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Acid Sulfate Soils Management Plan

The New Primary School at Warnervale

Prepared for Billard Leece Partnership
2 August 2019

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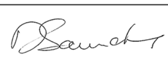
Signature:			
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1 Introduction

1.1 Project overview

The New South Wales Department of Education is delivering more than 170 new and upgraded schools to support communities across NSW. A new primary school in Warnervale is proposed as part of the NSW Government initiative.

The New Primary School at Warnervale is to be located at 75 Warnervale Road, Warnervale. The school is located amongst the planned growth suburbs of Warnervale and Wadalba, within the former Wyong Shire Council Local Government Area (LGA), which now forms part of the recently created Central Coast Local Government Area. The school is surrounded by a large area of bushland which contains a small number of residential properties and is opposite a well-established suburban area to the north-east of the site. Warnervale Oval, which contains playing fields and a 400 metre running track is also situated on the opposite side of Warnervale Road, to the north-east of the site. The site is in close proximity to public transport systems; with Warnervale Train Station being 500 metre (west) from the site, as well as a public bus stop 10m (west) of the school site, providing services to Warnervale Railway Station, Tuggerah Railway Station, Wyong Railway Station and Lake Haven Shopping Centre. The site is situated a short distance from the proposed university and education business park precinct, located to the west of Warnervale Station and forming a key component of the economic development strategy for the district.

The key features of the project include:

- New Core 35 Hall
- New Core 21 Administration & Staff Building
- New Core 21 OOSH
- New Core 21 Canteen
- New Core 21 Library
- New Core 21 (2x) Special Programs
- New Teaching Spaces 20 (Includes 2 Special Education Teaching Spaces)
- New Core 21 Student Amenities
- New Core 21 COLA
- Considerations for Future Expansion
- Staff Carpark 21 Spaces
- Visitor 5 Spaces
- Accessible 2 Spaces
- Related Road Works & Drop off/pick up Zone
- New Games Court

The design is intended to account for the possibility of future expansion of teaching and core facilities for up to 1,000 students.

1.2 Purpose of this report

The objective of this Acid Sulfate Soils Management Plan (ASSMP also referred to as 'this plan') is to provide guidance to designers and contractor on the requirements associated with the management of acid sulfate soils which may be disturbed within the areas of proposed construction works. The area associated with mapped acid sulfate soils risk is off site in areas shown in Figure 1-1 below. The site is however within 500 metres of a class five risk category and therefore requires this management plan to inform planning approvals, design and construction process.

During ongoing design and construction, in the event that Acid Sulfate Soils are encountered on site, the responsible entity for implementation of this plan will be the Principles contractor. The relevant sections of this plan should be incorporated into and inform the development of the Construction Environmental Management Plan (CEMP) prepared for the Site.

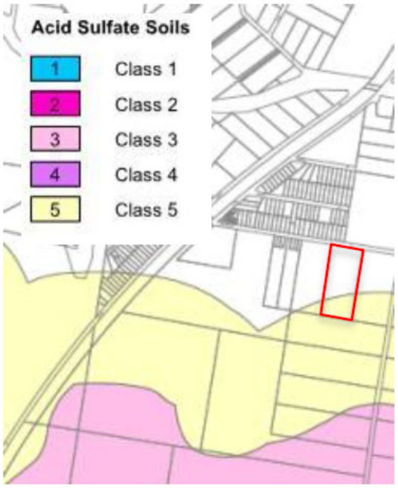

Figure 1-1 Acid sulfate soil risk mapping (Source Central Coast Council Local Environment Plan, 2014).

2 Scope of works

2.1 Limitations

The following limitations are noted in this plan:

- This plan does not specify the impact of acid sulfate soils on structural components such as foundations and culvert base slabs. Durability assessment and measures are outlined within a separate detailed design package (where appropriate)
- This ASSMP does not describe details of construction environmental management (such as water quality and sediment and erosion controls) which are to be addressed by the Contractor in their CEMP.
- This plan is based on the limited site investigations provided during the concept design report and has been informed by desktop assessment only for the risk setting of acid sulfate soil conditions being present on site.

2.2 Design specifications and compliance

This plan has been prepared with reference to the following applicable legislation and guidelines in Table 2-1 below.

Table 2-1 ASS Guidelines and Framework

Legislation / Guideline	State Produced
Protection of the Environment Operations Act 1997	NSW
Stone Y., Ahern C. R. and Blunden B. 1998. Acid Sulfate Soils Manual, Acid Sulfate Soil Management Advisory Committee, Wollongbar, NSW, Australia	NSW
National Working Party on Acid Sulfate Soils. 2000. National Strategy for the Management of Coastal Acid Sulfate Soils, NSW Agriculture, Wollongbar	NSW
Dear et al., 2014. Queensland Acid Sulfate Soil Technical Manual, Soil Management Guidelines Version 4.0.	QLD
Ahern CR, McElnea AE, Sullivan LA 2004. Acid Sulfate Soils Laboratory Methods Guidelines. In Queensland Acid Sulfate Soils Manual 2004. Department of Natural Resources, Mines and Energy, Indooroopilly, Queensland, Australia	QLD
Dear et al. 2004. Queensland Acid Sulfate Soil Technical Manual Legislation and Policy Guide, Version 2.2.	QLD
Ahern C. R., Ahern M. R. and Powell B. 1998. Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils in Queensland, Queensland Acid Sulfate Soils Investigation Team (QASSIT), Queensland Department of Natural Resources, Brisbane.	QLD

3 Site information

3.1 Background

3.1.1 Definitions

Acid Sulfate Soils (ASS) can be defined as “naturally occurring soil and sediment containing iron sulfides, principally the mineral iron pyrite, or containing acidic products of the oxidation of sulfides. When sulfides are exposed to air, oxidation takes place and sulfuric acid is ultimately produced when the soil’s capacity to neutralise the acidity is exceeded. If the sulfide soils remain under the water table, oxidation cannot occur, and the soils are quite harmless and can remain so indefinitely.” (National Working Party on Acid Sulfate Soils 2000, p. 5).

Actual ASS (AASS) can be defined as “soils containing highly acidic soil horizons or layers, resulting from the oxidation of soil materials that are rich in iron sulfides. This oxidation produces hydrogen ions more than the sediment’s capacity to neutralise the acidity, resulting in soils of pH of 4 or less when measured in dry season conditions. These soils can usually be recognised by the presence of pale yellow mottles and coatings of jarosite.” (RTA 2005)

Potential ASS (PASS) can be defined as “soils which contain iron sulfides or sulfidic material which has not been exposed to air and oxidised. The field pH of these soils in their undisturbed state is usually 4 or more (and may be neutral or even slightly alkaline).” (RTA 2005)

Acid Sulfate Materials (ASM) is the joint description for ASS as well as Acid Sulfate Rock and Monosulfidic Black Ooze (RTA 2005).

