Northern Beaches Council
c/o BBF Town Planners

Acid Sulfate Soil Management Plan

Passmore Reserve, Manly Vale, NSW
and
Frank Gray and Mike Pawley Ovals, Curl Curl, NSW

22 October 2019
57312 - 124732 (Rev 0)

JBS&G Australia Pty Ltd

www.jbsg.com.au

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Abbreviations

Term	Definition
AASS	Actual Acid Sulfate Soil
AHD	Australian Height Datum
ASS	Acid Sulfate Soil
ASSMP	Acid Sulfate Soil Management Plan
BGS	Below Ground Surface
CC	Construction Certificate
DA	Development Application/Approval
DCP	Development Control Plan
EPA	NSW Environment Protection Authority
ha	Hectare
LEP	Local Environmental Plan
LOR	Limit of Reporting
NBC	Northern Beaches Council
PASS	Potential Acid Sulfate Soil
SAC	Site Action Criteria
S_{Cr}%	Chromium Reducible Sulfur (%)
sPOCAS	Suspended Potential Oxidation Combined Acidity and Sulfur (test method)
S_{pos}%	Potential Oxidisable Sulfur
SWL	Standing Water Level
TAA	Total Actual Acidity
TPA	Total Potential Acidity
TSA	Total Sulfidic Acidity

1. Introduction

1.1 Background

JBS&G Australia Pty Ltd (JBS&G) has been engaged by BBF Town Planners on behalf of Northern Beaches Council (NBC, the client) to provide environmental services in relation to the identification, assessment and management of Acid Sulfate Soils (ASS) at two council owned properties located at:

- Passmore Reserve, Manly Vale, NSW (Lot 2743 Deposited Plan (DP) 752038); and
- Frank Gray and Mike Pawley Ovals, Curl Curl, NSW (Lot 2 DP 225041, Lot 2 DP 513842, Lot 2 DP 533226, part Lot 224 DP 752038, part Lot 7714 DP 1030407, part Lot 230 DP 752038, and Lot 1 DP 601091).

The ASS Management Plan (ASSMP) outlined herein applies to both properties, where applicable both shall be referred to as 'the site'. Passmore Reserve has a total area of approximately 3.9 hectares (ha), its location and layout are shown in **Figure 1** and **Figure 2A**, **Appendix A**. Frank Gray and Mike Pawley Ovals has a total area of approximately 5.5 ha, its location is shown in **Figure 1** and **Figure 2B**, **Appendix A**.

The proposed development plans show there are eight light poles to be installed around the perimeter of Passmore Reserve and six light poles to be installed around the perimeter of Frank Gray and Mike Pawley Ovals. JBS&G understand that all light pole footings will be excavated 0.6 m below ground surface (bgs) into soil and constructed of concrete with dimensions of 2 m length x 2m width x 0.6 depth.

Acid sulfate soil investigations were undertaken at both Frank Gray and Mike Pawley Ovals (JBS&G 2019a) and Passmore Reserve (JBS&G 2019b) to determine the likelihood of encountering Potential Acid Sulfate Soils (PASS) or ASS during proposed sub-surface excavation works. Advancement of boreholes associated with the proposed works, field testing and laboratory analysis of collected samples were undertaken. All of the laboratory results from samples taken at Frank Gray and Mike Pawley Ovals reported non-ASS conditions in soil. Three of the five samples submitted from Passmore Reserve reported ASS conditions in soil.

With consideration to the ASS results identified at Passmore Reserve JBS&G has been engaged by BBF Town Planners, on behalf of NBC to prepare an ASS Management Plan (ASSMP), based on soils anticipated to be disturbed during the proposed site redevelopment and the requirements for an ASS Management Plan for disturbance of Class 1 and Class 2 ASS identified in the Warringah LEP (2011).

This ASSMP has been prepared with consideration to the requirements of Section 6.1 of the Warringah LEP 2011, the *Acid Sulfate Soil Manual* (ASSMAC, 1998[1]) and with consideration to the National Acid Sulfate Soils Guidance (DAWR 2018[2]). Given the proposed works may include the generation of excess material, consideration has also been given to a future classification for off-site disposal of soils under the NSW EPA *Waste Classification Guidelines* (EPA 2014a[3] and 2014b[4]).

1 *Acid Sulfate Soil Manual, NSW Acid Sulfate Soil Management Advisory Committee, August 1998 (ASSMAC 1998)*

2 *National Acid Sulfate Soil Guidance. Australian Government Department of Agriculture and Water Resources (DAWR), June 2018 (AGDAW, 2018)*

3 *Waste Classification Guidelines Part 1: Classifying Waste. NSW EPA 2014 (EPA 2014a)*

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

1.2 Aims and Objectives

The aim of this ASSMP is to outline management techniques that may be employed to mitigate the potential environmental impacts associated with the risk of disturbance of ASS/PASS during the proposed site construction works. Specifically, the objectives of this ASSMP are to document:

- The known and anticipated site sub-surface characteristics that will be encountered during future excavation works to support design and implementation of future ASS investigation and management activities;
- A monitoring and sampling strategy to be implemented prior to and during the proposed ground disturbance activities so that ASS may be appropriately identified and managed during the excavation works;
- Evaluation of potential ASS management opportunities and constraints resulting in the identification of a preferred management strategy;
- Procedures for the management and validation of ASS treatment during the future site excavation works, to minimise the potential for adverse environmental impacts as a result of the ASS disturbance activities; and
- Outline the necessary off-site disposal requirements for potential ASS spoil generated from the proposed works.

