ACID SULPHATE SOIL ASSESSMENT & MANAGEMENT PLAN

RESIDENTIAL DEVELOPMENT

Lots 1-11 43-45 & 49 Warriewood Road Warriewood NSW

Prepared For:

Mr Shubham Loura
Warriewood Developers Pty Ltd

Prepared By:

Noel Child

4 September 2025

DOCUMENT CONTROL REGISTER

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TABLE OF CONTENTS

APPENDICES

LIST OF DIAGRAMS

LIST OF TABLES

1 SITE & DEVELOPMENT

1 SITE & DEVELOPMENT

1.1 SITE DETAILS

PROPRIETORSHIP

Warriewood Developers Pty Ltd is the developer of the project.

LOCATION

The proposed development site is bounded by Warriewood Road to the north; by prospective or existing residential developments to the east and west, and by Narrabeen Creek to the south and south-west.

The closest major road is Pittwater Road, some 50 metres to the east of the site.
Figure 1.1, below, provides a road map identifying the site location.

The direction of north is towards the top of the diagrams; an approximate scale is provided beneath.

The subject site is shown outlined in blue at the centre of the diagrams.

PROPERTY DETAILS

The site formally comprises Lots 1 & 2 in Deposited Plan (DP) 349085 and Lot 2 in DP 972209, and is known as 43-45 & 49 Warriewood Road, Warriewood.

The development site has an approximate area of 11,800 square metres, although the three parcels of land involved all extend to the south beyond the proposed development area, into wetlands associated with Narrabeen Creek.

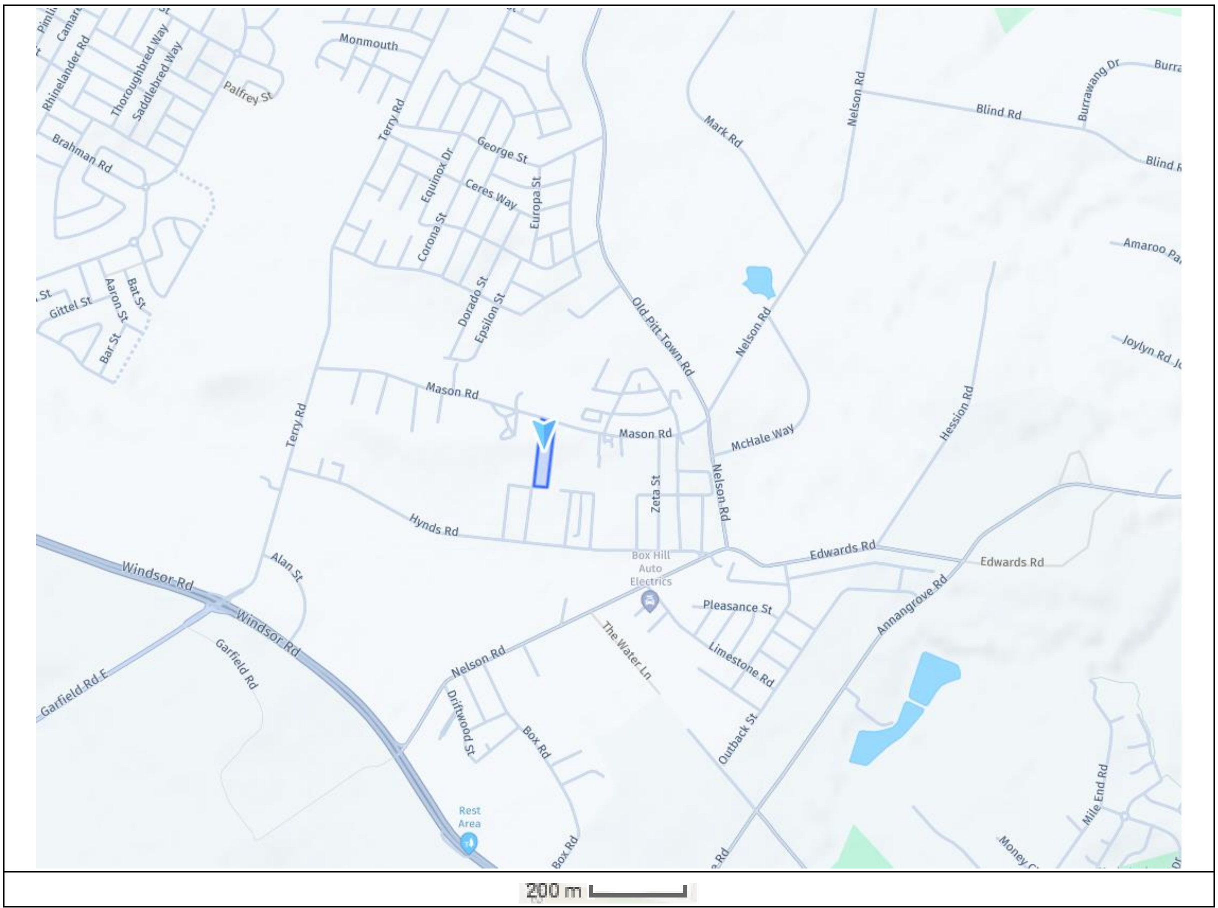


Figure 1.1 – Location of the Development

Figure 1.2 – Aerial View of the Proposed Development Site (May 28th, 2025)

1.3 ZONING

The zoning of the proposed development site, and surrounding properties, is shown in Figure 1.3, below.

The diagram provided in Figure 1.3 is sourced from the current Northern Beaches Local Environment Plan.

The site is shown at the approximate centre of Figure 1.9 and is zoned R3 Medium Density Residential.

Immediate surrounding land is also zoned R3 Medium Density Residential, with R2 low density residential land present on the opposite (northern) side of Warriewood Road, and a strip of public recreation land along the creek line bordering the site to the south.

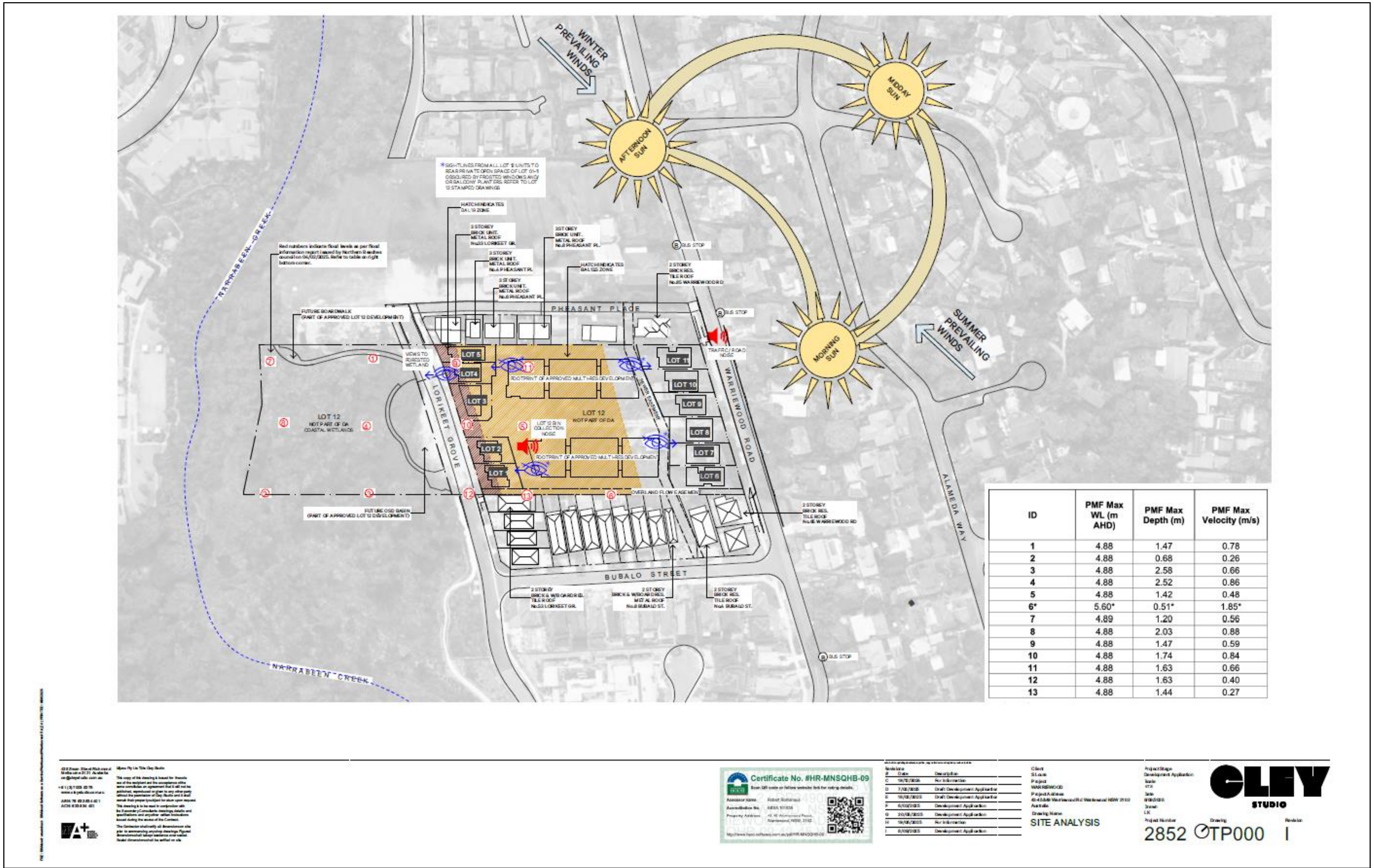
Figure 1.3 – Land Zoning Diagram

1.4 DEVELOPMENT DETAILS

PLANS & DRAWINGS

The proposed development is described in Figures 1.4 to 1.10 on subsequent pages, as follows:

Figure 1.4	Site Analysis
Figure 1.5	Existing Site Plan & Demolition Plan
Figure 1.6	Site and Construction Waste Plan
Figure 1.7	Cut & Fill Plan
Figure 1.8	Indicative Ground & First Floor Plans
Figure 1.9	Street Elevations
Figure 1.10	Rear Elevations