3.1.2 Identifying acid sulfate soils

The following preliminary indicators may indicate ASS presence:

- Waterlogged soils – unripe muds (soft, buttery, blue grey or dark greenish grey) or bottom sediments of estuarine areas (dark grey) or bottom sediments (dark grey to black)
- Presence of shells, sulfuric odour
- Jarosite soil horizons. Jarosite is a characteristic pale-yellow mineral deposit which can be found along cracks and root channels in acidified soils
- Scalded or bare areas of land, sometimes having a red or red/brown appearance
- Unusually clear or milky green/blue water
- A sulphur odour after rainfall following dry spell
- Extensive iron staining along standing water edges or flow paths

Appendix 1 to the ASSMAC Assessment Guidelines (Ahern et al., 1998) state that field pH (pHF) readings of less than or equal to 4 indicate the presence of actual ASS. Field pH values of greater than 4 but less than 5.5 may be the result of previous or limited oxidation of sulfides but does not confirm the presence of actual ASS.

Similarly, the ASSMAC Guidelines state that field peroxide (pHFOX) values and their analysis provide a stronger indication of the presence of PASS. Indicators to look for in these tests include the following:

- $pH_{FOX} < 3$
- The more the pH_{FOX} drops below 3, the more positive the presence of sulfides
- pH_{FOX} value is at least one pH unit below the pHF value
- Observed ‘strong’ reaction with peroxide

3.2 Summary of previous investigations

Previous investigations undertaken at the site are documented within the following:

- Geotechnical Factual Report (Douglas Partners, 2018)
- Initial Evaluation of Contamination Potential (Kleinfelder Australia Pty Ltd, 2018)

Relevant information has been summarised in the following sections.

3.2.1 Risk mapping

A review of the 1:25,000 Acid Sulfate Soils Risk Map for Wyong (Dept. Land and Water Conservation, 1998) indicated that

- The south eastern corner of the site is Class 5
- Remainder of the site is mapped in an area of no known occurrence of ASS

Figure 1-1 shows the acid sulfate soils risk mapping. A consideration of the potential for Acid Sulfate Rock for the Project was not applicable as the current design is expected to have minimal interaction with unoxidized rock (i.e. there are no deep 'cuttings' in fresh rock). Subsequent environmental assessment is required to confirm this low risk setting.

3.2.2 Subsurface conditions

Geotechnical investigations carried out by Douglas Partners during concept design are outlined within the Geotechnical Factual Report.

For the purposes of geotechnical characterisation of subsurface conditions for detailed design, the soil types encountered in the project area have been categorised into geotechnical soil units as shown in Table 3-1.

Table 3-1 Geotechnical soil units for The New Primary School at Warnervale

Unit name	Unit	Description
Gorokan	(gk)	Landscape—undulating low hills and rises on lithic sandstones of the Tuggerah Formation. Local relief <30 m; slope gradients <15%. Broad crests and ridges, long gently inclined slopes and broad drainage lines. Partially cleared low open-forest. Soils - moderately deep (50–150 cm) Soloths (Dy2.41, Dy3.41), Yellow Podzolic Soils (Dy3.11, Dy3.21) on ridges and crests; Soloths (Dy2.41, Dy3.41), Yellow Podzolic Soils (Dy3.11, Dy3.21) and Grey-brown Podzolic Soils (Db1.21, Db2.21) on slopes with Gleyed Podzolic Soils (Dg2.41) along drainage lines. Limitations—very high erosion hazard, foundation hazard (localised), seasonal waterlogging, hardsetting, strongly acid, low fertility, plastic, impermeable soils

3.2.3 Preliminary extent of ASS

The findings of sampling and testing for acid sulfate soils have not been addressed specifically due to initial desktop reporting provided by Douglas Partners indicates that there is no known occurrence of acid sulfate soil on site. The Central Coast Council Local Environmental Plan (LEP) however maps the sites to be located within 500 metres of a Class 5.

Acid sulfate soils are not typically found in Class 5 areas. Areas classified as Class 5 are located within 500 metres on adjacent class 1,2,3 or 4 land. Works in a Class 5 area that are likely to lower the water table below 1 metre AHD1 on adjacent class 1, 2, 3 or 4 land will trigger the requirement for assessment and may require management.

For the purposes of this ASSMP, the following is noted:

- A review of ASS risk maps for the area indicated that ASS could potentially occur within creek lines associated with the Porters Creek and wetlands. Other parts of the Project site were mapped in areas of no known occurrence and therefore ASS is not likely to be present.
- The limited boreholes drilled on site identified residual soils and sedimentary rocks not associated with ASS.
- As the soil mapping is indicative spatial information of soil properties, SMEC recommended that additional confirmatory ASS testing of site soils near Porters Creek tributaries may be carried out if the soils are disturbed at the time of construction.

3.2.4 Preliminary liming rates

No liming rates are available at this stage of design. In the event that ASS are encountered during ongoing site investigations or construction, the samples must be analysed for SPCAS or equivalent to establish neutralisation rates. The laboratory results for soil samples will be used to get an estimate of likely liming rates assuming that soils that require disturbance are managed via neutralisation with fine grained agricultural lime. A summary of calculations of lime rates at decreasing elevations is included in Table 3-2 and have been based on the following formula:

$$Liming\ rate\ \left(\frac{kg\ Lime}{m^3}\right) = \frac{A\ \left(\frac{molH^+}{tonne}\right) x\ B\ \left(\frac{tonnes}{m^3}\right) x \frac{100}{NV} x\ FOS}{C\ \left(\frac{molH^+}{kg}\right)}$$

Where:

- A = Net Acidity (A) = includes retained acidity and can take into account acid neutralising capacity (ANC) (where net acidity could be inaccurately influenced by coarse material buffering that is crushed in the laboratory, then ANC may need to be omitted from the net acidity calculation
- B = Dry bulk density = 1.65 tonnes/m3 (assuming sandy clay)
- FOS = Factor of Safety = 1.5 (assumes standard level of environmental protection)
- NV = neutralising value of lime = 98% (assumed)
- C = Neutralising capacity of lime = 19.98mol/kg (assumes fine grained agricultural lime)

Table 3-2 Lime rate estimates to be recorded with the following parameters for inputs to neutralisation planning.

Sample ID	Relevant Creek	Soil type sampled	Sample reduced level (m AHD)	Net Acidity	Liming Rate (kg. Lime/m^3)

3.2.5 Groundwater

Groundwater table drawdown can occur from excavation dewatering and affect acid sulfate soils as they can be exposed to oxygen and oxidise.

The ASSMAC 1998 guidelines state another 'principle issue with regard to triggering the need for a management plan and development consent is "is the groundwater level likely to be lowered and by how much". In coastal areas where there are acid sulfate soils and shallow groundwater, altering the water table (as a direct or indirect outcome of the proposed activity) can result in oxidation of the sulfidic material and acidification of both surface and groundwater.' (ASSMAC 1998).

