Appendix I: Acid Sulfate Soils Management Plan

TNG LIMITED

ACID SULFATE SOILS MANAGEMENT PLAN

DARWIN PROCESSING FACILITY

DARWIN, NORTHERN TERRITORY

NOVEMBER 2019

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EXECUTIVE SUMMARY

Acid Sulfate Soils (ASS) are naturally occurring soils, sediments and peats that contain iron sulfides, predominantly in the form of pyrite materials. These soils are commonly found in estuarine and river settings and low-lying land bordering the coast.

TNG Limited (TNG) proposes to construct and operate a magnetite concentrate processing facility (known as the Darwin Processing Facility) on Lot 1817, Hundred of Ayers, Middle Arm Industrial Precinct, Wickham, approximately 16 kilometres (km) south east of Darwin, Northern Territory. The Darwin Processing Facility will process magnetite concentrate to produce higher value products for export from East Arm Wharf to international customers.

The Project, with associated access roads, supporting infrastructure and services comprises a development envelope of approximately 264 hectares (ha) within the 507 ha site; of which 180 ha has already been cleared for extractive industries.

Cut-and-fill earthworks will be required to provide level ground surfaces for the construction of the Darwin Processing Facility, with approximately 500 millimetres (mm) of surface soil removed as part of this process. The majority of infrastructure will be constructed on pads above ground, consisting of steel framed structures placed on reinforced concrete foundations. Process water ponds and wastewater storage ponds will be excavated below ground level, with a high-density polyethylene membrane installed where necessary.

The objectives of this Acid Sulfate Soil Management Plan (ASSMP) are to minimise the risk to the environment resulting from ASS by:

- Defining areas of ASS;
- Outlining proposed management actions;
- Describing proposed monitoring requirements and contingency methods for implementation; and
- Outlining the proposed reporting, review and audit requirements.

The scope of this ASSMP includes all construction and operational activities that have the potential to disturb ASS.

The surface water quality at the locations sampled indicate that the water features are accumulations of rainwater that has not been influenced by the nearby marine environment. No contamination was detected in the surface water.

The concentrations of iron in the soil are indicative of the predominantly clayey nature of much of the encountered soil, and the acidic condition of the soil (lowest pH 5.1). The iron levels likely result from iron oxide precipitation from the underlying iron rich estuarine deposits.

ASS was detected at numerous locations. The distribution of the identified ASS indicates that the ASS is generally driven by the typical high-weathering potential and the site's climatic conditions. There is a high potential for ASS to be encountered more broadly across the site during the proposed construction works for the project.

Where possible, disturbance of ASS will be avoided. Where disturbance is unavoidable, disturbance will be minimised or otherwise managed to prevent environmental impacts caused by the oxidation of ASS. Monitoring activities will be undertaken throughout the life of the Project in relation to the identified objectives and targets. The detail of monitoring activities will be determined once infrastructure design and associated construction

methodologies have been decided upon, following completion of geotechnical investigations and relevant project approvals.

Reporting relative to ASS management will comprise an annual report capturing the key criteria, including volumes of ASS disturbed, monitoring results and quantities and methods of ASS treated and disposed of. The report will discuss and evaluate the performance of the ASSMP, including the effectiveness of the operating strategies, comparison of monitoring results against performance indicators, any incidents that have occurred and the effectiveness of any corrective action adopted.

Should an environmentally significant incident occur, this will be reported to the relevant statutory authority by the Environmental Manager within 24 hours of the incident being identified. Remedial actions (if required) will be discussed and agreed upon with the relevant statutory authority.

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
°	Degree
AHD	Above Height Datum
ASS	Acid Sulfate Soils
ASSMP	Acid Sulfate Soils Management Plan
Golder	Golder Associates Pty Ltd
ha	hectare
HAT	Highest Astronomical Tide
kg	kilogram
km	kilometre
LAT	Lowest Astronomical Tide
m	metre
mm	millimetre
PASS	Potential Acid Sulfate Soils
t	tonnes

1 INTRODUCTION

1.1 PROJECT OVERVIEW

The Proponent proposes to construct and operate the Darwin Processing Facility at Lot 1817, Hundred of Ayers, Middle Arm Industrial Precinct, (658 Channel Island Road) Wickham. The Project is approximately 16 kilometres (km) south east of Darwin, Northern Territory (NT). The purpose of the Project is processing magnetite concentrate "Concentrate" to produce higher value products for export from East Arm Wharf to international customers. The scope of the Project, is limited to activities within the Processing Facility allotment, encompassing construction, operation, decommissioning and closure of the Processing Facility.

The Project will comprise:

- Clearing of a partially vegetated allotment formerly utilised for extractive industries;
- Construction of a magnetite concentrate Processing Facility;
- Construction of a rail siding, unloading and loadout facilities on the Adelaide to Darwin railway;
- Unloading of concentrate from trains at the rail siding;
- Refining of concentrate; and
- Loading of trains at the rail siding with Processing Facility products.

New infrastructure requirements on Lot 1817 Middle Arm include:

- Rail siding – 3.8 km long, adjoining the Adelaide - Darwin railway line;
- Processing Facility;
- Concentrate and coke stockpiles and conveyor tunnels;
- Process water, raw water, cooling water and waste water ponds;
- Filter cake stockpile area / hardstand;
- Workshop and stores;
- Offices, administration area, including kitchen / mess-hall, emergency services;
- Electricity sub-station;
- Potable water, raw water and fire water tanks;
- Gatehouse;
- Oxygen plant;
- Acid regeneration plant;
- Tank farm and reagent storage;
- Laydown areas; and
- Car parking.

Construction is scheduled to commence in late 2020 with first production in late 2022, subject to statutory approvals, finance and TNG Board Financial Investment Decision approval of the Mount Peake Project. The construction period is anticipated to be 24 months continuing over both wet and dry seasons.

The Project, with associated access roads, supporting infrastructure and services comprises a development envelope of approximately 264 hectares (ha) within the 507 ha site; of which 180 ha has already been cleared for extractive industries.

Cut-and-fill earthworks will be required to provide level ground surfaces for the construction of the Darwin Processing Facility, with approximately 500 millimetres (mm) of surface soil removed as part of this process. The majority of infrastructure will be constructed on pads above ground, consisting of steel framed structures placed on reinforced concrete foundations. Process water ponds and wastewater storage ponds will be excavated below ground level, with a high-density polyethylene membrane installed where necessary.

The Darwin Processing Facility site is described as comprising a ‘northern peninsula’ and ‘southern peninsula’. The site will be constructed primarily on the southern peninsula, with associated infrastructure constructed on the northern peninsula. The indicative site layout for the Darwin Processing Facility is shown in Figure 1-1.

The design life of the Processing Facility is 40 years. Processing of concentrate would occur at a rate of 700,000 tonnes per annum. The life of the Processing Facility mirrors the production of concentrate from the Mount Peake Mine, the primary source of concentrate for the Project. Additional concentrate may in future be sourced from the Mount Peake area (subject to the results of further exploration drilling and economic evaluation) or from third parties. Ultimate decommissioning of the site would be evaluated throughout the operation of the Processing Facility and discussed with regulators as part of ongoing licence requirements.

