidity, which is calculated using the following method:

Net Acidity = All forms of acidity (potential, actual and retained) - Acid Neutralising Capacity

> *"The Net Acidity leached to the environment when ASS is disturbed depends not only on the amount and rate of acid generation, but also on the amount and reactivity of the neutralising components of the soil"* (DER 2013).

In this calculation, the values for each variable are determined as follows:

- *Potential Acidity* – determined using one of the following methods:
    - SCR (chromium-reducible sulphur) or SPOS (peroxide oxidisable sulphur) - measures sulfide content and is used to calculate potential sulfide acidity; or
    - TSA (total sulfide acidity) or TPA (total peroxide acidity) – measures sulfide-based acidity after oxidation minus self-neutralising capacity.
- *Existing (actual and retained) Acidity* - determined (when $pH_F < 5.5$) using one of the following methods:

- TAA (total actual acidity) – measures recently generated and soluble (readily available) acidity, or
- Acid soluble sulphur – SNAS (net acid soluble sulphur) and SRAS (residual acid soluble sulphur) – measures acidity retained on non-soluble minerals.

- *Acid Neutralising Capacity (ANC)* – measures the inherent self-neutralising capacity of the soil to buffer acidity and resist the lowering of the soil pH, modified by a 'fineness factor'. Further information on factors that affect the amount of acid-neutralising capacity under real field conditions is provided in pages 35 - 36 of the Acid Soils Guideline Series (DER 2003).

There are a range of other parameters analysed or calculated to arrive at a Net Acidity value for a soil; these are not discussed in detail in this report. Refer to the laboratory Certificates of Analysis (CoA) in **Appendix B** for these values. For further information refer to Acid Soils Guideline Series (DER 2003) and IB-655.1 (EPA 2009).

The analytical results were therefore assessed against criteria presented in **Table 5** below (this table is a reproduction of Table 3 in Appendix 3 of IB-655.1).

Table 5: Texture Based Action Criteria for Classification of Acid Sulfate Soil

Soil or sediment texture	Approx clay content (%)	NET ACIDITY CRITERIA			
		1-1000 tonnes		> 1000 tonnes	
		%S (oven-dry basis)	mol H^+/tonne (oven-dry basis)	%S (oven-dry basis)	mol H+/tonne (oven-dry basis)
Sands to loamy clays	< 5	0.03	18	0.03	18
Sandy loams to light clays	5 - 40	0.06	36	0.03	18
Medium to heavy clays and silty clays	> 40	0.1	62	0.03	18

It should be noted that the two different units for Net Acidity values (% Sulfur or %S and moles of hydrogen ions/tonne or mol H^+/tonne) are interconvertible according to the following conversion factor:

> To convert %S to mol H^+/tonne, multiply the %S value by 623.7.
>
> To convert mol H+/tonne to %S, divide the mol H^+/tonne value by 623.7.
>
> For example:
>
> Net Acidity of 0.03 %S = 0.03 x 623.7 = 18.711 mol H^+/tonne
>
> Net Acidity of 23 mol H^+/tonne = 23 / 623.7 = 0.0368 %S

For the purposes of this assessment, the results will be reported and discussed in %S units.

3 Results and Discussion

The soil bore logs are presented in **Appendix A**, the sample Chain of Custody (CoC) documentation and the laboratory Certificates of Analysis are presented in **Appendix B**, and a detailed summary of the analytical results is presented in **Appendix C**.

The soil type found in the samples was predominantly clay, typically stiff rather than soft and plastic, and frequently mottled red or orange, with colour ranging from light brown / orange to blue / grey. No unusual odour, particularly sulphurous odour, was detected.

Laboratory results showed that eight of the 10 sampling locations reported pH ≥ 5.8, suggesting that it was unlikely that these were acidogenic soils. Following peroxide oxidation, pH_{OX} either *increased* or fell by ≤ 0.3 units, again suggesting that it was highly unlikely that these were acidogenic soils.