2. Site Conditions

2.1 Site Identification and Description

The site as shown in **Figures 1** and **2,** and a summary of site details are provided in **Table 2.1**.

Table 2.1: Site Details

Frank Gray and Mike Pawley Ovals	
Lot / DP	Part Lot 2 DP 225041, Lot 2 DP 513842, Lot 2 DP 533226, Part Lot 224 DP 752038, Part Lot 7714 DP 1030407, Part Lot 230 DP 752038, and Lot 1 DP 601091
Address	Frank Gray and Mike Pawley Ovals, Stirgess Ave, North Curl Curl, NSW
Local Government Authority	Northern Beaches Council
Site Zoning	RE1 – Public Recreation (Warringal Local Environment Plan, 2011)
Current Use	Public open space, recreational/sporting fields.
Future Use	Public open space, recreational/sporting fields.
Passmore Reserve	
Lot / DP	Part Lot 2743 DP 752038
Address	Campbell Parade, North Curl Curl, NSW
Local Government Authority	Northern Beaches Council
Site Zoning	RE1 – Public Recreation (Warringal Local Environment Plan, 2011)
Current Use	Public open space, recreational/sporting fields.
Future Use	Public open space, recreational/sporting fields.

2.2 Site Condition

A detailed site description and environmental setting is provided in JBS&G (2019a & 2019b).

Frank Gray and Mike Pawley Ovals consisted of grassed sports fields, cricket nets and a changing / public toilet building bounded to the north by Greendale Creek and to the south by low density residential housing. To the east and west lay the greater John Fisher Park.

Passmore Reserve consisted of grassed sports fields and a playground, bounded to the north by Manly Creek and to the south by Campbell Parade

2.3 Investigation Data – Acid Sulfate Soil Conditions

Review of the Acid Sulfate Soil Risk Map for Sydney Heads[5], undertaken as part of Acid Sulfate Soil Assessment (ASS Assessment, JBS&G 2019a[6], JBS&G 2019b[7]), indicated that both sites are located in areas of disturbed terrain, including areas historically impacted by reclamation of low-lying wetlands, dredging, mining or urban development. The assessment also identified, in accordance with NSW Department of Planning, Industry and Environment Acid Sulphate Soils Risk Mapping (NSW DPI&E EPI, 2019), the site has been zoned into the following classifications:

2.3.1 Frank Gray and Mike Pawley Ovals:

- North and central portion of the site (along Greendale Creek) has been classified into Class 4, considered ASS conditions likely to be found beyond 2 metres below the natural ground surface; and
- Southern portion of the site has been classified into Class 5, considered unlikely to contain acid sulfate soil conditions (located within 500m on adjacent class 1-4 land).

Eleven soil samples were subject to field ASS testing in accordance with the field-testing procedure presented in the ASSMAC (1998), with field pH_f and pH_{fox} tests recorded. Five of these samples were sent to the laboratory for ASS testing having been identified to be the soils with the greatest

5 *'Acid Sulphate Soil Risk Map Edition Two – Sydney Heads, 1997 1:25 000 (NSW DLWC)*

6 *L001 – Acid Sulfate Soil Assessment, Frank Gray and Mike Pawley Ovals ,Curl Curl, JBS&G Australia Pty Ltd, 57312 – 124679, 22 October 2019, Rev 0 (JBS&G 2019a)*

7 *L002 – Acid Sulfate Soil Assessment, Passmore Reserve, Manly Vale, JBS&G Australia Pty Ltd, 57312 – 124680, 22 October 2019, Rev 0 (JBS&G 2019b)*

indicated potential for acid generation to provide the most conservative answers with regard to threshold levels for liming and associated liming rates.

2.3.2 Passmore Reserve:

- North/north-eastern portion of the site (along Manly Vale Creek) has been classified into Class 1, ASS conditions considered likely to be found on and below the natural ground surface;
- Central portion of the site has been classified into Class 2, ASS conditions considered likely to be found below the natural ground surface; and
- Southwest portion of the site has been classified into Class 5, considered unlikely to contain acid sulfate soil conditions (located within 500m on adjacent class 1-4 land).

Eleven soil samples were subject to field ASS testing in accordance with the field-testing procedure presented in the ASSMAC (1998), with field pH_f and pH_{fox} tests recorded. Five of these samples were sent to the laboratory for ASS testing having been identified to be the soils with the greatest indicated potential for acid generation to provide the most conservative answers with regard to threshold levels for liming and associated liming rates.

2.4 Investigation Data – Site Geology

2.4.1 Frank Gray and Mike Pawley Ovals

Reference to the 1:100 000 Geological Series Sydney Geological Survey of NSW Sheet 9130 (DMR 1983[8]), indicates that the site is underlain by Holocene Quaternary alluvial/fluvial deposits. These deposits are characterised by the presence silty to peaty quartz sand, silt and clay with ferruginous and humic cementation in place and common shell layers. The geology map indicates man-made fill overlies alluvial/fluvial sediments at the site and surrounding area. The nature of fill is noted to be varied, with a combination of putrescible and non-putrescible waste mixed with sandy material and sandstone boulders[9].