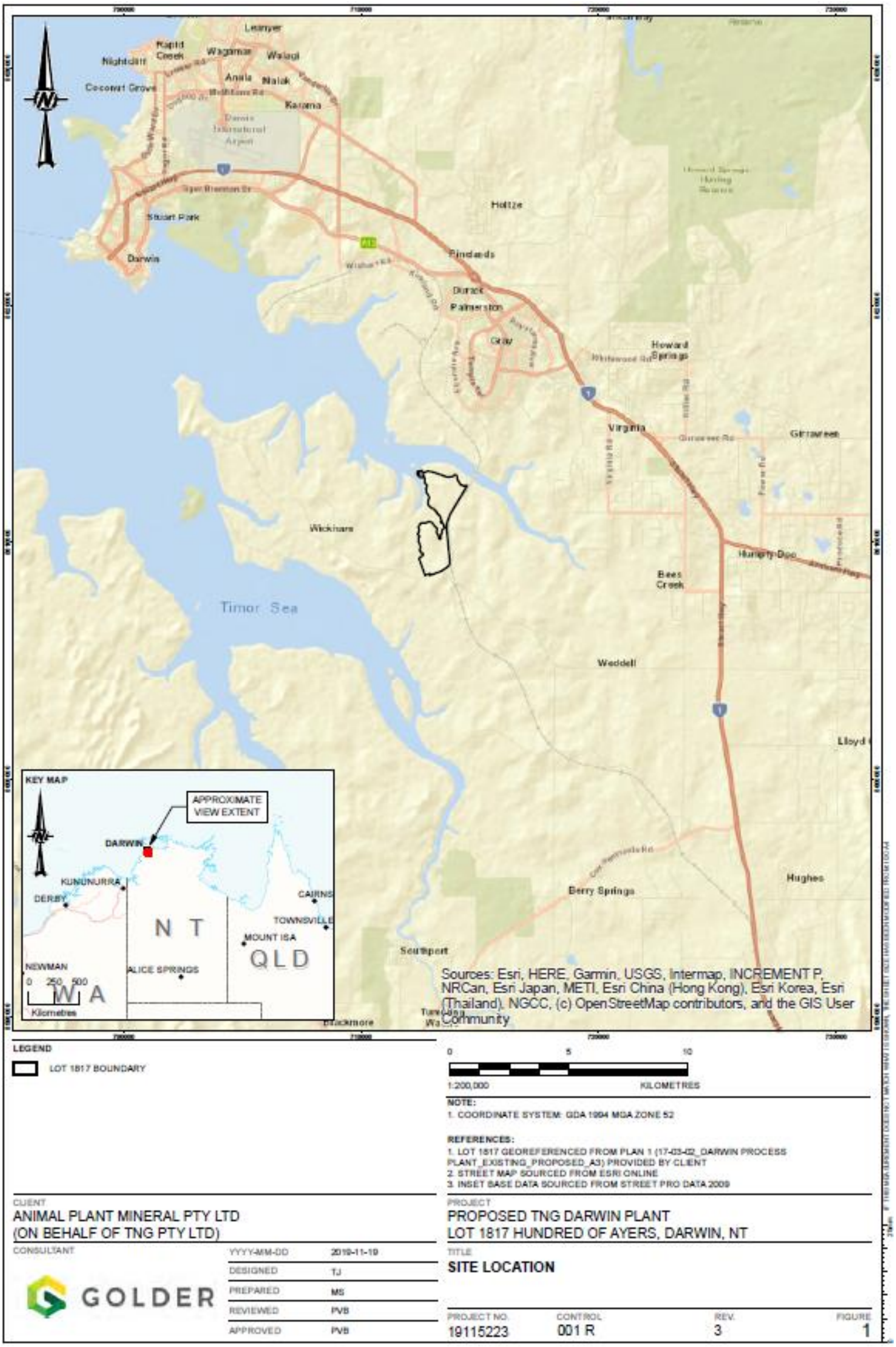

Figure 1-1: Site Location

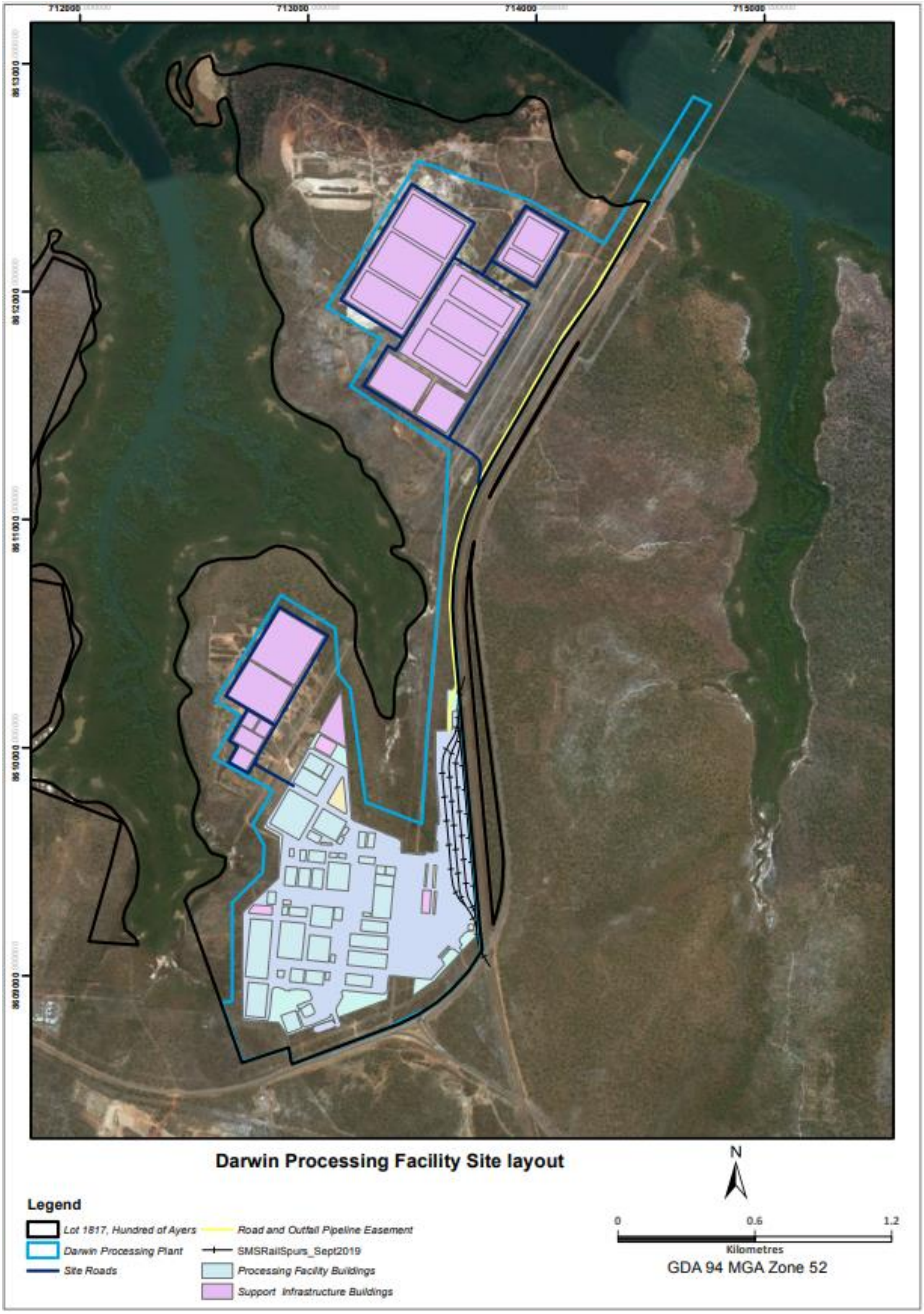

Figure 1-2: Darwin Processing Facility Site Layout

1.2 PROPONENT DETAILS

TNG operates the Project. TNG's details are summarised in Table 1-1.

Table 1-1: Operator Details

Company	TNG Limited
Contact	Paul Burton Managing Director
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1.3 SCOPE

The scope of this ASSMP includes all construction and operational activities that have the potential to disturb ASS.

Golder Associates Pty Ltd (Golder) conducted a preliminary site contamination investigation (PSI) and preliminary Acid Sulfate Soil assessment for the proposed Darwin Processing Facility Site (Golder, 2019). The objective of this work was to provide an indicative data set on the presence and distribution of PASS/ASS at the proposed Darwin Processing Facility site and provide indicative baseline soil and surface water quality data. The assessment included a desktop study, site based sampling (water and soil) and associated laboratory analysis and reporting. The Golder report is included as Appendix A.