Samples from CPT006 and CPT008 showed pH between 4.4 and 4.6 suggesting the presence of Potential ASS or ASS.

The results from the SPOCAS testing found that samples from locations CPT006 and CPT008 had:

- *Net Acidity* exceeding 0.02 (%S units), with values reported between 0.07 and 0.09 %S;
- *Actual titratable acidity* exceeding 3 mol H^+/tonne, with values reported between 36 and 46 mol H^+/tonne;
- *Peroxide oxidisable sulphur* exceeding 0.02 %S – in the case of sample BH2-2.3 (CPT006) and BH1-2.0 (CPT008), Peroxide Oxidisable Sulphur was reported to equal 0.02%S;
- *Liming rates* (calculated from the SPOCAS test results by the laboratory on the assumption that the $CaCO_3$ used was 100% effective at neutralising the acidity) greater than 1 kg $CaCO_3$ per tonne of soil - the values at both locations were between 3 and 4 kg $CaCO_3$ per tonne.

The results, and the classification arising from the data, are summarised in **Table 6**, below:

Table 6: Summary of Acid Sulfate Soil Analysis Results

Location	Comment	Sample ID (depth)	pH_{KCl}	pH_{Ox}	ΔpH^	Soil Type	Net Acidity (%S)	ASS or PASS* (Yes/No)
CPT006 (KP1.15)	In Hastings No unusual smell or colour was observed	BH2-2.0	4.6	4.5	-0.1	Clay	0.07	Yes
		BH2-2.3	4.4	4.6	+0.2	Clay	0.09	Yes
CPT008 (KP1.84)	In Hastings No unusual smell or colour was observed	BH1-2.0	4.5	4.8	+0.3	Clay	0.08	Yes
		BH1-2.3	4.5	4.8	+0.3	Clay	0.07	Yes
CPT012 (KP4.44)	In Warringine Park, Reid Pde, Hastings. No unusual smell or colour was observed	BH1/3 (3.2 m)	5.9	6.7	+0.9	Clay	< 0.02	No
CPT051 (KP19.1)	In Pearcedale. No unusual smell or colour was observed	BH1/2.5	6.2	6.3	+0.1	Sand	< 0.02	No
		BH1/3.0	6.2	5.8	-0.3	Sand	< 0.02	No
CPT057 (KP20.41	In Pearcedale. No unusual smell or colour was observed	BH2/3 (3.5 m)	6.4	6.3	-0.1	Clay	< 0.02	No
CPT067 (KP25.48)	In Devon Meadows. No unusual smell or colour was observed	BH5/3 (3.5 m)	6.7	6.4	-0.3	Clay	< 0.02	No
CPT073 (KP28.85)	In Devon Meadows. No unusual smell or colour was observed	BH4/2 (2.5 m)	6.5	6.5	0	Clay	0.02	No
CPT084 (KP33.41)	In Clyde. No unusual smell or colour was observed	BH6/2 (3.5 m)	5.8	5.6	-0.2	Clay	< 0.02	No
CPT104 (KP39.67)	In Cardinia. No unusual smell or colour was observed	BH7/2 (3.0 m)	6.6	7.2	+0.6	Clay	< 0.02	No
CPTP6 01 (KP21.05)	In Pearcedale. No unusual smell or colour was observed	BH3/3 (2.9 m)	6.2	6.7	+0.5	Silty clay	< 0.02	No
Potential or Actual Acid Sulfate Soil (EPA 2009):			**<5.0**		**> -2**		**> 0.03**	

^: ΔpH = pH_F (or pH_{KCL}) - pH_{Ox}, representing the acidity releasable by oxidation.

*: Actual (ASS) or Potential Acid Sulfate Soils (PASS) as defined by Table 3 of Appendix 3 to IB-655.1 (EPA 2009).