ID	PMF Max WL (m AHD)	PMF Max Depth (m)	PMF Max Velocity (m/s)
1	4.88	1.47	0.78
2	4.88	0.68	0.26
3	4.88	2.58	0.66
4	4.88	2.52	0.86
5	4.88	1.42	0.48
6*	5.60*	0.51*	1.85*
7	4.89	1.20	0.56
8	4.88	2.03	0.88
9	4.88	1.47	0.59
10	4.88	1.74	0.84
11	4.88	1.63	0.66
12	4.88	1.63	0.40
13	4.88	1.44	0.27

Figure 1.4 - Site Analysis

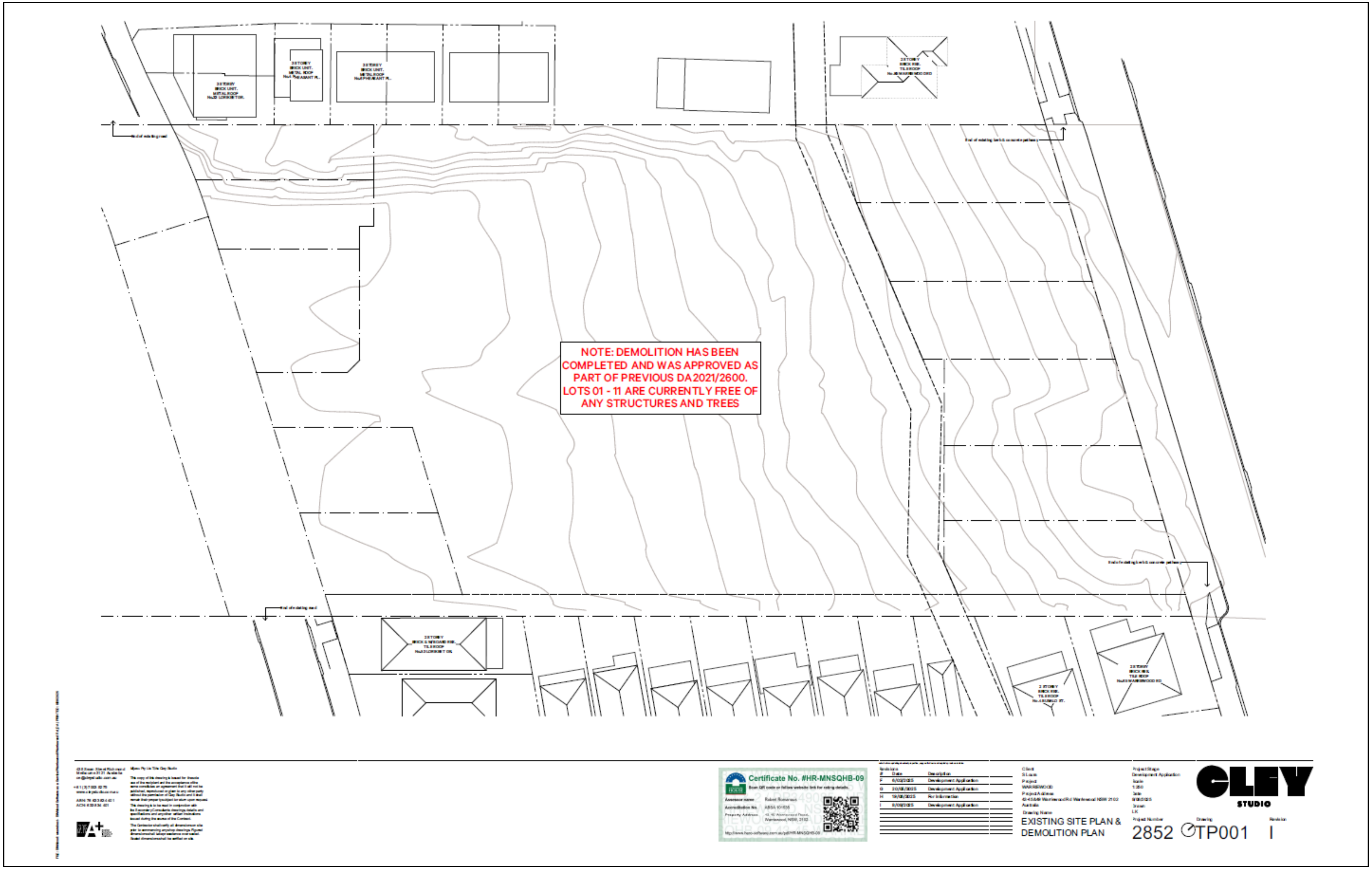


Figure 1.5 – Existing Site Plan & Demolition Plan