- Brown to black gravelly sandy silt (fill topsoil) with inclusions of rootlets to depths between 0.10-0.40 m bgs;
- Brown sandy gravelly clay (fill) at depths between 0.10-0.45 m bgs in BH001 only;
- Greyish brown sand to depths between 0.10-0.6m bgs;
- Orange to brown mottled white sand at depths between 0.35-1.0 m bgs;
- BH003 and BH006 refused on gravels at 0.65 m bgs and 0.70 m bgs respectively;
- No asbestos, staining or odours were observed within the excavated soils.
- No groundwater seepage was observed in any sample location.

2.4.2 Passmore Reserve

Reference to the 1:100 000 Geological Series Sydney Geological Survey of NSW Sheet 9130 (DMR 1983), indicates that the site is underlain by Holocene Quaternary alluvial/fluvial deposits. These deposits are characterised by the presence silty to peaty quartz sand, silt and clay with ferruginous and humic cementation in place and common shell layers.

Soil lithologies identified during the ASS Assessment (JBS&G 2019a) identified four types of fill materials including:

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8 1:100 000 Sydney Geological Map Sheet 9130 Edition 1. Department of Mineral Resources, Published 1983, DMR 1983;

9 John Fisher Park and Abbott Road Land Plan of Management. Warringah Council, November 2001. Obtained via https://files.northernbeaches.nsw.gov.au/sites/default/files/test-gab/jfpappendices.pdf Accessed 18 September 2019

- Black sandy silt (fill) with inclusions of rootlets to depths between surface and 1.0m bgs;
- Black silty sand (fill) observed between 0.25-0.40m in BH03;
- Grey sand (fill)observed in BH03 and BH04 at depths between 0.40/0.50-1.0m bgs;
- Gravelly silt (fill) observed in BH05 at depths between 0.30-0.50 m bgs;

2.5 Investigation Data – ASS Laboratory Data

2.5.1 Frank Gray and Mike Pawley Ovals

Analytical results from the sPOCAS procedure undertaken by the laboratory identified the following:

- All laboratory samples reported Titratable Peroxide Acidity (TPA) and Titratable Sulfidic Acidity (TSA) concentrations < 2 mol H^+/t within the sand fill material, below the adopted action criteria for coarse soils (based on 1-1000 tonnes disturbed) of 18 mol H^+/t.
- Peroxide Oxidisable Sulfur (% S_{POS}) was not detected above laboratory limits of detection (<0.02 % S) within any soil samples, significantly below the adopted site action criteria for coarse soils of 0.03 %w/w (based on 1-1000 tonnes disturbed).
- The laboratory results confirm the materials encountered during the investigation program, from surface to 0.1 m bgs are not considered to be acid sulfate soils and therefore the addition of agricultural lime would not be required to neutralise the soils during excavation works.

2.5.2 Passmore Reserve

Site investigation activities completed by JBS&G (2019a) included sPOCAS laboratory analyses as an initial screening assessment on representative natural soil samples. Based on the results of field pH_f and pH_{fox} tests, laboratory analysis was undertaken on selected samples to enable comparison to site assessment criteria (**Section 3.2**) adopted from ASSMAC (1998).

Assessment of the collated laboratory analysis results against ASSMAC criteria identified the following:

- Field analysis was conducted on soil samples taken for ASS analysis by the addition of deionised water with some of the sample and measuring the pH at the moment of addition and again after 5 minutes of mixing. This process was then repeated with hydrogen peroxide, with large drops in pH indicating PASS.
- The largest changes in pH after the addition of hydrogen peroxide were observed at BH001 0.8 m (Δ pH 2), all other landfill pH changed less than 1 pH unit, ranging from Δ –0.3 to Δ 0.9.
- The pH changes after the addition of hydrogen peroxide within the sand fill soils ranged between Δ -0.5 and Δ 0.6.
- No reaction was observed in any of the samples with the addition of deionised water.
- The addition of hydrogen peroxide slight reactions with minor bubbles being produced was observed. No heat generation was noted.

2.6 Potential Acid Sulfate Soil Assessment Conclusions

2.6.1 Frank Gray and Mike Pawley Ovals

Based on the inspection, field tests and review of the laboratory analytical data, and subject to the limitations in **Attachment 1**, the following conclusions are made:

- Field analysis indicated PASS at sample locations BH001, BH003 and BH005, however confirmation laboratory analysis confirmed ASS conditions are not present within these materials;

- Acid Sulfate Soil management by neutralisation will not be required during the excavation and construction of the lighting poles;
- All excavated soils should be managed in accordance with the EMP (JBS&G 2019b).