A search of the WaterNSW database (WaterNSW 17/09/18), identified 17 registered groundwater bores within a 2 km radius of the Site. Two bores were located within 500 metres of the Site and have been provided to characterised local groundwater conditions beyond the study site:

- GW080833 – Test Bore (120m to the north-east, adjacent to the Warnervale Oval). No details were provided on the well construction detail or water bearing zones; and
- GW200569 – Test Bore for irrigation (154m south-east, within adjacent property). The bore log identified that the well was drilled to 66m bgs, with the first water bearing zone comprising a sand deposit at substantial depth (24m bgs).

The cluster of five wells east of the site are listed as test wells and the cluster of nine wells to the north-east are listed as monitoring wells.

3.3 Additional assessment

To supplement previous results and visual indicators, field pH screening may also be carried out to assist identifying ASS (as per Section 3.1.2). The field screening procedure should be carried out as per Appendix 1 of the Assessment Guidelines within the NSW ASS Manual (ASSMAC, 1998).

Laboratory analysis should be carried out if there is ambiguity with the above screening indicators. Table 3-3 provides the texture-based action criteria that laboratory samples are compared against to determine the requirement for management of spoil material. Where soils containing concentrations at or above the action criteria are disturbed, management of spoil is required. As this Project is likely to disturb spoil greater than 1,000 tonnes, the two right hand columns should be used.

Table 3-3 Action criteria based on the ASS analysis for three broad texture categories

Type of Material		Action Criteria 1- 1000 tonnes disturbed		Action Criteria > 1000 tonnes disturbed	
Texture range (McDonald et al. (1990)	Approx. clay content (%<0.002 mm)	Sulphur trail % S oxidisable e.g. STOS or SPOS	Acid trail mol H+/tonne e.g. TPA or TSA	Sulphur trail % S oxidisable e.g. STOS or SPOS	Acid trail mol H+/tonne e.g. TPA or TSA
Coarse Texture Sands to loamy sands	≤5	0.03	18	0.03	18
Medium Texture Sandy loams to light clays	5 – 40	0.06	36	0.03	18
Fine Texture Medium to heavy clays and silty clays	≤40	0.1	62	0.03	18

Source: Ahern et al. 1998

4 Environmental Activities, Impacts and Risks

4.1 Construction activities

The Project construction activities which could potentially impact upon the environment from ASS include:

- Bulk earthworks associated with drainage assets
- Localised excavations associated with demolition of existing building
- Vertical boring associated with construction of footings or foundations
- Horizontal boring associated with utilities
- Dewatering activities (if required) associated with bridge piers or excavations below water table resulting in groundwater level drawdown (i.e. lowering of water table).

A description of the construction activities and scale of ASS disturbance expected is summarised in Table 4-1 below. The overall volume of ASS disturbance is likely to be less than 1,000m3 and therefore low risk. The areas where ASS disturbance is may be expected is at depth greater than site investigations have assessed to date.

The potential impacts from ASS if they are not managed may include:

- Generation of acidity from ASS disturbance
- Export of existing acidity upon disturbance and wetting
- Generation of low pH waters (surface and groundwater) and potentially elevated dissolved metals
- Impacts on sensitive environments (flora and fauna)
- Potential for soil structural decline
- Potential for infrastructure decline due to aggressivity to structures (corrosion etc)
- Community perceptions of the project.

The following sections outline the Project activities during construction that have the potential to impact on ASS in the project footprint. Management procedures have been developed in order to mitigate these potential impacts and are outlined in Section 5.

Table 4-1 Construction activities and ASS disturbance

Construction activity	Description / scale of construction activity	Extent of ASS disturbance expected (red dashed line)	Estimate volume of ASS disturbed (m3)
Drainage features	Stormwater assets	Above mapped area of know locations	No known engagement, however needs to be managed via an incidental finds process.

4.2 Potential impacts

The Project's construction activities can have a direct or indirect impact on the environment and can contribute to a larger environmental change.

The potential impacts from ASS if they are not managed may include:

- Generation of acidity from ASS disturbance
- Export of existing acidity upon disturbance and wetting
- Generation of low pH waters (surface and groundwater) and potentially elevated dissolved metals
- Impacts on sensitive environments (flora and fauna)
- Potential for soil structural decline
- Potential for infrastructure decline due to aggressivity to structures (corrosion etc)
- Community perceptions of the Project.

The following sections outline the Project activities during construction that have the potential to impact on ASS in the Project footprint. Management procedures have been developed to mitigate these potential impacts and are outlined in Section 5.

4.2.1 Excavations

Excavation may be required for minor cut to fill and utilities. The majority of these types of excavations would be less than 2.0 metres below ground level and usually not more than 0.5 metres. Potential impacts of excavations due to ASS materials include:

- Excavation of ASS with the immediate ability to export acid and potentially dissolved metals upon wetting
- Excavation of PASS with the potential to generate acid upon exposure to oxygen and acidify
- Exposure of the cut faces of excavations to oxygen and water that may generate additional acidity or mobilise existing acidity
- Water quality reduction due to acid spikes and elevated dissolved metal concentrations
- Long term water quality issues (low pH, elevated total acidity, soluble sulfate, insoluble iron hydroxides and metals, principally Al, Fe, Mn and Zn). This especially applies to shallow drainage cut into ASS. Aesthetically, drains and water appear unclean and stagnant
- Seepage of affected water into the shallow groundwater which may affect a larger initial area of disturbance
- Shallow dewatering for leachate drains, box culverts and discharge of potentially acidic water into adjacent surface water bodies
- Associated water quality impacts on sensitive receptors (flora and fauna)
- Increased aggressivity towards concrete and steel structures that water flows against and soil sits against. Steel would corrode quicker and the bonding of cement would break down faster to show underlying aggregate and possibly weaken structures over time.

4.2.2 Dewatering

Dewatering would be required where excavations occur below groundwater levels. Dewatering is unlikely, however may be required for deeper services trenches. Impacts from dewatering are similar to those described above.

For this ASSMP we have assumed that dewatering will not be required to a degree that would create groundwater drawdown and affect nearby ASS. Should this be the case then an addendum to this plan will be required.

4.2.3 Direct impacts

Direct impacts may result from soil disturbance or oxidation of areas of potential acid sulfate soils (i.e. earthworks).

Project areas which disturb ASS require management of all disturbed soils in accordance with the procedures outlined in this management plan. The usual management tool for excavated ASS is neutralisation with fine agricultural lime in accordance with the ASSMAC guidelines (refer Section 6.0).

