GROUNDED
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Acid Sulfate Soil Management Plan

Brookvale Westfield - AVAC Sewer Pump Station

145 Condamine Street, Brookvale NSW

Prepared for Scentre Design & Construction Pty Ltd

Project 71015.55

15 October 2024

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

Signature		Date
Author		15 October 2024
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Douglas Partners acknowledges Australia's First Peoples as the Traditional Owners of the Land and Sea on which we operate. We pay our respects to Elders past and present and to all Aboriginal and Torres Strait Islander peoples across the many communities in which we live, visit and work. We recognise and respect their ongoing cultural and spiritual connection to Country.

Acid Sulfate Soil Management Plan
Brookvale Westfield - AVAC Sewer Pump Station
145 Condamine Street, Brookvale NSW

1. Introduction

This Acid Sulfate Soil Management Plan (ASSMP) has been prepared by Douglas Partners Pty Ltd (Douglas) for the proposed AVAC Sewer Pump Station (the site) at Westfield, Warringah Mall, 145 Condamine Street, Brookvale NSW. The ASSMP was commissioned to proceed by email instruction dated 30 July 2023 from Micha Hinden of Scentre Design & Construction Pty Ltd and was undertaken in accordance with Douglas' proposal 71015.54.P.001.Rev2, dated 7 May 2024.

The purpose of this ASSMP is to provide management methods and procedures to minimise environmental impacts resulting from the disturbance of acid sulfate soils (ASS) during the construction of the proposed development. This ASSMP provides a summary of previous ASS test results, neutralisation and treatment methods, verification testing and monitoring requirements, emergency response procedures and groundwater / leachate water management procedures and contingency measures.

This ASSMP is devised on the basis of the guidelines and reference documents endorsed by the NSW Environment Protection Authority (EPA) and with reference to other national guidelines where considered appropriate as outlined in Section 15 and includes the following key guidelines:

- Stone Y, Ahern C R, and Blunden B, *Acid Sulfate Soil Manual* 1998. Acid Sulfate Soil Management Advisory Committee (Stone, Ahern, & Blunden, 1998);
- Dear, S. E., Williams, K. M., McElnea, A. E., Ahern, C. R., Dobos, S. K., Moore, N. G., & O'Brien, L. E. (2023). *Queensland acid sulfate soil technical manual: soil management guidelines version 5.1.* Department of Resources and the Department of Environment and Science (Dear, et al., 2024);
- Sullivan, L, Ward, N, Toppler, N and Lancaster, G 2018*, National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual*, Department of Agriculture and Water Resources, Canberra, ACT. CC BY 4.0 (Sullivan, et al, 2018a); and
- Sullivan, L, Ward, N, Toppler, N and Lancaster, G 2018, *National Acid Sulfate Soils guidance: National acid sulfate soils sampling and identification methods manual*, Department of Agriculture and Water Resources, Canberra ACT. CC BY 4.0 (Sullivan, et al, 2018b).

This report must be read in conjunction with all appendices including the notes provided in Appendix B.

2. Site information / environmental setting

Site address	Part of 145 Condamine Street, Brookvale NSW
Legal description	Part of Lot 103 Deposited Plan 1247294
Area	Approximately 200 m^2
Zoning	Zone E2 Commercial Centre
Local Council Area	Northern Beaches Council
Site Description	At the time of the investigation, the site was generally occupied by an on-grade, asphaltic concrete (AC) carpark within the Warringah Mall Shopping Centre. Adjacent portions of the Warringah Mall Shopping Centre include a multi-storey shopping mall buildings and associated multi-level parking structures to the west. .
Site topography	The ground surface level is at approximately RL 9 m relative to the Australian Height Datum (AHD).
Soil landscape	The Sydney 1:100,000 Soil Landscape Sheet indicates that the site is underlain by disturbed terrain. Disturbed terrain can comprise fill soils of unknown origin and consistency.
Geology	Reference to the Sydney 1:100 000 Geology Series Sheet indicates that the subject site is underlain by stream alluvium and estuarine deposits comprising silty to peaty quartz sand, silt and clay with ferruginous and humic cementation in places and common shell layers. The alluvial deposits are underlain by Hawkesbury Sandstone.
Acid sulfate soils	Reference to the Acid Sulfate Soil Risk mapping (data supplied by NSW Department of Environment and Climate Change based on published 1:25,000 Acid Sulfate Soil Risk Mapping, 1994-1998) indicates that the subject site is underlain by soil with “low probability of occurrence” of acid sulphate soil (ASS). Reference to the Northern Beaches Council “Warringah Acid Sulfate Soils Map WLEP 2000” indicates the site in located in an area of “Class 4” Acid Sulfate soil risk. Class 4 indicates Acid sulfate soils are likely to be found beyond 2 metres below the natural ground surface. Acid sulfate soil has previously been confirmed to be present at the site, as discussed herein.

Groundwater and Surface water	Brookvale Creek crosses through the Warringah Mall property (via a culvert in close proximity to the site), and surfaces in the Warringah Golf Course 50 m east of the property. Surface water and groundwater at the site is expected to discharge to Brookvale Creek and then Manly Lagoon. Groundwater levels have previously been measured at the Warringah Mall property, indicating that the groundwater surface is near-level to gently sloping towards Brookvale Creek with groundwater levels varying from RL 5 m AHD to 12 m AHD. Several registered groundwater bores are located in the region. Of note are three "domestic" bores located approximately 350 m east and south-east (down-gradient) of the site and one domestic well 350 m south-west (cross-gradient) of the site. The purpose of these wells is unknown but may include irrigation or drinking purposes

The approximate site boundary is shown on Figure 1 and on Drawing 1, Appendix A.

Figure 1: Site location

3. Background on acid sulfate soils

3.1 Formation

ASS are naturally occurring sediments that contain reduced inorganic sulfur (RIS), including iron sulfides, (primarily pyrite), commonly deposited in estuarine environments. RIS forms readily in landscapes under waterlogged, anoxic conditions where there is a ready supply of organic matter, sulfate and iron. Under such conditions, the formation of RIS occurs via microbially-mediated processes. The occurrence of ASS is associated with areas or regions that have previously been or are currently estuarine environments. Due to changes in sea level or geomorphologic changes to coastal systems, these sediments are often overlain by terrestrial sediments.

When ASS are exposed to air (e.g. due to bulk excavation or dewatering), the oxygen reacts with RIS in the sediment, producing sulfuric acid. This acid can be produced in large quantities and is highly mobile in water. The acid can result in severe acidification of soil and groundwater and mobilise metals (for example iron, aluminium, copper, cobalt, zinc), metalloids (for example arsenic), nutrients (for example phosphate) and rare earth elements. The sulfuric acid generated from the site has the potential to impact site soils, groundwater and structures, and can drain into waterways causing severe short and long term socio-economic and environmental impacts, including damage to man-made structures and natural ecosystems (for example fish kills).

ASS can either be classified as ‘actual acid sulfate soils’ (AASS) which are soils that have already reacted with oxygen to produce acid, or ‘potential acid sulfate soils’ (PASS). PASS are soils containing iron sulfide that have not been exposed to oxygen (e.g. soils below the water table). PASS therefore have not produced sulfuric acid but have the potential to do so if exposure to oxygen occurs. The factor common to all ASS materials is that RIS components have either had, or may have, a major influence on the properties or behaviour of these soil materials. AASS and PASS are often found in the same soil profile, with AASS overlying PASS.

Field and laboratory based criteria for determining if soils are classified as PASS / AASS and / or exceed the Action Criteria for management if disturbed are provided in Appendix C.

3.2 Management and risk characterisation

Dear, et al. (2024) relates environmental risk from ASS to the treatment level and volume of disturbance of ASS. Based on the tonnage of ASS to be disturbed and the average net acidity, the proposed disturbance of the site soils is categorised as one of the following:

- Low level of treatment: Category L;
- Medium level of treatment: Category M;
- High level of treatment: Category H;
- Very High level of treatment: Category VH; and
- Extra High level of treatment: Category XH.

It is noted that where disturbance involves groundwater dewatering[1], or if the site is close to an environmentally sensitive area / acidophilic ecosystem, then Dear, et al. (2024) indicates the disturbance will need to be treated as per Category XH and an environmental management (EM) Plan (i.e. an ASSMP) prepared.

Details of the criteria and management requirements for each of the categories is provided in Appendix H.

The assessment of risk categorisation for this ASSMP is provided in Section 6.2.

4. Proposed development

It is proposed to construct a new vacuum pump station to replace the existing temporary system. The design of the new system was still in development at the time of reporting but is understood to include an above ground sewer pump station and an underground holding tank with associated service connections. It is understood that the connection between the new system and existing sewer may involve trenches or possibly an under bore extending from the proposed tank location. The inground tank is understood to be about 6 m x 3 m with the total excavation area (including shoring) being approximately 28 m^2

Based on this, the maximum excavation depth for the development expected to be about 6 m. The works are expected to require the drilling of piles to rock, installation of services (to a depth of approximately 3 m) and associated dewatering to facilitate the construction works.

The proposed development is located in the vicinity of a number of large stormwater culverts which cross the greater Warringah Mall site in a roughly northwest to southeast orientation. An extract from the he provided drawings (SDC-42.0002, RevB dated 4.10.2024 is provided as Figure 1.

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[1] (Dear, et al., 2024) defines groundwater dewatering as the process of extracting water from a saturated soil or sediment that results in alteration of the water table level, however, does not include short-term pumping (<1 day duration) of saturated soils or sediments from small volume excavations.

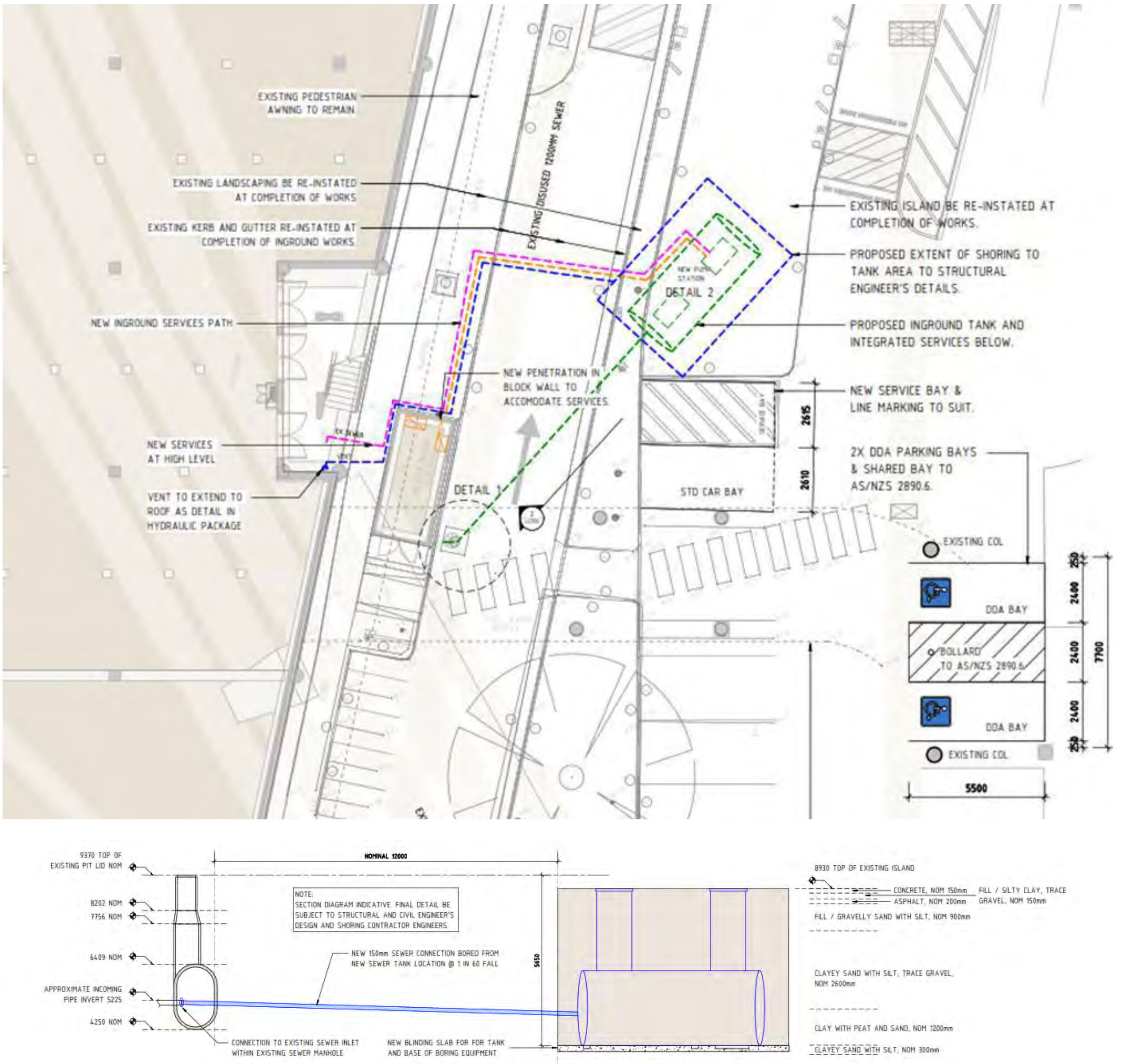

Figure 2: Extract of Sewer Pump Configuration from high level mark-up provided by Scentre Group

5. Review of previous investigation

Douglas has previously undertaken a targeted contamination investigation for the proposed AVAC station which included an acid sulfate soil assessment, with the results present in *Report on Targeted Contamination Assessment, Brookvale Westfield - AVAC Sewer pump station, Warringah Mall, 145 Condamine Street, Brookvale NSW* Report No. 71015.55.R.001.Rev0 dated 10 July 2024 (Douglas, 2024). The fieldwork was undertaken in conjunction with a concurrent geotechnical investigation.