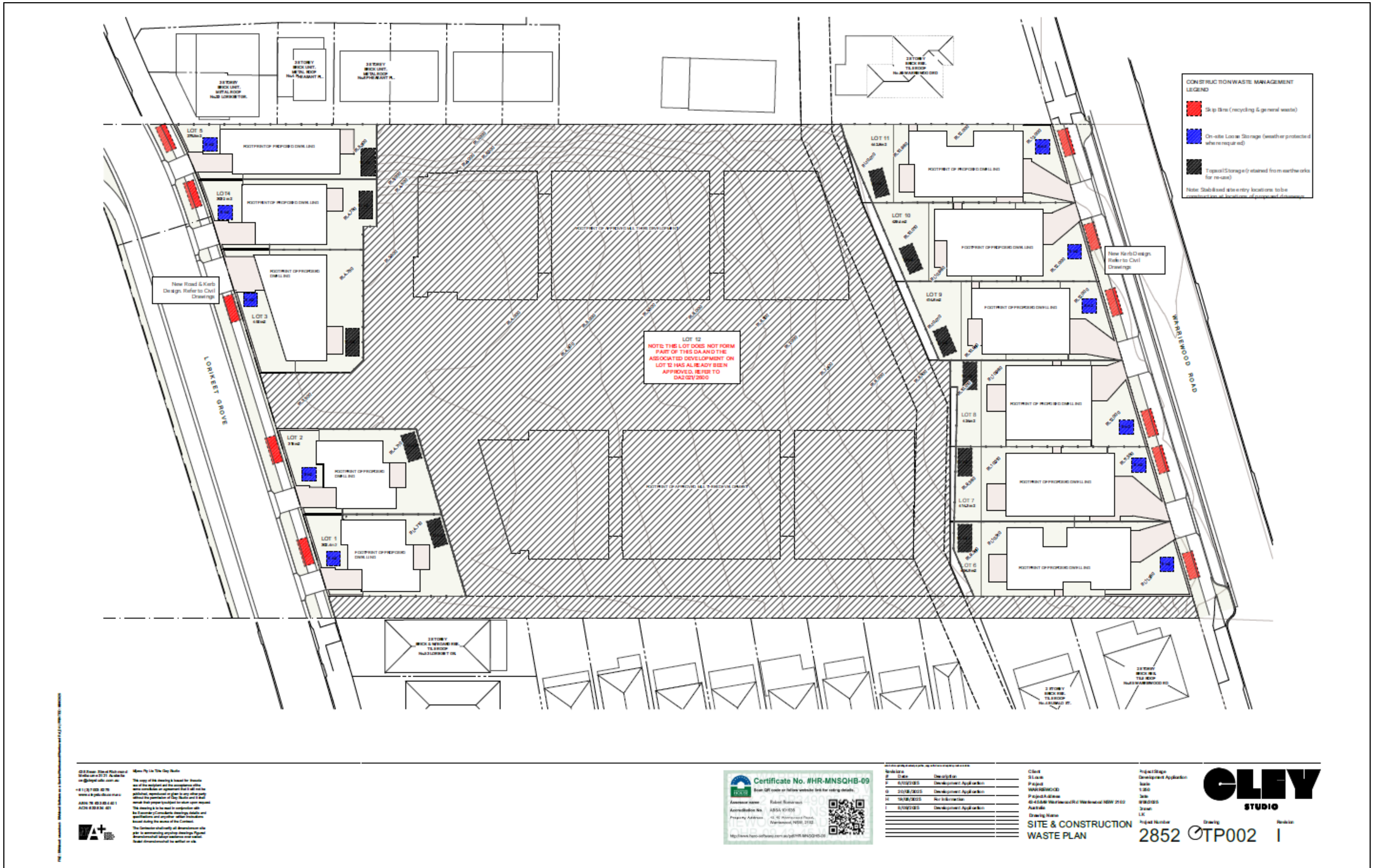


Figure 1.6 – Site and Construction Waste Plan

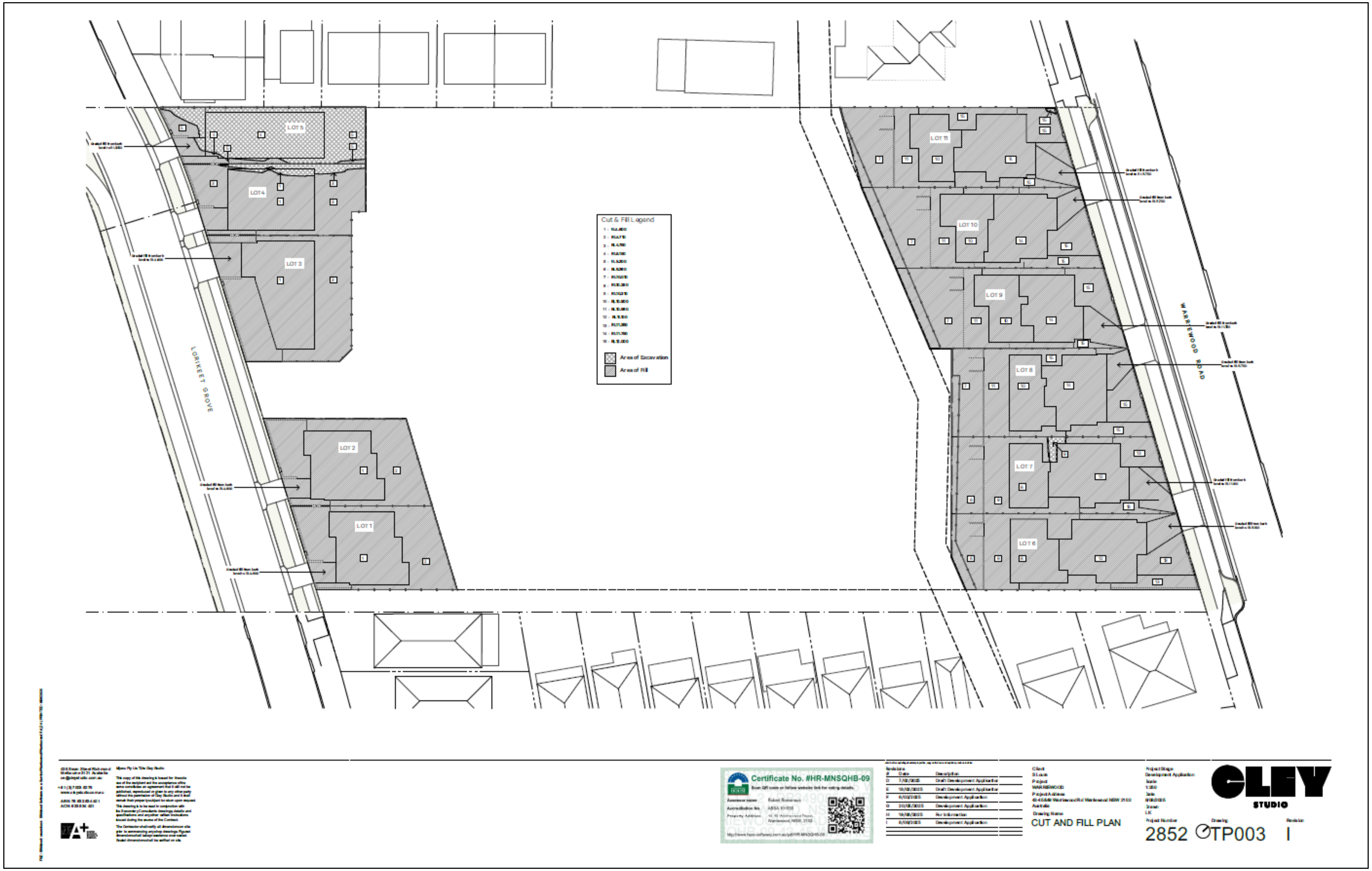


Figure 1.7 – Cut & Fill Plan

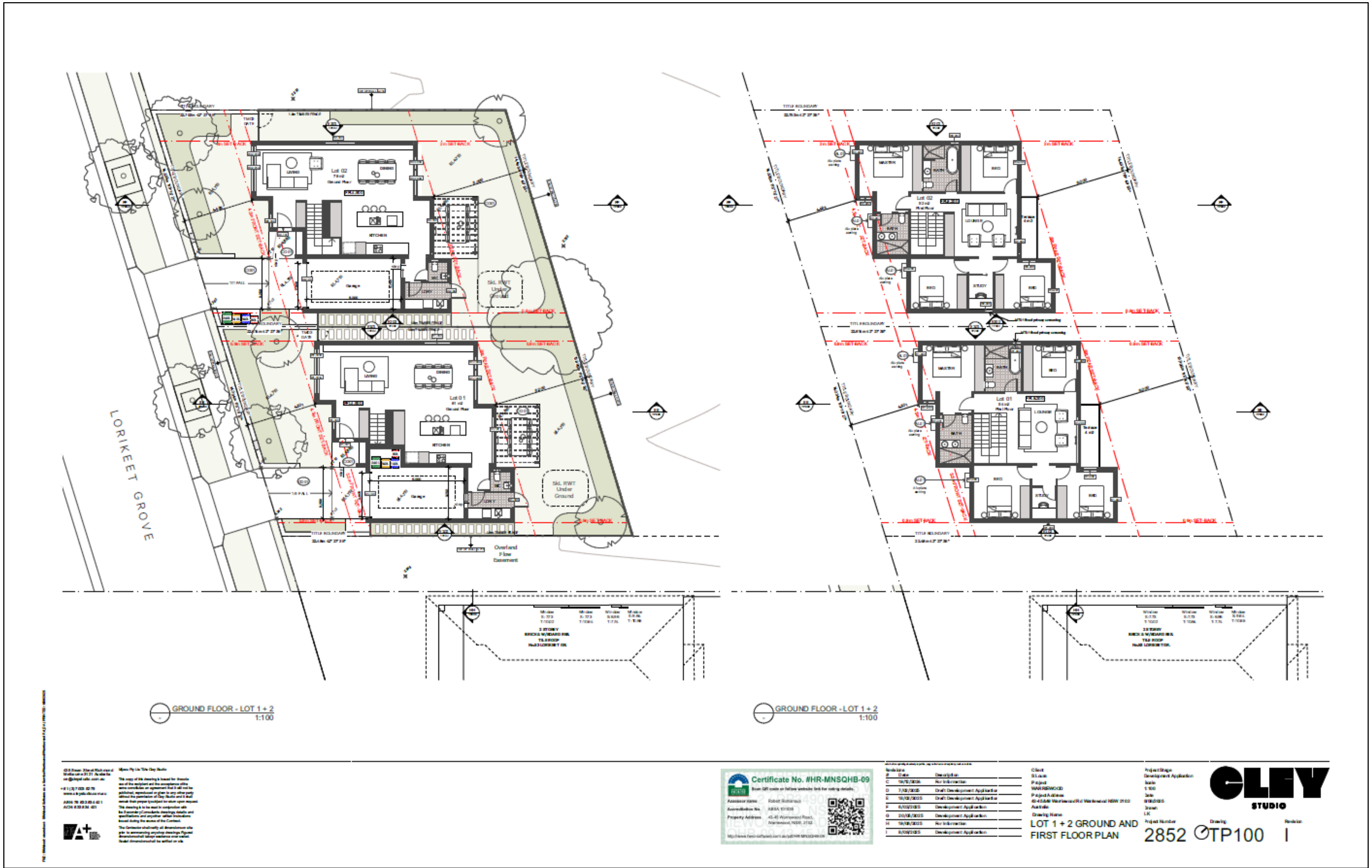


Figure 1.8 – Indicative Ground & First Floor Plans

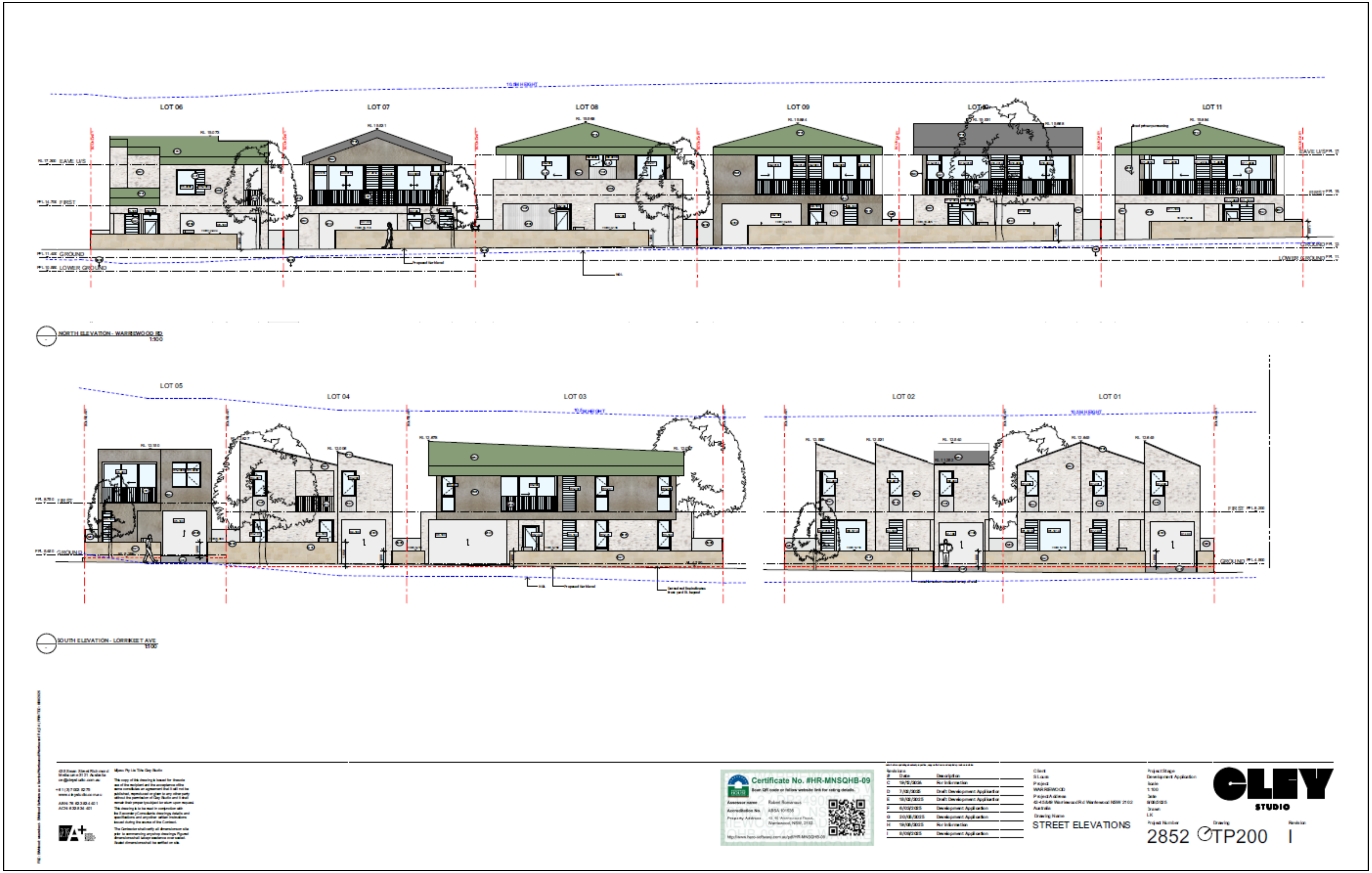


Figure 1.9 - Street Elevations

Section:	1 – Site & Development			Version	1
Effective Date:	September 4th, 2025	Prepared By:	Noel Child	Page:	1 - 10