2.6.2 Passmore Reserve

Based on the inspection, field tests and review of the laboratory analytical data the following conclusions were made:

- Field and laboratory analysis of material found there to be PASS/ASS conditions at BH01, BH06 and BH07 sample locations;
- Laboratory samples were not collected from sample locations BH02, BH05 and BH08 however similar material types were observed across the site;
- Given similar material types identified to be widespread across the site, at proposed development depths, ASS/PASS management by neutralisation, with the addition of Ag lime is required for all excavated soils;
- sPOCAS laboratory testing procedure reported the highest liming rate of **3kg $CaCO_3$ per tonne** is required as a starting point to neutralise ASS/PASS material and is therefore recommended this amount of Ag lime be used to neutralise excavated soils.
- The development of an Acid Sulfate Soil Management Plan should be prepared to document the management procedures surrounding disturbed acid sulfate soils during the proposed development and facilitate the requirements for ongoing field pH testing and liming rate adjustment during excavation and treatment, including disposal of any excess soils that may exhibit ASS conditions.

2.7 Summary of Investigation Data

While ASS conditions were not reported in the laboratory results submitted from Frank Gray and Mike Pawley Ovals PASS was encountered at three locations (BH001, BH003 and BH005). During the proposed works if ASS is encountered the management procedures outlined from **Section 4** shall be implemented.

As ASS was reported in three samples submitted for laboratory analysis from Passmore Reserve the document herein is relevant for any proposed excavation works undertaken.

3. Acid Sulfate Soil General Information

3.1 Acid Sulfate Soil Background

Acid sulfate soils (ASS) is a common name given to naturally occurring sediments and soils containing iron sulphides (generally as iron sulphide or iron disulphide). These soil profiles are typically located in coastal, low-lying alluvial or estuarine areas such as mangroves, salt marshes, coastal rivers and creeks, estuaries, tidal lakes and coastal floodplains where historical iron rich sediment deposition in the presence of a sulfate source (commonly salt water), organic matter and microbial action over time has resulted in the formation of particular environmental conditions. ASS is predominantly encountered in areas with an elevation of less than 5 m AHD and may be found close to the ground level or at depth in the soil profile where continued deposition has resulted in raising of the ground levels.

Changes in environmental conditions which result in the exposure of these materials to air, via excavation or drainage of subsurface soils, can lead to the reaction of the iron sulphides with oxygen, causing the generation of sulfuric acid. This may result in significant environmental and infrastructure damage if the produced acid is spread by groundwater or surface water.

ASS consist of two major categories:

- Actual Acid Sulfate Soils (AASS) are soils that have been exposed to oxygen which has caused the oxidation of iron sulphides to form sulfuric acid. Some of this acid is commonly neutralised by other soil particles in a process known as buffering, however the excess acid is spread by water movement through the soil; and
- Potential Acid Sulfate Soils (PASS) are soils which contain iron sulphides, which have not been oxidised. These soils are generally kept from contact with air by permanent waterlogging or the density of the soil profile and so are relatively stable, or in equilibrium. In this state the soils are generally non-acidic and are considered harmless to the environment. However, oxidation of such soils through disturbance has the potential to generate acid.

Commonly, an acid sulfate soil profile will consist of a combination of both AASS and PASS material as a result of ongoing chemical reactions in response to environmental changes including groundwater fluctuations and seasonal soil moisture changes.

The following types of site activities may result in disturbance of ASS (both AASS and PASS) during urban development:

- Bulk excavation works to achieve basement levels, installation of drainage infrastructure, alteration of existing site levels to achieve modified ground levels, dredging or otherwise mobilisation such that sediment may become oxidised, etc.;
- Dewatering activities associated with construction works proposed at elevations below the standing water table, for example, installation of drainage infrastructure, etc., which may result in ASS beyond the excavation extent becoming exposed to oxygen due to a lowering of groundwater levels, thereby generating acidic conditions; and
- Generation of spoil which may return ASS to the ground surface associated with foundation construction works, including piling spoil during bored pile installation activities, directional drilling works for infrastructure services installation, etc.

In NSW, development of land subject to ASS occurrence is managed at a planning level in accordance with the *Acid Sulfate Soil Manual* (1998) prepared by the Acid Sulfate Soil Management Advisory Committee (ASSMAC). Local Environmental Plans (LEP) provide a regulatory regime for the sustainable management of acid sulfate soils in the coastal zone. The ASS Manual provides guidance

on the assessment of acid sulfate soil conditions and appropriate management strategies for development of ASS identified land.

3.2 Laboratory Assessment Guidelines

The assessment of site soil conditions with respect to ASS occurrence is completed in accordance with the guidance provided in ASSMAC (1998). The requirement to manage soils for ASS is evaluated by comparison of laboratory analysis results with Site Action Criteria developed based on three broad soil texture categories. The SAC are based on the percentage of oxidisable sulfur or equivalent acid trail (i.e. titratable actual acidity-TAA or titratable potential acidity-TPA) results. There are two categories based on the scale of the proposed disturbance, with the SAC for small scale (i.e. less than 1000 tonnes) works based upon the texture of the soil material, and the SAC for large scale works (i.e. >1000 tonnes) adopting the most sensitive SAC being the SAC for coarse textured soils in small scale works. The proposed development works are anticipated to generate less than 1000 tonnes.