The investigation included the drilling of two boreholes, BH1 and BH2. The boreholes were drilled to depths between 9.0 m to 9.6 m below ground level (bgl), with weathered rock encountered at depths between 5.35 m (BH1) to 6 m (BH2) bgl.

The borehole logs for this assessment are included in Appendix D. The logs recorded the following general sub-surface profile:

Pavement / Fill	Generally comprised 60 mm of asphaltic concrete (AC) or, 150 mm of concrete pavement over 200 mm of AC pavement overlying fill comprising cemented road base and silty clay with trace sandstone and ironstone gravels to depths of up to 1.4 m.
Alluvial Soil:	Very loose and loose organic clayey and peaty sand, with occasional quartz gravel, encountered to depth of between 5.4 m and 4.0 m. Very soft alluvial clay with peat and sand encountered below the alluvial sands in BH2 only at 4.0 m to a depth of 5.2 m.
Extremely Weathered Sandstone:	Very dense fine to coarse grained clayey sand and possibly very low strength rock encountered below the alluvial soils to depth of about 6 m.
Sandstone:	Fine to coarse grained, slightly to moderately weathered Hawkesbury Sandstone encountered at depths between 5.9 m to 6.0 m and extending to the maximum investigation depth of 9.6 m. Initially very low to low strength, improving to medium strength from about 7.9 m to 8.2 m.

After installation, the groundwater monitoring well installed within BH2 and a previously installed well at BH510 was gauged. A summary of the well construction details and groundwater measurements taken following installation of the groundwater wells are presented in Table 1. Groundwater levels are transient, and change over time, including with prevailing weather.

Table 1: Well construction details and groundwater levels

BH Ref	Ground surface level (m AHD)	Filter zone depth (m)	Depth of water (m bgl)	Groundwater level (m AHD)	Filter zone material
BH2	8.9	2.2 – 5.5	2.52	6.38	Alluvial soil
BH510	8.6	3.0 – 6.0	3.86	4.74	Alluvial soil

Notes:

*Surveyed by dGPS
AHD – Australian Height Datum
SWL – standing water level
bgl – below ground level
Groundwater levels measured on 5 June 2024

Based on the groundwater level measurements and previous Douglas investigations, groundwater is interpreted to be flowing to the west towards Brookvale Creek. Brookvale Creek runs below the site (in a culvert) and surfaces 50 m south-east of Warringah Mall in Warringah Golf Course. The creek flows into Manly Lagoon.

Selected soil samples were tested for acid sulfate soil screening and chromium reducible (Scr) tests to assess for acid sulfate soils.

The results are presented in Table D1, Appendix D and are summarised as follows:

- pH_F was within the threshold criterion (<4 pH units, indicative of actual ASS) in all samples, ranging from 6.6 to 7.6 pH units;
- pH_{FOX} was below the threshold criterion (<3.0 pH units, indicative of potential ASS) in eight of the nine samples tested with a range of 2.1 to 3.0 pH units;
- All samples exceeded the threshold criterion for the drop in pH_F (>1 pH units), ranging from 3.6 to 5.0 pH units; and
- The SCr test results indicated that four of the five samples tested exceeded the action criterion for net acidity of >0.03% S. The exceedances ranged from 0.041% S to 0.084% S.

Taking into consideration the ASS results and cross-referencing of borehole logs, the S_{Cr} results suggest that ASS is present at the site at depths of between 1.4 m bgl and 6.0 m bgl (the top of bedrock) and is likely to be associated with the alluvial deposits across the site.

It was noted that due to the use of NDD which precluded the collection of samples from the fill for acid sulfate soil testing it is recommended that a precautionary approach be adopted and the fill be treated as potential ASS and managed accordingly, unless further testing does not record acid sulfate soil in the fill.

The assessment criteria adopted for the pervious investigation (and this ASSMP) are provided in Appendix C.

6. Potential for oxidising ASS and risk categorisation

6.1 ASS oxidation potential

Based on the proposed development (refer to Section 4) excavations and potential exposure of ASS are proposed as follows:

- Bulk excavations to allow construction of below ground infrastructure. Excavation to depth of 6 m (RL 3) is anticipated;
- Drilling of piles into rock. (Sandstone depth of approximately 5.5 m bgl (3.5 m RL);
- Excavations or horizontal boring for service installations. Excavations up to 4.5 m (RL 4.5) are anticipated; and
- Dewatering for construction of the tank which is anticipated to result in drawdown of less than 1 m below groundwater levels recorded herein (noting groundwater levels are transient).

Based on the above, the volume of ASS likely to be disturbed by the development is approximately 100 m^3 (estimated to be approximately 180 to 200 tonnes based on a sand matrix).

ASS outside the excavation footprint may also be exposed during dewatering, if dewatering is required to facilitate excavation.

Based on the results of previous investigations (refer to Section 5) any excavations which disturb or uncover natural alluvial soils below a depth of 1.4 m to the top of bedrock have the potential to oxidise PASS and / or disturb AASS. It is also possible that the overlying fill may contain PASS.

Any disturbance (e.g. excavation or dewatering) of ASS must be undertaken in accordance with this ASSMP.

6.2 Assigned risk categorisation

The following key issues were considered when assigning the risk categorisation and formulating this ASS management strategy:

- Identify if there is a sensitive receptor (i.e. environmentally sensitive community, creek, wetland or residential properties) or acidophilic ecosystem nearby;
- Confirm whether the groundwater table level is likely to be altered;
- Heterogeneity, geochemical and textural properties of soils on site including the adequacy of previous assessments (preliminary or detail assessment completed); and
- Identify any management and planning requirements of local or state governments (i.e. DA requirement to prepare an ASSMP).

Section 7 of this ASSMP provides the appropriate ASS management procedures for the below risk categorisation.

6.2.1 Soil excavation risk category

Dear, et al., (2024) relates environmental risk from ASS to the treatment level and volume of disturbance of ASS. Based on the proposed development and subsequent tonnage of ASS to be disturbed (estimated 200 tonnes as per Section 7) and the maximum net acidity (0.084 %w/w S as per Section 6.1):

Medium (M) to High (H) level of treatment

6.2.1 Groundwater dewatering risk category

Dear, et al., (2024) defines groundwater dewatering as the process of extracting water from a saturated soil or sediment that results in alteration of the water table level, however, does not include short-term pumping (<1 day duration) of saturated soils or sediments from small volume excavations). Douglas understands that less than one day of dewatering is required and that the cone of depression formed by the dewatering will be limited by the piled cut off wall. As such, the risk from the dewatering is assessed to be minimal, and no further management specific to acid sulfate soil is required.

If the dewatering is not managed as assumed above, then further management specific to acid sulfate soil is expected to be required.

7. ASS management

7.1 Management options

The Acid Sulfate Soils Manual (Stone, Ahern, & Blunden, 1998) and Queensland Acid Sulfate Soil Technical Manual (Dear, et al., 2024) provides the following potential soil management options:

1. On-site treatment (neutralisation) followed by:
    - Off-site disposal;
    - On-site re-use;
2. Off-site treatment and disposal;
3. On-site reburial below the permanent water table without treatment (PASS only); and
4. Off-site reburial below the permanent water table without treatment (PASS only).

Based on the proposed development Option 1 – on-site treatment followed by off-site disposal (and / or on-site reuse) has been identified as the preferred management option, with reference to the relevant guidelines and reference materials.

7.2 Proposed management strategy

7.2.1 General

The general process for the treatment of ASS is as follows:

- Prepare a treatment pad as described in Section 7.2.2, including management measures for leachate and surface water;
- Manage ASS during stockpiling and treatment to minimise dust and leachate generation (e.g. by covering, or lightly conditioning with water). If wet weather prevails, stop works and cover the stockpiled soil with plastic sheeting to reduce the formation of leachate;
- Untreated stockpiled soils should be treated as soon as possible following excavation. For coarse soils (i.e. sands), treatment should occur within approximately 12 to 18 hours (or less) following excavation. For fine-grained soils (i.e. clays), treatment should occur within approximately 40 to 60 hours following excavation. Faster oxidation rates are possible, particularly in warm weather;
- Transport ASS requiring treatment and place on the guard layer of the treatment pad;
- Spread the ASS over the guard layer in layers of up to 0.3 m thick, leaving a 1 m buffer between the toe of the spread soil and the containment bund or drain. When spreading the first soil layer, care should be taken not to churn up the guard layer;
- Apply agricultural lime (commonly known as aglime) over the 0.3 m layer at the minimum lime dosing rate (refer to Section 7.2.3 and harrow / mix thoroughly. Use of rotary plough equipment (e.g. auger bucket) may be appropriate for cohesive soils, where adequate mixing is difficult to achieve. Note: If ASS materials are too wet, adequate mixing of aglime cannot be achieved and soils may require a period of drying prior to mixing;

- Completion of verification testing (as outlined in Section 9) to confirm that the ASS have been adequately neutralised in each layer prior to placement of the next layer to be treated. If verification testing indicates that additional neutralisation is required, add additional aglime (at an appropriate liming rate) and mix as described above;
- Continue the spreading / liming / harrowing / verification cycle for each 0.3 m layer until excavation is finished;
- When verification testing indicates that the ASS have been adequately neutralised, the soil may be removed from the treatment pad for disposal off-site in accordance with the waste classification;
- (or) When verification testing indicates the ASS have been adequately neutralised, subject to geotechnical suitability, the soil may be removed from the treatment pad for on-site reuse in accordance with the site management plan etc;
- Management of leachate water and groundwater may also be required where leachate is produced and / or if groundwater is impacted by the works as outlined in Section 8 and Appendix G; and
- A layer of fine agricultural lime ('aglime') should be applied over the base of excavation in ASS to neutralise downward seepage from exposed ASS, to minimise acidification of groundwater following re-establishment of groundwater levels and to act as a buffer between the ASS and engineered materials in the constructed holding tank.

7.2.2 Preparation of treatment pads

The key features of the treatment area and design considerations are summarised below and shown in Figure 3 below:

- **Treatment pad area** – The treatment pad should be of an appropriate area for the volume of soil to be treated / stored, and should be prepared on relatively level or gently sloping ground to minimise the risk of potential instability issues, with a fall to the project drainage sump;
- **Pad location** – The pad should be located as far as practical from any potential ecological receptors (i.e. Brookvale Creek or drainage lines which enter the stormwater system / creek));
- **Lining** – the treatment pad should be lined to minimise the potential for leachate seepage into underlying soils. Options for lining include the following:
    - Geosynthetic liner (such as HDPE sheeting);
    - Impervious physical barrier, such as a concrete slab or bitumen sealed hardstand;
    - Natural low permeability clay; and
    - A compacted clay layer.
- **Guard Layer** – A guard layer of fine agricultural lime ('aglime') should be applied over the clay subgrade or lining to neutralise downward seepage. For the proposed development, a guard layer of 5 kilograms fine aglime per m^2 per 300 mm of placed ASS requiring treatment should be placed at the surface of the treatment pad prior to placement of untreated ASS;
- The guard layer should be re-applied following removal of treated soils prior to addition of untreated ASS. Guard layers may need to be applied between each placed ASS layer in situations where multiple layers of ASS are placed on the same treatment pad;

- **Bunding** – The treatment pad should be bunded to contain and collect potential leachate runoff within the treatment pad area and to prevent surface water from entering the treatment pad (i.e. hydrologically isolated). The inner bund slopes should be lined to prevent leachate seeping into the ground surface, and sized to prevent overflow of untreated leachate onto the site.

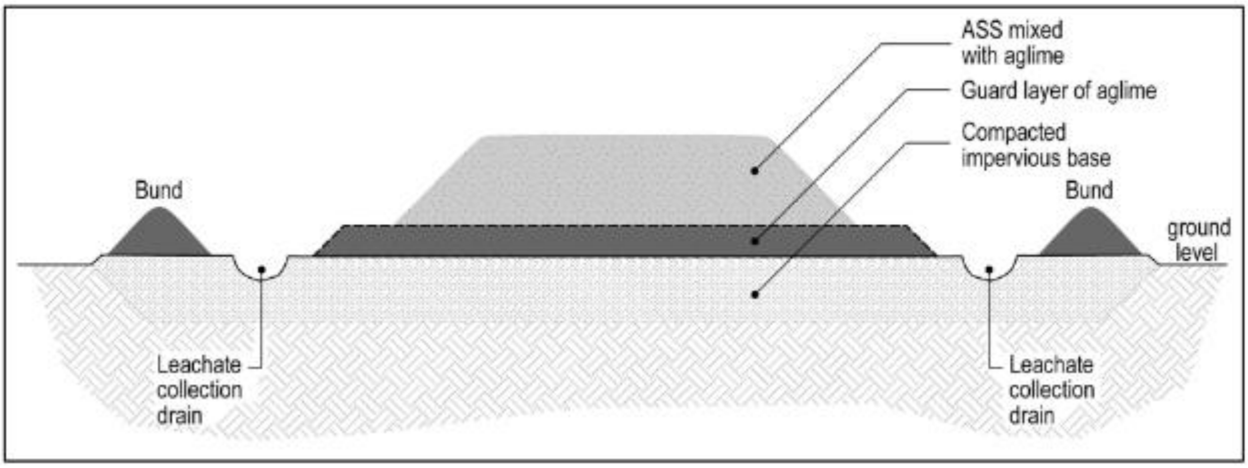

Figure 3: Schematic cross-section of a treatment pad, including compacted impervious base (clay layer), guard layer, leachate collection drains and bunding (Fig 5 (Dear, et al., 2024))

If a treatment pad is not practical due to limited space an alternative approach (such as a lined skip bin) can be considered. Further advice from a suitably qualified person should be sought in this regard if an alternative treatment pad is to be considered.