3.1 Management Options for Acid Sulfate Soils

The Victorian best practice management strategies for CASS (DSE 2010) include the following (in order of preference):

- Avoiding disturbance of CASS.
- Minimising disturbance.
- Preventing oxidation.
- Treating to reduce or neutralise acidity.
- Offsite reuse or disposal.

Further details of these strategies as they could apply to this Project are provided below.

Avoiding disturbance of CASS

This approach would involve avoiding the section of the pipeline around CPT006 and CPT008 by changing the alignment or changing the installation method from trenching to an alternative construction method that avoids disturbing the soil in this area.

Minimising disturbance

This approach would involve minimising disturbance to the soil and groundwater, particularly avoiding large scale or long-term fluctuation in groundwater levels. Impacts to such should be carefully planned to minimise the extent or length of time the groundwater table is raised or lowered.

Preventing oxidation

Exposure of disturbed ASS to air should be minimised to reduce the risk of acid generation and subsequent acid-mediated transport of contaminants into the environment. This approach would involve limiting the exposure duration of the excavated material - the maximum 'safe' exposure time depends on the soil texture, since finer materials like clay take longer to produce significant quantities of acid than coarse materials such as sand.

Table 7 below provides a guide on 'safe' short term stockpiling durations based on soil texture (see Dear et al. 2002).

Table 7: Suggested short term stockpiling durations based on soil texture

Type of material (McDonald et al., 1990)	Approx. clay content %	Duration of stockpile
Coarse (sands to loamy sands)	≤ 5	Overnight (≤18 hours)
Medium (sandy loams to light clays)	5-40	≤2.5 days (≤70 hours)
Fine (medium to heavy clays and silty clays.	≥ 40	≤5 days (≤140 hours)

Disturbances should be carefully staged so that sulfidic sediments are exposed to air for the minimum amount of time possible, thereby limiting the oxidation of sulfide minerals.

If this strategy is adopted, an earthworks strategy should be prepared to document the volumes to be moved and the duration that they will be exposed, combined with regular monitoring of stockpiled materials for pH_F and pH_{FOX} to identify any potential oxidation or acid generation in the stockpiled material. Contingencies such as bunding for wet weather conditions should also be developed.

Treating to reduce or neutralise acidity

The results of the SPOCAS testing indicate that the deeper natural soils around CPT006 and CPT008 are acidic and potentially acidogenic, requiring up to 4kg of Calcium Carbonate per tonne to neutralise the acidogenic potential.

Offsite reuse or disposal

EPA publication 655.1 (EPA 2009) and the IWMP (Government of Victoria 1999) details the requirements for offsite disposal of ASS in Victoria.

It should be noted that as presented in the hierarchy of best practice management strategies (DSE 2010) offsite reuse and disposal is the least preferred management option for large disturbances and that all offsite movements of ASS need to be documented (DSE 2010).

In addition, documentation on contamination status in accordance with EPA Publications IWRG 621 and IWRG 702 may also be required, to comply with EPA requirements for waste transport.

In accordance with EPA publication 655.1 offsite disposal or reuse of ASS may occur only at premises:

- that are licensed to dispose of ASS under the Environment Protection Act 1970
- where an environmental management plan, prepared in accordance with EPA guidance, has been approved by the EPA.

4 Summary and Recommendations

4.1 Acidogenic Potential

The results of the SPOCAS testing indicate that the deeper natural soils at the southern end of the pipeline route, around locations CPT006 and CPT008, are acidic and potentially acidogenic. Exposure of these soils to air could ultimately lead to acidification of surface and groundwaters adjacent to the route. The SPOCAS results also indicate that the soils around CPT006 and CPT008 require up to 4kg of Calcium Carbonate per tonne to neutralise their acidogenic potential.

Over the rest of the route, while there may be some minor potential for acid generation on oxidation at some locations, this is balanced and even counteracted by excess acid neutralising capacity in the soil (see Ahern et al. 2004).