1.3.1 Objectives

The objectives of this Acid Sulfate Soil Management Plan (ASSMP) are to minimise the risk to the environment resulting from ASS by:

- Defining areas of ASS;
- Outlining proposed management actions;
- Describing proposed monitoring requirements and contingency methods for implementation;
- Outlining the proposed reporting, review and audit requirements.

1.4 LEGISLATION

This Acid Sulfate Soils Management Plan has been prepared to fulfil the commitment made by the Proponent to the Northern Territory Environmental Protection Authority (**NT EPA**) when preparing the Environmental Impact Statement (**EIS**).

1.5 ACID SULFATE SOILS

Acid Sulfate Soils (ASS) are naturally occurring soils, sediments and peats that contain iron sulfides, predominantly in the form of pyrite materials. These soils are commonly found in estuarine and river settings and low-lying land bordering the coast.

ASS materials are benign when in a waterlogged state. However, when these soils or sediments are drained or excavated, oxygen from the atmosphere reacts with the iron sulfides in the soil; resulting in the production of sulfuric acid. This acidity releases elements such as metals and nutrients from the soil profile which can then be mobilised/transported to waterways, wetlands and groundwater systems, often with damaging environmental and economic impacts (DER, 2015a).

The oxidation of metal sulfides is a natural weathering process that generally occurs slowly and does not pose an environmental concern. However, excavation and drainage can exponentially increase the rate of acid generation. Additionally, water draining from oxidised ASS can be strongly acid, which acts on soils and sediment to produce high solution concentrations of toxic metals, especially aluminium and iron. These high concentrations of metals may have a deleterious effect on human health, the environment and potentially damage infrastructure.

Potential Acid Sulfate Soils (PASS) are soils containing iron sulfides or sulfidic materials in an anaerobic environment and therefore have not been exposed to air and oxidised. However, if disturbed and exposed to air and oxidised, PASS become Actual Acid Sulfate Soils (AASS).

For the purpose of this management plan, the term ASS also includes PASS.

2 EXISTING ENVIRONMENT

2.1 DARWIN REGION

2.1.1 Climate, Topography and Soils

The average annual rainfall for Darwin is 1,720 millimetres (mm), with the wettest months being January to March. Rainfall is higher than evaporation from December to March and lower from April to November. The mean maximum temperature range is from 30.6°C (July) to 33.3°C (October and November) (Golder, 2019).

The Darwin Processing Facility site is in a low-lying area of the Middle Arm Peninsula adjacent to the Elizabeth River (Figure 1-1). The intertidal areas associated with the Elizabeth River estuary are 50 to 200 m from the edge of the site and drain into the Darwin Harbour after periods of regular rainfall. During periods of prolonged rainfall (particularly during the wet season) the surface soil layer becomes saturated leading to overland flow in some areas of the site and localised pooling of surface water in other areas.

The site boundary ranges between 0.1 m and 20 m above height datum (AHD), with the land sloping down toward the river and upward inland. The topography of the surrounding region is similar. The clayey nature of the underlying soils and the surrounding area results in localised pooling of rainfall and limited/low infiltration rates.

The site is largely vegetated with trees and other vegetation; although there are several tracks and previously cleared areas throughout. The coastline of the site is fringed by mangrove to the north and west (Golder, 2019).

2.2 GEOLOGY

2.2.1 Regional Setting

The underlying geology of the area as reported by Golder (2019) is shown in Figure 2-1 and described as:

- Quaternary (Q):
  - Qcl - Sand; silt; clay: colluvial sediments deposited by unconcentrated surface runoff
  - Qca - Mud; clay; silt: intertidal marine alluvium
- Tertiary (Cz):
  - Czs - Unconsolidated sand; ferruginous, clayey, sandy and gravelly soil; common limonite pisolites
  - Czl - Pisolitic and mottled laterite; Ferricrete: in situ and reworked remnants of standard laterite profile
- Early Proterozoic – Finniss River Group – Burrell Creek Formation (Pf)
  - Pfb - shale, siltstone and phyllite in places colourbanded fine to very coarse sandstone (quartz arenite, sublitharenite, arkose); quartzite; quartz pebble conglomerate; minor graphitic phyllite; quartz -mica schist and gneiss.

The Burrell Creek Formation consisting of shale, siltstone and phyllite is present across the whole site. These rocks are understood to be steeply dipping and tightly folded, having undergone metamorphism altering the parent rock to phyllite. Slates, mica schist, and gneiss are also believed to be present in the Burrell Creek Formation. Hard black mica schist has been encountered in the southern peninsula at a depth of approximately 50 m bgl. The upper portion of the formation has undergone significant weathering and is in some areas described as residual soil.

The exposed Burrell Creek Formation in a tropical monsoonal climate environment has resulted in chemical weathering producing lateritic soils. The geological map (Figure 2-1) indicates that lateritic soils (CzS, Czl) are present over most of the Darwin Processing Facility site, predominantly consisting of sand and gravel. In the southern part of the southern peninsula (upper reaches of the tributaries flanking the site) colluvial sediments (Qcl) from surface runoff are present. The intertidal marine alluvium is present along the fringes of the site, in the intertidal zone of Elizabeth River and the tributaries, which is covered by mangrove (Golder, 2019).

2.2.2 Local Setting

The subsurface conditions at the site have been generalised as:

- Sandy gravel/gravelly sand (inferred to be lateritic soils) extending from surface to the depths of 2.5 m bgl (maximum thickness of 2.5 m) overlying
- Silt and clay (inferred to be weathered Burrell Creek Formation) extending to the end of investigation depth at 21.5 m bgl (maximum thickness of 17 m).

The soil and weathering profile have been historically modified by quarrying activities, which removed the gravels from the laterite weathering profile areas. Many areas now comprise of sandy re-laid soils on weathered bedrock.