Table 3.1 ASSMAC Site Action Criteria based on General Soil Texture Categories

Type of material		Action Criteria 1-1000 tonnes disturbed		Action Criteria if more than 1000 tonnes disturbed	
Texture Range. McDonald at al. (1990)	Approx. clay content (%<0.002 mm)	Sulfur trail % S oxidisable (oven-dry basis) e.g. S_{Cr} or S_{pos}	Acid trail Mol H^+/tonne (oven-dry basis) e.g., TPA or TSA	Sulfur Trail % S oxidisable (oven-dry basis) e.g. S_{Cr} or S_{pos}	Acid trail Mol H^+/tonne (oven-dry basis) e.g., TPA or TSA
Coarse Texture Sands to loamy sands	≤5	0.03	18	0.03	18
Medium texture Sandy loams to light clay	5-40	0.06	36	0.03	18
Fine texture Medium to Heavy clays and silty clays	≥40	0.1	62	0.03	18

Exceedance of the SAC attributable to ASS material generally triggers the need to prepare a management plan and is based on the percentage of oxidisable sulfur (or equivalent TPA, TAA) for broad categories of soil. However, it is noted that other soil properties and constituents may cause acidic conditions in soils that are not related to acid sulfate soil conditions. This may include sources of organic acidity where the soils have a pH of less than 5 and positive titratable actual acidity (TAA) or titratable potential acidity (TPA) but have no detectable sulfur source (i.e. no S%). In this case, exceedance of the Acid Trail SAC does not trigger treatment of these soils (DWAR 2018e).

For the purposes of the proposed works at Passmore Reserve (installation of eight light posts) and given the dimensions of the concrete footing (2 m^2 x 0.6 m bgs) giving an approximate volume of soil to be excavated (19 m^3)[10]. Therefore, as a conservative measure the ASS results have been compared to the criteria of assuming less than 1000 tonnes of ASS/PASS materials is disturbed. As both Coarse Texture (sand) and Fine Texture (silty sand) soil types were noted in previous investigations a Medium Texture has been adopted, the SAC adopted for assessment and management of ASS at this site are:

- Sulfur Trail Criteria (S_{pos} or S_{Cr} %) > 0.06 %;
- Acid Trail Criteria (TSA, TPA) > 36 mol H^+ / tonne soil.

10 *Total footing dimensions (4 m2 x 0.6) x 8 = 19.2 m3*

3.3 Other Regulatory Guidance

In addition to ASSMAC (1998), this management plan has been prepared with reference to the following:

- *Waste Classification Guidelines Part 1: Classifying Waste* (EPA 2014a);
- *Waste Classification Guidelines Part 4: Acid Sulfate Soils* (EPA 2014b); and
- *Protection of the Environment Operations Act* 1997 (POEO Act) and associated regulations.

Note is also made of the National Acid Sulfate Soil Guidance issued in June 2018 by the Australian Government Department of Agriculture and Water Resources (DAWR), including:

- *National Acid Sulfate Soil Guidance: A Synthesis* (DAWR 2018a);
- *National Strategy for the Management of Coastal Acid Sulfate Soils* (DAWR 2018b);
- *National Acid Sulfate Soils Sampling and Identification Methods Manual (DAWR 2018c); and*
- *National Acid Sulfate Soils Sampling and Laboratory Methods Manual (DAWR 2018d).*

4. Management Procedures

The aim of the following management procedures is to identify PASS material and implement appropriate mitigation measures such that the potential environmental impacts associated with disturbance of PASS during the proposed site construction works may be appropriately managed. Specifically, the objectives are to provide:

- A methodology for the identification of materials requiring management;
- Protocols for the on-site treatment and management of PASS materials and associated leachate water (as required) during the proposed works;
- Excavation inspection and validation assessment protocols to be implemented during the proposed works such that the extent of PASS material may be delineated from non-PASS material to enable off-site disposal of the balance of the natural soils as virgin excavated natural material (VENM);
- Water and soil quality targets for the excavation, treatment and removal of material encountered during the proposed works; and
- A contingency framework in the event that additional ASS conditions are encountered during the site works or the proposed treatment strategy fails.

4.1 Scope of Soil Disturbance Activities

The proposed development includes:

- Excavation of soils to allow for the installation of footings for light posts; and
- Construction of eight light posts around the perimeter of the fields.

It is anticipated that once development consent has been obtained for the proposed works the contractor will consider the nature and extent of ASS/PASS material in development of the proposed construction methodology and so the minimisation of activities with the potential to result in disturbance of ASS/PASS will form part of the evaluation strategy.

4.2 Investigation of Occurrence of ASS and/or PASS Material

It is considered that the current investigations have adequately characterised ASS at Passmore Reserve (JBS&G 2019b) and PASS at Frank Gray and Mike Pawley Ovals (JBS&G 2019a) to the anticipated depth of excavation for the proposed developments. Further assessment of PASS/ASS conditions would only be warranted if more extensive and deeper excavations than proposed were required, or if unexpected conditions are encountered during excavations, and could be completed at the time using the protocols in **Section 4.4** of this ASSMP under the guidance of a suitably qualified and experienced environmental consultant.