As shown by the data in **Table 5**, only the samples from locations CPT006 and CPT008 present positive indicators of ASS. Regardless of the soil texture and the quantity of soil to be disturbed along the pipeline route, none of the soil represented by the other samples analysed can be classified as ASS, since the Net Acidity is in all cases less than 0.03% S or 18 mol H^+ per tonne.

Sulfide-based acidity is the most potent form of acidogenic potential in acidogenic soils. The other form of acidogenic potential is known as “speciated metal acidity” and is related to the amount of aluminium and iron in the soil (Ahern et al. 2004). Both Aluminium (Al) and Iron (Fe) can contribute to soil acidity by preferentially up-taking soil components that contribute to alkalinity, either hydroxide (OH^-) ions or carbonate/bicarbonate (CO_3^{2-}/HCO_3^-) anions, reducing the amount of natural soil buffering capacity. Although the analysis of these soil samples did not look at Al or Fe levels, it is clear from the very low ∆pH values observed that the buffering capacity of the soils along the route (even around locations CPT 006 and CPT 008) is high.

The observed acidogenic status of the samples from this sector of the route (see **Figure 2**) is consistent with the data provided by CSIRO’s ASRIS database (CSIRO 2014).

4.2 Potential for Adverse Environmental Effects

There is a possibility that exposure of the soils around CPT006 and CPT008 to air could ultimately lead to acidification of surface and groundwaters adjacent to the route, with potential adverse effects on fauna and flora. It is also possible that water infiltrating excavations in this sector could become acidic, complicating de-watering measures. Possible mitigation measures are discussed below.

For the remainder of the pipeline route outside locations CPT006 and CPT008, the SPOCAS results suggest that excavation of the soil and exposing it to air is unlikely to present corrosion or aggressivity risk factors to concrete or metal structures buried in the soil.

4.3 Recommended Excavation Management Options

Sector around CPT006 and CPT008

To minimise the risk of acid generation and contaminant transport within the project area, it is recommended that disturbance to the section around CPT006 to CPT008 be avoided by employing other construction methods along this area.

However, if trenching is employed at this location, it is recommended that an ASS management strategy be developed to address the following:

1) Lining and bunding of stockpiles,

2) Limiting the exposure of the stockpile to a minimum by staging the works,
3) Developing protocols to neutralise soil acidity of the stockpile using the proper liming rates and soil blending techniques,
4) Regularly monitoring the pH of the stockpile and groundwater accumulated in the trench,
5) Monitoring stockpile volumes and exposure periods to ensure backfilling or disposal prior to oxidation,
6) Containment and treatment of groundwater accumulated in the trench prior to disposal (collecting and neutralising infiltrated water, and removing silt and other contaminants prior to discharge),
7) Developing contingencies for rain events,
8) Developing protocols for offsite disposal of the stockpile.

The recommended management measures discussed above should be incorporated in the Construction Environmental Management Plan (CEMP) for the project.

Remainder of the pipeline route

Monarc considers that the risk of acidogenesis outside the area around CPT006 and CPT008 is not sufficient to require specific management measures. However, the standard measures proposed in the pipeline CEMP should still apply.

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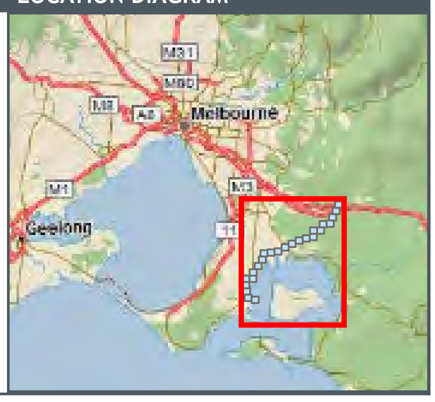
Crib Point Pakenham Pipeline Project
Figure 1: Overview of Pipeline Alignment