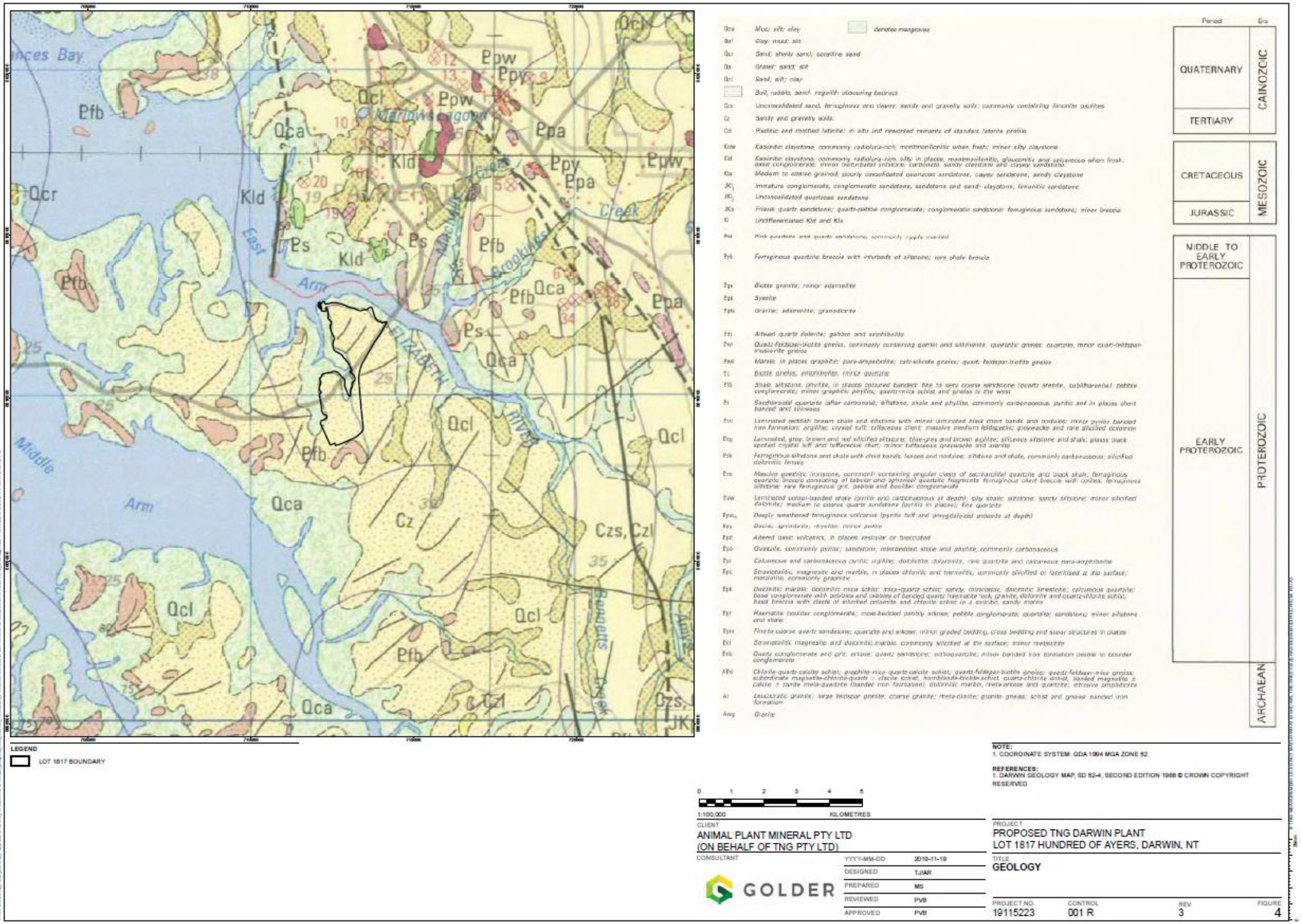

Figure 2-1: Underlying Geology of the Area

2.3 HYDROGEOLOGY

Aquifers within the proposed Darwin Processing Facility site are likely to occur locally within unconfined sediments and within weathered or fractured bedrock.

The aquifer at the site consists of:

- Unconfined lateritic sand and gravel, overlying
- The weathered and fractured rock aquifer of the Burrell Creek Formation overlying
- The unweathered (low yielding) rock aquifer of the Burrell Creek Formation.

In general, the regional groundwater flow would be north westerly towards Elizabeth River; however, locally the groundwater flow is expected to flow radially from the centre of the site towards the tributaries and Elizabeth River.

The aquifers are likely unconfined and therefore receive direct rainfall recharge. The rainfall infiltrates first into the laterite soils, then into the weathered and unweathered formation below.

Groundwater discharges into tributaries or the Elizabeth River before flowing into the Darwin Harbour. The groundwater level generally follows the topography of the site. Groundwater levels were recorded in May 2019 with depths ranging from 1.5 m bgl (northern peninsula) to 3.1 m bgl (southern peninsula). There may be significantly large seasonal variation in groundwater level (Golder, 2019).

2.4 HYDROLOGY

Golder (2019) identified the following hydrological features at or around the site:

- Elizabeth River
- Two areas associated with the Elizabeth River Estuary
- Three surface water features located at the northern peninsula
- Two surface water features located at the southern peninsula

The surface water features include two small dams that were presumably associated with the historical quarrying activities. The clayey nature of the underlying surface soils results in limited/low infiltration rates and may result in in localised pooling of water at surface after significant rainfall events.

Darwin Harbour is characterised by a macro-tidal regime with a maximum range of 8.1 m. Additionally, Darwin Harbour has a semi-diurnal tide cycle, meaning it experiences two high and two low tides of approximately equal size every 24 hours (Golder, 2019).

The highest and lowest expected tidal level at any location is termed Highest Astronomical Tide (HAT) and Lowest Astronomical Tide (LAT) respectively. In Darwin Harbour the HAT is 4.0 m AHD and the LAT is –4.2 m AHD. Potential storm surge levels can be approximately 5 m AHD.

2.5 CURRENT AND HISTORICAL LAND USE

2.5.1 Historical Use

The northern peninsula appears to have been used historically as a quarry for the extraction of sand, soil and gravel, commencing in 2002 and ceasing around 2017 (Golder, 2019). Little publicly accessible information is available regarding land use prior to quarrying activities.

2.5.2 Local Usage of Ground and Surface Waters

Groundwater and surface water are within the 'Darwin Rural' water control district and were previously used for historical quarrying activities. Golder (2019) reported three registered bores within a 1km radius of the proposed Darwin Processing Facility site, and one additional borehole within 1km of the site boundary. The locations of these bores are shown in Figure 2-2. The use of these bores was likely associated with the use of groundwater for industrial use in historical quarrying activities.

2.6 POTENTIAL TRANSPORT PATHWAYS AND RECEPTORS

Potential transport pathways of ASS include:

- Vertical infiltration from surface to groundwater due to areas of permeable/granular enabling gradual infiltration
- Later migration of surface water/runoff, particularly in areas where soil infiltration is poor and surface pooling is commonplace
- Lateral migration via groundwater (with groundwater anticipated to migrate radially towards Elizabeth River and Darwin Harbour Upper Estuary).

Potential receptors of contaminated soil include:

- Ecological receptors of the Elizabeth River and Upper Darwin Harbour Estuary (flora and fauna)
- People using Elizabeth River and Upper Darwin Harbour Estuary (recreational users and consumption of fish).