7.2.3 Liming rate

Based on the assessment results (Douglas, 2024), natural alluvial soils (and fill unless further testing shows this is not required) that are to be disturbed during excavation are to be treated using aglime prior to reuse on-site or off-site disposal. Table 2 provides indicative liming rates for neutralisation of the ASS likely to be disturbed.

Table 2: Indicative liming rate for soil

Material	Net Acidity (%S)	'Ag' Lime Application Rate for Treatment of Soil ^{b} (kg/tonne)
Alluvial Soil: Very loose and loose organic clayey and peaty sand, with occasional quartz gravel, encountered to depths of between 5.4 m and 4.0 m. Very soft clay with peat and sand encountered below the alluvial sands in BH2 only at 4.0 m to a depth of 5.2 m.		

Material	Net Acidity (%S)	'Ag' Lime Application Rate for Treatment of Soil [b] (kg/tonne)
Based on Maximum Net Acidity	0.084 (0.041-0.084)[c]	3.6 (6.4 kg/m^3)
Based on Average Net Acidity	0.06	2.6 (4.6 kg/m^3)

Notes:

a Maximum Net Acidity. Net Acidity to be determined based on the equations provided in Appendix C,
b lime application rate calculated using maximum net acidity for soil unit/type using equations in Appendix F.
c Net Acidity range

Depending upon the source of the aglime and ultimately the representative Effective Neutralising Value (ENV) of the aglime selected, the minimum lime dosing rate may be increased or decreased. Prior to the commencement of works, the minimum lime dosing rate should be finalised following review of the ENV of the selected aglime.

7.2.4 Neutralising materials

Agricultural lime, commonly known as aglime, is the preferred neutralisation material for the management of ASS, as this material is usually the cheapest and most readily available product for acid neutralisation. Furthermore, aglime is slightly alkaline (pH of 8.5 to 9), non-corrosive, of low solubility and does not present handling problems or generate high pH leachate and it only liberates alkalinity in the presence of acid.

Dolomite and calcined magnesia also have low solubility; however, they produce magnesium sulfate during neutralisation reactions which is quite soluble and may degrade water quality in waterways if large quantities are produced. Agricultural lime on the other hand hydrates to gypsum which is less soluble and therefore less likely to affect water quality and also has other beneficial impacts on soil properties particularly soil structure.

Aglime comprises calcium carbonate ($CaCO_3$), typically made from limestone that has been finely ground and sieved to a fine powder. Aglime with the following properties are the preferred neutralising agent:

- Purity of at least 98% or better (i.e. NV > 98, where NV is the neutralising value, a term used to rate the neutralising power of different forms of materials relative to pure, fine calcium carbonate which is designated NV = 100);
- NOTE: There could be economic justification for using a less pure grade of aglime, however, under these circumstances, the individual lime dosing rates described in Section 7.2.3 would need to be carefully considered, as the cost savings from using less pure material may be offset by the corresponding increase in the required dosing rates (lime volumes required), and the transport and disposal costs; and
- Fine ground (at least <0.5 mm) and dry, as texture and moisture can decrease the effective NV.

Aglime requires no specialised handling, however, use of safe work practices and good hygiene practices are recommended to avoid eye or skin contact and inhalation. Aglime should be stored in a cool, dry, well-ventilated area inaccessible to the general public and removed from incompatible substances and foodstuffs (refer to Aglime SDS from supplier for further details). It would be advisable to cover any aglime stockpiles (where relevant) with a tarpaulin both to minimise wind erosion and wetting, as the material is more difficult to spread when wet.

Due to its low solubility in water, aglime is not suitable for the neutralisation of leachate, which requires a product with a very quick reaction and high solubility. A suitable neutralising agent for leachate and retained drainage water / groundwater is slaked lime or hydrated lime (calcium hydroxide ($Ca(OH)_2$)). This is made by treating burnt lime (calcium oxide (CaO)) with water (slaking) and comes as a fine white powder. It has a typical NV of about 135. Due to its very strong alkalinity (pH or about 12.5 to 13.5), slaked lime or hydrated lime should not be allowed to come into contact with the skin or be inhaled and care must be taken to not overshoot pH adjustment with such alkaline agents. Hydrated lime is not recommended for soil neutralisation. Hydrated lime should be stored in cool protected place (e.g. locked store inaccessible to the general public) away from moisture, strong oxidants or acids and to minimise dust emissions and (refer to Hydrated Lime suppliers SDS for further details). Alternatively, commercial neutralisation products for water may be available and suitable for use.

7.3 **Alternative strategy or contingency plan**

Where the proposed primary management option is not possible, or practical, alternative or contingency strategies, with reference to the applicable guidelines, may be considered and implemented following a ‘fit for purpose’ assessment. These options are outlined in Appendix E.

8. Leachate water and groundwater management

Potential leachate water and groundwater management strategies are provided in Appendix G.

9. Verification testing of treated soils and water

Verification testing to assess whether ASS have been adequately neutralised will be undertaken by means of the following:

- Screening tests (pH_F and pH_{FOX}) at the frequencies detailed in Table 3; and
- Acid base accounting (e.g. using chromium suite) of testing at the frequencies detailed in Table 3.

Based on a ‘Category H’ treatment level, verification testing of the ASS and leachate water (if present) is required after the addition of lime to test whether the soil / water has been adequately neutralised, whether or not adequate mixing of the ASS has been achieved, and to reduce the risk of acidic water being returned to the environment (including watercourses). The verification testing frequency for ASS is presented in Table 3.

Table 3: Verification testing frequency for ASS

Test	Frequency
Field test: pHF and pHFox screening	• One sample / soil type; OR • One sample / 25m^3 of treated soil (whichever is the greater frequency); AND • At least three to six samples / 200 mm to 300 mm deep soil treatment layer.
Laboratory analysis: Acid Base Accounting (including chromium reducible sulfur (Scr) method)	• One sample / soil type; OR • Volumes of <250 m^3 = two samples OR • Volumes 251–500 m^3 = three samples AND • At least one sample / 200 mm to 300 mm deep soil treatment layer.

Note:

Verification testing frequencies should be adjusted (either increased or decreased) depending on net acidity value, performance, material quantities and purpose/reuse, and may be subject to change by the appropriate regulatory authority in the event of a review.
Laboratory analysis on untreated soils for each treatment layer should be considered where heterogenous materials are present and initial ASS investigations indicate the presence of existing ANC (unverified).

In addition, the pH of all ponded leachate water around the confines of the treatment bunds and adjacent surface waters should be measured daily and results assessed against the criteria provided in Table 4 and also against background (pre-construction) levels. The soil and water contained within the bunded treatment area should not be removed until the target values presented in Table 4 below have been achieved. Treatment of deeper soil layers should not be commenced until the existing surface layer has been validated and removed.

It should be noted that laboratory tests will require at least four days turnaround, possibly longer, and hence sufficient time should be allowed in the treatment programme for such verification testing. Only appropriately skilled staff should collect and test verification samples.

Table 4: Target levels of neutralised soil and water

Test	Component	Target level
Monitoring of water (leachate, surface water)	pH	6.5 < pH < 8.5, or one pH unit from background levels
	Turbidity	To comply with either values determined in consultation with the Authority or less than local background levels (baseline monitoring required).
	Total Suspended Solids (TSS)	≤50 mg/L or equivalent turbidity measure (in NTU) where a statistical correlation between the TSS and turbidity has been determined

Test	Component	Target level
	Electrical Conductivity (EC)	To comply with either values determined in consultation with the Authority or less than local background levels (baseline monitoring required).
	Dissolved Oxygen (DO)	To comply with either values determined in consultation with the Authority or less than local background levels (baseline monitoring required).
	Aluminium (Al) and Iron (Fe) Tested prior to discharge	Establish local water quality data prior to site disturbance and ensure that these values are not exceeded.
	VCH (tested prior to discharge)	Chlorinated ethenes must comply with the (ANZG, 2018) Trigger Levels for 95% Level of Protection for fresh ecosystem
Field screening of soil[b]	pH_F	$6.5 \le pH_F \le 8.5$
	pH_{FOX}	$6.5 \le pH_{FOX} \le 8.5$
Acid Base Accounting (including chromium reducible sulfur (Scr) method) for soils	Net acidity[a]	Zero or negative
	pH_{KCL}	$6.5 \le pH_{KCL} \le 10$

Notes:

a determined using equations C3 or C4, Appendix C
b used as a guide only to assess when adequate neutralisation and soil mixing has been achieved.

10. General site monitoring

It is recommended that prior to commencement of works, a Construction Environmental Management Plan (CEMP) should be developed by the lead contractor. The CEMP should also include a programme for general site monitoring pertinent to the ASS. A typical monitoring programme is provided in Table 5 below and should be implemented by the responsible parties.

Table 5: General monitoring requirements

Task	Frequency	Standard	Reporting / record keeping	Responsibility
Inception Meeting	Pre-start	ASSMP	Minutes	Project Manager, Site supervisor, Environmental Consultant
Site inspection	Daily	Visual/olfactory signs of ASS	File note	Site supervisor

Task	**Frequency**	**Standard**	**Reporting / record keeping**	**Responsibility**
Site inspection	Monthly	Visual / olfactory signs of ASS	File Note	Project Manager
Monitoring of disturbed excavations that are in ASS	Daily	Visual until backfilled	File note	Site supervisor
Monitoring of ASS treatment area/s	Daily	Visual Daily pH testing until results show ASS or leachate has been neutralised (refer Section 10 for criteria and testing requirements)	File note and results of pH testing to be recorded in field sheets	Site supervisor
Dewatering excavation in ASS	Prior to planned discharge	Treated and tested to demonstrate compliance with ASSMP guidance or regulatory requirements prior to discharge (refer to Table 4)	Field sheets and permit to discharge	Site supervisor / environmental consultant
Groundwater	Monthly during works and at completion of dewatering	pH, EC, DO, Al, VCH, total and dissolved Fe testing, tested to demonstrate compliance with ASSMP guidance or regulatory requirements prior to discharge	Field sheets, laboratory reports and permit to discharge	Site supervisor / environmental consultant
Surface Waters	Daily (field parameters) Weekly (Metals and VCH), plus prior to and following discharge	pH, EC, DO, Al, VCH, total and dissolved Fe testing, tested to demonstrate compliance with ASSMP guidance or regulatory requirements prior to discharge	Field sheets, laboratory reports and permit to discharge	Site supervisor / environmental consultant

11. Emergency incident response plan

Construction activities which may cause potential environmental impacts with respect to ASS are summarised in Table 6 below together with recommendations for "Emergency Response Procedures".

Table 6: Emergency response procedures

Construction activity	Potential environmental threat	Emergency response
All	Potential off-site migration of ASS impacted soil / water	• Assess need to report the incident the EPA, Council etc, and report as required. • Additional responses as per below.
Excavations	Flooding of open excavation causing adjacent groundwater levels to rise, leading to potential acid leachate once the excavation is drained	• Inform site foreman and project manager / environmental officer; • Determine pH of groundwater / floodwater in excavation; • Correct groundwater / floodwater pH by application of slaked lime (hydrated lime) to bring pH in range of 6.5 to 8.5 or to pre-construction background levels; and • Drain pit to tanks / ponds for water quality assessment prior to discharge, or dispose of directly off-site to a suitably licenced liquid waste facility.
Treatment / Neutralisation	Soil washes or slips outside of bunded treatment area	• Inform site foreman and project manager / environmental officer; • Estimate volume of material breaching bund; • Conduct pH analysis of adjacent watercourses (if any) and correct pH if potentially impacted; • Remove escaped soil into a bunded treatment area; and • Over-excavate impacted area to 0.2 m depth (if area is unpaved ground), apply and mix lime at rate as for guard layers (5 kg to 10 kg lime per m^2 of surface).
	Breach in containment bund	• Inform site foreman and project manager / environmental officer; • Close breach in bund; • Conduct pH analysis of adjacent watercourses (if any); and

Construction activity	Potential environmental threat	Emergency response
		• Correct pH in any adjacent watercourse (if required).
	Extracted untreated groundwater, surface water or leachate is exiting the site in an uncontrolled manner	• Inform site foreman and project manager / environmental officer; • Restrict / stop source of water; and • Conduct pH analysis of adjacent watercourses (if any).

For all construction activity incidents which pose a potential environmental impact, an incident report must be completed in order that:

- The cause of the incident may be determined;
- Additional control measures may be implemented; and
- Work procedures may be modified to reduce the likelihood of the incident re-occurring.