LEGEND

Pipeline Alignment

LOCATION DIAGRAM



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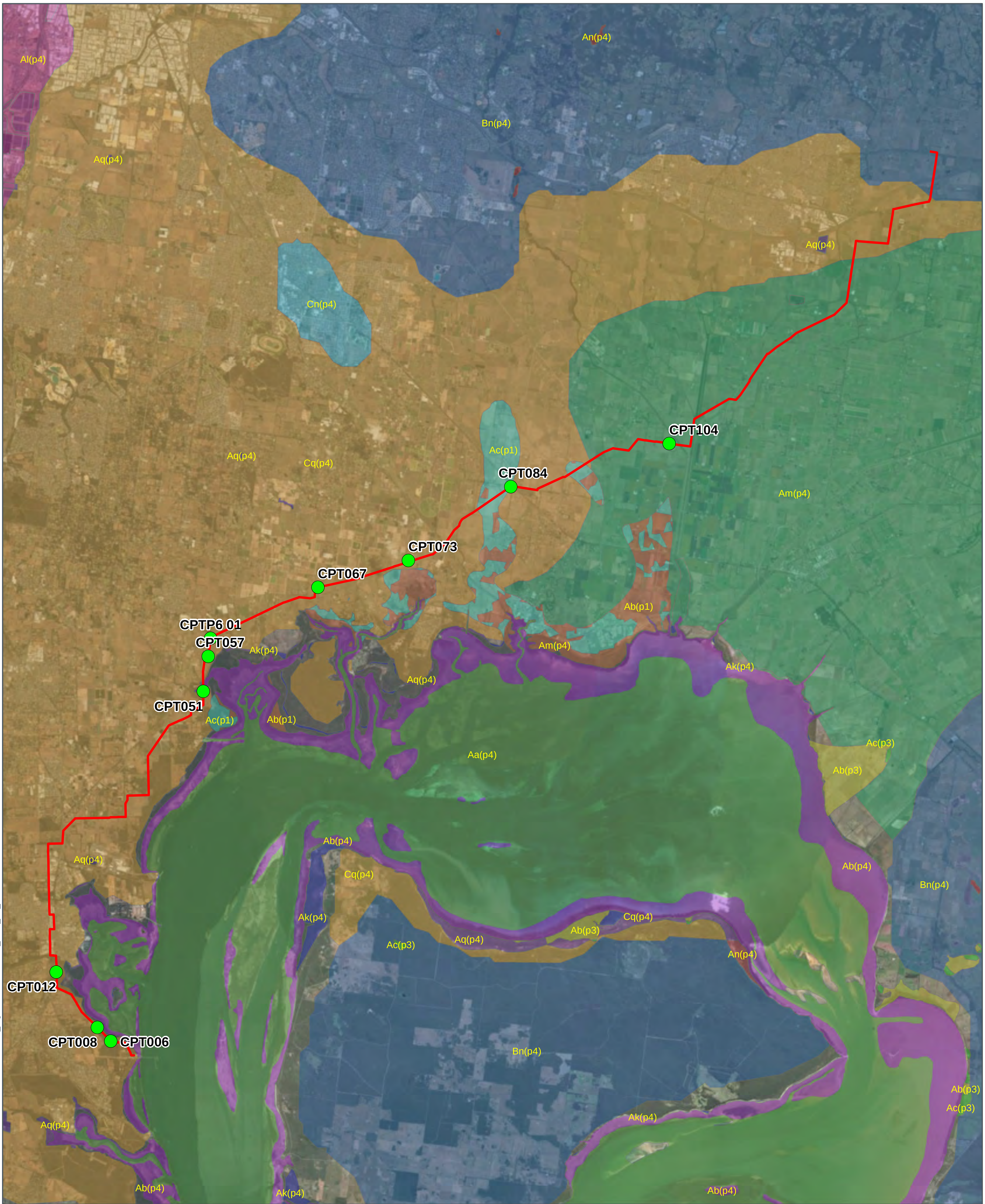