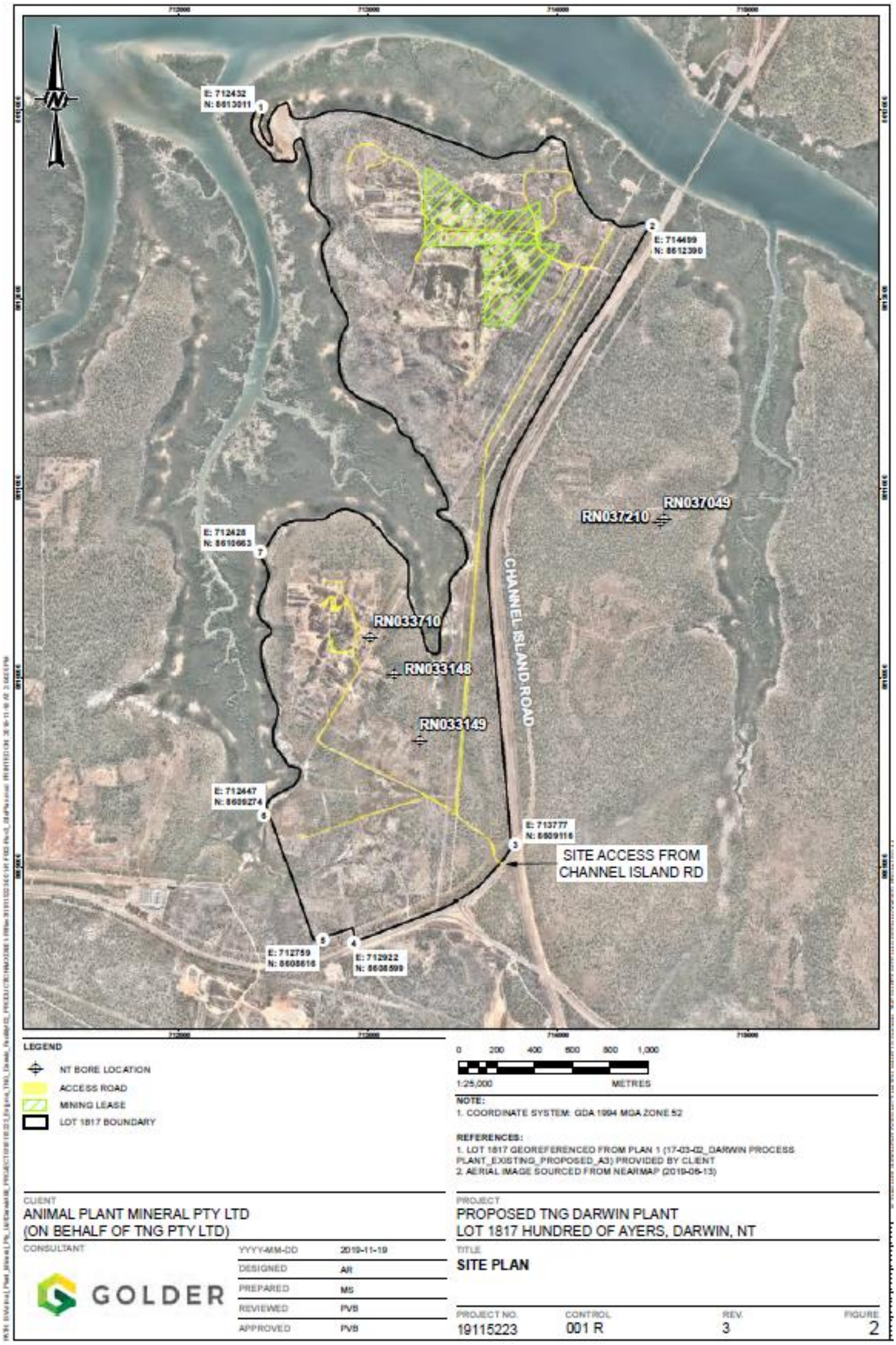

Figure 2-2: Location of Existing Bores in the Area

2.7 SITE INVESTIGATION AND RESULTS

2.7.1 ASS Investigation

Golder (2019) undertook soil sampling in general accordance with the National Environment Protection (Assessment of Site Contamination) Measure 'Schedule B2 Site Characterisation'. Soil samples were transferred directly into a clean, laboratory-supplied sample jar for subsequent analyses. Each sample location was logged in the field and visually inspected for particle size, colour, staining and odour. Full methodology details, quality assurance and control measures and results of the soil testing are presented in Appendix A.

A total of 110 soil samples were submitted for ASS field screening analysis (comprising pH_F and pH_{FOX}), to identify the presence of PASS and ASS. The adopted assessment criteria are shown in Table 2-1.

Table 2-1: Field Screening Assessment Criteria

pH Value and Reaction	Result
A strong reaction of soil with hydrogen peroxide	An indicator of ASS but cannot be used in isolation
pH_{FOX} value at least of one unit below pH_F; accompanied by a reaction to hydrogen peroxide	May indicate PASS but is dependent upon the initial and final pH values
pH_{FOX} <3, accompanied by a strong reaction to hydrogen peroxide, and a large change in pH	Strong indication of PASS
pH_{FOX} 3-4, accompanied by a reaction hydrogen peroxide	Possible indication of PASS
pH_{FOX} 4-5	Inconclusive test results
pH_{FOX} >5, accompanied by little change in pH from pH_F but accompanied by a reaction to hydrogen peroxide	Little net acidifying ability is indicated

The results of this analysis indicated:

- No samples had a high potential for PASS
- Medium potential for PASS was determined in 87 samples
- Low potential for PASS was determined in 22 samples.

Based on these results, a further 33 samples were selected for Chromium Reducible Sulfur (CrS) analysis. These results provide a concentration of inorganic sulfur which is not subject to potential interference from concentrations of organic sulfur. The suite of analyses is used to confirm the presence of PASS or ASS according to the criteria in Table 2-2.

Table 2-2: Chromium Reducible Sulfur Suite Assessment Criteria

pH Value and Reaction	Result
A strong reaction of soil with hydrogen peroxide	An indicator of ASS but cannot be used in isolation
pH_{FOX} value at least of one unit below pH_F; accompanied by a reaction to hydrogen peroxide	May indicate PASS but is dependent upon the initial and final pH values
pH_{FOX} <3, accompanied by a strong reaction to hydrogen peroxide, and a large change in pH	Strong indication of PASS
pH_{FOX} 3-4, accompanied by a reaction hydrogen peroxide	Possible indication of PASS
pH_{FOX} 4-5	Inconclusive test results
pH_{FOX} >5, accompanied by little change in pH from pH_F but accompanied by a reaction to hydrogen peroxide	Little net acidifying ability is indicated

This analysis found no areas of PASS; however, 15 different samples were assessed to be ASS. These samples were obtained from seven different locations (Figure 2-3):

<u>Northern peninsula</u>

- BH01 – weathered laterite and clay of weathered siltstone
- BH06 – silt and weathered siltstone

<u>Southern peninsula</u>

- BH02 – inferred weathered laterite
- BH05 – weathered laterite
- BH07 – weathered laterite and siltstone
- BH09 – weathered laterite, clay and weathered siltstone
- BH10 – weathered laterite and siltstone.

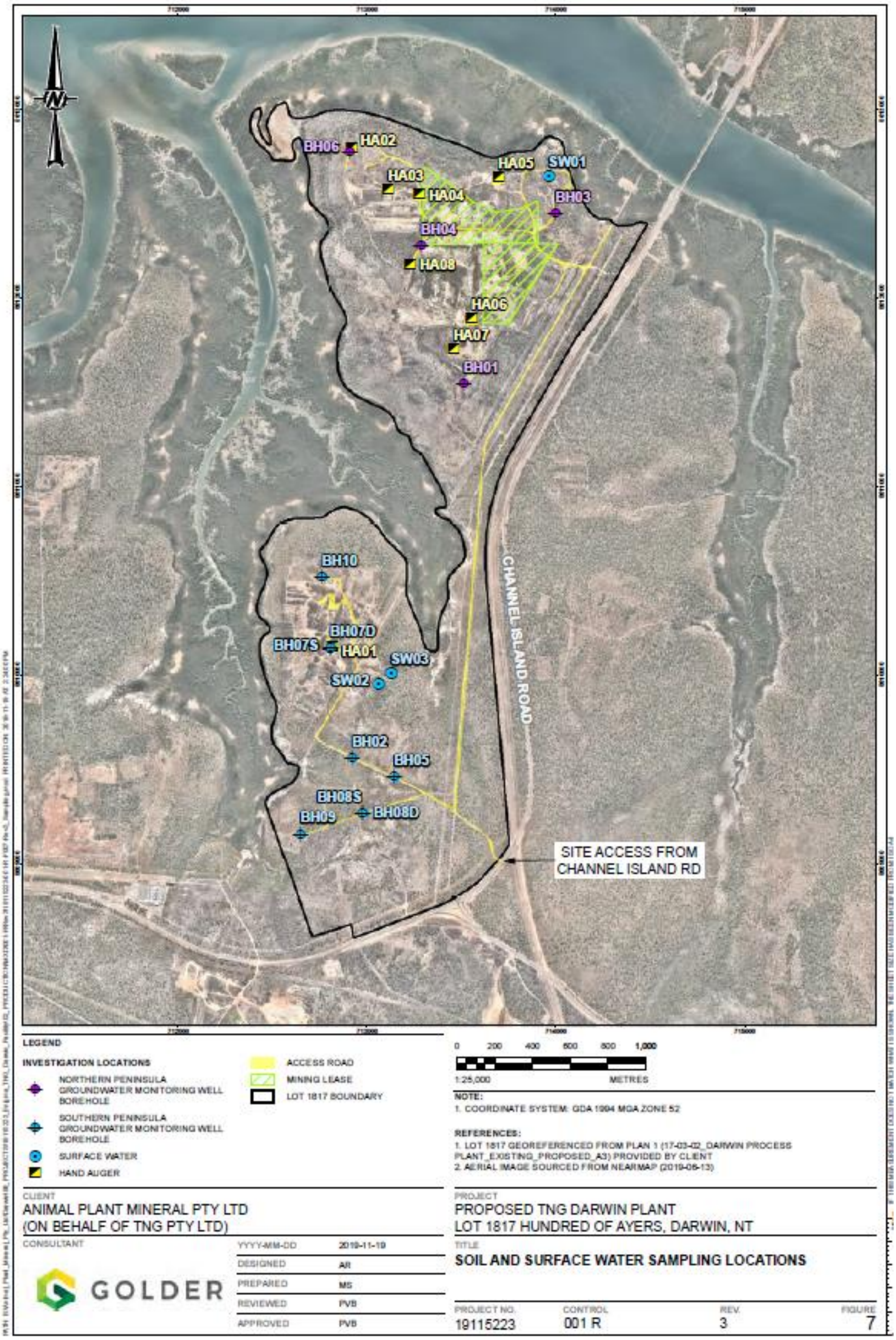

Figure 2-3: Soil and Surface Water Sampling Locations

2.7.2 Soil Investigation

Golder (2019) reported the encountered sub-surface conditions during the soil sampling were broadly in accordance with that described in Section 2.2. The encountered shallow strata comprised superficial coastal alluvium (including estuarine deposits and can be summarised as:

- Clay – Medium plasticity, sandy, slightly gravelly red-grey mottled clay. Sand is brown, fine, sub-rounded to sub-angular. Gravel is medium grained, sub-angular to sub-rounded with variable moisture, no odour.
- Clayey sand – Brown, fine to medium, slightly clayey, sub-rounded to sub angular sand with variable moisture, no odour.
- Sand – Yellow, fine to medium grained, slightly gravelly, sub-rounded to sub-angular sand. Gravel is medium grained, sub-angular to sub-rounded with variable moisture, no odour.

The encountered lithologies were noted to be variably clayey and gravelly, and the extent of grey/red mottling was also noted to vary across the site (Golder, 2019).

No elevated levels of nutrients were detected, and low levels of chloride measured were consistent with the geography of the land and proximity to the marine environment (Golder, 2019). All soil samples were acidic with a pH ranging from 4.9 - 6.1 (average pH 5.4).

Soil quality baseline data is provided in Appendix A.

2.7.3 Water Investigation

Surface water quality at the locations sampled indicated water bodies are accumulations of rainwater that has not been influenced by the nearby marine environment. No contamination was detected in the surface water.

Surface water quality baseline data is provided in Appendix A.

2.8 ASS INVESTIGATION – SUMMARY

The surface water quality at the locations sampled indicate that the water features are accumulations of rainwater that has not been influenced by the nearby marine environment. No contamination was detected in the surface water.

The concentrations of iron in the soil are indicative of the predominantly clayey nature of much of the encountered soil, and the acidic condition of the soil (lowest pH 5.1). The iron levels likely result from iron oxide precipitation from the underlying iron rich estuarine deposits.

ASS was detected at numerous locations. The distribution of the identified ASS indicates that the ASS is generally driven by the typical high-weathering potential and the site’s climatic conditions. There is a high potential for ASS to be encountered more broadly across the site during the proposed construction works for the project.

Further information regarding the investigation conducted by Golder (2019) is provided in Appendix A.

Golder (2019) recommended additional investigation of ASS be undertaken at the specific locations that will be disturbed by the proposed construction works, to inform the ASS management measures that will be required.

3 IMPACTS AND RISK ASSESSMENT

3.1 POTENTIAL IMPACTS

Unmanaged disturbance of areas of ASS and consequent acid drainage from these areas can cause adverse impacts to the terrestrial environment, including, but not limited to:

- Adverse changes to the quality of soil and water;
- Degradation of wetlands, water-dependent ecosystems and ecosystem services;
- Loss of habitat ecosystem complexity and biodiversity, both terrestrial and benthic habitat and communities;
- Invasion and dominance of wetlands and waterways by acid-tolerant water plants and plankton species;
- Reduction of soil stability and fertility;
- Deterioration in water quality sources for stock, irrigation and human use by increasing acidity and heavy metal concentrations;
- Acidification of surface water bodies increasing mosquito breeding, which may increase the prevalence of mosquito-borne diseases such as Ross River virus;
- Loss of visual amenity due to rust coloured stains from iron precipitates at the soil surface;
- Long term infrastructure damage through acidic water corroding metallic and concrete structures; and
- Increased financial burden of treating and rehabilitating affected areas and maintenance of infrastructure.

3.2 RISK ASSESSMENT

Risk assessment is a process which determines the frequency of occurrence of an event and the probable magnitude of adverse effects. It involves identifying environmental aspects, related hazardous events, their causes and environmental impacts. Risk analysis examines the controls to prevent the environmental impact from occurring or mitigate the severity of the impact (consequence). It also analyses the potential consequence and the likelihood of an impact of this severity occurring. Table 3-1 and Table 3-2 define the Likelihood and Consequence categories used in the risk assessment, whilst Table 3-3 shows the Environmental Risk Matrix.

An indicative summary of the key potential impacts expected with construction of the Darwin Processing Facility site, with respect to ASS, and their associated management measures are provided in Table 3-4.

along with the associated severity, likelihood and residual risk. This risk assessment is subject to change as the project develops and will be reviewed and updated as necessary throughout the life of the project.

Table 3-1: Likelihood of an Environmental Risk Occurring

Likelihood	#	Description
Almost Certain	A	The event/ impact will occur or is expected to occur. The impact occurs regularly in association with similar projects and/ or in similar environments.
Likely	B	The impact will probably occur in most circumstances but there is some uncertainty about the likelihood. The impact has occurred on more than one occasion in association with similar projects and/ or in similar environments.
Possible	C	The impact could occur in some circumstances. The impact has occurred infrequently on similar projects and/ or in similar environments.
Unlikely	D	The impact is not expected to occur. The impact occurs very infrequently on similar projects and/ or in similar environments.
Rare	E	The impact is very unlikely to occur. The impact has not occurred on similar projects and/ or in similar environments.

Table 3-2: Consequence of an Environmental Risk

Consequence	#	Description
Insignificant No noticeable/ measurable impact to values	1	No measurable soil disturbance, erosion or contamination.
Minor A Minor impact has two or more of the following characteristics: Limited - Impact limited to the Site Very Low - Impact does not significantly alter the quality, distribution or abundance of environmental values Short term - Impact that is felt up to completion of construction	2	Short term soil disturbance, erosion or contamination in the vicinity of the Site that is reversible without significant remedial works.
Moderate A Moderate impact has two or more of the following characteristics: Localised - Impact is confined to the Site and areas directly adjacent to the Site, such as other allotments, Elizabeth River, and estuarine watercourses adjacent to the Site Low - Impact alters the quality, abundance or distribution of environmental values without compromising their integrity, and can be easily and cheaply reversed Medium term - Impact that is felt up to completion of operations	3	Medium term soil disturbance, erosion or contamination in the vicinity of the Site that that alters soil characteristics but with no measurable impact to environmental values that rely on good soil quality and can be remediated.
Major Regional - Impact extends to the Darwin/ Palmerston region, and/ or greater Darwin Harbour Moderate - Integrity of environmental values altered but impact can practicably be reversed Long term - Impact that is measurable post-Project	4	Soil disturbance, erosion or contamination that compromises regional environmental values that rely on good soil quality, and would be costly and technically challenging to remediate
Severe A Severe impact has two or more of the following characteristics: Widespread - Impact occurs at a NT, national, international or global scale High Intensity - Impact irreversibly compromises the integrity of environmental values Permanent - environmental values will not recover on human time scales	5	Soil disturbance, erosion or contamination that is measurably and permanently impacting environmental values that rely on good soil quality throughout the NT

Table 3-3: Environmental Risk Matrix

			Consequence				
			1	2	3	4	5
			Insignificant	Minor	Moderate	Major	Severe
Likelihood	A	Almost Certain	Medium	Medium	High	Very High	Very High
	B	Likely	Medium	Medium	High	Very High	Very High
	C	Possible	Low	Medium	Medium	High	Very High
	D	Unlikely	Low	Low	Medium	Medium	High
	E	Rare	Low	Low	Low	Medium	High

