

organochlorine and organophosphate pesticides (OCPs and OPPs), polychlorinated biphenyls (PCBs) and asbestos.

Four natural soil samples from a variety of depths were analysed for acid sulfate soil characteristics using the sPOCAS analytical methods detailed in AS4969-2008/09. The laboratory testing was undertaken by Envirolab Services (NATA Accreditation Number – 2901). Reference should be made to the laboratory reports (Ref: 146262, 146262A) attached in the appendices for further information.

6 RESULTS OF THE INVESTIGATION

6.1 Subsurface Conditions

The subsurface conditions encountered generally consisted of silty sand fill material to depths ranging from 0.3m to 0.5m below ground level, underlain by marine sands. Clay bands were encountered in BH1 and BH3 at depths of approximately 15m-17m. Sandstone bedrock was encountered below the natural soils at depths ranging from 21.8m to 24.0m. Groundwater was encountered in all boreholes at depths between 0.8m to 0.9m below ground level.

6.2 Field Screening

A photoionisation detector (PID) was used to screen the samples for the presence of VOCs. The sensitivity of the PID is dependent on the organic compound and varies for different mixtures of hydrocarbons. Some compounds give relatively high readings and some can be undetectable even though present in identical concentrations. The PID is best used semi-quantitatively to compare samples contaminated by the same hydrocarbon source.

The PID is calibrated before use by measurement of an isobutylene standard gas. All PID measurements are quoted as parts per million (ppm) isobutylene equivalents. PID screening for VOCs was undertaken on soil samples using the soil sample headspace method. VOC data was obtained from partly filled zip-lock plastic bags following equilibration of the headspace gases.

PID soil sample headspace readings are presented in the attached report tables and the COC document attached in the appendices. All results were 0ppm equivalent isobutylene which indicates a lack of PID detectable VOCs.

6.3 Laboratory Results – Preliminary Waste Classification

The soil laboratory results are compared to the relevant waste classification criteria in the attached report tables. A summary of the results is presented below.

Table 6-1: Summary of Soil Laboratory Results

Analyte	Results Compared to Waste Classification Guidelines
Heavy Metals	All heavy metal results were less than the CT1 criteria with the exception of lead in two fill soil samples, BH3 (0.4-0.5) and BH4 (0.0-0.1) in which lead concentrations of 650mg/kg and 170mg/kg respectively were detected, exceeding the CT1 criterion of 100mg/kg. TCLP leachates were prepared from the two samples and analysed for lead. The results were less than the TCLP1 criterion.
TRH	All TRH results were less than the relevant CT1 criteria.
BTEX	All BTEX results were less than the relevant CT1 criteria.
PAHs	All PAH results were less than the relevant CT1 criteria with the exception of benzo(a)pyrene in sample BH3 (0.4-0.5) in which a concentration of 1.3mg/kg was detected, exceeding the CT1 criterion of 0.8mg/kg. A TCLP leachate was prepared from the sample and analysed for PAHs including benzo(a)pyrene. The result was less than the TCLP1 criterion.
OCPs & OPPs	All OCP and OPP results were less than the relevant CT1 criteria.
PCBs	All PCB results were less than the CT1 criteria.
Asbestos	Asbestos was not detected in the samples analysed for the investigation.

6.4 Laboratory Results – Acid Sulfate Soil Assessment

The soil laboratory results were assessed against the guidelines adopted for the investigation. The results are presented in the attached report tables and summarised below.

Table 6-2: Summary of ASS Results

Analyte	Results Compared to ASS Guidelines
pH _{KCl} and pH _{ox}	The pH_{KCl} results ranged from 5.1 to 9.2. The results indicate that prior to oxidation the pH values of the soil suspended in potassium chloride solution ranged from moderately acidic to moderately alkaline. Following oxidation, the pH_{ox} results for the samples ranged from 2.5 to 7.5. These results are strongly acidic to mildly alkaline. The pH of the samples dropped by an average of 2.7 units following oxidation, with the largest drop of 4.3 units occurring in sample BH4 (7.2m-7.65m).

Analyte	Results Compared to ASS Guidelines
Acid Trail	- TAA results ranged from less than the PQL to 6mol H⁺/tonne. All of the results were below the action criteria of 18mol H⁺/tonne; - TPA results ranged from less than the PQL to 180mol H⁺/tonne. Two of the results were above the action criteria of 18mol H⁺/tonne; and - TSA results ranged from less than the PQL to 180mol H⁺/tonne. Two of the results were above the action criteria of 18mol H⁺/tonne.
Sulfur Trail	The S _{pos} % results ranged from 0.04% to 0.31%. All of the results were above the action criterion of 0.03% as shown in Table C.
Liming Rate	The liming rate required for neutralisation was approximately 13 to 14kgCaCO ₃ /tonne.