12. Reporting and record keeping

With reference to (Dear, et al., 2024), it is good practise for the contractor to maintain a record of treatment of ASS. Such records should include the following details:

- Date;
- Location / area / treatment pad;
- Time of excavation;
- Neutralisation process undertaken;
- Lime rate utilised including:
  - Receipts showing quantities of aglime purchased;
  - Evidence of composition, purity, particle size and effective neutralising value (ENV) of the aglime used;
  - Record of aglime use (e.g. per treatment pad, use in guard layers etc.); and
  - Photographic evidence of incorporation of neutralising agent(aglime).
- Results of monitoring;
- Disposal and / or re-use location; and
- Tonnages and disposal / transfer dockets (if applicable).

A record should also be maintained confirming contingency measures, additional treatment if undertaken and any incidents. A final report should be issued upon completion of the works presenting the monitoring regime and results, and confirming that appropriate management of ASS has occurred during the works.

13. Conclusions and recommendations

This ASSMP provides the ASS management procedures to be enacted to minimise the impact of ASS disturbance on the environment during the proposed works.

14. References

Ahern, C. R., McElnea, A. E., & Sullivan, L. A. (2004). *Acid Sulfate Soils Laboratory Methods Guidelines. In Queensland Acid Sulfate Soils Manual 2004.* (QASSIT) Indooroopilly, Queensland, Australia: Department of Natural Resources, Mines and Energy.

CRC CARE. (2017). *Risk-based Management and Remediation Guidance for Benzo(a)pyrene.* Technical Report no. 39: Cooperative Research Centre for Contamination Assessment and Remediation of the Environment.

Dear, S. E., Williams, K. M., McElnea, A. E., Ahern, C. R., Dobos, S. K., Moore, N. G., & O'Brien, L. E. (2024). *Queensland acid sulfate soil technical manual : soil management guidelines version 5.1.* Department of Resources and the Department of Environment and Science.

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Douglas. (2024). *Report on Targeted Contamination Assessment, Brookvale Westfield - AVAC Sewer pump station, Warringah Mall, 145 Condamine Street, Brookvale NSW.* Report 71015.55.R.001.Rev0 dated 10 July 2024.

EPA. (2014). *Waste Classification Guidelines.* NSW Environment Protection Authority (EPA).

NEPC. (2013). *National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013) [NEPM].* Australian Government Publishing Services Canberra: National Environment Protection Council.

NSW EPA. (2014a). *Waste Classification Guidelines, Part 1: Classifying Waste.* NSW Environment Protection Authority.

NSW EPA. (2014b). *Waste Classification Guidelines, Part 4: Acid Sulfate Soils.* NSW Environment Protection Authority.

NSW EPA. (2020). *Guidelines for Consultants Reporting on Contaminated Land.* Contaminated Land Guidelines: NSW Environment Protection Authority.

NSW EPA. (2022). *Contaminated Sites, Sampling Design Guidelines.* NSW Environment Protection Authority.

NSW RTA. (2005). *Guidelines for the Management of Acid Sulfate Materials: Acid Sulfate Soils, Acid Sulfate Rock and Monosulfidic Black Ooze.* Version 1, RTA/Pub. 05.032: NSW Roads and Traffic Authority.

Stone, Y., Ahern, C. R., & Blunden, B. (1998). *Acid Sulfate Soils Manual.* Wollongbar, NSW, Australia: Acid Sulfate Soil Management Advisory Committee.

Sullivan, et al. (2018a). *National Acid Sulfate Soils Guidance: National Acid Sulfate Soils Identification and Laboratory Methods Manual.* Canberra ACT CC BY 4.0: Sullivan, L; Ward, N; Toppler, N; Lancaster, G, Department of Agriculture and Water Resources.

Sullivan, et al. (2018b). *National Acid Sulfate Soils Guidance: National Acid Sulfate Soils Sampling and Identification Methods Manual*. Canberra ACT CC BY 4.0: Sullivan, L; Ward, N; Toppler, N; Lancaster, G, Department of Agriculture and Water Resources.

15. **Limitations**

Douglas Partners Pty Ltd (Douglas) has prepared this report for this project at Warringah Mall, 145 Condamine St, Brookvale NSW in accordance with Douglas' proposal 71015.54.P.001.Rev2, dated 7 May 2024 and acceptance received from Micha Hinden dated 30 July 2023. The work was carried out under contract No.: 14635, dated 15 May 2024). This report is provided for the exclusive use of Scentre Design & Construction Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of Douglas, does so entirely at its own risk and without recourse to Douglas for any loss or damage. In preparing this report Douglas has necessarily relied upon information provided by the client and / or their agents.

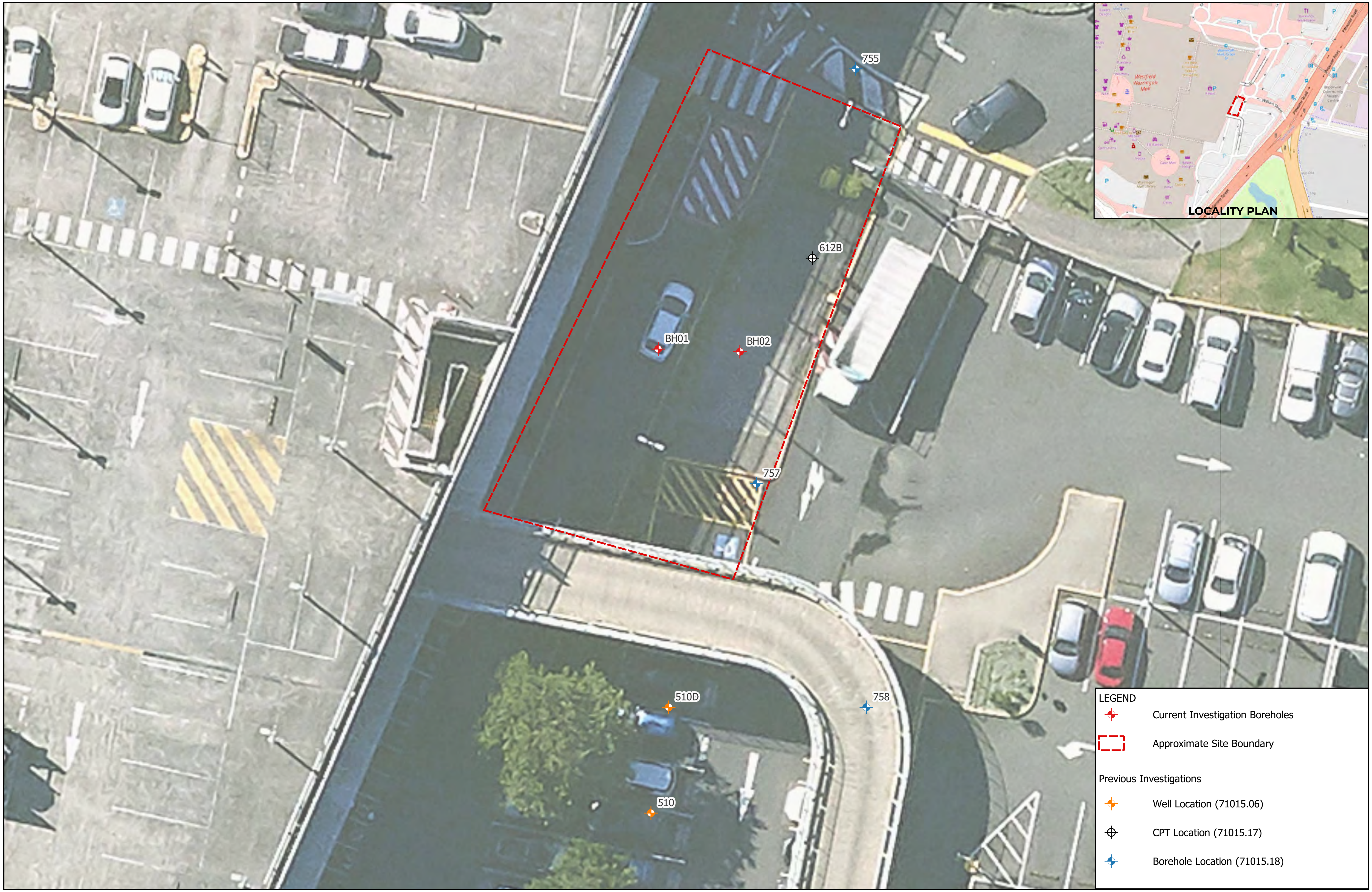
The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and / or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after Douglas' field testing has been completed.

Douglas' advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by Douglas in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and / or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

The assessment of atypical safety hazards arising from this advice is restricted to the (geotechnical / environmental / groundwater) components set out in this report and based on known project conditions and stated design advice and assumptions. While some recommendations for safe controls may be provided, detailed 'safety in design' assessment is outside the current scope of this report and requires additional project data and assessment.

Appendix A

Drawings



LEGEND

✦	Current Investigation Boreholes
⬚	Approximate Site Boundary

Previous Investigations

✦	Well Location (71015.06)
⌖	CPT Location (71015.17)
✦	Borehole Location (71015.18)

REV	DESCRIPTION/COMMENT	DATE	DRAWN BY
0	INITIAL ISSUE	10.07.2024	EC

SCALE:
0 2 4 6 8 10 m
1:200 @ A3

N

Douglas
PARTNERS
OFFICE: SYDNEY
96-98 Hermitage Rd, West Ryde NSW 2114
(02)9809 0666

CLIENT:
Scentre Design &
Construction Pty Ltd

NOTE:
1: Basemap from Metromap (Dated 25.03.2024)

COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 56

PROJECT NAME:
Brookvale Westfield - AVAC
Sewer Pump Station
PROJECT ADDRESS:
Warringah Mall 145
Condamine St, Brookvale

DRAWING TITLE:
TEST LOCATION PLAN

PROJECT NO:
710015.54
DRAWING NO:
1
REVISION:
0

Appendix B

Notes About This Report

About this Report

November 2023

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

continued next page

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

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Appendix C

Action Criteria and Verification of Treatment

1. Introduction

This appendix details the acid sulfate soil action criteria, acid sulfate soil treatment verification criteria, equations for net acidity and waste classification criteria. The action criteria are based on Sullivan (2018).

2. Action criteria

The following section provides the action criteria to determine if the soil is classified as PASS/ASS and therefore if acid sulfate soil management is required.

2.1 Field screening

Field screening indicators do not form part of the Assessment Criteria as such but can be used to provide an indication of the ASS status and to assist in selecting samples for laboratory testing.

Field screening is indicative only and can give false positive and false negative indications of the presence of ASS. False positives can be caused by organic matter, which often "froths" during oxidation. False negatives can be caused by shells in the soil. Indicators of ASS from field screening comprise:

- Field pH is less than or equal to pH 4;
- pHfox is less than 3;
- A decrease of one pH unit or more from the field pH to the pHfox;
- Bubbling, production of heat or release of sulphur odours during pHfox testing; and
- Change in colour from grey to brown tones during oxidation.

2.2 Laboratory analysis

The action criteria trigger are the basis for determining if an ASSMP is required. They are based on Net Acidity. As clay content tends to influence a soil's natural buffering capacity, the action criteria are grouped by three broad texture categories – coarse, medium and fine. If the Net Acidity of any individual soil tested is equal to or greater than the action criterion, management is required.

The test results can be used to evaluate the presence / absence of ASS in accordance with Sullivan (2018) and the reference guidelines. If the results indicate the absence of ASS treatment is not required. The following Table C1 provides the action criteria.

Table C1: Action criteria

Type of Material		Net Acidity#			
		1-1000 t materials disturbed		>1000 t materials disturbed	
Texture Range (NCST 2009)*	**Approximate Clay Content %)**	**% S-equiv (oven dried basis)**	**Mol H+/t (oven dried basis)**	**% S-equiv (oven dried basis)**	**Mol H+/t (oven dried basis)**
Coarse and Peats: sands to loamy sands	<5	≥ 0.03	≥ 18	≥ 0.03	≥ 18

Notes to Table:

* If bulk density values are not available for the conversion of cubic meters to tonnes of soil, then the default bulk densities based on the soil texture in Table C2, may be used.

\# Net Acidity can only include a soil material's measured Acid Neutralising Capacity where this measure has been corroborated by other data (for example slab incubation data) that demonstrates the soil material does not experience acidification during complete oxidation under field conditions (Equation C1). Where the Acid Neutralising Capacity has not been corroborated, the Net Acidity must be determined using Equation C2.

Table C2: Default bulk densities based on soil texture

Texture	Bulk Density (t/m^3)
Sand	1.8
Loamy Sand	1.8
Sandy Loam	1.7
Loam	1.6
Silty Loam	1.5
Clay Loam	1.5
Clay	1.4
Peat	1.0

3. Verification of treatment

The following section provides the equations and methods of verifying that the neutralisation treatment has been successful / completed.

3.1 Field screening

Field screening results will be considered to be acceptable when the results are below the adopted criteria. When soils meet the following criteria, confirmatory laboratory testing should be undertaken.

- Field pH is ≥ 5.5 (but ideally between pH 6.5 and 8.5); and
- pHfox ≥ 6.5.

3.2 Laboratory testing

3.2.1 Thresholds

The soil will be considered successfully treated where:

- pHKCL is ≥ 6.5;
- Total actual acidity (TAA) = 0; and
- Net acidity ≤ 0. Net Acidity must be determined by one of the methods outlined in Section 3.2.1

3.2.2 Net acidity calculation

Net Acidity is the quantitative measure of the acidity hazard of ASS. It is determined from an Acid Base Accounting (ABA) approach using one of the equations below. Equations C1 and C2 are used to determine the net acidity prior to treatment of ASS PASS and therefore if (further) acid sulfate soil treatment is required. Equation C3 is used to determine the neutralisation treatment has been successful.