Table 3-4: Environmental Risk Assessment

Risk	Potential Impact	Risk Ranking	Mitigation	Residual Risk Ranking
Disturbance of ASS during clearing and earthworks	Acidification of soils, surface water and groundwater (including potential metal leaching and contamination) Integrity of infrastructure compromised due to exposure to acidic environment	Medium (C3)	Disturbance of ASS to be avoided where possible, including constructing infrastructure on piles above ground level. Excavated ASS to be treated during construction to prevent acidic fluids leaching into surface water or groundwater. Project design to incorporate corrosion resistant materials where required.	Medium (D3)
Incorrect handling of ASS/PASS	Acidification of surface water and groundwater (including potential metal leaching and contamination)	Medium (C3)	Material free of ASS will be used to construct any bunds that may be required. Preparation of compliant treatment pads. The area will be fully contained/constructed such that drainage/runoff water from the pad is directed to an appropriate receptacle for testing and treatment (if required). Any spilled ASS material is to be transferred to the treatment pad immediately.	Medium (D3)
Incorrect treatment of ASS/PASS		Medium (C3)	ASS treatment pads will have a guard layer of aglime applied at a nominal rate of 10kg/m^2. ASS material will be transferred to the treatment pad and placed on top of the guard layer. If ASS is to be treated in more than one layer, enough time will be allowed for validation testing and compliance of a layer before addition of extra material. ASS material is to be spread out in windrows of 300 mm loose thickness for drying. Once dry, fine aglime will be applied evenly over the surface and thoroughly mixed into the soil. The Acid Neutralising Value (ANV) of the aglime supplied may not be 100% (as assumed for pure lime) and will be identified from documentation provided by the lime supplier. If less than 100% a correction factor of 100/ANV will be applied to reach the equivalent of pure fine aglime. Treated ASS shall not be removed from the site until monitoring shows that performance indicators have been met.	Low (E3)
Retained water becomes acidified		Medium (C3)	All stormwater or ASS leachate from stockpiles or other exposed areas shall be diverted to a retention ponds for monitoring and treatment (if required). pH, water level, Electrical Conductivity, total iron and aluminium concentrations to be monitored within any pond of retained water in current operation. Hydrated lime to be available for pH adjustment of water if required.	Medium (D3)

Risk	Potential Impact	Risk Ranking	Mitigation	Residual Risk Ranking
			Monitoring of wastewater conducted prior to discharge indicates parameters comply with the performance indicators.	
Large scale vegetation clearing	Soil erosion resulting in disturbance of ASS	Medium (C3)	Vegetation clearing to be undertaken in stages and in dry season conditions wherever possible. Erosion protection measures (bunding, spoon drains, silt fencing and sediment ponds) will be installed to contain any erosion.	Medium (D3)
Incorrect storage of lime and hydrated lime	Damage to or death of native flora	Medium (C2)	Lime will be stored in a containment area adjoining the treatment pad (so that any discharge from the area is directed into the treatment pad). Appropriate weatherproof storage of hydrated lime.	Low (E2)

4 MANAGEMENT STRATEGIES

In situations where a potential to disturb ASS exists, the works will require the implementation of the controls detailed in this plan. Prior to any excavation in areas not previously sampled for ASS, a representative surface and sub surface soil sampling and analysis program will be undertaken to characterise the material to be excavated.

No dewatering or groundwater extraction will occur at the site. Water bores will be used for monitoring purposes only.

4.1 MANAGEMENT OF ASS MATERIAL

Prior to construction, further investigations for ASS will be undertaken at specific locations that have not been previously sampled and will be disturbed by the proposed construction, to assess the extent of ASS. In order to verify the nature of the disturbed or excavated material during construction, material will be sampled and tested in a laboratory using National Association of Testing Authorities (NATA) approved methods.

Where possible, disturbance of ASS will be avoided. Where disturbance is unavoidable, disturbance will be minimised or otherwise managed to prevent environmental impacts caused by the oxidation of ASS. Potential management actions are outlined in Table 4-1.

Table 4-1: Mitigation measures for terrestrial environmental quality

Risk	Mitigation hierarchy	Mitigation measure
Exposure of humans and the environment to COPC's from fly-tipped waste	Avoid, minimise	• Removal of fly-tipped waste from the site using accredited waste specialists • Inspection of disturbed areas and fly-tipped waste for the presence of asbestos; removal, transport and disposal of asbestos using licensed specialists.
Disturbance of ASS during clearing and earthworks	Avoid, minimise, rehabilitate	• Undertake a geotechnical assessment prior to construction, incorporating ASS assessment. • Disturbance of ASS to be avoided where possible, including constructing infrastructure on piles above ground level. • Excavated ASS to be treated during construction to prevent acidic fluids leaching into surface water or groundwater.
Incorrect handling of ASS/PASS	Avoid, minimise, rehabilitate	• Material free of ASS will be used to construct any bunds that may be required. • Preparation of compliant ASS treatment pads. The area will be fully contained/constructed such that drainage/runoff water from the pad is directed to an appropriate receptacle for testing and treatment (if required). • Any spilled ASS material is to be transferred to the treatment pad immediately.
Incorrect treatment of ASS/PASS	Avoid, minimise, rehabilitate	• ASS treatment pads will have a guard layer of agricultural lime applied at a nominal rate of 10kg/m^2. • ASS material will be transferred to the treatment pad and placed on top of the guard layer. If ASS is to be treated in more than one layer, enough

Risk	Mitigation hierarchy	Mitigation measure
		time will be allowed for validation testing and compliance of a layer before addition of extra material. • ASS material is to be spread out in windrows of 300 mm loose thickness for drying. Once dry, fine agricultural lime will be applied evenly over the surface and thoroughly mixed into the soil. • The Acid Neutralising Value of the agricultural lime supplied may not be 100% (as assumed for pure lime) and will be identified from documentation provided by the lime supplier. If less than 100%, a correction factor of 100/ Acid Neutralising Value will be applied to reach the equivalent of pure fine agricultural lime. • Treated ASS shall not be removed from the site until monitoring shows that performance indicators have been met.
Retained water becomes acidified	Avoid, minimise, rehabilitate	• All stormwater or ASS leachate from stockpiles or other exposed areas shall be diverted to a retention ponds for monitoring and treatment (if required). • pH, water level, Electrical Conductivity, total iron and aluminium concentrations to be monitored within any pond of retained water in current operation. • Hydrated lime to be available for pH adjustment of water if required. • Monitoring of wastewater conducted prior to discharge indicates parameters comply with the performance indicators.

The recommended neutralising agent is fine agricultural lime (Aglime) composed of a minimum 97% (preferably 99%) calcium carbonate ($CaCO_3$). Liming rate has been identified in the Golder report (2019) as one kilogram (kg) $CaCO_3$/t. A Lime Register detailing deliveries and lime application records will be maintained. Treated soils may be used as backfill or disposed of at designated sites.

Covering in situ soils with clean fill

If groundwater levels are not affected by earthworks, undisturbed in situ ASS can be covered with a significant volume of fill. A suitable depth of fill will be determined on a location specific basis, depending on the severity and extent of ASS.

Maintaining soils beneath the water table

If development is to occur in an area underlain by ASS, it may be possible to maintain in situ soils beneath the water table to prevent oxidation of sulfides, before the commencement of earthworks. Soils may be flooded or remain buried in water to maintain a saturated state.

Staged disturbance of ASS

Where the volume of ASS to be disturbed is greater than 100 m^3, disturbance will be staged such that any potential effects on any area disturbed at any one time are limited and managed, the amount of time that ASS is exposed to the atmosphere is minimised (i.e. minimise the time that excavations are left open) and neutralisation of ASS materials occurs as soon as practicable.

4.1.1 Stockpiling

Significant quantities of acid can build up, especially in porous sandy stockpiles, if left in an oxidising condition for even short periods of time. Large stockpiles are difficult to neutralise, primarily due to the earthmoving needed. Stockpiles will be created, up-gradient of development sites, such that all leachate and run-off water will be directed towards already-disturbed ASS areas.