Potential direct impacts of excavations due to ASS materials include:

- Excavation of actual ASS with the immediate ability to export acid and potentially dissolved metals upon wetting
- Excavation of potential ASS with the potential to generate acid upon exposure to oxygen and acidify

- Exposure of the cut faces of excavations to oxygen and water that may generate additional acidity or mobilise existing acidity
- Short term water quality issues due to acid spikes (low pH) and elevated dissolved metal concentrations
- Long term water quality issues (low pH, elevated total acidity, soluble sulfate, insoluble iron hydroxides and metals, principally Al, Fe, Mn and Zn). This especially applies to shallow drainage cut into ASS. Aesthetically, drains and water appear unclean and stagnant
- Seepage of affected water into the shallow groundwater which may affect a larger initial area of disturbance
- Shallow dewatering for leachate drains, box culverts and discharge of potentially acidic water into adjacent surface water bodies
- Associated water quality impacts on sensitive receptors (flora and fauna)
- Increased aggressivity towards concrete and steel structures that water flows against and soil sits against. Steel would corrode quicker and the bonding of cement would break down faster to show underlying aggregate and possibly weaken structures over time.

4.2.4 Indirect impacts

Indirect impacts may arise from Project construction activities which result in oxidation of potential acid sulfate soils from groundwater changes (i.e. dewatering).

Temporary dewatering may be required where excavations occur below groundwater levels and to prevent the ingress of groundwater is required. For works within creeks (i.e. demolition of existing bridge columns, it is expected that temporary coffer dams would be used to prevent ingress of soils and groundwater. Bored cast-in-place piles are unlikely to require dewatering noting that the methods usually involve injection of concrete (relative dense) which displaces any water ingress into surrounding soils.

Impacts from dewatering are like those described above. Potential indirect impacts from dewatering also include:

- Temporary or permanent groundwater level lowering during or changes to hydrological regime
- Short term or long-term water quality issues due oxidation of potential acid sulfate soils resulting in acid spikes (low pH) and elevated dissolved metals concentrations
- Short term or long-term water quality issues following incorrect treatment or placement of lime-treated acid sulfate soils (i.e. excess lime) resulting in alkaline (high pH) and associated changes to the environment.

For this ASSMP we have assumed that dewatering will not be required to a degree that would create groundwater drawdown and affect nearby ASS. Should this be the case then a revision to this plan will be required.

Channel widening can potentially lead to the drawdown of the water table. There have been demonstrated variations of the groundwater table are apparent in response to rainfall (refer to Section 3.2.5). SMEC consider that the channel widening near Harris Creek will not lead to substantial drawdown of the water table, beyond that which is already occurring.

4.3 Preliminary risk assessment

A preliminary assessment of the likelihood and consequence of the potential impacts from acid sulfate soils on the environment. A summary of the risks identified are included in Table 4-2. These risks have been included within the Project risk register.

Table 4-2 Summary of risk assessment

Construction activity	Potential impacts	Adopted control measures
Bulk or localised excavations within or adjacent to creeks	Direct disturbance on potential acid sulfate soils resulting in oxidation (acid generation and release)	• Controlled earthworks to be managed by procedures in this plan under supervision of qualified environmental consultant • Redirect creek flows around work areas • Lime neutralisation away from Creeks at designated treatment pad

Construction activity	Potential impacts	Adopted control measures
	Groundwater level dropping resulting in oxidation (acid generation and release)	• Surface water and groundwater quality monitoring (refer to Section 5.6)
	Indirect disturbance of creek sediments through concentrated creek flows	• Progressive installation of scour protection measures • Additional temporary measures as outlined within Erosion and Sediment Management Report
Vertical boring of piles for bridge construction	Direct disturbance on potential acid sulfate soils resulting in oxidation (acid generation and release)	• Pile casing/surrounding soils will act as barrier to any immediate acid release. Spoil contained in vicinity of borehole. • Surface water and groundwater quality monitoring (refer to Section 5.6)
Horizontal boring associated with utilities crossings beneath creeks	Direct disturbance on potential acid sulfate soils resulting in oxidation (acid generation and release)	• Pile casing /surrounding soils/pile casing will act as barrier to any immediate acid release. • Concrete has neutralising effect. Resulting spoil contained in vicinity of borehole. • Surface water and groundwater quality monitoring (refer to Section 5.6)

5 Acid Sulfate Soil Management Procedures

5.1 Management hierarchy

The management associated with projects located within ASS can be grouped into eight key principles described in Table 5-1.

Table 5-1 ASS Hierarchy

Principle Item	Summary of Principle
1	The disturbance of ASS should be avoided wherever possible
2	Where disturbance of ASS is unavoidable, preferred management strategies are: • Minimisation of disturbance • Neutralisation • Hydraulic separation of sulfides either on its own or in conjunction with dredging • Strategic reburial (re-interment). Other management measures may be considered but must not pose unacceptably high risks.
3	Works should only be performed when it has been demonstrated that the potential impacts of works involving ASS are manageable to ensure that the potential short and long term environmental impacts are minimised.
4	The material being disturbed (including in situ ASS) and any potentially contaminated waters associated with ASS disturbance, must be considered in developing a management plan for ASS and/or complying with general environmental due diligence
5	Receiving marine, estuarine, fresh or brackish waters are not to be used as a primary means of diluting and/or neutralising ASS or associated contaminated waters.
6	Management of disturbed ASS is to occur if the ASS Action criteria is exceeded or reached
7	Stockpiling of untreated ASS above permanent ground water table with (or without) containment is not an acceptable long-term management strategy. For example, soil that is to be stockpiled, disposed of, used as fill, placed as a temporary or permanent cover on land or in waterways, sold or exported off the treatment site or used in earth bunds, that exceed the Action Criteria should be treated and managed.
8	The following issues should be considered when formulating ASS management strategies: • The sensitivity and environmental values of the receiving environment. This includes the conservation, protected or other relevant status of the receiving environment (e.g. Fish Habitat Area, Marine Park, or protected/threatened species) • Whether ground waters and/or surface waters are likely to be directly or indirectly affected • The heterogeneity, geochemical and textural properties of soil on site • The management and planning strategies of local government and/or state government, including Regional or Catchment Management Plans/Strategies and State and or Regional Coastal Policies/Plans.

The following sections provide environmental management measures to limit adverse impacts to the environment from disturbance of ASS. If required, a review of sampling locations, sample depths and results should be completed to provide site specific data for areas of disturbance. Disturbed ASS is proposed to be managed through neutralisation.

These mitigation and management measures would be further developed by the Primary Contractor and incorporated into their CEMP (as required based on their specific works).