The equations can be applied as follows:

- Equation C1 - when the effectiveness of a soil's measured Acid Neutralising Capacity has been corroborated by other data demonstrating the soil does not experience acidification during complete oxidation under field conditions [note: this had not been verified at the site at the time of reporting], or
- Equation C2 - when the effectiveness of a soil's measured Acid Neutralising Capacity has not been corroborated by other data, or
- Equation C3 – when the effectiveness of a management approach involving the addition of liming materials is being verified post treatment via calculation of the Verification Net Acidity.

Equation C1 Net Acidity whereby acid neutralising capacity (ANC) has been corroborated by other data.

Net Acidity = potential sulfidic acidity + actual acidity + retained acidity – Acid Neutralising Capacity.

Net Acidity = Scr + S-TAA at pH 6.5 + SNAS - s-ANCBT

Equation C2 Net Acidity whereby ANC has not been corroborated by other data.

Net Acidity = potential sulfidic acidity + actual acidity + retained acidity.

Net Acidity = Scr + S-TAA at pH 6.5 + SNAS.

Equation C3 Verification Net Acidity.

Verification Net Acidity = potential sulfidic acidity + actual acidity + retained acidity – (post neutralised Acid Neutralising Capacity – pre neutralised Acid Neutralising Capacity).

Verification Net Acidity = Scr + S-TAA at pH 6.5 + SNAS – (ANCBT of treated material – ANCBT of untreated material).

4. Off-site disposal requirements

Prior to disposal off-site the soil must be classified in accordance with the relevant guidelines.

4.1 Virgin excavated natural material

The POEO Act defines virgin excavated natural material (VENM) as:

'*natural material (such as clay, gravel, sand, soil or rock fines):*

(a) That has been excavated or quarried from areas that are not contaminated with manufactured chemicals, or with process residues, as a result of industrial, commercial, mining or agricultural activities; and

(b) That does not contain any sulfidic ores or soils or any other waste.

and includes excavated natural material that meets such criteria for virgin excavated natural material as may be approved for the time being pursuant to an EPA Gazettal notice.'

PASS / ASS and treated PASS / ASS cannot be classified as VENM.

4.2 Waste classification

If soil is proposed to be disposed to landfill (post treatment), it must be classified in accordance with the POEO Act, including the current guidelines, namely:

- NSW EPA Waste Classification Guidelines (2014) (EPA, 2014).

5. Disposal as PASS

Further guidance for the disposal of untreated soil as PASS is provided in Appendix E.

6. References

NEPC (2013) *National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013)*

Acid Sulfate Soils Management Advisory Committee (ASSMAC) Acid Sulfate Soils Management Guidelines (1998) (ASSMAC, 1998).

NSW Environment Protection Authority (EPA) Waste Classification Guidelines (2014) (EPA, 2014)

Sullivan, L, Ward, N, Toppler, N and Lancaster, G 2018, National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual, Department of Agriculture and Water Resources, Canberra, ACT. CC BY 4.0 (Sullivan *et al* 2018a);

Appendix D

Previous Results

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 8.74 AHD
EASTING: 339548.41
NORTHING: 6262248.54
DIP/AZIMUTH: 90°/--

BORE No: 755
PROJECT No: 71015.18
DATE: 30/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing				Water	Well Construction Details
				Type	Depth	Sample	Results & Comments		
	0.05	ASPHALT							
		FILLING - brown, sandy gravel filling (roadbase)		E	0.4 0.5		PID<1 ppm		
8	0.5	FILLING - grey, sand filling with trace roots		E	0.9 1.0		PID<1 ppm		
	1			E	1.4 1.5		PID<1 ppm		1
7	1.7	CLAY - soft, dark brown, clay with trace silt, moist		E	1.9 2.0		PID<1 ppm		2
6	2.2	SAND - brown and grey, medium grained sand with trace clay, moist to wet - saturated from 2.7m		E	2.9 3.0		PID<1 ppm	▼	
	3.0	Bore discontinued at 3.0m - target depth reached							3
5	4								4
4	5								5
3	6								6
2	7								7
1	8								8
0	9								9
-1									

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased
TYPE OF BORING: 100mm diameter solid flight auger
WATER OBSERVATIONS: Free groundwater observed at 2.7m whilst drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Westfield Design and Construction Pty Ltd
PROJECT: Contamination Assessment
LOCATION: Warringah Mall, Brookvale

SURFACE LEVEL: 8.59 AHD
EASTING: 339542.89
NORTHING: 6262225.44
DIP/AZIMUTH: 90°/--

BORE No: 757
PROJECT No: 71015.18
DATE: 30/4/2013
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Well Construction Details
	0.07	ASPHALT	■						
8	0.5	FILLING - brown, gravelly sand filling (roadbase)	▩	E	0.4 0.5		PID<1 ppm		
	0.7	FILLING - light brown, sand filling with some sandstone fragments (ripped sandstone)	▩	E	0.7		PID<1 ppm		
	1								1
	1.2	SAND - dark brown, fine to medium grained sand with trace clay, humid	⁘	E	0.9 1.0		PID<1 ppm		
7	1.6	CLAYEY SAND - brown, fine to medium grained clayey sand, damp	▨	E	1.4 1.5		PID<1 ppm		
	2								2
	2.3	CLAY - soft, brown clay with trace sand, moist	▨	E	1.9 2.0		PID<1 ppm		
6									
	3 3.0	SAND - brown, medium grained sand, damp	⁘	E	2.9 3.0		PID<1 ppm		3
		Bore discontinued at 3.0m - target depth reached							
5									
	4								4
4									
	5								5
3									
	6								6
2									
	7								7
1									
	8								8
0									
	9								9
-1									

RIG: Bobcat **DRILLER:** S. Gregor **LOGGED:** DW **CASING:** Uncased
TYPE OF BORING: 100mm diameter solid flight auger
WATER OBSERVATIONS: No free groundwater observed whilst drilling
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Scentre Design & Construction Pty Ltd
PROJECT: Brookvale Westfield - AVAC Sewer pump station
LOCATION: Warringah Mall, 145 Condamine St, Brookvale, NSW 21
SURFACE LEVEL: 9.1 AHD
COORDINATE: E:339537.4, N:6262232.9
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°
LOCATION ID: BH1
PROJECT No: 71015.54
DATE: 27/05/24 - 28/05/24
SHEET: 1 of 2

CONDITIONS ENCOUNTERED

GROUNDWATER	DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) / DENSITY(*)	MOISTURE
	0.06	ASPHALTIC CONCRETE PAVEMENT: 60 mm thick.			
		FILL / Silty Gravelly SAND: grey-brown; fine to medium; low plasticity silt; fine to medium, blue metal gravel. Cemented road base.	FILL	ND	ND
	1.40	Clayey SAND, trace gravel; fine to coarse; low plasticity clay; fine to medium, quartz gravel. From 1.40m: Organic odour	ALV	L	M
	2.35	Peaty SAND, with silt, trace gravel: dark grey; fine to coarse; coarse, quartz gravel. 5.10m: Very low 'TC' bit resistance	ALV	L VL	M W
	5.35	Continued as rock			

SAMPLE / TESTING AND REMARKS

REMARKS	TYPE	DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
PFAS	A/ES	1.40 – 1.50	PID	2.5ppm
	ES	1.90 – 2.00	PID	1.6ppm
	ES	2.40 – 2.50	PID	1.2ppm
		2.50	PID	1.3ppm
	SPT	2.50	SPT	2,2,3 N=5
		2.90		0ppm
	ES	2.90 – 3.00	PID	
	ES	3.40 – 3.50	PID	0ppm
	ES	3.90 – 4.00	PID	0ppm
		4.00	PID	1.2ppm
	SPT	4.00 – 4.45	SPT	1,0,1 N=1
				2/0 (HB)

NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Bobcat
OPERATOR: Ground Test (JJ)
LOGGED: CSY
METHOD: DT to 1.4m, VE to 1.5m, AD/T to 5.35m, NMLC to 9.00m
CASING: HWT to 5.5m
REMARKS:

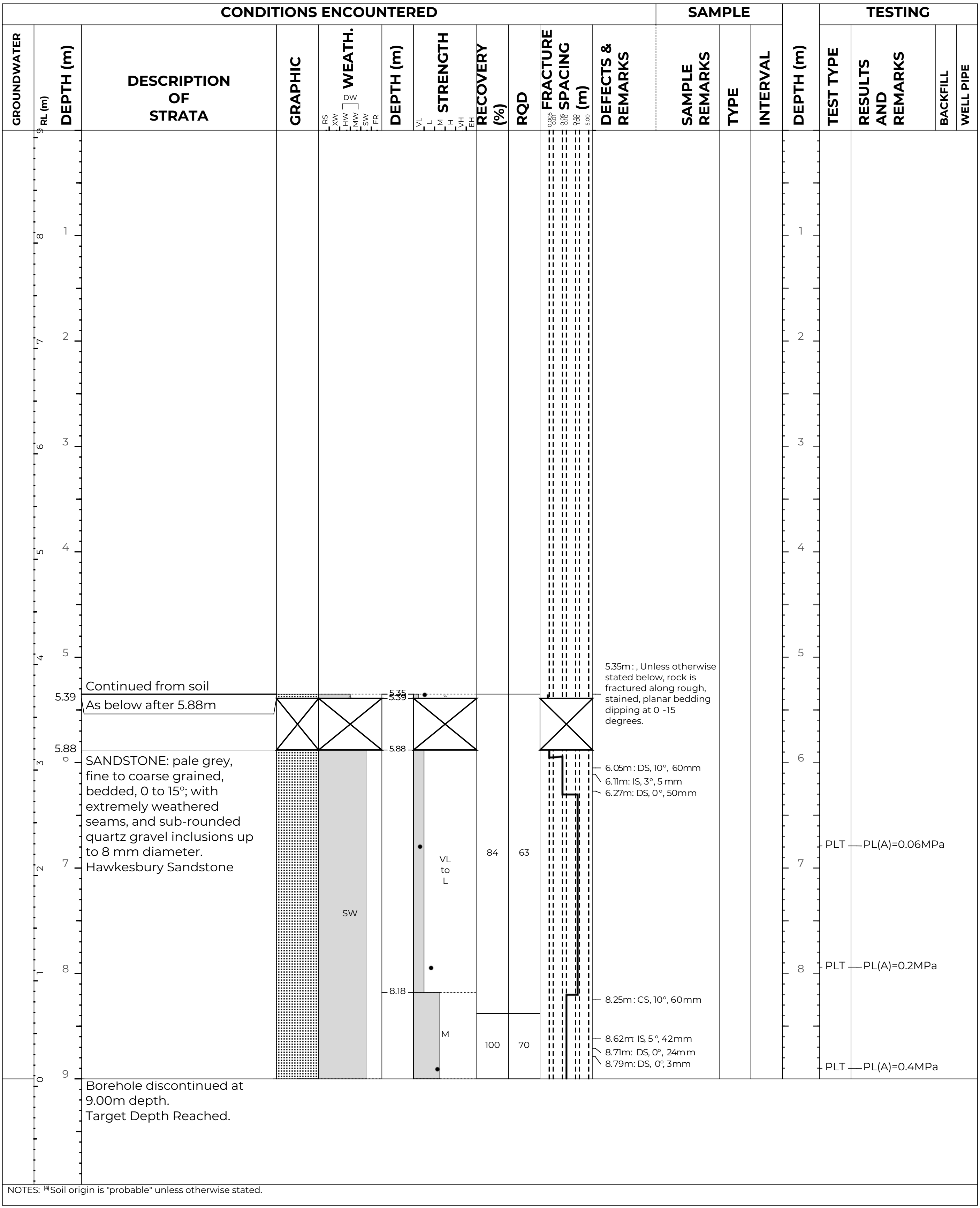
Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Scentre Design & Construction Pty Ltd
PROJECT: Brookvale Westfield - AVAC Sewer pump station
LOCATION: Warringah Mall, 145 Condamine St, Brookvale, NSW 21

SURFACE LEVEL: 9.1 AHD
COORDINATE: E:339537.4, N:6262232.9
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH1
PROJECT No: 71015.54
DATE: 27/05/24 - 28/05/24
SHEET: 2 of 2



Continued from soil

As below after 5.88m

SANDSTONE: pale grey, fine to coarse grained, bedded, 0 to 15°; with extremely weathered seams, and sub-rounded quartz gravel inclusions up to 8 mm diameter.
Hawkesbury Sandstone

Borehole discontinued at 9.00m depth.
Target Depth Reached.

5.35m : , Unless otherwise stated below, rock is fractured along rough, stained, planar bedding dipping at 0 -15 degrees.

6.05m : DS, 10°, 60mm
6.11m: IS, 3°, 5 mm
6.27m: DS, 0°, 50mm
8.25m : CS, 10°, 60mm
8.62m: IS, 5 °, 42mm
8.71m: DS, 0°, 24mm
8.79m: DS, 0°, 3mm

PLT — PL(A)=0.06MPa
PLT — PL(A)=0.2MPa
PLT — PL(A)=0.4MPa

NOTES: ⁽ᵃ⁾Soil origin is "probable" unless otherwise stated.