4.3 Evaluation of Potential Management Strategies

Where the presence of ASS has been identified, evaluation of options to minimise the level of disturbance and to mitigate the potential impact of disturbance (if necessary) of the materials is required. As per ASSMAC (1998)/DAWR (2018), potential mitigation approaches have been identified:

- Avoid ASS materials being encountered during works by not undertaking the proposed excavation works into natural ASS/PASS soils, or by altering the proposed development plans (i.e. removing excavation requirements, installing piles);
- Where encountering ASS/PASS during works cannot be avoided, manage the potential for acid generation by neutralising disturbed materials, preventing movement of acid impacted water, and the use of suitable construction materials;

- If ASS/PASS materials have previously been disturbed, undertake works to mitigate the existing conditions, minimise the production of further acid during the proposed works and rehabilitate impacted areas;
- Treat soil by allowing full oxidation of the sulphide component under controlled conditions followed by flushing the acid from the soil with water and neutralisation of the subsequent leachate;
- Avoid using untreated ASS/PASS materials as fill material in non-ASS areas by either leaving material on-site, or managing the potential for acid generation prior to material being transported from the site of origin; and/or
- Reburial of ASS/PASS materials beneath the permanent water table or beneath a dense soil profile which excludes oxygen exposure such as an engineered clay cap. This may be undertaken on-site if there are low lying areas where reburial and consequential flooding of the soil profile or construction of a suitable capping layer can be undertaken as part of development works, or at an alternative off-site location provided that sufficient stabilisation of material is undertaken to minimise acid generation during transportation and handling.

The potential suitability of the various options is further discussed in the following sections.

4.3.1 Avoidance Strategies

Avoidance of ASS/PASS disturbance is generally considered to be the preferred means of ASS/PASS risk management where such actions can be achieved. However, given the nature of the footings and limited extent into the ground (0.6 m bgs) avoidance as a large-scale risk management strategy is not a suitable option.

4.3.2 Management by Neutralisation

Neutralisation techniques can be used to treat ASS by the addition of chemicals that react with the produced acid to ensure that acid is not released from the treated material. The neutralisation activities should result in the pH of the disturbed materials (water and/or soil) being between 5.5 to 7.5 and requires that ASS material disturbed during site activities be treated with the preferred neutralising agent.

Laboratory analysis is used to assess the levels of existing and/or actual acidity and indicates the level of neutralising capacity required to react with all potential acidity that may be generated during/following disturbance of the ASS material.

The potential uncertainty associated with the quantity of neutralising capacity to be added is commonly managed by the use of a factor of safety of 1.2 or 2 depending upon the level of uncertainty.

Sufficient capacity in terms of a suitable treatment area, machinery, budget to purchase the neutralising agent and time is necessary to successfully implement ASS neutralisation. Implementation of environmental controls is also necessary to ensure that all potentially acidic leachate produced during the treatment process is captured and appropriately managed. This can be done with sand bags or silt fencing placed around the excavated materials to ensure water can be treated and neutralised prior to either evaporation, use as dust suppression or placement back into the excavation.

For the purposes of this plan, the neutralising chemical is assumed to be high quality agricultural lime (ag lime). Further details on other potential neutralising agents are provided in **Section 4.4.2**.

During works, a sufficient quantity of ag lime will be required to be kept on site at all times. A sufficient quantity will be based on requirements for: the treatment of ASS to be neutralised within

the treatment area; application on exposed excavation faces where ASS is expected or suspected; and for wet weather events where existing applications will require replacement and/or treatment of acidic water as necessary. Receipts, dockets and other field records showing the storage locations of all chemicals and location of all applications of neutralising agents must be kept.

ASS management by neutralisation is considered to be a suitable option for the proposed works as:

- Material disturbed to achieve construction of the concrete footing foundations will subsequently be surplus to development requirements, and as such neutralisation of the material following excavation will not affect the construction program (material may be set aside for treatment by others dependent upon available space, whilst further excavation works continue, following which the material will be disposed of off-site);
- Appropriate machinery to mix the soil and neutralisation chemicals can be supplied by the civil works/earthwork's contractors completing works on site; and
- Following successful completion of the neutralisation process, the treated soils are no longer considered to be ASS materials and so may be removed off-site as waste.

4.3.3 Full Oxidation and Leachate Collection

Although not a preferred option, in the event that the acid production potential is relatively low, or there is a relatively low quantity of material to be treated, consideration may be given to the excavation and exposure of the soils to promote full oxidation. This option requires the implementation of environmental controls to ensure that all acid produced is flushed from the soil as leachate. Similar to management by neutralisation, a suitable treatment area is necessary where material can be spread and reworked to allow oxygen to react with the sulphides in the soil and where all leachate produced can be captured and treated by neutralisation.

This method is considered not to be a viable option for the proposed works as the process of soil oxidation may take extended periods (weeks to months) to reach completion. There is also a significant level of uncertainty in the volumes of leachate that would require neutralisation and disposal due to climatic variation, including rainfall events. Given the nature of the site (sports fields) and the requirement to maintain environmental controls for a long period, this option is considered undesirable when compared to the relatively low cost of neutralisation chemicals as discussed in **Section 4.3.2** above.