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Crib Point Pakenham Pipeline Project
Acid Sulfate Soil Sample Locations
Figure 2

LEGEND

- Sample Location
- Crib Point Pakenham Alignment

Acid Sulfate Soils

Aa(p4)	Ac(p1)	An(p4)
Ab(p1)	Ac(p3)	Aq(p4)
Ab(p3)	Ak(p4)	Bn(p4)
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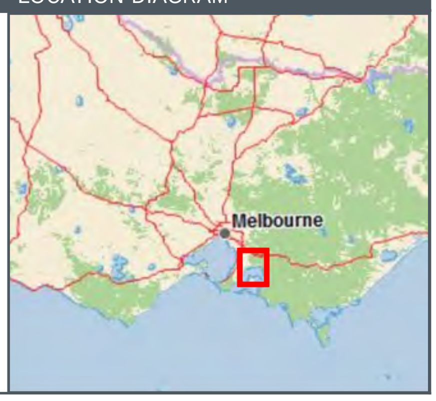
	Am(p4)	Cq(p4)

LOCATION DIAGRAM



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DATA SOURCES:
Australian Atlas of Acid Sulfate Soils © Commonwealth Scientific and Industrial Research Organisation, 2015
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Crib Point Pakenham Pipeline Project
Acid Sulfate Soil Sample Locations
Figure 3

LEGEND

- Sample Location
- Kilometre Points
- Crib Point Pakenham Alignment
- Alignment Footprint

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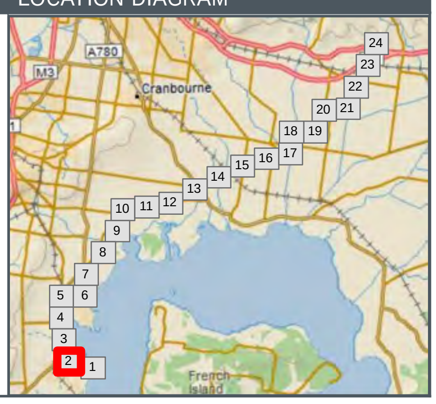

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Crib Point Pakenham Pipeline Project
Acid Sulfate Soil Sample Locations
Figure 4

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LEGEND

- Sample Location
- Kilometre Points
- Crib Point Pakenham Alignment
- Alignment Footprint

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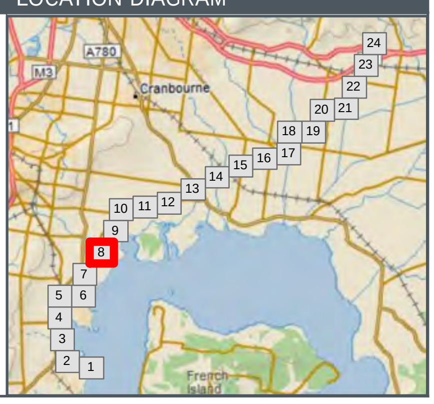

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Crib Point Pakenham Pipeline Project
Acid Sulfate Soil Sample Locations
Figure 5

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LEGEND
- Sample Location
- Kilometre Points
- Crib Point Pakenham Alignment
- Alignment Footprint

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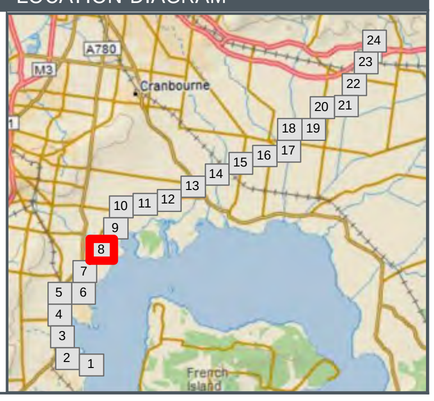

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Crib Point Pakenham Pipeline Project
Acid Sulfate Soil Sample Locations
Figure 6

LEGEND

- Sample Location
- Kilometre Points
- Crib Point Pakenham Alignment
- Alignment Footprint