Stockpiling of untreated ASS will only be undertaken as a short-term activity. Short-term stockpiling may be needed due to weather conditions preventing treatment or delays obtaining laboratory results.

4.2 GROUNDWATER MANAGEMENT

Activities that may cause the water table to fall in areas underlain by ASS have the potential to cause sulfide minerals in the soil to oxidise and leach, arsenic, metals and nutrients into groundwater, and increase acidity. Additionally, the discharge of acidic contaminated groundwater to nearby wetlands or waterways can adversely affect the health of these aquatic ecosystems and may also make these water features unsuitable for recreational use.

Activities that can cause the water table to fall during construction activities include (but are not limited to) groundwater abstraction for dust suppression and excessive use of bores. No dewatering or groundwater extraction will occur at the site. Wastewater will be discharged to Elizabeth River or East Arm via a pipeline. Existing water bores will be used for monitoring purposes only.

5 MONITORING AND REPORTING

5.1 MONITORING

Monitoring activities will be undertaken throughout the life of the Project in relation to the identified objectives and targets. The detail of monitoring activities will be determined once infrastructure design and associated construction methodologies have been decided upon, following completion of geotechnical investigations.

Indicative monitoring includes:

- Treated soil will be monitored for successful neutralisation before being moved or covered. One test (comprising six composite samples) of the limed material will be conducted per 250 m^3 of treated material. Sample handling, transport and testing will be conducted using the appropriate guidelines, chain-of-custody protocols and accredited laboratory.

- Existing water bores will be utilised for the purpose of groundwater monitoring, including pH and groundwater level. Groundwater monitoring will be conducted on a quarterly basis.

- Monitoring of pH and total acidity of any pools of water collected within bunds and treatment of water to keep the pH in the range of baseline data.

5.2 OBJECTIVES, TARGETS AND INDICATORS

The objectives, targets and indicators for the management of ASS are shown in Table 5-1.

Table 5-1: ASS Management Objectives, Targets and Indicators

Objectives	Targets	Indicators
Minimise disturbance of ASS outside designated construction and earthworks areas	No incidents of disturbance to ASS outside of the areas of unavoidable disturbance required for infrastructure construction	Incident reports and the area and quantity of disturbance outside the designated footprint
Handle and dispose of all excavated ASS in accordance with outlined management strategies	No incidents of excavated ASS handled or disposed in a manner outside of the agreed management strategies	Records of ASS removal to approved disposal facilities or locations Incident reports of non-compliance with management strategies
Disturbed ASS is treated and neutralised in accordance with outlined strategies	All treated ASS is successfully neutralised	Monitoring of treated ASS indicates no net acidity in soil
Minimise changes in surface and groundwater quality	No significant alteration in pH or heavy metal concentration in surface and groundwater, above baseline data range	Monitoring results indicate pH and heavy metal concentration are within baseline data range

5.3 AUDITING, NON-COMPLIANCE AND CORRECTIVE ACTIONS

The Environmental Manager will be responsible for ensuring that a regular auditing program of activities and ASS management measures is implemented. The audit program shall aim to ensure compliance with the ASSMP and relevant statutory requirements. The audit will take the form of a visual inspection of the works, treatment sites, associated control measures and a review of monitoring data. A written record of auditing undertaken will be maintained, including details on the date of the audit, activities undertaken, observations made and any nonconformances identified. Frequency of these audits may gradually decrease if a high level of compliance with the ASSMP is evident.

Non-compliance with any of the controls outlined in this document will be classified as an incident. Any non-compliance to the ASSMP must be addressed as soon as is practical. The personnel responsible for the non-compliance must be notified immediately for purposes of issuing rectification instructions. The detection of incidents associated with ASS will trigger internal notifications, reporting requirements, investigation and corrective and preventative actions. Incidents include:

- Changes in sediment, surface or groundwater pH; or heavy metal concentrations above baseline monitoring data
- Changes in vegetation health adjacent to ASS areas caused by acid drainage
- Non-compliance with the agreed handling, treatment and disposal management procedures of ASS
- Failure to meet identified objectives and targets.

Corrective actions that may be triggered as a result of incident investigations include:

- Increased sampling (frequency and/or location) to confirm the sources of acid leaching or heavy metal contamination

- Construction of leachate drains to capture acidic water for neutralisation
- Neutralising ASS where practicable
- Refresher training to site personnel on ASS management procedures
- Review of ASS management practices to assess practicability of their implementation and/or identify new management practices.

5.4 RESPONSIBILITIES

The Site Manager is responsible for ensuring that all requirements of the ASSMP are met during the project, including ensuring the strategies and procedures outlined in this ASSMP are implemented in accordance with the specified performance criteria.

The Environmental Manager is responsible for reviewing compliance with the ASSMP and development of actions to address non-conformance.

All other site personnel are responsible for implementing strategies and procedures outlined in the ASSMP, as applicable to their work activities.

5.5 REPORTING REQUIREMENTS

Reporting relative to ASS management will comprise an annual report capturing the key criteria, including volumes of ASS disturbed, monitoring results and quantities and methods of ASS treated and disposed of. The report will discuss and evaluate the performance of the ASSMP, including the effectiveness of the operating strategies, comparison of monitoring results against performance indicators, any incidents that have occurred and the effectiveness of any corrective action adopted.

Should an environmentally significant incident occur, this will be reported to the relevant statutory authority by the Environmental Manager within 24 hours of the incident being identified.

Following completion of the project, a closure report will be prepared and submitted in accordance with the relevant guidelines. The report will include the relevant management measures undertaken at the site, the results of monitoring programs, potential risks to human health or the environment and the discussion of any remedial measures required

6 TRAINING AND AWARENESS

Training will be conducted for all personnel involved in excavation, transport or handling of soils on site and shall be conducted prior to the disturbance of any soils on site. Training will be designed to ensure that personnel are aware of ASS issues on site, can recognise ASS and are aware of their responsibilities in managing ASS. A training register, listing people trained, training dates, name of trainer and signatures of all trainees, will be maintained by TNG.

Toolbox meetings will be conducted on an as needed basis to address issues encountered during the operation and ensure personnel have a current understanding of environmental issues and controls.

7 COMMUNICATIONS

Concerns or complaints raised by the community (or other parties) in relation to ASS will be directed to the Environmental Manager for action. The Environmental Manager will maintain a complaints register including the name of the complainant, the nature of the complaint, details of any investigations, the conclusions from investigations and details of any corrective actions or responses.

Remedial actions (if required) will be discussed and agreed upon with the relevant statutory authority.

8 REFERENCES

ANZECC/ARMCANZ (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1 [online]. Available at: https://www.waterquality.gov.au/sites/default/files/documents/anzecc-armcanz-2000-guidelines-vol1.pdf

DER (2015a). Identification and investigation of acid sulfate soils and acidic landscapes [online]. Available at: https://www.der.wa.gov.au/images/documents/your-environment/acid-sulfate-soils/fact_sheets/Identification_and_investigation_of_acid_sulfate_soils_and_acidic_landscapes.pdf

DER (2015b). Treatment and management of soil and water in acid sulfate soils landscapes [online]. Available at:https://www.der.wa.gov.au/images/documents/your-environment/acid-sulfate-soils/guidelines/Treatment_and_management_of_soil_and_water_in_acid_ss_landscapes.pdf

Golder Associates Pty Ltd (2019). Preliminary Site Investigation and Shallow Soil Baseline Assessment. Proposed TNG Darwin Processing Facility Lot 1817 Hundred of Ayers, Darwin, NT. Unpublished report for Animal Plant Mineral Pty Ltd.

9 APPENDICES (REFER TO APPENDICES LIST IN EIS)

APPENDIX A: Technical Report for Soils

(Refer to Appendix H of the Draft EIS)