Figure 1.10 - Rear Elevations

2 ACID SULPHATE SOIL

2 ACID SULPHATE SOIL

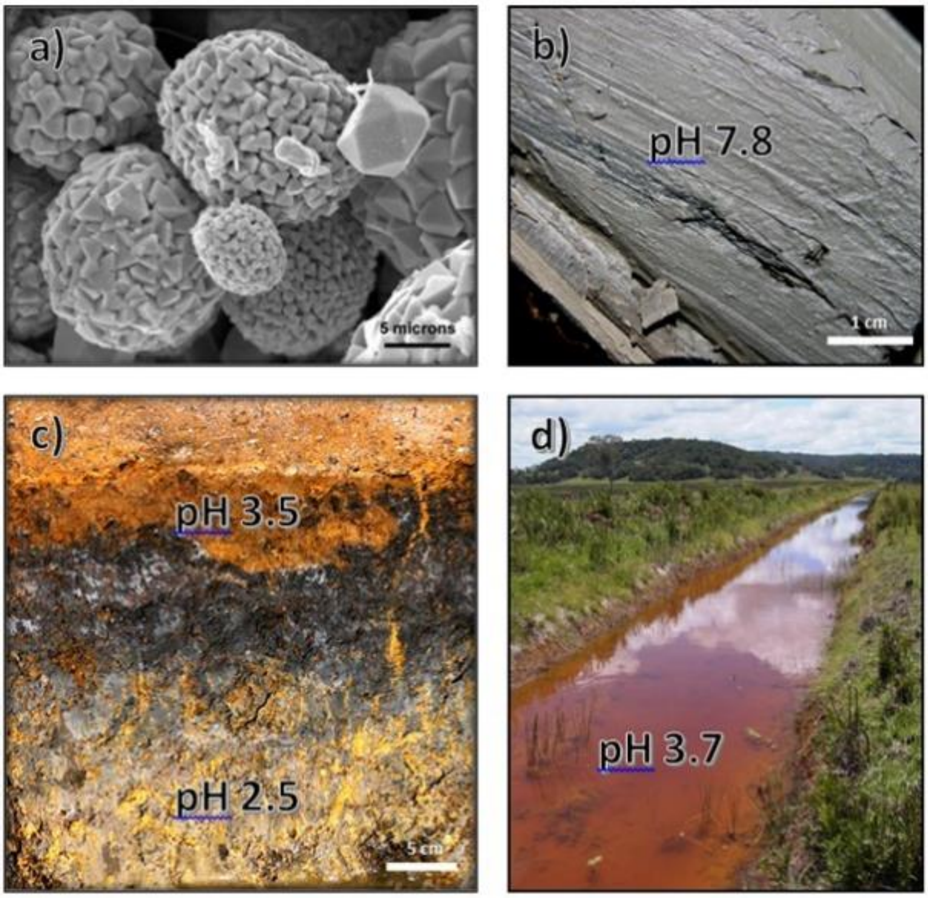
2.1 INTRODUCTION

Guidelines for the acid sulphate soil assessment of land are presented in the Australian Government document *National Acid Sulphate Soils Guidance: National acid sulphate soils sampling and identification methods manual; Water Quality Australia; June 2018*.

Those guidelines have been taken into account in the preparation of this Plan.

2.2 DEFINING ACID SULPHATE SOILS

Acid sulphate soil (ASS) materials are distinguished from other soil or sediment materials (referred to as “soil materials” in this document) by having properties and behaviour that have either: 1) been affected considerably by the oxidation of Reduced Inorganic Sulphur (RIS), or 2) the capacity to be affected considerably by the oxidation of their RIS constituents (Figure 2.1). 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. These soils are typically found in low-lying coastal areas and saline inland areas, however, they have been identified in a wide range of environmental settings.



Note: a) PASS containing framboidal pyrite (FeS_2) crystals. b) Blue-greenish grey PASS. c) AASS profile showing surficial iron oxide and yellow jarosite segregations. d) Iron staining (by schwertmannite and goethite) of a drain in an ASS landscape.
Source: National Acid Sulphate Soils Guidance

Figure 2.1 - Examples of Acid Sulphate Soils

In a waterlogged anoxic state (that is depleted of dissolved oxygen), these materials remain benign and do not pose a significant hazard to human health or the environment. However, ASS disturbance, and exposure to oxygen, may result in a wide range of environmental hazards, including:

- severe acidification of soil and drainage waters (below pH 4 and often pH less than 3),
- mobilisation of metals (for example iron, aluminium, copper, cobalt, zinc), metalloids (for example arsenic), nutrients (for example phosphate) and rare earth elements,
- deoxygenation of water bodies, • production of noxious gases (for example hydrogen sulfide),
- production of greenhouse gases, and
- scalding (that is de-vegetation) of landscapes.

These hazards have the potential to cause a number of significant environmental and economic impacts such as fish kills, loss of biodiversity in wetlands and waterways, contamination of groundwater resources, loss of agricultural productivity, and corrosion of concrete and steel infrastructure.

Acid sulphate soil materials include Potential acid sulphate soils (PASS or sulfidic soil materials) and Actual acid sulphate soils (AASS or sulfuric soil materials).

These are often found in the same profile, with AASS overlying PASS.

Potential acid sulphate soils (PASS) are soil materials which contain RIS such as pyrite (for example Figure 4.1a). The field pH of these soils in their undisturbed state is usually more than pH 4 and is commonly neutral to alkaline (pH 7–9) (for example Figure 4.1b). These soil materials are invariably saturated with water in their natural state. Their texture may be peat, clay, loam, silt or sand and is often dark grey in colour and soft in consistence (for example Figure 4.1b), but these materials may also exhibit colours that are dark brown, or medium to pale grey to white.

Actual acid sulphate soils (AASS) are soil materials which contained RIS such as pyrite that have undergone oxidation. This oxidation results in low pH (that is pH less than 4) and often a yellow (jarosite) and/or orange to red mottling (ferric iron oxides) in the soil profile (for example Figure 4.1c). Actual ASS contains Actual Acidity, and commonly also contains RIS (the source of Potential Sulfuric Acidity) as well as Retained Acidity.

Projects involving the disturbance of ASS materials must assess the hazards associated with disturbance and consider potential impacts. Activities with a potential to disturb ASS materials, either directly, or by lowering the water table, need to be managed appropriately to avoid environmental harm.

Successful management of ASS materials depends on a detailed investigation to determine the nature of the hazards presented by these soil materials and hence a determination of the most appropriate management strategy.

Wherever possible, management measures should be governed by the guiding principle of avoiding disturbance of ASS materials.

2.3 "ACID" SOIL AND "ACID SULPHATE" SOILS

The acidity hazard of soil materials that are strongly acidic due to processes other than RIS oxidation is not considered an ASS acidity hazard. While Actual ASS and sulfuric soil materials are acid soil materials, not all acid soil materials are Actual or sulfuric ASS materials.

Naturally-occurring acidic soils are not considered an environmental hazard and indeed are usually part of acidophilic ecosystems whose health depends on maintaining an acidic environment. As an example, many soil materials in naturally acidic landscapes, such as acidic peatlands and coastal heaths, often have low pH values and high acidities.

If it can be demonstrated the majority of the acidity of acidic soil materials is not or could not be derived from the oxidation of RIS, then these materials should not be treated as if they were ASS materials. To do so may result in the liming of naturally acidic ecosystems.

This could lead to unnaturally alkaline environments resulting in severe ecological damage to the acidophilic organisms that relied on the acidic nature of these ecosystems.

Field investigation can help determine whether acidic soil materials are ASS materials or not. The presence of jarosite in a soil material, or adjacent soil material, is strong evidence of prior oxidation of RIS. Documented jarosite, along with field pH's less than 4, can be used to identify these soil materials as Actual ASS materials rather than just acid soil materials. Further information is provided in the National Acid Sulphate Soils Identification and Laboratory Methods Manual (Sullivan et al, 2018b) to help distinguish naturally-occurring acidic soil materials from Actual ASS materials.

2.4 ACID SULPHATE SOIL FORMATION

The formation of acid sulphate soils (ASS) materials occurs under waterlogged conditions in the presence of no or minimal oxygen.

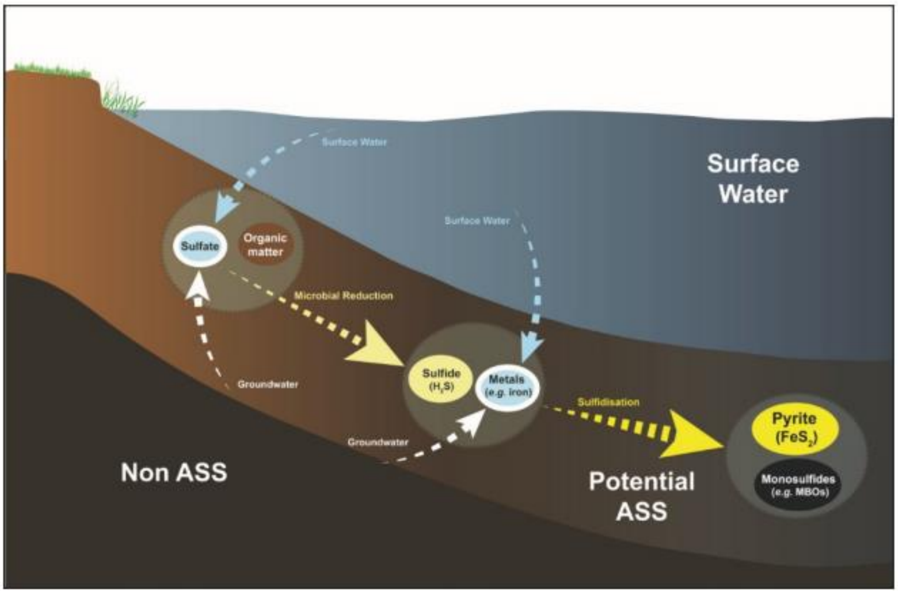
Under these anaerobic conditions, sulphate-reducing bacteria in the soil materials convert dissolved sulphate present in the pore water into Reduced Inorganic Sulfur (RIS). The RIS produced then reacts with metals, particularly iron, resulting in the formation of metal sulfides (principally pyrite). A supply of easily decomposable organic matter (such as decaying vegetation) is also required to provide sufficient energy for the bacteria to convert the sulphate into RIS. Under favourable environmental conditions iron monosulphides (for example FeS) may form, sometimes resulting in the accumulation of monosulphides black ooze (MBO).

Figure 2.2 on the following page summarises the key processes leading to the formation and accumulation of ASS materials.

For further details on the formation and accumulation of MBO see the Overview and Management of Monosulphidic Black Ooze (MBO) Accumulation in Waterways.