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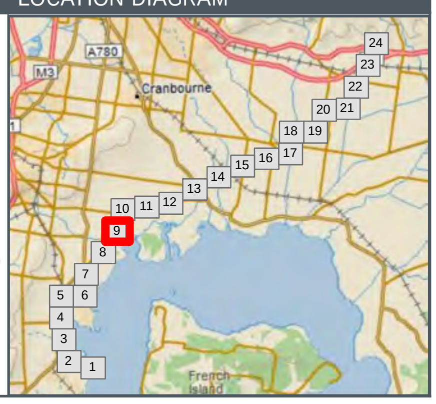

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Crib Point Pakenham Pipeline Project
Acid Sulfate Soil Sample Locations
Figure 7

LEGEND

- Sample Location
- Kilometre Points
- Crib Point Pakenham Alignment
- Alignment Footprint

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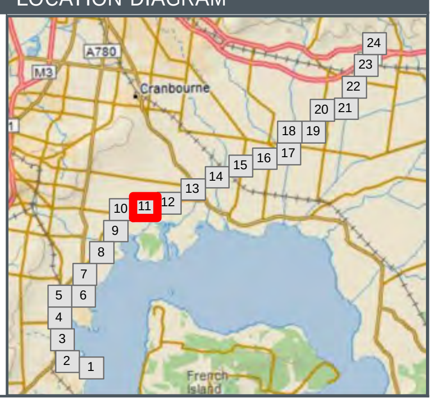

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Crib Point Pakenham Pipeline Project
Acid Sulfate Soil Sample Locations
Figure 8

LEGEND

- Sample Location
- Kilometre Points
- Crib Point Pakenham Alignment
- Alignment Footprint

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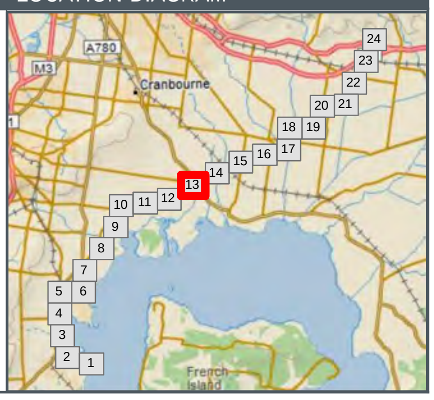
0 100 200
Metres
1:8,500
(A3) GDA 1994 MGA Zone 55

LOCATION DIAGRAM



WORK REQUEST NUMBER: 31-02984.00

DATA SOURCES:
Service Layer Credits: Copyright:© 2018 Garmin
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

ISSUE DATE	AUTHOR	QA CHECK	APPROVED	MAP REV.	REVISION NOTE
17/08/2018	JT	AB	CC	A	Issued for Review
24/08/2018	JT	AB	MV	B	Issued for Review

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APA Transmission Pty Limited - 31-02984.00

Crib Point Pakenham Pipeline Project
Acid Sulfate Soil Sample Locations
Figure 9

LEGEND

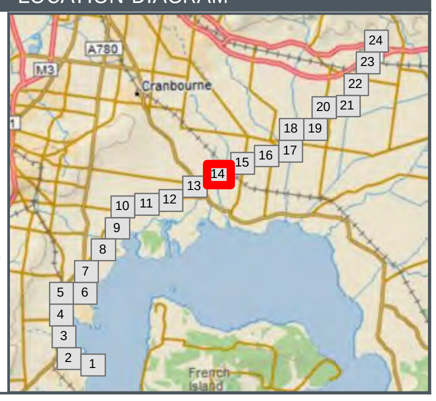
- Sample Location
- Kilometre Points
- Crib Point Pakenham Alignment
- Alignment Footprint

monarc ENVIRONMENTAL

apa

0 100 200
Metres
1:8,500
(A3) GDA 1994 MGA Zone 55

LOCATION DIAGRAM



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