PLANT: Bobcat
METHOD: DT to 1.4m, VE to 1.5m, AD/T to 5.35m, NMLC to 9.00m
REMARKS:

OPERATOR: Ground Test (JJ)

LOGGED: CSY
CASING: HWT to 5.5m

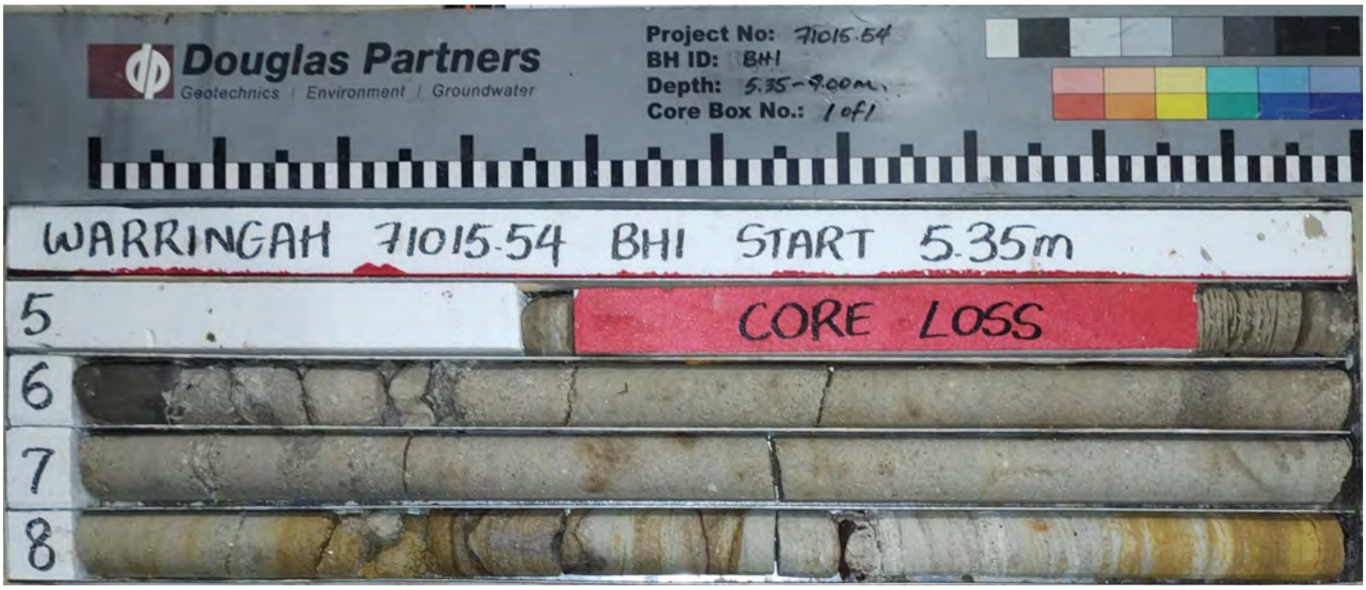
Refer to explanatory notes for symbol and abbreviation definitions

CORE PHOTO LOG

CLIENT: Scentre Design & Construction Pty Ltd
PROJECT: Brookvale Westfield - AVAC Sewer pump station
LOCATION: Warringah Mall, 145 Condamine St, Brookvale, NSW 21

SURFACE LEVEL: 9.1 AHD
COORDINATE: E:339537.4, N:6262232.9
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH1
PROJECT No: 71015.54
DATE: 27/05/24 - 28/05/24
SHEET: 1 of 1



Generated with CORE-GS by Geroc - Split Soil-Rock Log

BOREHOLE LOG

CLIENT: Scentre Design & Construction Pty Ltd
PROJECT: Brookvale Westfield - AVAC Sewer pump station
LOCATION: Warringah Mall, 145 Condamine St, Brookvale, NSW 21

SURFACE LEVEL: 8.9 AHD
COORDINATE: E:339542.0, N:6262232.8
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

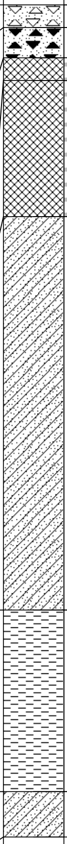
LOCATION ID: BH2
PROJECT No: 71015.54
DATE: 28/05/24 - 29/05/24
SHEET: 1 of 2

CONDITIONS ENCOUNTERED

DEPTH (m)	DESCRIPTION OF STRATA	ORIGIN(#)	CONSIS.(*) DENSITY.(*)	MOISTURE
0.15	CONCRETE PAVEMENT: 150 mm thick.		ND	ND
0.35	ASPHATIC CONCRETE PAVEMENT: 200 mm thick.	FILL	(MC)	w=PL
0.50	FILL / Silty CLAY, trace gravel: red-brown mottled brown; medium to high plasticity; fine to medium, sandstone and ironstone gravel.	FILL	ND	ND
1.40	FILL / Gravelly SAND, with silt; fine to coarse; fine to coarse, blue metal gravel; Cemented road base.			
	Clayey SAND, with silt, trace gravel: dark grey; fine to medium; low plasticity clay; fine to medium, quartz gravel.	ALV	L	M W
4.00	CLAY, with peat, with sand: dark grey; low plasticity; fine to coarse sand; Strong organic odour.	ALV	VS	W
5.20	Clayey SAND, with silt: pale grey; fine to coarse; low plasticity clay.	XWM	(D)	
5.50	Continued as rock			

GROUNDWATER: ▼ Observed on completion of auger drilling 27/05/24 01:00

RL (m): 8, 7, 6, 5, 4, 3, 2, 1, 0, -1
DEPTH (m): 1, 2, 3, 4, 5, 6, 7, 8, 9

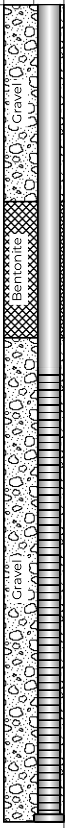


SAMPLE

REMARKS	TYPE	INTERVAL DEPTH (m)
	ES	0.35 - 0.50
	ES	1.40 - 1.60
	ES	1.80 - 2.00
	ES	2.30 - 2.50
	SPT	2.50 - 2.95
	ES	2.80 - 3.00
	ES	3.50 - 3.80
	ES	3.90 - 4.00
	SPT	4.00 - 4.45
	A/ES	4.30 - 4.50
	ES	4.80 - 5.00
	ES	5.20 - 5.30
	SPT	5.30 - 5.41

TESTING AND REMARKS

DEPTH (m)	TEST TYPE	RESULTS AND REMARKS
0.35	PID	2.7ppm
1.40	PID	2.1ppm
1.80	PID	0ppm
2.30	PID	0ppm
2.50	SPT	1,3,3 N=6
2.80	PID	0ppm
3.50	PID	0ppm
3.90	PID	0ppm
4.00	SPT	0 1 blow sunk > 450 mm
4.30	PID	0ppm
4.80	PID	0ppm
5.20	PID	0ppm
5.30	SPT	18/110 (HB)



NOTES: (#)Soil origin is "probable" unless otherwise stated. (*)Consistency/Relative density shading is for visual reference only - no correlation between cohesive and granular materials is implied.

PLANT: Bobcat
METHOD: DT to 0.4m, VE to 1.5m, AD to 5.5m, NMLC to 9.6m
REMARKS:

OPERATOR: Ground Test (JJ)

LOGGED: CSY
CASING: HWT to 5.5m

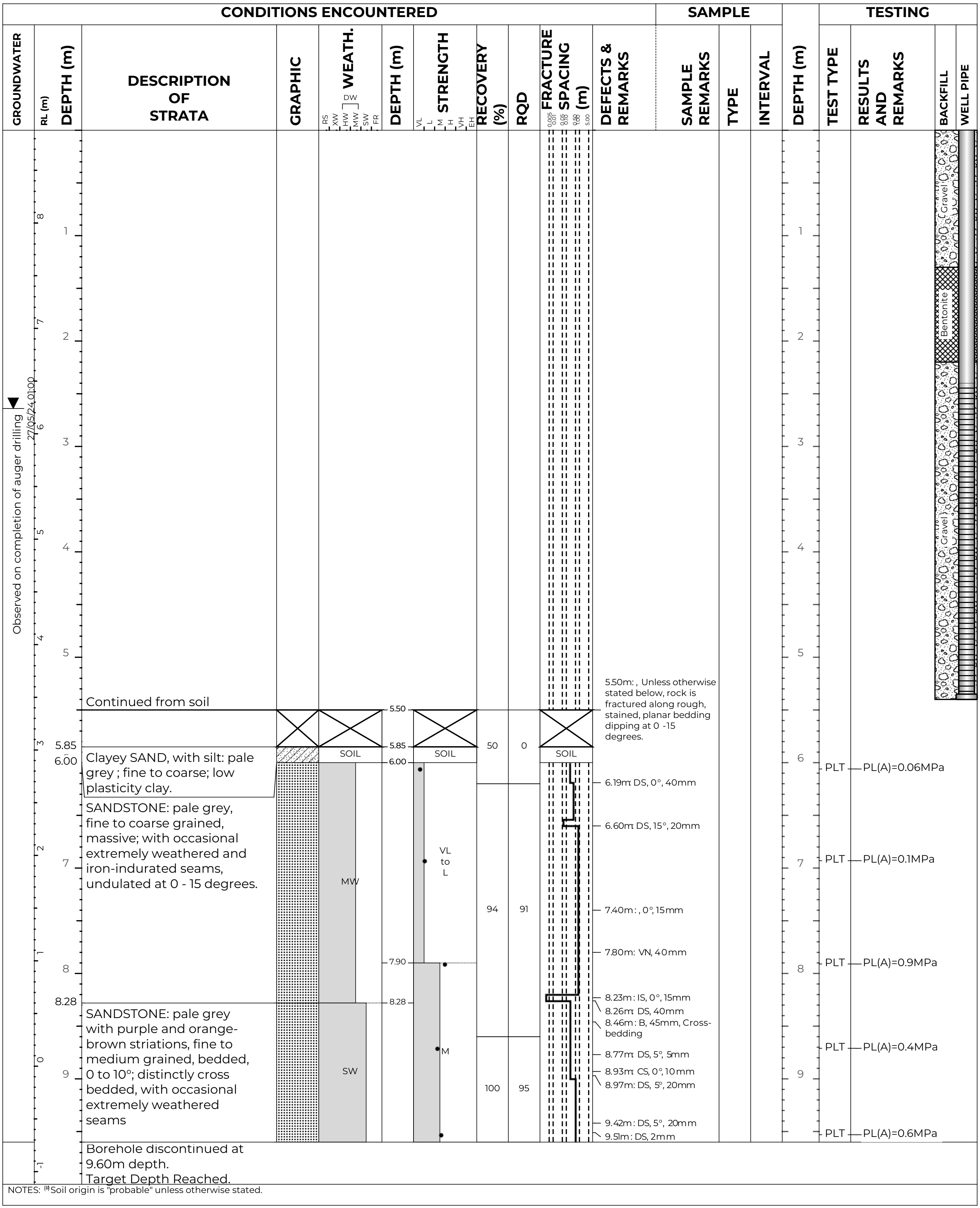
Refer to explanatory notes for symbol and abbreviation definitions

BOREHOLE LOG

CLIENT: Scentre Design & Construction Pty Ltd
PROJECT: Brookvale Westfield - AVAC Sewer pump station
LOCATION: Warringah Mall, 145 Condamine St, Brookvale, NSW 21

SURFACE LEVEL: 8.9 AHD
COORDINATE: E:339542.0, N:6262232.8
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH2
PROJECT No: 71015.54
DATE: 28/05/24 - 29/05/24
SHEET: 2 of 2



DEPTH (m)	RL (m)	DESCRIPTION OF STRATA	WEATH.	STRENGTH	RECOVERY (%)	RQD
5.50		Continued from soil				
5.50 – 5.85					50	0
5.85 – 6.00		Clayey SAND, with silt: pale grey ; fine to coarse; low plasticity clay.	SOIL	SOIL		
6.00 – 8.28		SANDSTONE: pale grey, fine to coarse grained, massive; with occasional extremely weathered and iron-indurated seams, undulated at 0 - 15 degrees.	MW	VL to L (to 7.90)	94	91
8.28 – 9.60		SANDSTONE: pale grey with purple and orange-brown striations, fine to medium grained, bedded, 0 to 10°; distinctly cross bedded, with occasional extremely weathered seams	SW	M (from 7.90)	100	95
		Borehole discontinued at 9.60m depth. Target Depth Reached.				

DEFECTS & REMARKS

5.50m: , Unless otherwise stated below, rock is fractured along rough, stained, planar bedding dipping at 0 -15 degrees.
6.19m: DS, 0°, 40mm
6.60m: DS, 15°, 20mm
7.40m: , 0°, 15mm
7.80m: VN, 40mm
8.23m: IS, 0°, 15mm
8.26m: DS, 40mm
8.46m: B, 45mm, Cross-bedding
8.77m: DS, 5°, 5mm
8.93m: CS, 0°, 10mm
8.97m: DS, 5°, 20mm
9.42m: DS, 5°, 20mm
9.51m: DS, 2mm

TESTING

TEST TYPE	RESULTS AND REMARKS
PLT	PL(A)=0.06MPa
PLT	PL(A)=0.1MPa
PLT	PL(A)=0.9MPa
PLT	PL(A)=0.4MPa
PLT	PL(A)=0.6MPa

NOTES: (#)Soil origin is "probable" unless otherwise stated.