Highly favourable conditions for RIS formation and the accumulation of ASS materials were widespread following the last major sea level rise and resulted in the accumulation of extensive deposits of Holocene age (less than 10 000 years BP) ASS materials in coastal floodplains and intertidal swamps worldwide (Dent 1986).

Pyrite (the most common form of RIS in ASS materials) is also found in older sediments in Australia (that is Pleistocene age) and continue to form and accumulate in coastal and inland environments where suitable conditions for their formation exist. While ASS materials can be found in a wide variety of areas, some of the general situations where ASS materials are found are listed in Table 2.1, on the next page.



Note: not to scale.
Source: Adapted from EPHC & NRMMC (2011) and Ward et al. (2013).

Figure 2.2 - Formation and Accumulation of ASS Materials

Table 2.1 - Areas Where ASS Materials are Generally Found

a) Areas depicted on geology and/or geomorphological maps as 'geologically recent' such as:
- shallow tidal flats or tidal lakes, • shallow estuarine, or shallow marine deposits,
- stranded beach ridges and adjacent swales,
- interdune swales or coastal sand dunes,
- coastal alluvial valleys,
- wetlands (groundwater dependent and perched),
- floodplains,
- waterlogged areas,
- scalded areas,
- sump land,
- marshes, and
- swamps.

b) Areas depicted in vegetation mapping as:
- mangroves,
- wetland-dependent vegetation such as reeds and paperbarks (Melaleuca spp.), and
- areas where the dominant vegetation is tolerant of salt, acid and/or waterlogged conditions for example mangroves, salt couch, swamp-tolerant reeds, rushes, paperbarks and swamp oak (Casuarina spp.).

c) Areas identified in geological descriptions or in maps as:
- bearing iron sulfide minerals,
- former marine or estuarine shales and sediments,
- coal deposits, and
- mineral sand deposits.

d) Areas known to contain peat or a build-up of organic material.

e) Areas where the highest known water table level is within 3 metres of the surface.

f) Land with elevation less than 5 metres above Australian Height Datum (AHD).

g) Any areas (including inland areas) where a combination of all the following pre-disposing factors exist:
- organic matter,
- iron minerals,
- waterlogged conditions or a high water table, and
- sulfidic minerals.

2.5 ACID SULPHATE SOIL DISTURBANCE PROCESSES AND IMPACTS

In a waterlogged anoxic state potential acid sulphate soils (PASS) materials are benign. However, when these soil materials are drained or excavated, oxygen from the atmosphere reacts with the RIS in the soil resulting in the production of sulfuric acid. This acidity releases constituents such as metals and nutrients from the soil which may also be transported to waterways, wetlands and groundwater systems, often with adverse environmental and economic impacts. Development projects may adversely disturb ASS materials where they involve temporary or permanent lowering of the water table, excavation, compaction of saturated soil materials, and/or lateral displacement of previously saturated soil materials. A list of some of these types of developments is provided in Figure 4.2.

The disturbance of ASS materials can adversely affect soil, water and biota, and have a detrimental impact on agriculture, fishing, aquaculture, recreation and tourism, as well as on human health and visual amenity. The impacts of ASS leachate may persist over a long time, or peak seasonally with the first drought-breaking rains after extended dry periods. For example, in some areas of Australia, ASS materials drained 100 years ago are still releasing acid.

2.6 ACID SULPHATE SOIL TEST CRITERIA

NATA certified laboratories typically specify that the full SPOCAS laboratory analytical suite (Suspension Peroxide Oxidation Combined Acidity and Sulphur), the Chromium suite of tests and the Chip Tray method (pHF/pHox and pHINC) are undertaken to provide a detailed definition of acid sulphate soils.

These will provide results for both the ‘acid’ trail and the ‘sulphur’ trail allowing comparison of results to guideline values.

the full SPOCAS suite (Suspension Peroxide Oxidation Combined Acidity and Sulphur), Chromium suite of tests and the Chip Tray method (pHF/pHox and pHINC).These will provide results for both the ‘acid’ trail and the ‘sulphur’ trail allowing comparison of results to guideline values. AVS (Acid Volatile Sulfur) and field test analysis is also available, along with appropriate suites for water analysis in acid sulfate soil terrains.

Typical and useful indicative testing to gauge whether or not acid sulphate soils are present include “pH in H_2O”, and “pH in H_2O_2”.

Criteria for the presence of acid sulphate soils, based on these indicative screening laboratory tests, are:

pH in H_2O (water) < 4

pH in H_2O_2 (hydrogen peroxide) < 3

Difference between pH in H_2O & pH in H_2O_2 > 1

pH values greater than those listed above (that is less acidic) indicate the absence of acid sulphate soils, as do differences of less than 1 between the water and peroxide based pH measurements.

More detailed information and guidance is provided at Appendix A.

3 WARRIEWOOD ACID SULPHATE SOIL ENVIRONMENT

3 ACID SULPHATE SOILS ENVIRONMENT

3.1 INTRODUCTION

This section summarises what is known or understood regarding the acid sulphate soil environment applicable at the Warriewood site.

3.2 ACID SULPHATE SOIL MAPPING

Assessed acid sulphate soil risk associated with the general site area is provided in the mapping associated with the current Northern Beaches Council Local Environment Plan (LEP).

Acid sulphate soil conditions for the Warriewood site, as identified in that mapping , are described in Figure 3.1 below.

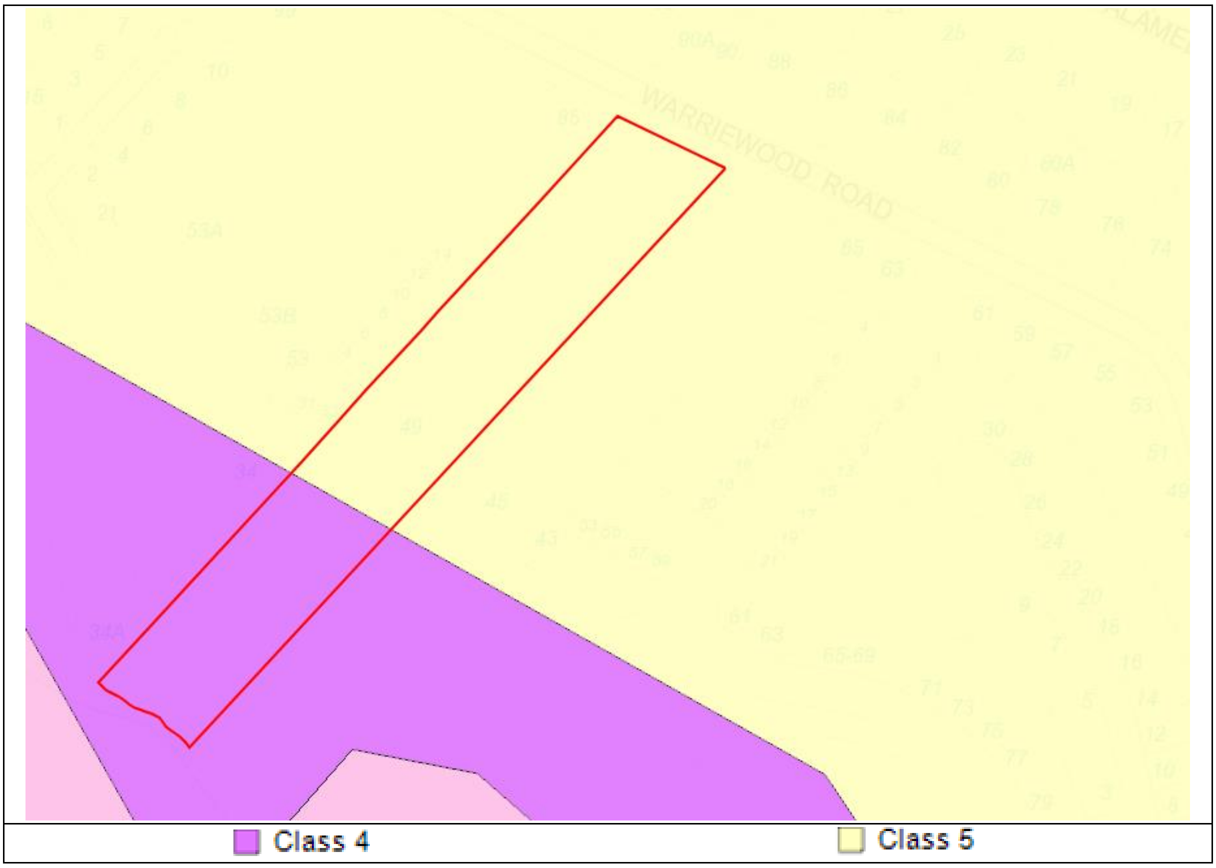


Figure 3.1 – Acid Sulphate Soil Risk Diagram 43-45 & 9 Warriewood Road

This mapping shows that approximately two-thirds (the northeastern portion) of the site is located in what is referred to as a “Class 5” acid sulphate soil area, while the remaining portion of the land (the southwestern portion) is located in a “Class 4” acid sulphate soil area.

The implications of these acid sulphate soil classifications are explained on the following page.

Acid sulfate soils have been classified based on the likelihood of the acid sulfate soils being present in particular areas and at certain depths.

There are five classifications. The five classifications, with conventional colour codes used, are as follows:

Class 1 - Acid sulfate soils in a class 1 area are likely to be found on and below the natural ground surface. Any works[2] will trigger the requirement for assessment and may require management.

Class 2 - Acid sulfate soils in a class 2 area are likely to be found below the natural ground surface. Any works[2] beneath the natural ground surface, or works[2] which are likely to lower the water table, will trigger the requirement for assessment and may require management.

Class 3 - Acid sulfate soils in a class 3 area are likely to be found beyond 1 metre below the natural ground surface. Any works[2] that extend beyond 1 metre below the natural ground surface, or works[2] which are likely to lower water table beyond 1 metre below the natural ground surface, will trigger the requirement for assessment and may require management.

Class 4 - Acid sulfate soils in a class 4 area are likely to be found beyond 2 metres below the natural ground surface. Any works[2] that extend beyond 2 metres below the natural ground surface, or works[2] which are likely to lower the water table beyond 2 metres below the natural ground surface, will trigger the requirement for assessment and may require management.

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

Note: [1] Australian Height Datum, and [2] 'work' is defined as any works that disturb more than one (1) tonne of soil or lower the water table.