7 **CONCLUSION**

7.1 **Preliminary Waste Classification**

The preliminary waste classification of soil for off-site disposal is summarised in the following table.

Table 7-1: Preliminary Waste Classification

Site Extent / Material Type	Classification	Disposal Option
Fill material over the majority of the site	General Solid Waste (non-putrescible) (GSW)	A NSW EPA landfill licensed to receive the waste stream. The landfill should be contacted to obtain the required approvals prior to commencement of excavation. Alternatively, the fill material is considered to be suitable for re-use on the subject site (only) provided it meets geotechnical and earthwork requirements.
Sandstone bedrock	Virgin excavated natural material (VENM)	VENM is considered suitable for re-use on-site, or alternatively, the information included in this report may be used to assess whether the material is suitable for beneficial reuse at another site as fill material. Alternatively, the natural material can be disposed of as VENM to a facility licensed by the NSW EPA to receive the waste stream.

Site Extent / Material Type	Classification	Disposal Option
Natural sands after lime treatment	General Solid Waste containing treated acid sulfate soil	A NSW landfill licenced to receive treated acid sulfate soil. Alternatively it may be possible to re-use the treated material on-site.

7.2 Acid Sulfate Soil Assessment

The soil samples analysed for this investigation encountered results which were above the action criteria adopted for the acid sulfate soils assessment. Based on these results, the risk of generating ASS conditions following disturbance of the natural soils for the proposed development at the site is considered to be high.

An acid sulfate soil management plan (ASSMP) is required for the proposed development. A site specific management plan is outlined in the section below.

8 ACID SULFATE SOIL MANAGEMENT PLAN (ASSMP)

8.1 Introduction

The most effective management strategy for dealing with PASS is to avoid disturbing the material. If this is not a viable option then the ASSMP should be implemented. The objective of the ASSMP is to reduce the potential on-site and off-site environmental impacts associated with disturbance of PASS identified at the site. The ASSMP has been prepared generally in accordance with the ASS Manual 1998. Reference has also been made to the Queensland Acid Sulfate Soil Technical Manual v 3.8¹⁵.

The following issues are addressed in the ASSMP:

- Strategies for the management of PASS during development;
- Implementation of a soil and groundwater monitoring program; and
- Contingency procedures to be implemented in the event of the failure of management strategies.

8.2 Management of PASS

The following options are available for the management and disposal of PASS:

¹⁵ Queensland Acid Sulfate Soil Technical Manual. Soil Management Guidelines version 3.8

Table 8-1: Management of PASS

Option	Details	Applicability for this Site
<u>Option A:</u> Disposal of PASS Beneath the Water Table at a Landfill	Immediate transport of natural PASS to landfill for disposal beneath the water table. A number of conditions have to be satisfied for burial beneath the water table to be viable. This option is not suitable for fill material or natural soil that has been impacted by contaminants.	May be a viable option for the underlying natural soil. However logistical issues often make this option difficult to implement. Described in detail in Section 8.2.1.
<u>Option B:</u> Treatment of PASS, waste classification and disposal to a landfill	PASS is excavated and neutralised with lime. A Waste Classification is assigned for the off-site disposal of the treated PASS to a landfill.	Considered the most viable option. Described in detail in Section 8.2.2.
<u>Option C:</u> Treatment of PASS and on-site re-use.	PASS is excavated and neutralised with lime. The treated material is re-used on site with adequate capping. This option is not suitable for PASS that has been impacted by contaminants.	Not considered suitable for this site as the soil is being excavated for construction of a basement.

8.2.1 Disposal of PASS Beneath the Water Table at a Landfill (Option A)

Natural soil classed as PASS may be disposed of below the water table at a landfill facility without lime treatment provided that the following conditions are met:

- The material is disposed below the water table **within 24 hours** of excavation;
- The material meets the definition of 'virgin excavated natural material' (VENM) under the *Protection of the Environment Operations Act (1997¹⁶)*, even though it contains sulfidic ores;
- The receiving landfill is licensed by the NSW EPA to dispose of PASS below the water table; and
- The material meets the highly stringent pH criteria.

The procedures outlined in the following table should be implemented for this option:

Table 8-2: Management Procedure for Option A

Procedure	Details
<u>Step 1:</u> Contact Landfill	Prior to commencement of excavation works, the landfill should be contacted and the necessary approvals should be obtained for disposal.

¹⁶ *Protection of Environment Operations Act*, NSW Government, 1997 (POEO Act 1997)

Procedure	Details
<u>Step 2: Excavation & Handling</u>	Natural soil classified as PASS should be excavated/disturbed in stages. PASS must be kept wet at all times during excavation and subsequent handling, transport and storage until they can be disposed of safely.
<u>Step 3: pH testing</u>	The pH of the soil should be checked using the test method(s) outlined in the ASS Manual 1998 (Methods 21A and or 21Af). The pH of each load and the time of extraction should be recorded and forwarded to the landfill. If the pH is less than 5.5 then the material is not suitable for burial beneath the water and Option B should be implemented.
<u>Step 4: Transport</u>	Provided that the pH of the excavated PASS is not less than 5.5 the material can be loaded onto trucks and transported immediately to the landfill. Prior to burial the landfill will check the pH of each load. Any loads that do not meet the acceptance pH criteria will be turned away.