PLANT: Bobcat
METHOD: DT to 0.4m, VE to 1.5m, AD to 5.5m, NMLC to 9.6m
REMARKS:

OPERATOR: Ground Test (JJ)

LOGGED: CSY
CASING: HWT to 5.5m

Generated with CORE-GS by Geroc - Split Soil-Rock Log

Refer to explanatory notes for symbol and abbreviation definitions

Douglas PARTNERS

CORE PHOTO LOG

CLIENT: Scentre Design & Construction Pty Ltd
PROJECT: Brookvale Westfield - AVAC Sewer pump station
LOCATION: Warringah Mall, 145 Condamine St, Brookvale, NSW 21

SURFACE LEVEL: 8.9 AHD
COORDINATE: E:339542.0, N:6262232.8
DATUM/GRID: MGA2020 Zone 56
DIP/AZIMUTH: 90°/---°

LOCATION ID: BH2
PROJECT No: 71015.54
DATE: 28/05/24 - 29/05/24
SHEET: 1 of 1

Liming rate calculation

Soil type	Sand	
Neutralising agent	Hydrated Lime	
Factor of safety (FOS)	1.5	Typically = 1.5 to 2
Bulk density (t/m^3)	1.8	Based on soil type
Effective neutralising value (ENV)	1.10	Based on neutralising agent

Max Net Acidity (%S) (from Tab 2.0)	0.08	
Maximum liming rate	3.6	kg lime/tonne
	6.4	kg lime/m^3

Average Net Acidity (%S) (from Tab 2.0)	0.06	
Average liming rate	2.6	kg lime/tonne
	4.6	kg lime/m^3

User Inputted Net Acidity (%S)		
Liming rate	0.0	kg lime/tonne
	0.0	kg lime/m^3

NOTE: Lime rates are based on the stoichiometry of the following reaction:

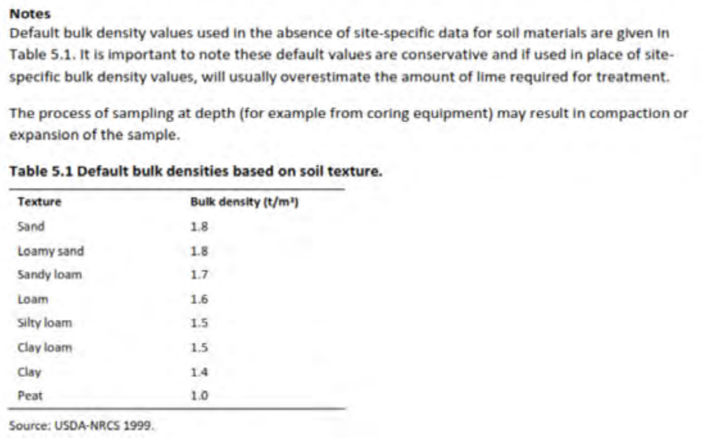
$CaCO_3 + 2H^+ \rightarrow Ca_2+ + H_2O + CO_2$

Lime Rate = %S x 623.7 (%S to mol H+/t) ÷ 19.98 (mol H+/t to kg $CaCO_3$/t) x (100/ENV(%)) x FOS x Bulk Density (kg lime/t)

See ASS Laboratory Method Guidelines Version 2.1 for Details

From Sullivan, L., Ward, N., Toppler, N., & Lancaster, G. (2018). National Acid Sulfate Soils Guidance: National Acid Sulfate Soils Sampling and Identification Methods Manual. Canberra ACT CC BY 4.0: Department of Agriculture and Water Resources.

Default bulk densities based on soil texture - Table 5.1 NASSG (2018)



Notes

Default bulk density values used in the absence of site-specific data for soil materials are given in Table 5.1. It is important to note these default values are conservative and if used in place of site-specific bulk density values, will usually overestimate the amount of lime required for treatment.

The process of sampling at depth (for example from coring equipment) may result in compaction or expansion of the sample.

Table 5.1 Default bulk densities based on soil texture.

Texture	Bulk density (t/m^3)
Sand	1.8
Loamy sand	1.8
Sandy loam	1.7
Loam	1.6
Silty loam	1.5
Clay loam	1.5
Clay	1.4
Peat	1.0

Source: USDA-NRCS 1999.

Neutralising Agent

Name	ENV
Hydrated Lime	1.10
Grade 1 Ag Lime	0.95
Custom	0.00

Soils

Texture	Bulk density (t/m3)
Sand	1.8
Loamy sand	1.8
Sandy loam	1.7
Loam	1.6
Silty loam	1.5
Clay loam	1.5
Clay	1.4
Peat	1.0
Custom	0.00

Table D3: Summary of results - acid sulfate soils

Project No:

Project Name:

Location:

Sample Information						Screening Test Results				Laboratory Analysis Results (Acid Base Accounting)								
Location ID	Depth from (m)	Depth to (m)	Reduced level (AHD)	Sample Description	Adopted Texture	pH_F (pH units)	pH_{FOX} (pH units)	Reaction Strength	pH change (pH units)	pH_{KCl} (pH units)	S_{KCl} (%S)	S_{HCl} (%S)	Scr (%S)	TAA (%S)	S_{NAS} (%S)	ANC_{BT} (%S)	ANC Corroborated (Y/N)	Net Acidity (%S)
Assessment Criteria (pH units)						**<4**	**<3**	-	**1.0**	Action Criteria (%S)		Coarse texture: sands to loamy sands and peats						0.03
BH01	1.40	1.50	7.70 to 7.60	Clayey sand	C	5.9	**2.1**	Medium reaction	**3.8**	5.1	NT	NT	0.009	0.030	NT	NT	N	0.041
BH01	1.90	2.00	7.20 to 7.10	Clayey sand	C	6.8	**2.1**	Medium reaction	**4.7**	-	-	-	-	-	-	-	N	-
BH01	2.40	**2.50**	6.70 to 6.60	Peaty sand	C	6.7	**2.3**	Medium reaction	**4.4**	4.6	NT	NT	0.010	0.050	NT	NT	N	0.066
BH01	**2.50**	**2.95**	6.60 to 6.15	Peaty sand	C	6.7	**2.2**	Medium reaction	**4.5**	4.7	NT	NT	0.030	0..05	NT	NT	N	0.084
BH01	**2.80**	**3.00**	6.30 to 6.10	Peaty sand	C	6.6	3.0	Medium reaction	**3.6**	-	-	-	-	-	-	-	N	-
BH01	**3.40**	**3.50**	5.70 to 5.60	Peaty sand	C	7.0	**2.5**	Medium reaction	**4.5**	5.6	NT	NT	0.040	<0.01	NT	NT	N	0.050
BH01	**3.90**	**4.00**	5.20 to 5.10	Peaty sand	C	7.0	**2.8**	Medium reaction	**4.2**	-	-	-	-	-	-	-	N	-
BH01	**4.00**	**4.45**	5.10 to 4.65	Peaty sand	C	6.9	**2.7**	Medium reaction	**4.2**	5.8	NT	NT	<0.005	<0.01	NT	NT	N	<0.005
BH02	**4.30**	**4.60**	4.60 to 4.30	Clay with peat	C	7.6	**2.6**	Medium reaction	**5.0**	-	-	-	-	-	-	-	N	-
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Notes:

Adopted texutre - C = coarse, M = medium, F = fine

pH_F - Soil pH in water

pH_{FOX} - Soil pH in peroxide

Reaction strength: L - Low , M - Medium, H - High, X - Extreme, V - Volcanic, F - Frothing (indicative of organic material)

pH change = pH_F - pH_{FOX}

pH_{KCL} - KCl extractable pH

S_{KCl} - KCl extractable sulfur

S_{HCl} - HCl extractable sulfur

S_{cr} - potential sulfidic acidity

TAA - titratable actual acidity (reported if pH_{KCL}<6.5)

S_{NAS} – retained acidity (reported if pHKCl < 4.5)

ANC_{BT} – acid neutralising capacity (reported if $pH_{KCl} \geq 6.5$)

NT - Not tested

Blue depths indicate where samples have been collected at or below the groundwater table

Bold results are indicators of ASS conditions, noting:

- Assessment criteria are considered a reasonable initial screening for AASS or PASS
- pH_F<4 is indicative of the presence of Actual ASS (AASS), although it is not conclusive of ASS on its own as naturally occurring non ASS soils can have pH_F<5
- pH_{FOX}<3 or pH Change ≥1 may indicate potential ASS (PASS), although exception apply. Laboratory testing required to confirm presence of Reduced Inorganic Sulfur (RIS)
- Refer to Table 5.1, A2, A3 of Sullivan,L. et al (2018) for further details

🟥 Shaded results trigger action (i.e. equal to or exceed the action criteria). Criteria is specific for soil texture and anticpated tonnage of soil disturbed.

Net Acidity can only include the measured ANC where the ANC has been corroborated by other data (for example slab incubation data) that demonstrates the soil material does not experience acidification during complete oxidation under field conditions.

a - Action criterion for disturbance of 1-1000 tonnes of material

b - Action criterion for disturbance of more than 1000 tonnes of material

The action criteria apply only to ASS materials and not to other acidic soils such as acidic peatlands and coastal heaths.

Appendix E

Contingency to On-Site Treatment

1. Introduction

This Appendix provides contingency options should they be required to supplement the selected management strategy, e.g. due to unexpected ground conditions

For the purpose of this ASSMP, PASS are defined by NSW Environment Protection Authority (EPA) Waste Classification Guidelines (2014) (EPA, 2014) Part 4 (Acid Sulfate Soils). PASS are defined as:

- 'Soils that contain iron sulfides or sulfidic materials that have not been exposed to air and thus are not oxidised. The pH of these soils in their undisturbed state is 5.5 or more, making them neutral or slightly alkaline.'

2. Off-site treatment and disposal

Where on site treatment of PASS is not possible and / or practical then off-site treatment at a facility appropriately licenced to accept and treat such soil can be considered. The following general procedure is recommended for off-site treatment:

The below works will be undertaken:

- Agreement with the receiving facility regarding days / times they could receive the waste;
- Loading the soil into trucks. Note if the soils are wet, they will be heavier than soils as normally transported at field moisture. This should be taken into consideration when loading trucks to ensure that trucks are not overloaded;
- Transport must be conducted in a sealed truck which prevents water leaking from the truck during transport;
- Completion of site records of the above and all information required by the treatment facility, and provision of copies of these records to the treatment facility;
- Transporting of soil to the treatment facility;
- Once the ASS have been accepted by the treatment facility they will treat and manage it in accordance with their Environment Protection Licence (EPL) conditions, subject to the verification procedures documented herein. The liming rate will be based on the liming rate presented in this report or based on results that supersede those presented herein), refer to Section 7.2.3 of this ASSMP;
- Verification of the treatment of the ASS and classification of the soil by the treatment facility or an Environmental Consultant; and
- Transport of the treated, classified ASS to the final receiving site / disposal facility.

3. Off-site disposal as PASS

3.1 PASS criteria

EPA (2014), Part 4 defines potential acid sulfate soils (PASS) and states that it may be disposed of off-site without treatment below the permanent water table, provided:

- The soils meet the definition of virgin excavated natural material (VENM) in all aspects other than the presence of sulfidic soils or ores;
- The pH of soils in their undisturbed state is pH 5.5 or more;
- The soil has not dried out or undergone any oxidation of its sulfidic minerals;
- Soil is received at the disposal point within 16 hours of excavation, and kept wet at all times between excavation and reburial at the disposal point;
- Appropriate records are provided to the receiving site with every truck load confirming that it meets the above criteria; and
- The receiving site is licenced by the EPA to accept PASS, and meets its obligations under EPA (2014) and its EPL conditions.

Prior approval from is recommended prior to implementation of this disposal methodology.

3.2 Disposal as PASS

The below works will be undertaken by appropriately trained staff:

- Agreement with receiving site on acceptance requirements, including days / times for trucks, allowable time lapse between excavation and acceptance by receiving site, and any specific requirements relating to pH testing or results prior to leaving the site;
- Soils will be kept wet at all times, and should be sprayed with water if required to keep them wet;
- Recording of the excavation date, time and source depth of the excavated soil;
- Inspection of the excavated soil for moisture content, material texture / signs of contamination concern, such as anthropogenic odours, staining or inclusions by all personnel involved in the management / handling of the spoil;
- If visual inspection of the spoil identifies materials not consistent with the materials assessed in situ (e.g. anthropogenic impact or fill are observed), then the spoil will be segregated for further assessment;
- Measuring the pH as required by the receiving facility, with a minimum of at least one sample per 50 m^3, or 10 samples per shift (whichever is greater), using a calibrated pH meter;
- If the pH is less than 5.5, the soil will not be classified as PASS, and the soil will be segregated for treatment;
- Loading the soil into trucks and ensuring the soil is moist enough to prevent it drying out during transport. Note: due to the soils being wet, they will be heavier than soils as normally transported at field moisture (PASS estimated to be approximately 2 t/m^3). This should be taken into consideration when loading trucks to ensure that trucks are not overloaded;

Soil should be loaded and transported as soon as possible to minimise the risk of oxidisation, which prevents it from being classified as PASS;

Transport must be conducted in a sealed truck which prevents water leaking from the truck during transport;

- Completion of site records of the above;
- Completion of records of all information required by the receiving site, and provision of copies of these records to the receiving site, including copies sent with the truck driver for the load being carried. Copies also to be kept by the site;
- Transporting of soil meeting the PASS requirements to the receiving site as soon as practicable, within 16 hours of excavation (or earlier if required by the receiving site);
- Once the PASS have been accepted by the receiving site, they are required to manage it in accordance with their EPL conditions and EPA (2014). It is not the role of this document to discuss management of soil once they have been accepted by the receiving site; and
- Any soil which is rejected by the receiving facility will be transported back to the site and managed in accordance with the ASSMP.