In this case the bulk of the site involves Class 5 risk land, where acid sulphate soils are not typically found.

Approximately one third of each of the two constituent properties (45 and 49 Warriewood Road) comprising land closest to Narrabeen Creek to the rear or south-west property boundaries involves the second lowest acid sulphate soil risk, Class 4, where acid sulphate soils are not anticipated within two metres of the land surface.

3.3 PREVIOUS REPORTS & AVAILABLE DATA

The following report in relation to the acidity and other chemical characteristics of water/soil systems in the immediate vicinity of the Warriewood development was prepared in February of this year:

Baseline Water Quality Monitoring Report – Pre-Construction Monitoring:
43-49 Warriewood Road, Warriewood (H2O Consulting Group; 17 February 2025)

This report provides data on a range of chemical parameters.

In terms of acidity, this report found that:

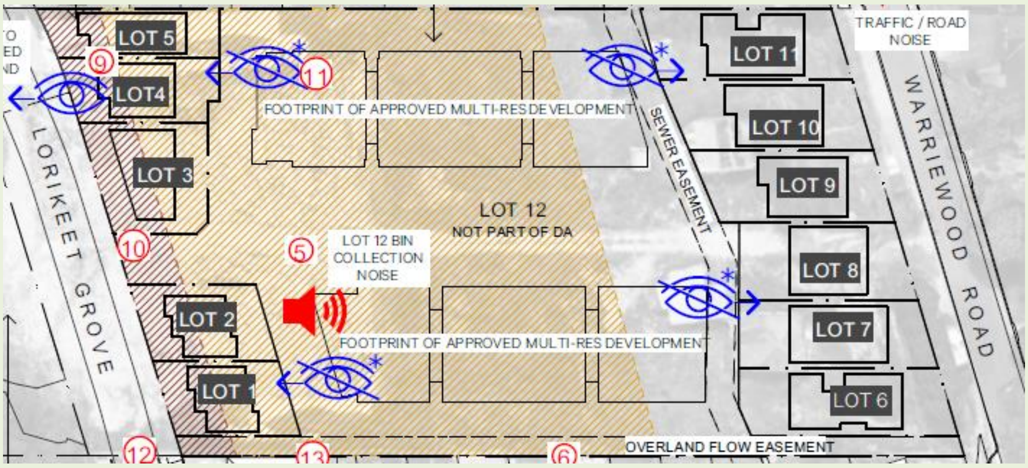
pH values remained highly consistent throughout the assessment, and were typically within the ANZECC Guidelines (2000) of 6.5 – 8.0, averaging at 6.7

Based on the criteria presented in Section 2.6, these results indicate the absence of acid sulphate soil conditions.

Confirmatory testing involving the full range of acid sulphate soil assessment criteria has been recommended as part of the Management Plan presented in Section 4 of this document.

3.4 CONSTRUCTION IN RELATION TO ASS CLASSIFICATIONS

The residential development proposed for the Warriewood site involves eleven lots, as shown below:



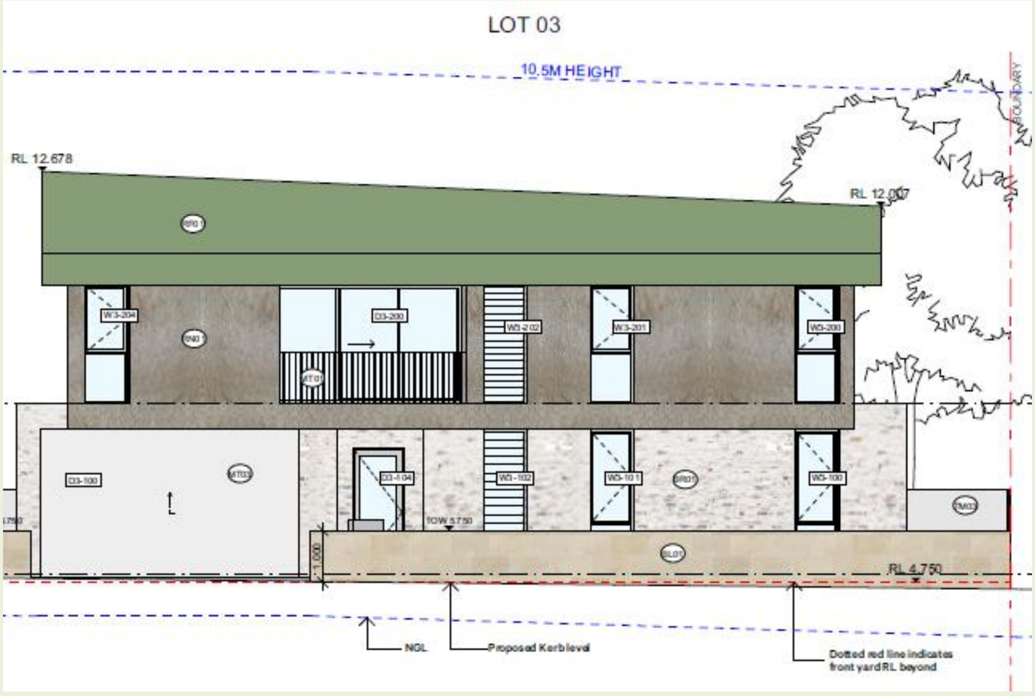
Lots 6 – 11 are located along the northeastern or Warriewood Road boundary of the site, and Lots 1 – 5 are located along the southwestern or Lorikeet Grove boundary.

Lots 6 – 11 are in a Class 5 ASS area, where acid sulphate soil conditions are not typically found.

Lots 1 – 5 are in a Class 4 ASS area, where acid sulphate soils, if present, are typically more than two metres below the natural ground surface.

3.5 PROPOSED CONSTRUCTION LEVELS

For the five development Lots in the Class 4 ASS area, typical construction levels are indicated by the proposed central or Lot 3 elevation (as viewed from Lorikeet Grove) shown below:



Natural ground level is indicated by the dotted blue line.

It can be seen that the five proposed residential developments along the Lorikeet Grove boundary will be constructed above the natural ground level, and construction is not proposed to involve excavation works that would intersect the [possible ASS risk depth, which for a Class 4 ASS area is defined as 2 metres or more below the natural ground level.

3.6 SUMMARY

The key factors to emerge from this overview of the acid sulphate soil environment at the Warriewood site are considered to be as follows:

- The six proposed development Lots (Lots 6 – 11) along the Warriewood Road site boundary are located in the lowest or Class 5 ASS risk area;
- The five proposed Lots (Lots 1 – 5) along the Lorikeet Grove site boundary are located in the second lowest or Class 4 ASS risk area, where acid sulphate soil conditions, if present, are typically present at least two metres below natural ground level; and
- Construction on Lots 1 – 5 is proposed on filled ground, above natural grounds level.

On this basis, while a prudent and precautionary approach (as detailed in the Management Plan presented in Part 4) is appropriate, the risk of encountering acid sulphate soil issues during the development appears to be relatively low.

4 ACID SULPHATE SOIL MANAGEMENT PLAN

4 ACID SULPHATE SOIL MANAGEMENT PLAN

ACID SULPHATE SOIL MANAGEMENT PLAN

A proposed Acid Sulphate Soil Management Plan for the proposed residential development on Lots 1-11 within the 43-45 & 49 Warriewood Road Warriewood property is presented in this Section. Elements of the Plan include:

- Policy & Management
- Personnel
- Acid Sulphate Risk Levels
- General precautions and Controls
- Design & Site Management Precautions
- Unexpected Events
- Confirmatory Soil Sampling & Analysis
- Continuous Improvement

4.1 POLICY & MANAGEMENT

POLICY & COMMITMENT

To manage any acid sulphate soil conditions encountered during the proposed residential development of Lots 1 – 11 at 43-45 & 49 Warriewood Road Warriewood in a safe and appropriate manner, and in accordance with all relevant guidelines, regulations and requirments.

PROCEDURE & PURPOSE

This Acid Sulphate Soil Management Plan provides a written procedure that can be used as part of the overall Plan of Management for the development, to help ensure that the development is undertaken in accordance with Acid Sulphate Soil standards and goals established by the NSW Environmental Protection Authority and other authorities.

COMMUNICATION & DISPLAY OF PLAN

The content of this Acid Sulphate Soil Management Plan shall be effectively communicated to all Warriewood Developers Pty Ltd staff and all appointed contractors involved in the proposed development.

WORKING HOURS

Working hours at the site are anticipated to be 7:00 am and 5:00 pm, Mondays to Fridays, and 8:00 am to 1:00 pm Saturdays, with no work on Sundays or public holidays..

4.2 PERSONNEL

KEY PEOPLE

Developer:

Organisation: Warriewood Developers Pty Ltd,
3 Kerrie Road Oatland NSW 2117

Name: Mr Shubham Loura Mobile: + 61 481 069 050

Site Works Contractor:

Organisation: tba

Name: tba Mobile: tba

Site Supervisor:

Name: tba Mobile: tba

It is noted that:

The Site Works Contractor will be appointed by Warriewood Developers Pty Ltd.

The Site Supervisor or Site Manager will be appointed by the Site Works Contractor.

STAFF TRAINING & COMPETENCE

Warriewood Developers Pty Ltd recognises the importance of ensuring that staff are properly trained; understand the importance of responding in a timely and effective manner to any acid sulphate soil issues that may arise during the development, and are fully conversant with the provisions of this Acid Sulphate Soil Management Plan.

STAFF AWARENESS

Staff and any appointed contractors are fully aware of the need to comply with all applicable regulations and guidelines re the management of the acid sulphate soil environment at the Warriewood site, of their roles and responsibilities in implementing the provisions of this Plan, and in responding when required to any acid sulphate soil issues that may arise during the ongoing residential development proposed for the site.

4.3 ACID SULPHATE RISK LEVEL

The acid sulphate soil assessment presented in Section 3 has indicated that the Warriewood Road site falls within Class 5 and Class 4 areas in terms of acid sulphate soil risk.

> Class 4 - Acid sulfate soils in a class 4 area are likely to be found beyond 2 metres below the natural ground surface. Any works[2] that extend beyond 2 metres below the natural ground surface, or works[2] which are likely to lower the water table beyond 2 metres below the natural ground surface, will trigger the requirement for assessment and may require management.
>
> Class 5 - Acid sulfate soils are not typically found in Class 5 areas. Areas classified as Class 5 are located within 500 metres on adjacent class 1,2,3 or 4 land. Works[2] in a class 5 area that are likely to lower the water table below 1 metre AHD[1] on adjacent class 1, 2, 3 or 4 land will trigger the requirement for assessment and may require management.