4.3.4 Reburial of ASS Material

Strategic reburial or interment techniques can be used to manage ASS/PASS material by prevention of oxidation through permanent storage in an anoxic environment. These techniques are often adopted where areas are available for reburial and cost savings can be achieved by avoiding soil handling labour and neutralisation chemical costs. An alternative method of achieving reburial is over excavation of non-acid sulfate soil materials followed by reinstatement of the excavation with potential ASS material. Potential reburial sites must have a permanent groundwater table level above the proposed top of the reburial cell or alternatively measures to minimise oxygen exposure to ensure that the material is returned to an anoxic environment.

Reburial may occur within the site or alternatively, where appropriate licences are obtained, at a site lawfully able to accept this material in accordance with the requirements of EPA (2014).

Excavation of ASS and creation of re-interment voids must be staged to ensure that adequate space is available for all ASS materials to be adequately reburied below a permanent water table and that the ASS will not be buried in conditions that may cause the formation of acidic conditions. A maximum period of time between the commencement of disturbance and completion of interment works of approximately 48 hours should be adopted in all instances. If the material is to remain

exposed for longer the 24 hours the pH levels should be monitored every 12 hours to ensure acid conditions are not developing.

On this site, given the proposed development works consist of excavation works above the current water table strategic reburial of PASS without neutralisation is considered unlikely to be a practicable management option.

4.3.5 Separation Techniques

Separation techniques are increasingly being implemented to reduce the quantity of PASS material requiring treatment in areas where works include the disturbance of large quantities of PASS. These activities include the removal of fine ASS particles including pyrite and monosulfides from coarser grained soil particles. This results in two material streams, concentrated 'ASS fines' and non-ASS material which can be removed from the management process. Management of ASS fines would then involve implementation of other ASS management techniques such as reburial, neutralisation, etc.

Separation is typically implemented by creating a soil slurry where fine particles can be suspended in solution away from heavier soil particles using methods such as sluicing or cycloning. Typically, such methods require suitably grained soils such as sand or non-consolidated sediments and a significant water source to implement the separation.

Environmental controls are required during the separation processes to ensure that the PASS fines do not undergo oxidation prior to the implementation of other management measures and validation of the non-ASS stream would then be necessary to confirm that the ASS fines have been adequately removed.

On this site, separation techniques are considered not to be a viable management option as these techniques cannot be used as a standalone management option and as such the ASS fines once separated would still require further treatment.

4.3.6 Selection of Preferred Management Strategies

Evaluation of potential management strategies has identified that the use of neutralisation techniques where disturbance cannot be avoided is considered the most appropriate technique for this site. As the excavations will not allow for generated soil spoil to be used as backfill material due to the installation of a concrete footing, reburial of treated PASS/ASS materials (if found to be in large quantities) within the excavation is not considered a viable option.

Management measures for excavated PASS material will include the application of neutralisation chemicals, neutralisation of exposed excavation faces during works and neutralisation of any groundwater seepage and drainage leachate produced during the excavation and treatment works. Following validation to confirm the acid generation potential of the material has been appropriately neutralised, the material will either be set aside for use as engineered fill material within the development site (if required), or alternatively, will require off-site disposal as per the requirements of EPA (2014).

4.4 General Site Management Strategy

The site management strategy to be implemented during works which may disturb ASS/PASS materials will ensure the following:

- Adequate treatment of ASS/PASS material such that there is sufficient acid neutralising capacity and no net acidity following stabilisation (as measured through appropriate field testing and laboratory validation);
- Water discharged from the excavation and treatment areas (including run-off, water from dewatering and leachate) is neutral and discharged to stormwater once it has been shown

to meet with the criteria specified in this plan or alternatively, shall be reused on site for dust suppression, or removed off site as liquid waste; and

- Implementation of additional assessment procedures during earthworks operations for the effective treatment and management of any drained, disturbed or excavated acid sulfate soils.

4.4.1 Pre-disturbance Works

Subsequent to the additional investigation activities identified in **Section 4.2**, and prior to the commencement of excavation works which may disturb PASS materials at the site, including activities with the potential to generate spoil, the following preparations should be considered:

- The sequencing of proposed excavation, services installation and other activities should be planned in detail taking into account the time and space necessary to complete the ASS/PASS management activities outlined in this document. The planning should provide a contingency for treatment of additional quantities of materials in the event that the proposed works require additional excavation extents to those currently identified and/or the quantity of ASS/PASS material generated is greater than anticipated during implementation of the site works, or heavy rainfall events result in significant additional quantities of collected impacted water; and
- The actual areas of ASS/PASS occurrence where disturbance/excavation will occur during each stage of works (excavation, services installation etc.) as part of the site activities should be identified and suitable location(s) for treatment areas and/or storage of treatment bins close to the areas of disturbance identified (e.g. adjacent the excavation). Based on the proposed works, the available space for treatment and the approximate volume anticipated to be disturbed, staging of the disturbance activities should then be planned such that sufficient drying and mixing time can be achieved for all materials needing treatment. The staging should also allow for adequate time to obtain the results of verification testing before the material is placed at the final location or removed from the site.