Some of the natural soils may have pH values less than 5.5, making them unsuitable for this method of disposal. This will require a very rigorous monitoring regime to be implemented for this option. If successful only a fraction of the PASS may be found to be suitable for disposal by this method. Consequently the additional time and cost associated with this option may not be worthwhile.

8.2.2 Treatment, Waste Classification and Disposal to Landfill (Option B)

Potential acid generation is typically managed by the addition of lime to neutralise acid that may be generated during and after the excavation works. The treated material should then be assigned a waste classification (WC) in accordance with the *NSW EPA Waste Classification Guidelines - Part 1: Classifying Waste (2014¹⁷)* and disposed of to a NSW EPA licensed landfill facility.

¹⁷ NSW EPA, (2014), *Waste Classification Guidelines, Part 1: Classifying Waste*. (referred to as Waste Classification Guidelines 2014)

The procedures outlined in the following table should be implemented for this option:

Table 8-3: Management Procedure for Option B

Procedure	Details
<u>Step 1: Lime selection</u>	A slightly alkaline, low solubility product such as agricultural lime should be used. This form of lime is chemically stable and any excess lime takes a significant period of time (years) to influence soil pH beyond the depth of mixing. The lime particles eventually become coated with an insoluble layer of ferrihydrite ($\text{Fe}(\text{OH})_3$) that inhibits further reaction. Long term alteration of groundwater conditions is not expected to occur as a result of the use of lime during the proposed development works. The material safety data sheet (MSDS) from the lime supplier should be obtained and the appropriate safety measures implemented as specified on the MSDS.
<u>Step 2: Set up Treatment Area/s</u>	For this site the treatment area is expected to be the entire basement footprint. The lime neutralisation work will only need to commence after the excavation has encountered the acid sulfate soil strata. Therefore the basement perimeter will form a natural bund.
<u>Step 3: Manage water run-off</u>	For this site the surface water (rainfall) will be enclosed within the excavation perimeter. Any discharge of water out of the excavation will be monitored (see Section 8.3 Error! Reference source not found.).
<u>Step 4: Excavation & Handling</u>	Once the excavation has reached the acid sulfate strata the lime treatment should commence. The quantity of lime to be added will be dependent on the laboratory results. For this site it is likely that any acid sulfate soil treatment will take place within the excavation footprint. In general the following procedure should be adopted: • We assume that the treatment will take place in sequential 30cm layers through the acid sulfate strata; • The volume of lime required to treat each 30cm layer should be calculated (taking into account the area of the basement footprint); • The surface of the excavation should be dusted with the volume of lime calculated to neutralise a 30 cm deep layer; • An excavator should mix in the lime to a depth of approximately 0.3m using the tines of a large excavator bucket; • The treated layer should then be loaded out and disposed off-site; and • The process should be repeated for each 0.3m layer of PASS to be excavated.

Procedure	Details
<u>Step 5:</u> Lime Treatment & pH Testing	The pH of the treated soil should be checked using the test method(s) outlined in the ASS Manual 1998 (Methods 21A and or 21Af) to confirm that PASS have been neutralised by lime addition. If required, additional lime should be added to the soil and additional mixing undertaken. Following treatment with lime the pH of the soil should be in the 5.5 to 8.5 range.
<u>Step 6:</u> Monitoring by qualified personnel	Monitoring should be undertaken by qualified personnel to ensure the mixing is undertaken to a suitable extent as the success of the neutralisation method relies on the effectiveness of the mixing process.
<u>Step 7:</u> WC and off-site disposal	Following treatment the material should be tested and assigned a waste classification in accordance with the Waste Classification Guidelines 2014. All neutralised material should be disposed of off-site to a NSW EPA landfill licensed to accept treated PASS/ASS.

8.3 Groundwater Seepage and Dewatering

The procedure for managing groundwater seepage and dewatering during development works is outlined in the following table:

Table 8-4: Procedure for Managing Groundwater Seepage and Dewatering

Procedure	Details
<u>Step 1:</u> Minimise the depth of dewatering	Where possible the depth of dewatering should be minimised to reduce the generation of ASS and/or acidic conditions. Excavation and dewatering works should be staged over short durations to reduce the time and volume of PASS exposed to oxidation.
<u>Step 2:</u> Approvals for Groundwater Disposal	Reference should be made to the local council, NSW Office of Water (NOW), Sydney Water and other relevant authorities' approval requirements for further information in relation to disposal of water to either the sewer or stormwater systems.