5.2 Excavations

Where excavations occur within or in close proximity to the inferred extent of ASS, the following steps would be undertaken:

- Identify the location of disturbance against sampling locations and results.
- Determine and document the construction activity and controls
- Determine approximate volume of materials that may be disturbed
- Carry out field screening and/or additional testing as required to confirm ASS extents
- Determine the liming rates required to neutralise all disturbed ASS materials
- To mitigate the impacts on the receiving waterways:
  - Excavations that could intersect ASS should be avoided during/after wet weather conditions when surface water acidity issues may be exacerbated.
  - Soil cuttings generated from the excavations should be contained within the immediate vicinity of the excavation.
  - Water generated from dewatering the excavations should be contained to prevent runoff into creeks and drainage lines.
- Collect all excavated ASS impacted materials and place in a containment area for treatment
- Apply aglime to excavated faces if ASS is likely to be left exposed, at a rate of 5kg/m² to limit acid generation
- Monitor any pooled water within the excavation for acidity issues daily is required. Monitoring for water quality parameters should include pH, Electrical Conductivity (EC), Dissolved Oxygen (DO) and turbidity.
- Treat any water with acidity issues at rates indicated in the CEMP
- Monitor the disturbed area for any acidity issues

5.3 Shallow Dewatering

Dewatering would be required where excavations occur below groundwater levels. Dewatering is unlikely, however may be required for deeper services trenches. Impacts from dewatering are similar to those described above.

For this ASSMP we have assumed that dewatering will not be required to a degree that would create groundwater drawdown and affect nearby ASS. Should this be the case then an addendum to this plan will be required.

Shallow dewatering refers to small excavations for construction activities that may intercept the shallow groundwater table or rainfall that drains into an excavated pit. Where shallow dewatering for activities such as construction of sediment basins, box culverts, pipes, services and shallow excavations occurs, the following steps would be undertaken:

- Discharge water into specific holding basins or tanks.
- Observe pit or excavated area for signs of acidity daily and lime cut faces at a rate of 5 kg/m² to limit acid build up and leaching.
- Test holding basins and pond water quality and ensure water is within the construction guideline criteria prior to discharge.
- When activities are completed, remove pump and feeder line and treat base and side of pit with aglime at a rate of 5 kg/m² to neutralise any acidity present.
- Observe area of works weekly after disturbance for any acidity issues and treat accordingly until equilibrium has been reached.
- Complete dewatering record forms as required.

Note this does not refer to deep dewatering activities (excavations beyond 2 metres past the groundwater table) that may have a wider cone of depression and impact. No deep dewatering requirements have been identified as part of the Project works. If these works are identified as being required, a specific detailed ASS Management Plan would be prepared prior to works commencing.

5.4 Temporary stockpiling

Short to medium term stockpiling of ASS would only be undertaken when transport to or treatment in the treatment area is not practicable (i.e. end of shift). In this case, stockpiling would be in accordance with Table 5-2 below.

Table 5-2 Stockpiling of ASS material

Type of Material		Maximum Duration of Stockpiling Prior to Treatment
Texture Range	Approx. Clay Content (%)	
Coarse Texture (sands to loamy sands)	<5	Overnight (18 hours)
Medium Texture (sandy loams to light clays)	5-40	2 nights (42 hours)
Fine Texture (medium to heavy clays and silt clays)	>40	3 nights (e.g. 'over the weekend' – 66hrs)

Source - Dear et al (2014)

5.5 Lime treatment

5.5.1 Treatment pad

In the event that ASS or PASS conditions are encountered, neutralisation would be carried out on a treatment or liming pad. All excavated ASS would be stockpiled in a low permeability bunded area capable of containing all materials and associated leachate that may be produced either by seepage (drying) or rainfall.

The location of the treatment or liming pad would be determined by the Contractor during preconstruction planning stages. Proposed ancillary sites for this Project have been identified within the Erosion and Sediment Management Report and are subject to approval within the EIS.

In summary, the following stockpile construction elements would be implemented:

- Stockpiles would be placed away from creek lines, flow lines, and any other type of water body
- A low permeability dense clay with minimal sand and coarse materials would be used for bunding and base materials
- Clay would be compacted to reduce permeability further
- A base layer of >80-micron plastic sheeting or geo - synthetic may be used to reduce permeability when suitable clay fill is unavailable
- Bunds must be high enough to contain all materials stockpiled and leave some room at the base for leachate to collect and drain to a low point, discharge point (sump) or attached holding pond
- Clay base layers must be a minimum 0.5m thick (compacted)
- Where ASS will remain permanently at its treatment location, a 'guard layer' of lime should be applied. The minimum guard layer rate beneath any treated-in-place ASS will be 5kg fine aglime per m2 per vertical metre of fill. Where the highest detected sum of existing and potential acidity is more than 1.0% S-equivalent, the rate will be at minimum 10 kg fine aglime/m3.

A schematic cross-section of a treatment pad, including a compacted clay layer, guard layer, leachate collection system and containment with bunding is provided in Figure 5-1 and Figure 5-2 below. Example of bunded treatment area for ASS (Figure 5-3) and lime application (Figure 5-4) are also provided.

The sketches provided are examples only. Other methods of containing and treating materials may be more appropriate. In each case, no untreated and monitored leachate should escape the stockpiling area and the placement of the treatment area would be on high ground with minimal potential for run-off into the area. Due regard for sensitive receptors and environmental risk would also be accounted for in design, transport and placement.