4. References

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Appendix F

Liming Rate Calculation

1. Introduction

This Appendix provides the equations for the calculation of liming rates.

2. Liming rates

The required liming rate can be calculated from one of the following formulas.

Equation F1 (by mass):

Neutralising Material Required (kg) per tonne of soil (t) = $\left(\frac{\%\,\mathrm{S\ x\ 623.7}}{19.98}\right)\ \mathrm{x}\ \frac{100}{\mathrm{ENV(\%)}}\ x\ FOS$

Equation F2 (by volume):

Neutralising Material Required (kg) per unit volume of soil (m^3) = $\left(\frac{\%\,\mathrm{S\ x\ 623.7}}{19.98}\right)\ \mathrm{x}\ \frac{100}{\mathrm{ENV(\%)}}\, x\ D\ x\ FOS$

Where:

Net Acidity (%S) is derived using the maximum Net Acidity (%S) using the methods in Appendix C;

623.7 = converts % S to mol H^+ / t;

19.98 converts mol H^+ / t to kg $CaCO_3$/tonne;

FOS (factor of safety) = a minimum value of 1.5 needs to be adopted, although values of up to 2 can be suitable;

ENV Effective Neutralising Value (e.g. approximate 98% for fine (0.3 mm grain size) ag lime with an NV of 98%);

D Bulk density, site specific results can be used, or the bulk densities in Table 2 of Appendix C should be used.

Notes:

- The ENV is calculated based on the molecular weight, particle size and purity of the neutralising agent and should be assessed for proposed materials in accordance with ASSMAC (1998).

An initial liming rate (kg $CaCO_3$/t) based on the laboratory result calculation (excluding ANC) is considered appropriate based on it including a safety factor of 1.5 and the use of aglime with an NV of at least 98% and a grain size of less than 0.3 mm. The laboratory result must be multiplied by the soils bulk density (D) to convert to lime rate per volume of soil (kg $CaCO_3$/m^3).

Depending upon the source of the aglime and ultimately the representative ENV of the aglime selected, the minimum required aglime dosing rate may increase or decrease. Prior to the commencement of works, the minimum dosing rate should be finalised following review of the ENV of the selected aglime.

The liming rate to be calculated from the analytical results should be considered as a 'starting point', and pH monitoring should be conducted during treatment to assess the progress of the neutralisation and the need for additional mixing and / or addition of aglime. Soil will only be considered to have been successfully treated when all soil has been verified in accordance with Section 9 and Appendix C of this ASSMP.

3. References

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Appendix G

Water and Groundwater Management

1. Introduction

Water is the main mechanism by which acid and metals from oxidised ASS are mobilised and transported. Careful management of water is therefore paramount to the effective management of potential adverse impacts from ASS disturbance. Management is required to provide control of treated waters for discharge and provide some margin for heavy rain periods.

The below sections provide potential strategies for management, assessment and disposal of water leaching from ASS, surface water and water from groundwater dewatering.

1.1 Leachate and surface water collection

All water that has been in contact with ASS / assumed ASS must be managed, assessed, treated and appropriately disposed of in accordance with development consent conditions / the dewatering management plan.

1.2 Dewatering and extracted groundwater

In general, risks associated with dewatering in areas underlain by ASS include:

- Acidification of in situ soils drained within the dewatering cone of depression and difficulties associated with neutralising these in situ soils (this can also impact the possible PASS classification of some soils);
- Acidification of groundwater remaining within the dewatering cone of depression after the system has re-flooded;
- Iron, aluminium and heavy metal contamination of groundwater arising from mobilisation of these compounds under low pH conditions; and
- Acidification and contamination of surface water bodies which receive groundwater.

It is considered that there is the potential to expose soils within the proposed excavation areas to air which will allow some acidification to take place. However, the water and ASS from within these areas will be removed and treated, mitigating associated risks.

The dewatering should be designed to not significantly affect groundwater levels outside of the areas of excavation, and therefore the potential for oxidation of ASS outside of the excavation areas is expected to be limited.

The following dewatering risk management methods are recommended for the project:

- Drawdown outside of the excavation areas should be minimised;
- Drawdown should be maintained as close as practical to the invert excavation depth;
- Minimise the time and volume of exposed ASS (i.e. stage excavation and dewatering); and
- Monitoring and treatment prior to disposal of the dewatering effluent.

1.3 Water storage and treatment

Water from dewatering and the ASS leachate should either be pumped directly to an on-site treatment plant for treatment or should be stored in a tank or lined drains / detention basin for assessment and treatment.

At a minimum, the combined storage should be designed to store enough water to contain leachate and extracted water from a 1 in 10-year (1 hour) storm event.

1.4 Water assessment for disposal

All water which has potentially come into contact with ASS requires assessment (and if necessary, treatment). The recommended testing and frequency is provided in Table 4 of Section 9 of the ASSMP Treatment.

1.4.1 Standard treatment plant

The potential impacts of ASS on water generally comprise a decrease in pH, possible elevated total suspended solids (TSS) / turbidity, iron, aluminium and other metals.

Treatment of water from construction sites is commonly required for pH and TSS prior to disposal. Aeration and removal of TSS also generally decreases metal concentrations in the water. Therefore, an on-site water treatment plant is considered likely to be suitable for treatment of ASS impacted water that has not been oxidised. It is noted, however, that elevated precipitation of iron, and possibly other metals, is common from ASS impacted

An alternative treatment method for pH is provided in Section 1.5.2 in case treatment of excess water above the capacity of the treatment plant is required.

If a suitable treatment method for man-made contaminants in the water (e.g. VOC, PAH, TPH, BTEX, OCP, metals etc) cannot be implemented for disposal to stormwater, an alternative disposal method may be required (refer to Section 1.6, noting these may have other pre-treatment requirements).

1.4.2 Alternative pH treatment method

It is noted that aglime is generally not suitable for the treatment of leachate / dewatering effluent due to its low solubility in water. A commercial pH adjustment product can be used, or else slaked lime (hydrated lime) as discussed below.

Alternative neutralisation materials include calcined magnesia (magnesium hydroxide, burnt magnesite, or magnesia) and calcium hydroxide (commonly called slaked or hydrated lime).

Calcined magnesia (magnesium hydroxide, burnt magnesite, or magnesia) produces a two-step reaction, which proceeds rapidly at acidic pH and slows down as higher pH is approached, and hence reduces the potential for over-neutralisation. It should be added to the leachate as a slurry and mixing achieved via use of an agitator.

A calcium hydroxide (commonly called slaked or hydrated lime) solution can be produced by stirring calcium oxide (commonly called quicklime) into water, in a container of sufficient volume (for example, a plastic 200 litre drum). The slurry should be allowed to settle, and the clear solution (which will be caustic, with a pH of approximately 12.5 to 13) can be pumped or sprayed into the standing water in small amounts, with some agitation and monitoring. This procedure should be continued until the pH is adjusted to acceptable levels. Adequate care should be taken not to 'overshoot' the desired pH with calcium hydroxide.

Quicklime is very reactive, and relatively corrosive (due to its caustic nature). When quicklime is mixed with water, the resulting reaction generates heat. Therefore, if utilised, the material should be added in increments to a large amount of water to control the reaction. Slaked or quicklime should not be allowed to come into contact with the skin or be inhaled during use.

The amount of neutraliser required to be added to the discharged groundwater can be calculated from the equation below:

Equation G1:

$$\textit{Alkali Material Required (kg)} = \frac{M_{Alkali} \text{ x } 10^{-pH\ initial}}{2 \text{ x } 10^{3}} \text{ x } V$$

Where: *M_{Alkali} = molecular weight of alkali material (g/mole) (molecular weight of slaked lime ($Ca(OH)_2$) = 74 g/mole.)*

pH initial = initial pH of leachate

V = volume of leachate (litres)

As a guide, the approximate quantities of slaked lime required to neutralise acidic water (i.e. raise existing pH to pH 7) are provided in Table G2.

Table G2: Approximate liming rates for water (based on slaked lime (kg of $Ca(OH)_2$))

Water pH	Volume		
	10 m^3	50 m^3	100 m^3
2	3.7	18.5	37
3	0.37	1.85	3.7
4	0.037	0.185	0.37
5	0.0037	0.0185	0.037
6	0.00037	0.00185	0.0037

1.5 Water discharge

Disposal options generally comprise disposal to stormwater, to sewer (in accordance with a specific Trade Waste Agreement which would need to be obtained from Sydney Water, and is generally only available for water with man-made contamination) or to a licenced liquid waste facility (i.e. trucking off-site)

Following treatment (if required) the water should be assessed to determine if it meets the discharge / disposal criteria. Water meeting the conditions can then be disposed of accordingly.

Depending on site conditions, alternative options for water disposal include on-site reinjection, or infiltration via an excavation.

2. References

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Appendix H

Risk Categorisation

1. Introduction

The environmental risk posed by a planned disturbance is primarily evaluated in Dear, et al., (2024) based on the level of treatment required. Five risk-based treatment categories (low, medium, high, very high and extra high) are utilised and are based on Table 3 (Section 3.3 (Dear, et al., 2024)) which defines the treatment category on the basis of the total weight of ASS disturbed (including ASS exposed by groundwater drawdown and disturbance to off-site ASS), the Net Acidity of the soils and the required quantity of pure agricultural lime ($CaCO_3$) required for treatment (neutralisation).

The treatment categories relate to managing risk by neutralisation of ASS so that there is no adverse impact on the receiving environment.

Dear, et al., (2024) notes that if the disturbance involves groundwater dewatering or if the site is close to an environmentally sensitive area / acidophilic system (even if <5t of $CaCO_3$ treatment is required) then the disturbance needs to be treated as per the Extra High level of treatment.

The management requirements for each treatment category as defined in Dear, et al., (2024) are outlined below.

Low level of treatment – Category L

For disturbances of ASS requiring treatment with less than 0.1 tonnes of fine $CaCO_{3:}$:

- Treat soils with a suitable neutralising agent to counter the Net Acidity;
- Manage site run-on, runoff, infiltration; and
- Document and record the ASS management strategies implemented.

Medium level of treatment – Category M

For disturbances of ASS requiring treatment with 0.1 to 1 tonne of fine $CaCO_3$ where the seasonally lowest water table elevation will not be altered:

- Treat soils with a suitable neutralising agent to counter the Net Acidity;
- Thoroughly mix neutralising agent with soil;
- Manage site run-on, runoff, infiltration; and
- Document and record the ASS management strategies implemented.

High level of treatment – Category H

For disturbances of ASS requiring treatment with >1 to 5 tonnes of CaCO3, where the seasonally lowest water table elevation will not be altered:

- Treat soils with a suitable neutralising agent to counter the Net Acidity;
- Thoroughly mix neutralising agent with soil;
- Validation sampling and laboratory testing to verify thorough mixing and appropriate neutralisation (refer to Section 9);

- Bunding must be provided to divert run-on and collect all site runoff during earthworks;
- Monitor the pH of water within bunds, sumps, pooled areas (particularly after rain) and appropriately treat prior to release or re-use to keep pH in the range 6.5 to 8.5 (or as per site-specific conditions);
- All leachate from treatment pads and / or discharge water from excavations should be contained and must meet acceptable standards of pH, metal content (particularly iron and aluminium), and turbidity prior to release;
- Application of a guard layer of neutralising material to treatment pad surfaces to help intercept and neutralise leachate from ASS; and
- Document and record the ASS management strategies implemented.

Very high level of treatment – Category VH

For ASS disturbances requiring treatment with >5 to 25 tonnes of fine CaCO3, and no alteration of the seasonally lowest water table elevation is involved:

- Treat soils with a suitable neutralising agent to counter the Net Acidity;
- Thoroughly mix neutralising agent with soil;
- Validation sampling and laboratory testing to verify thorough mixing and appropriate neutralisation;
- Bunding must be provided to divert run-on and collect all site runoff during earthworks;
- Monitor the pH of water within bunds, sumps, pooled areas (particularly after rain) and appropriately treat prior to release or re-use to keep pH in the range 6.5 to 8.5 (or as per site-specific conditions);
- Treatment pads are to be designed as per Section 7.4 of Dear, et al., (2024);
- All leachate from treatment pads and / or discharge water from excavations should be contained and must meet acceptable standards of pH, metal content (particularly iron and aluminium), and turbidity prior to release;
- Application of a guard layer of neutralising material to treatment pad surfaces to help intercept and neutralise leachate from ASS;
- Prevent infiltration from passing through ASS to groundwater using impermeable materials. Otherwise, apply extra layer of neutralising material to intercept and neutralise leachate from ASS;
- Provide a simple but thorough environmental management plan (ASSMP) that meets the requirements of assessing authorities; and
- On completion of works, provide documentation of ASS management activities to the assessment manager in the form of a simple closure report (validation report), including information on the final placement / use of disturbed soil.

Extra high level of treatment – Category XH

For ASS disturbances requiring treatment with more than 25 tonnes of $CaCO_3$:

- Comprehensive environmental management plan (ASSMP) required, and a risk assessment undertaken. The ASSMP must consider groundwater dewatering if the seasonally lowest water table level will be altered; and
- Detailed closure (validation) report will be required.

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