Data currently available indicates that acid sulphate soils are not present on the eleven Lots proposed for residential development at the site. However, this currently available data is limited, and a prudent and precautionary approach is appropriate, and has been reflected in this Plan.

4.4 GENERAL PRECAUTIONS & CONTROLS

To minimise the risk of acid sulphate soil issues at the site, the following precautionary recommendations are made:

During Excavations:

- During excavations for services, keep the volume of soil removed to a minimum.
- Any excavated soils from depths greater than 2.0 on the area of the site designated as Acid Sulphate Soil Class 4 shall be stockpiled and covered to reduce exposure to the elements, including cover with suitable material and construction of earth bunds around each pile if required to prevent run-off from the pile spreading to adjacent areas.

Response to any Indications of Acid Sulphate Soil:

- Section 2 of this document provides general descriptions of acid sulphate soils and acid sulphate soil conditions.
- If physical indications of acid sulphate soils (or other contaminants are noted), appropriate advice and instructions should be sought from and provided by a suitably qualified and experienced person.
- A suitably qualified and experiences person is a person with appropriate tertiary qualifications and associated experience in the identification, assessment and management of acid sulphate soils,

Actions for Excavated Soils to be Exported from the Site :

Subject to confirmation and advice as reasonably required from a suitably qualified person as described above, the following actions and controls will apply to any soils excavated from and removed from the site.

- Excavated soils to be removed from the site shall be assessed by a suitably qualified and experienced person to ensure that no acid sulphate or other contamination issues apply.
- If soils to be exported from the site are assessed as other than Virgin Excavated Natural Material (VENM), appropriate classification and disposal practices should be applied.

Actions for Excavated Soils to be Re-Used at the Site

Subject to confirmation and advice as reasonably required from a suitably qualified person as described above, the following actions and controls will apply to any soils excavated from and re-used at the site.

- Any soils excavated from depths greater than 2.0 metres and to be reused on-site shall be treated with lime (neutralized) as a precautionary measure before being utilized as fill on site.
- Neutralising shall be based on the mixture of one (1) x 20 kg bags of fine agricultural lime per fifteen (15.0) m^3 of excavated soil.
- Mix the lime thoroughly with any soil to be utilized as fill. This prevents acid being generated and leachate migrating from the site.
- Materials placed as fill on site after mixing shall be compacted (in maximum 200 mm deep layers) to minimize the entry of air and water.

4.5 DESIGN & SITE MANAGEMENT PRECAUTIONS

General Design Precautions:

These following precautions are considered supplementary to any structural and/or foundation design measures for the proposed development and are intended to apply during th ongoing use of the building.

Reactive clays are prone to heave/shrink movements with changes in soil moisture content, due to natural or artificial means.

The basic design philosophy employed for the building structure is to provide a foundation/superstructure adequate to accommodate ground movements, due to extreme seasonal moisture changes only.

The possibility of other abnormal and/or localised moisture changes has been assumed to be controlled by the following “site management: procedures and controls.

Surface Water Run-Off:

- All surface water runoff must be directed away from building construction areas by appropriate grading, in order to prevent bonding near foundations. Site drainage must form part of the building contract.

Impermeable Pathways

- Peripheral impermeable pathways should be provided around construction areas.
- This action supplements site drainage and assists in the stabilisation of moisture conditions near foundations.

Brickwork Units

- All brickwork should be suitably articulated into discrete units to accommodate the expected movements. In particular, brickwork over doors and windows should be avoided.

Internal Walls

- Internal and external walls should be arranged. along straight lines.

Water Pipes & Drains

- All house drains and water pipes must be provided with sufficient flexibility to accommodate the expected differential movements (between foundation and uncovered outside area) at the level of service.

Avoid Extension of Services through Slabs

- The extension of services through slabs should be avoided, where possible, in order to prevent hidden leaks under the slab area.
- Most plumbing fixtures can be arranged to exit through outside walls.

Septic Systems

- Septic systems must not be located within any influence (preferably downhill) of the house or neighbouring foundations. Alternatively, a pump-out system must be employed.

Lining of Subgrades

- Subgrades beneath elevated and well-ventilated floors should be covered with an impermeable liner (with protective soil blanket) to minimize excessive desiccation.

Avoid Abnormal Moisture Variations

- In addition, normally applicable site management' precautions must be adhered to during the life of the structure.
- These precautions generally relate to the control of abnormal moisture variations due to the effects of drainage and vegetation.

Prompt Attention to Leaking Plumbing or Drains

- Leaking plumbing or blocked drains should be repaired promptly and site grading maintained to prevent ponding near foundations.

Watering of Gardens or Landscaped Areas

- The watering of gardens or landscaped areas, particularly by fixed systems, should be controlled carefully to avoid gross over watering.
- As far as practicable, the maintenance of gardens and landscaped areas should produce year round uniform moisture conditions.
- Trees and some shrubs can cause a substantial drying of the soil and associated shrinking of reactive clays. This effect is most likely to result in damage when added to the drying from a drought or a long dry spell. The problem can be minimized by planting trees at substantial distances from the building structures. The distance depends upon the species and soil conditions, and specific advice should be obtained from a suitably qualified and experienced arborist or landscape consultant.

4.6 UNEXPECTED EVENTS

It is possible that unexpected events may occur during the construction of the proposed residential development.

Any such events that relate to acid sulphate soil should as part of this plan be reported immediately by the appointed Site Supervisor or manager, who will in turn seek further advice as required.

The Site Supervisor or Manager will be responsible to take immediate action to ensure that any such unexpected events are dealt with in an urgent and appropriate manner, to ensure that environmental harm or exposure are controlled and minimised at the site.

The Site Supervisor or Manager may take further advice from Warriewood Developers Pty Ltd, and if appropriate from Warriewood Developers Pty Ltd’s appointed environmental or acid sulphate soil specialist or others as nominated by Warriewood Developers Pty Ltd.

Current contact details are provided in Part 4 of this document.

4.7 CONFIRMATORY SOIL SAMPLING & ANALYSIS

Confirmatory ASS sampling and analysis should be undertaken from appropriate locations near Lots 1-5, and Lots 6-11, in consultation with the appointed acid sulphate soils consultant, with the results used to inform the acid sulphate soil management process as necessary.

4.8 CONTINUOUS IMPROVEMENT

This Management Plan will be updated as required by Warriewood Developers Pty Ltd to ensure that any changes in circumstances or site knowledge are taken fully into account.

4 CONTACT DETAILS

4 CONTACT DETAILS

Contact details for Warriewood Developers Pty Ltd and its currently appointed Acid Sulphate Soil Consultant for the Warriewood Road, Warriewood residential development are provided below.

The Plan will be amended as required to show changes and updates to these contact details.

ACUITY GROWTH DEVELOPMENT MANAGEMENT:

Warriewood Developers Pty Ltd
3 Kerrie Road Oatland NSW 2117

Contact: **Mr Shubham Loura**
Director
Phone: + 61 481 069 050
Emai: 45warriewoodcc@gmail.com

ACID SULPHATE SOIL CONSULTANT:

Noel Child
22 Britannia Road
Castle Hill NSW 2154

Contact: **Noel Child**
Phone: + 61 2 9899 1968
Mobile + 61 409 393 024
Email: ngchild@canda.com.au

APPENDIX A

Acid Sulphate Soils Guidance

1 Field soil and water characteristics as indicators of ASS materials

If soil materials or associated water bodies display one or more of the indicators of ASS material, the presence of ASS materials is likely, but not conclusive.

The determination of the soil field pH (pH_F) provides a useful quick indication of the likely presence and severity of Actual ASS (AASS). In undertaking pH_F testing at the site inspection stage the sampling frequency, as a minimum, should be similar to that required during soil sampling (Stage 3), with a higher density of testing in areas where the site characteristics indicate ASS materials may be present. The location of soil samples should be recorded using the full Australian Map Grid reference and current surface height, relative to Australian Height Datum (AHD). Further details on the sampling frequency requirements in Stage 3 are given in the Minimum soil sampling density section in Section 6.

Field pH readings should be taken at regular intervals down the soil profile (that is at least every 25 cm, or where there is a change in soil horizon, whichever is the smallest interval).

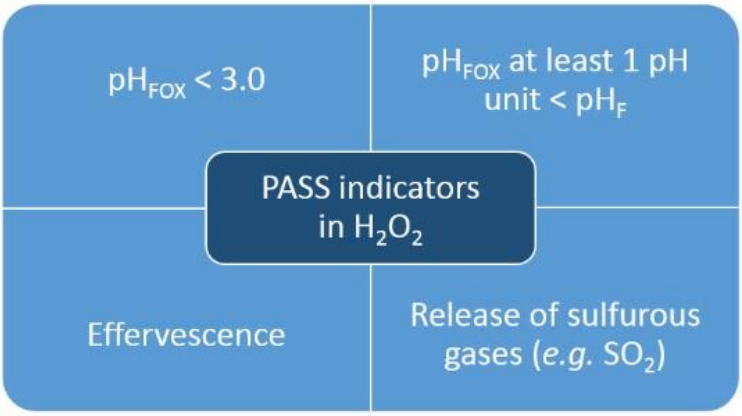
pH_F readings less than 4, along with other indicators of ASS such as jarosite and/or reddish-orange iron mineral staining in the horizon, or the presence of jarosite and/or reddish-orange iron mineral staining or PASS in the vicinity, indicates the soil is an AASS with past oxidation of RIS, resulting in an acidic soil material (and acidic soil pore water).

pH_F readings greater than 4 may indicate the absence of AASS but PASS may still be present.

A field pH peroxide test (pH_{FOX}) is often used as an indicator of the presence of Reduced Inorganic Sulfur (RIS) and hence PASS. This field test for PASS uses concentrated (that is 30 %) hydrogen peroxide to rapidly oxidise RIS within a sample of soil, resulting in the production of acidity and a corresponding drop in pH. A positive peroxide test for PASS may include one, but preferably more, of the indicators shown in Figure 1.

However, it is important to note that false positives are common when high levels of organic material or manganese are present in the soil material tested.