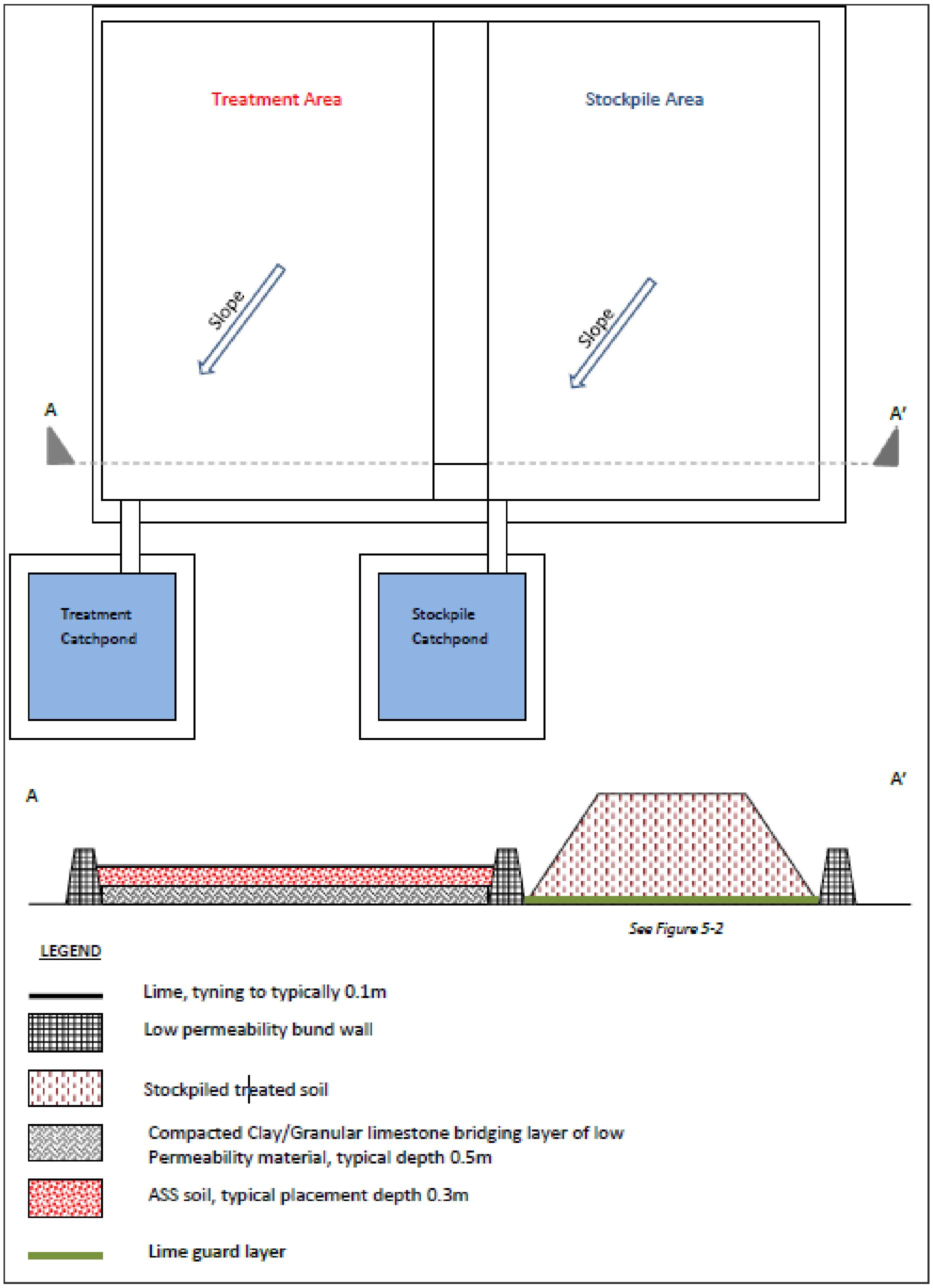

Figure 5-1 Treatment pad design with treatment area and stockpile area.

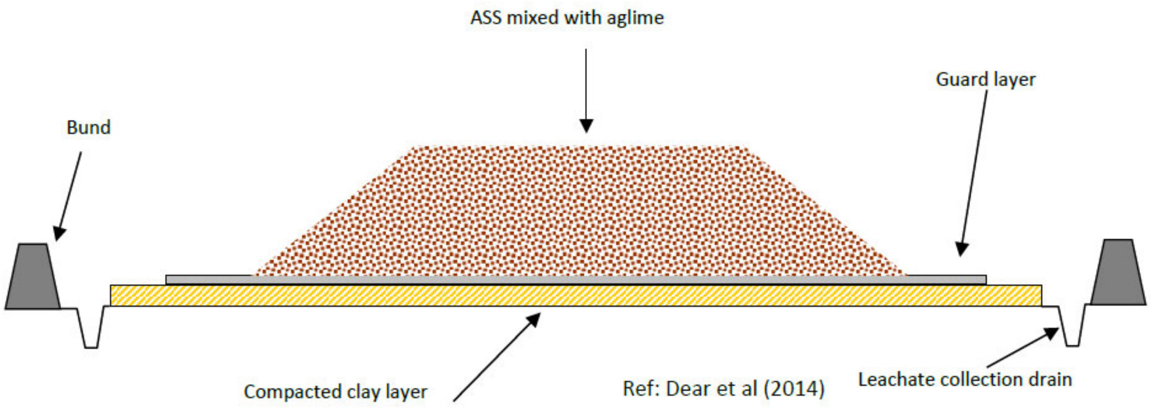

Figure 5-2 Cross section of stockpile of lime treated ASS

Figure 5-2 Cross section of stockpile of lime treated ASS

Figure 5-3 Example of bunded treatment area for ASS (Ref: Dear et al (2014)

Figure 5-4 Example of lime application (Ref: Dear et al (2014)

5.5.2 Liming rate

Soils containing ASS which are excavated will require treatment with pure fine lime (CaCO3) at a calculated liming rate. Liming rates presented within Section 3.2.4 are a preliminary indication only. They are based on existing available sampling and testing data summarized in Appendix C. The actual lime rate should be confirmed during construction stage using existing and additional soil sampling data.

The following steps would be undertaken:

- Interpretation of analytical data would be carried out by an appropriately qualified environmental professional experienced in dealing with ASS management
- A sufficient number of soil samples should be tested to assess the liming rate including:
  - Minimum 3 test samples or 1 sample per 200m3 per stockpile
  - Each test sample to be made from a composite of six individual samples to obtain better representation
  - Samples to be tested using the Chromium Reducible Sulphur (SCR) suite with full acid base accounting including retained acidity. Samples should be tested at a NATA accredited laboratory.
- Where works will be staged in a way that requires small stockpiles to be created frequently, then either in-situ sampling or review of data for consistency after a few stockpiles can be carried out to reduce the need for ongoing sampling
- The amount of lime to be added will be determined based on the results of laboratory analysis taking into consideration existing acidity, potential acidity, retained acidity and acid neutralising potential. A factor of safety should also be applied to the lime rate calculation of between 1.5 and 2 and will depend on the likely area of reuse for this material and environmental sensitivity.
- Aglime rates would be as determined through analytical assessment to establish an equivalent S%. The lime rate will be calculated as per equation below:
  - kg CaCO3/tonne (by dry weight) = %S x 30.59 x 1.02 x FOS
- Where:

  - o %S = net acidity (includes retained acidity and can consider acid neutralising capacity (ANC)) (Note: where net acidity could be inaccurately influenced by coarse material buffering that is crushed in the laboratory, then ANC may need to be omitted from the net acidity calculation)
  - 30.59 converts %S to sulfuric acid equivalent (H2SO4)
  - 1.02 converts to CaCO3
  - FOS = factor of safety (typically 1.5 to 2)
- Fine grained agricultural lime with a neutralising value (NV) of at least 95 should be used. Note: The use of hydrated lime is not recommended due to potential for over-liming and resulting high pH in surface water runoff.

Appendix D includes a table for estimating treatment levels and Aglime required to treat total weight of disturbed Acid Sulfate Soils (Ref: Dear et al, 2014).

5.5.3 Liming application

Lime application would be carried out by suitably experienced and trained contractor's/machine operators in accordance with the determined liming rate. The Contractor shall carry out site specific risk assessments (SWMS) should cover any hazards from the transport, storage, handling and application of lime.

The following steps would be taken:

- Soil treatment will occur in the designated treatment areas. Soil layers not to exceed 0.5 metres depth and preferably 0.15 - 0.3 metres to allow for efficient mixing and drying of potentially wet sediments
- When materials are sufficiently dry (not saturated), apply aglime at the calculated rates for the material and spread evenly and mix thoroughly (several times as required). Mixing of lime is likely to involve thorough mixing by several turns with an excavator and/or tyning.

5.5.4 Validation

Validation is required to verify that appropriate quantities of lime have been used during treatment. A validation plan should be prepared in consultation with an experienced ASS consultant which will be based on Section 8.2 of Dear et al (2014) and will depend on the quantities and production rates of ASS treatment.

A lime register will be maintained by the Contractor. The register will list the amount of lime delivered to the site (verified by delivery dockets), and where/when the lime has been used.

The following steps would be undertaken:

- Validation would be carried out by an appropriately qualified environmental professional experienced in dealing with ASS management
- Lime registers and site records would be checked to confirm correct liming application
- Validation sampling and testing in accordance with the following:
  - Minimum 3 test samples or 1 sample per 200m3 per stockpile
  - Each test sample to be made from a composite of six individual samples to obtain better representation.
  - Samples to be tested using the SCR suite with full acid base accounting including retained acidity.
- The performance criteria would be based on criteria for disturbance of >1000 tonnes and assumes the soil type is medium- and fine-textured material (sandy loams, light clays, heavy clays and silty clays).

Performance criteria for validation during the Project include:

- No single sample shall exceed a net acidity of 18 mol H+/tonne (0.03% S).

If any single sample is between 0 and 18 mol H+/tonne (0.00 to 0.03% S), then the average of any four spatially adjacent samples (including the exceeding sample) shall have an average net acidity of zero or less.

- If results fail to meet the above criteria, then continue lime application, repeating the lime application procedure as required, compact for the next layer.
- If results pass the above criteria, then soils can be place in a separate placement area for ASS that has passed the validation process.
- Earthworks processes may require adjustment to suit the requirements of processing and treatment of ASS.

5.5.5 Reuse of treated ASS

Validated materials (i.e. treated ASS) may be reused onsite or disposed offsite in accordance with the Material Reuse and Management Plan (if required). Validated material can be reused onsite as general fill, subject to the material being:

- Geotechnically suitable for the intended use
- Placed above the water table
- Placed greater than 50 metres away from any receiving drainage or surface water feature unless approved otherwise by a suitably qualified environmental consultant.

Any offsite disposal should be carried out in accordance with guidelines applicable at the time, such as the NSW EPA (2014) Waste Classification Guidelines: Part 1 Classifying Waste and NSW EPA (2014) Waste Classification Guidelines: Part 4 Acid Sulfate Soils.

5.6 Water quality monitoring

Monitoring would be carried out on a regular basis (i.e. minimum quarterly) during Project construction phase. Subject to risk assessment, more frequent monitoring (i.e. weekly or monthly) may be required before, during and/or after construction activities in areas where ASS is present, including:

- Bulk earthworks associated with widening of Harris Creek and Williams Creek
- Vertical boring for bridge piles within Harris Creek and Williams Creek
- Horizontal boring for utilities creek crossings
- Any other activity resulting in creek bed sediment disturbance.

The following steps would be taken:

- Water monitoring and interpretation would be carried out by an appropriately qualified environmental professional experienced in dealing with ASS management
- Surface water and groundwater quality monitoring locations would be sampled and tested as per the above requirements. Field measurements such as pH, oxidation reduction potential (ORP), electrical conductivity (EC), and temperature will be measured in the field. The depth to groundwater will also be recorded.
- Comparison of sample data to baseline water quality would be carried out and an assessment of change made
- An assessment of water quality will be presented within factual monitoring reports. Where monitoring data do not meet criteria, an investigation to be carried out and/or modification to work activities to confirm the reasons for the change.

5.7 Leachate and water liming

Ponded leachate from excavated ASS materials should not be appreciably acidic, since the management protocols have been formulated to prevent build-up of significant acidity. However, heavy or sustained rainfall during excavation, especially over weekends, may produce leachate from excavated stockpiles, which have pH less than the receiving water, since they have not had sufficient time to contact and react with the neutralising agent.

In accordance with principles (Ahern et al, 1998), the following steps would be undertaken:

- Contain all potentially ‘polluted’ water within the site boundary by ensuring sufficient bunding or levees (using non-ASS soils or materials)
- Treat waters to acceptable levels prior to discharge to surrounding environments and in line with existing environmental approvals and conditions. Treatment measures most commonly include liming but may include other measures if suitable
- Monitor water quality at the discharge point (minimum, pH and EC) and record in field documentation.

5.8 Managing compliance with ASSMP

5.8.1 Roles and responsibilities

The Project team’s organisational structure and roles and responsibilities are to be detailed in the Contractor’s CEMP. Specific responsibilities in relation to mitigation measures are also to be included. The Contractor would also detail appropriate personnel for the responsibilities relevant to ASS management for the Project which are described below, and these responsibilities would be documented and communicated as part of site induction and training:

- Toolbox talks – ASS issues relevant to the stages of Project works.
- Site Induction – Environmental Awareness (ASS)
- Ensure relevant personnel are aware of their responsibilities under the management plan
- Update of management plan as required
- Review and understanding of Management Plan/s
- Organise the appropriate storage of neutralising agent on site
- Ensuring ASS management hierarchy principles are adopted
- Knowledge of ASS locations and extent(s)
- Administer the relevant controls and environmental management measures as per relevant sections of this management plan
- Ensure that suitably bunded areas are constructed in suitable locations prior to earthworks in areas of PASS
- Liaise with Superintendent/Foremen to ensure all adequate environmental controls and management as per this management plan are in place and maintained
- Coordinate the testing of stockpiles and treated ASS in line with this management plan
- Ensure that no ASS materials are imported on to site
- If treated ASS is reused on site, ensure it has passed validation testing and is in accordance with this management plan
- Record locations of ASS reuse for use within the Operational Management Plans (if required)
- Advise if ASS incidents or unidentified ASS is encountered
- Establish and complete checklists for disturbance of ASS and PASS
- Organise the correct ordering, material quality and distribution of neutralising agent on site
- Direct the mixing rates for neutralising agents and treatment of ASS throughout the Project
- Ensure stockpiles and treatment areas for ASS are away from direct flows to waterways and drainage systems
- Ensure stockpile treatment pads are constructed in accordance with this management plan
- Ensure validation results for ASS are below the Project set criteria
- Ensuring subcontractors comply with this management plan and procedures
- Assessment of physical controls in accordance with this management plan
- Water quality monitoring (surface and groundwater) in areas of ASS disturbance and reuse areas
- Dust suppression for ASS stockpiles
- Liaison with laboratory conducting validation or testing during construction
- Documentation of all monitoring data and validation records.

5.8.2 Training and awareness

Training requirements would be defined in the Contractor's CEMP. The Contractor should appoint a representative to be responsible for managing ASS and be responsible for understanding the contents of this plan, the CEMP and implementing ASS management for the Project.