Figure 1 - Indicators of a Potential ASS materials following field peroxide testing.



For inland situations only, electrical conductivity (EC; greater than 1750 µS/cm in water or greater than 400 µS/cm in 1:5 soil:water extract) and sulfate concentrations (greater than 10 mg/L in water or greater than 100 mg/L in 1:5 soil:water extract for dry soil) can be used to indicate the likely presence of ASS materials (EPHC & NRMMC 2011).

2 Groundwater analysis as indicators of impact from ASS materials

An examination of the groundwater quality in the proposed area can also be used to provide an indication of whether RIS oxidation has occurred in the vicinity. Groundwater quality parameters that can be used to indicate the presence of ASS materials include a soluble sulfate to soluble chloride (SO_4^{2-}:Cl^-) of more than 0.25 (Mulvey 1993), and a pH of less than 4 (for example DER 2015a, 2015b). The analysis of groundwater (and drain water) for SO_4^{2-}:Cl^- ratio has frequently been used as an indicator of ASS. As seawater has a sulfate concentration of approximately 2700 mg/L and chloride concentration of approximately 19 400 mg/L, the SO_4^{2-}:Cl^- ratio of seawater and coastal landscapes on a mass basis is 0.14.

The ratio of dominant ions in saline water remains approximately the same when diluted with rainwater, and therefore, estuaries, coastal saline creeks and associated groundwater can be expected to have similar dominant anion ratios to seawater. Any other source of sulfate ions (such as the oxidation of RIS) in these locations can lower this ratio and hence provide an indication of the possible presence of ASS materials in the surrounding landscape.

A SO_4^{2-}:Cl^- ratio of greater than 0.5 is a strong indicator of an extra source of sulfate from RIS oxidation (Mulvey 1993).

The utility of the SO_4^{2-}:Cl^- ratio to identify ASS materials diminishes as the salinity of groundwater approaches that of freshwater.

The SO_4^{2-}:Cl^- ratio of groundwater (or indeed of the soil material's soluble ions) is especially useful to help discriminate between Actual ASS materials and naturally-occurring acidic soil materials.
Other indicators that have been used as indicators of RIS oxidation and associated acidification in groundwater, and their indicative values are presented 1.

Table 1 - Additional indicators of RIS oxidation in groundwater and indicative values.

Indicator	Indicative value	Comments
SO_4/alkalinity ratio	> 0.2	May indicate sulphide oxidation and/or consumption of alkalinity
Al/Ca mole ratio	> 1	May indicate Ca depletion and potential for Al toxicity to plants
Alkalinity	< 10 mg/L	pH can reduce rapidly if alkalinity decreases to 0. Noting decreasing trends is important prior to extreme acidification
Al	> 1 mg/L	Indicative of Al mobilisation; should correlate with pH–note that Al may be present as colloids at higher pH, and small filter sizes (for example 0.1–0.2 µm)
Other trace metals & metalloids	variable	Useful to monitor and compare with ANZECC guideline values for ecosystem protection

Source: Modified from Shand et al. (2017).

3 Identification of Monosulphidic black oozes (MBOs)

An initial field assessment of sediments may provide an indication of whether monosulphidic black oozes (MBOs) are present at the site. Unoxidised MBOs typically have a near neutral pH (pH 7–8), together with high organic matter contents and low redox potentials (Eh). MBOs also usually have a distinct strong black colour, gel consistence and sometimes an oily appearance (Figure 2); some MBOs are dark grey in colour. A rotten egg odour from the reduction of sulfate to hydrogen sulfide may also further indicate the presence of MBOs; hydrogen sulfide gas can be detected by its odour at very low concentrations.

However, the defining characteristic of a MBO is its enrichment with monosulphides. In the field the addition of concentrated hydrochloric acid (HCl) to MBOs will yield H_2S (that is 'rotten egg gas'). This test should only be carried out using small amounts of material (that is less that a teaspoon) with only a few drops of concentrated HCl in a well-ventilated setting. The field identification of MBO must be confirmed by the appropriate laboratory analysis [see Sullivan et al (2017a, b)].

Figure 2 - Black oily appearance of MBO gel collected from the Peel region, Western Australia.

Source: Sullivan et al. (2006).

The environmental setting of the sediments may also indicate the likelihood of the presence of MBOs. Monosulfidic black oozes accumulate in large quantities in locations with the appropriate conditions for their formation, including waterways affected by one or a combination of ASS materials, eutrophication or salinisation. These sites are usually dominated by low velocity flow conditions where there is an abundant supply of organic matter, iron and sulfate. Recent research by Wong et al. (2016) indicates accumulation of sulfidic materials (including monosulfidic materials) occurs preferentially downstream of channel obstructions, such as submerged logs or in scour pools. The accumulation of these MBOs was not limited to lower energy parts of the channel as would be expected for fine-grained organic sediments.

Further information in relation to MBO is available in the following national ASS guidance document: Overview and Management of Monosulfidic Black Ooze (MBO) Accumulation in Waterways (Sullivan et al, 2018c).

4 Consideration of soil, water and groundwater indicators

Once all the site assessment data has been collected a preliminary determination should be made as to whether ASS materials are present or absent at the site. All field soil and water indicators (**Error! Reference source not found.**), including field pH test results, and any groundwater SO_4^{2-}:Cl^- ratio results should be considered in this determination.

Table 2 contains a range of outcomes and possible interpretation of these results. The table includes suggestions for further investigations to clarify the presence or absence of ASS. Please note there are circumstances where these general indicators do not apply because of the soil, geology or water characteristics.

Table 2 - Soil and water indicators for the presence or absence of ASS materials.

Field pH of water	Water analysis SO_4^{2-}:Cl^- (by mass)	Field soil or water indicators	Typical soil reaction to 30% H_2O_2	Preliminary assessment
6–8	Approx. 0.14 but may be in the range 0.1–0.2	Nil	Nil reaction and no drop in pH	No PASS material present. Must be verified by laboratory chemical analysis
		PASS indicators present	Mild to strong effervescence and drop in pH	PASS present but has probably not been oxidised at any time. Must be verified by laboratory chemical analysis
< 5	Approx. 0.14 but may be in the range 0.1–0.2	Nil	Nil reaction and no drop in pH	No PASS present and low pH can be attributed to causes other than RIS oxidation. Must be verified by laboratory chemical analysis
		PASS indicators present	Mild effervescence and drop in pH	PASS present but probably has not been oxidised at any time. Existing low pH can be attributed to other causes. Must be verified by laboratory chemical analysis
6–8	0.2–0.5	Unclear indicators	Mild effervescence and drop in pH	Presence of PASS is uncertain. Must be verified by laboratory chemical analysis
	> 0.5	Indicators of AASS or PASS present	Mild to strong effervescence and drop in pH	Presence of PASS plus the presence of substantial Acid Neutralising Capacity. Must be verified by laboratory chemical analysis
< 5	0.2–0.5	Unclear indicators	Mild effervescence and drop in pH	Presence of PASS is uncertain. Must be verified by laboratory chemical analysis
< 5	> 0.5	Indicators of AASS or PASS	Mild to strong effervescence and drop in pH	Presence of PASS with little or no Acid Neutralising Capacity. Must be verified by laboratory chemical analysis

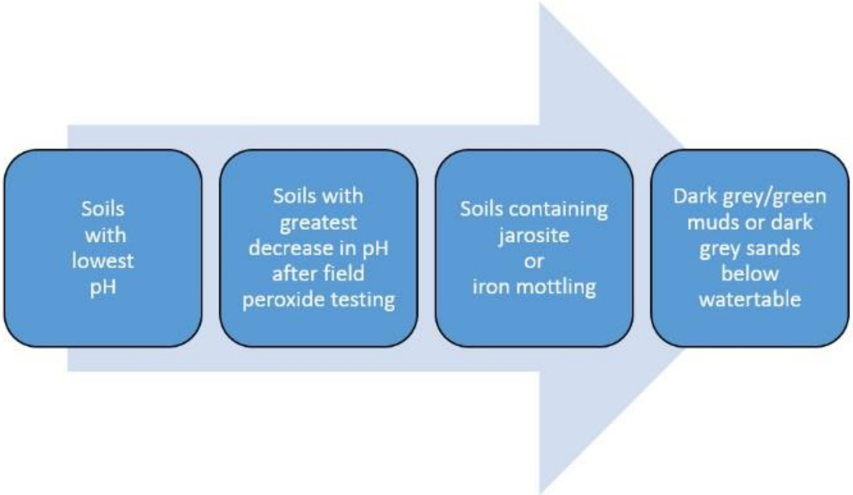
Source: Modified from Ahern et al. (1998b).

5 Laboratory chemical analysis to confirm presence or absence of ASS

Samples of materials need to be tested in the laboratory to definitively indicate the presence or absence of ASS materials.

A sufficient number of samples with the highest probability of being ASS, based on field pH testing (pH_F and pH_{FOX}) and soil characteristics (for example jarosite, iron mottling), should undergo laboratory chemical analysis to either ensure ASS materials are not found on site, and hence an ASS management plan is not required, or to help confirm the presence of ASS materials. Figure 3 shows the criteria commonly used to select soils samples for preliminary laboratory chemical analysis.

Figure 3 - Selection criteria for preliminary chemical analysis of soil samples.



Sufficient number of samples should be analysed from all areas which have a high probability of ASS materials to ensure its absence or indicate its presence. The total number of samples for analysis depends on factors such the areal extent and depth of the planned disturbance and the associated hazards.

At this stage of the assessment process and for the later development of management plans, it is important to know which areas of the site and which soil layers are unlikely to contain ASS materials.

Laboratory chemical analysis of the selected samples should be undertaken to ascertain if PASS and Actual ASS materials are present and to quantify the Net Acidity (See Sullivan et al, 2018b). If the Net Acidity of any individual ASS material tested is equal to or greater than the action criterion, a detailed ASS management plan will need to be prepared.

Details on the laboratory analyses required to determine Net Acidity, and the action criteria triggering an ASS management plan, are provided in the National Acid Sulfate Identification And Laboratory Methods Manual (Sullivan et al, 2018b).

Source:

Australian Government Initiative

WATER QUALITY AUSTRALIA

National Acid Sulfate Soils Guidance

National acid sulfate soils sampling and identification methods manual

June 2018