Other project personnel, subcontractors and consultants would receive training in environmental obligations during the inductions and toolbox talks including ASS when there is potential for their work to intersect or be in areas with ASS. ASS management training would generally include:

- Unexpected discovery of ASS
- Location of known ASS within the alignment and the ASS treatment areas
- The requirements of the ASSMP.

Training records for Project personnel would be kept and maintained.

If required, a suitably qualified Environmental Consultant could be engaged to assist or train the Contractor in the identification of ASS.

5.8.3 Inspection, surveillance and monitoring

Daily visual inspections targeting the ASS management areas to identify actual or potential ASS concerns would be undertaken during construction by the Contractor. These inspections would form part of the Contractor's management and mitigation schedule in their CEMP of the ASSMP and be used to identify and rectify any ASS management issues.

ASS management issues identified through site inspections and monitoring of construction works would be managed in accordance with the Contractor's the CEMP.

Environmental inspections and monitoring events would be recorded and actioned to facilitate compliance with the ASSMP.

Discharge of water from ASS treatment basins would be in accordance with the Contractor's CEMP. Prior to controlled discharge of water from ASS treatment areas (including basins) to the environment, sampling and testing would be undertaken by the Environmental Officer or trained site delegates and laboratory confirmation would occur to ensure that the water quality criteria listed in CEMP are met. Reporting and documentation regarding water discharge would be in accordance with the CEMP.

5.8.4 Reporting requirements

Project reporting would be undertaken in accordance with the Contractor's CEMP. The following reports would be prepared as part of the CEMP:

- A daily record would be maintained at all ASS sites and would include inspections, dates, times, sampling dates, locations and corrective actions if required
- Weekly and monthly inspection report on the effectiveness of the programs to treat and neutralise ASS in accordance with the ASSMP
- Dewatering records for all dewatering activities.

Additional reporting required in relation to ASS management may be required if unexpected finds of contamination or new ASS are encountered during works.

5.8.5 Non-conformance

Any non-conformance with Environmental Procedures specified in the CEMP must be addressed in 48 hours and enacted as soon as practical. The personnel responsible for the non-conformance must be notified immediately for issuing corrective action requests.

5.8.6 Corrective action requests and instructions

Any non-conformance would be documented on an appropriate form stating the nature of the nonconformance and the mechanisms implemented to rectify the problem.

5.8.7 Review and improvement

During construction of the Project, it is anticipated that the management of ASS would be improved through a variety of mechanisms including:

- Reviewing past performance and identifying opportunities for improvement
- Monitoring current performance and evaluating against relevant Project goals and objectives
- Identifying causes for non-conformances with goals and objectives
- Implementing actions to address deficiencies including corrective and preventative actions
- Ongoing monitoring to evaluate current effectiveness of changes.

6 Managing Compliance with ASSMP

6.1 Risk of ASS

As discussed in Section 3, the study are is low risk for on site occurrences of ASS. No data has been collected during site investigation to date and this must be provided to close this risk out completely. It is noteworthy that the review of the 1:25,000 Acid Sulfate Soils Risk Map for Wyong (Dept. Land and Water Conservation, 1998) indicated that

- The south eastern corner of the site is Class 5
- Remainder of the site is mapped in an area of no known occurrence of ASS

Subsequent environmental assessment is required to confirm this low risk setting and this management plan must be implemented to support civil design and construction.

6.2 Training and Awareness

Training requirements would be defined in the Contractor's CEMP all project personnel, subcontractors and consultants would receive training in environmental obligations during the inductions and toolbox talks. From time-to-time staff may also attend specific training sessions, where deemed necessary by Principal contractor.

All Project personnel would undergo a general Project induction prior to commencing work on site. This would include a PASS/ASS component for civil designers and civil constructions contractors to reinforce the importance of management and the measures that would be implemented to address PASS/ASS issues. Toolbox talks would highlight the specific site environmental requirements and activities being undertaken. These would be based on the measures outlined in the Contractor's specific safe work method statement (SWMS) and relevant CEMP Sub Plans.

In accordance with the Contractor's CEMP, all relevant Project personnel would undertake PASS/ASS awareness training aligned with their specific role in relation to PASS/ASS management. PASS/ASS management training would generally include:

- Unexpected discovery of PASS/ASS
- Location of known PASS/ASS within the project boundary and the PASS/ASS treatment areas
- The requirements of the ASSMP.

Training records for relevent Project personnel would be kept and maintained in a register detailing names, dates, content and type of training undertaken.

6.2.1 Inspection, Surveillance and Monitoring

Daily visual inspections targeting the PASS/ASS management areas to identify actual or potential PASS/ASS concerns would be undertaken during construction by the Contractor. These inspections would form part of the Contractor's management and mitigation schedule in their CEMP of the ASSMP and be used to identify and rectify any PASS/ASS management issues.

PASS/ASS management issues identified through site inspections and monitoring of construction works would be managed in accordance with the Contractor's the CEMP.

Environmental inspections and monitoring events would be recorded and actioned to facilitate compliance with the ASSMP.

Discharge of water from PASS/ASS treatment basins if required would be in accordance with the Contractor's CEMP. Prior to controlled discharge of water from PASS/ASS treatment areas (including basins) to the environment, sampling and testing would be undertaken by the Environmental Officer or trained site delegates and laboratory confirmation would occur to ensure that the water quality criteria listed in CEMP are met. Reporting and documentation regarding water discharge would be in accordance with the CEMP.

6.2.2 Validation Sampling

If validation samples are required, then Acid neutralisation tests are required at a frequency of 1 sample every $50m^3$ of treated soil to demonstrate enough Aglime has been added to the PASS/ASS stockpiles to suitably neutralize acidity. The frequency of testing may be adjusted subject to the specific requirements of the receiving landfill.

6.2.3 Reporting Requirements

Project reporting would be undertaken in accordance with the Contractor's CEMP. The following reports would be prepared as part of the CEMP:

- A daily record would be maintained at the Project site and would include inspections, dates, times, sampling dates, locations and corrective actions if required.
- Weekly and monthly inspection report on the effectiveness of the programs (if required) to treat and neutralise ASS in accordance with the ASSMP.
- Dewatering records for all dewatering activities.

Additional reporting required in relation to PASS/ASS management may be required in the event that unexpected finds of contamination or new PASS/ASS are encountered during works.

6.3 Review and Improvement of the ASSMP

During design and construction of the Project, it is anticipated that the management of PASS/ASS would be improved through a variety of mechanisms including:

- Reviewing past performance and identifying opportunities for improvement
- Monitoring current performance and evaluating against relevant project goals and objectives
- Identifying causes for non-conformances with goals and objectives
- Implementing actions to address deficiencies including corrective and preventative actions
- Ongoing monitoring to evaluate current effectiveness of changes.

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