4.4.2 Neutralisation Chemicals

An evaluation of potential neutralisation chemicals should be undertaken during the planning process and appropriate quantities of the preferred chemicals sourced for the duration of the site activities. For the purposes of this plan, the neutralising chemical is assumed to be high quality agricultural lime (ag lime). The ag lime should be fine ground (<1 mm) calcium carbonate ($CaCO_3$) or calcite (limestone or marble powder). In the event that neutralising products other than high quality ag lime are selected for use in this project, there are several issues that should be considered:

- Is there any potential environmental risk associated with use of the compounds (i.e. other components that may contaminate water, result in a much higher pH value (i.e. hydrated lime), stain treatment areas, etc); and
- Will the neutralising agent be of comparable effectiveness or will properties including: neutralising value, effective neutralising capacity, solubility, pH, chemical components, moisture content, impurities and particle size; require the quantity of agent addition to be varied by a consistent factor.

It is recommended that small scale treatment trials be implemented prior to broad scale implementation of alternative neutralising compounds. The small-scale trials should document the effectiveness of the revised approach in terms of the time, cost, availability, suitability, etc.

4.4.3 Treatment Area Design

As noted above, the treatment area should be situated in an appropriate location(s) with respect to site disturbance activities. In addition, consideration should also be given to the ease with which environmental controls can be implemented and potential requirement for off-site disposal of the material once stabilised and validated.

Small Quantities

For small scale disturbance activities, it is anticipated that a large lined skip bin or suitable structure could be used as a 'treatment cell' to minimise the potential for release of acidic leachate or partially treated soil.

Significant Excavation Quantities

Should quantities of material disturbed in a staged manner exceed that able to be managed in a large skip bin, a treatment area should be established with consideration of the following:

- The treatment areas should be established separate to the area of disturbance but able to be accessed from the area of disturbance by plant/vehicles transporting the material to be treated and material to be removed from the treatment area at the completion of stabilisation activities;
- The treatment areas should be sufficiently large to facilitate a pre-treatment stockpile area, a treatment pad, water/sediment collection and treatment measures, post treatment stockpile storage area and lime storage area.
- The treatment area should be isolated from major external surface water catchments, including overland surface water flow and potential flood water, excavation flooding by rainfall events, by ground surface contouring, installation of perimeter drains, or bunds covered with an impervious layer (concrete, geomembrane, compacted non-ASS clay, etc.).
- A layer of lime stabilised soil should be prepared on the ground surface within the treatment area that will act to neutralise any acidic water that my infiltrate the ground surface during treatment activities. The minimum application should be no less than 5 kg lime/m^2 of treatment area. This application should not be taken into account when material to be treated is placed within the treatment area as the neutralisation capacity of these added chemicals will decrease with time as a result of formation of an insoluble iron coating and it is difficult to ensure that there has been adequate mixing of the neutralising agent within the soil added to the site.
- Pre-treatment and post-treatment stockpile areas should be separately bunded or drained to minimise the potential for re-acidification of treated material.
- The treatment pad should be of a size that would allow treatment of material by a single machine over a reasonable timeframe to minimise the oxidation of material during spreading and treatment. Assuming the material the subject of treatment is spread to a depth of approximately 0.3 m, a single treatment area 10 m by 20 m could treat 60 m^3 of material per treatment cycle. Should capacity to treat more material be required, two or three treatment pads could be established, separated by a suitable width to allow for excavator movement between the bunds of each pad.
- The bund surrounding each treatment pad may be constructed of concrete, compacted non-ASS clay, sand and lime filled sandbags or other suitable materials that are relatively impervious and can be coated with a guard layer of lime to neutralise acidic leachate that may contact the bund.

- The base of the treatment pad should be surfaced with concrete, asphaltic concrete, or soil mixed with lime as discussed above. This base should be graded where possible at a minimum fall of 1° to facilitate drainage of leachate such that it can be collected and/or pumped to a treatment/holding tank.
- Once well mixed with a suitable quantity of neutralisation agent, the material should be transferred to the post treatment stockpile area. Here the validation testing will be completed, and the material will remain until receipt of the validation results. The material will then be cleared for beneficial reuse within the site, or alternatively for off-site disposal to landfill.
- Surface water flows will be diverted around the treatment area where possible. Water falling within the various portions of the treatment area will be collected at appropriate locations and transferred either to a holding tank or artificial detention basin. The water quality will be monitored to ensure only water of suitable quality is discharged from the treatment area of the site. Dilution of water collected within the treatment area is not an acceptable method of treatment at this site. Contaminants resulting from oxidation of ASS should be collected, treated and/or managed on-site. Water discharges from the site must not have a significant impact on pH, buffering capacity, turbidity, colour or ionic composition of the receiving water body (stormwater, groundwater, sewer, etc) as per the requirements of the POEO Act (1997).
- A sufficient supply of ag lime should be kept on site at all times for the treatment of ASS to be neutralised within the treatment area, for application on exposed excavation faces where ASS is expected or suspected; and for wet weather events where existing applications will require replacement and/or treatment of acidic water is necessary. Receipts, dockets and other field records showing the storage locations of all chemicals and location of all applications of neutralising agents must be kept.
- The supply shall be stored in a covered and bunded area to prevent accidental exposure to water and deterioration of the inherent neutralising capacity. ASS treatment materials should be stored in a manner that minimise the exposure of the materials to wet or humid conditions. Such conditions may result in the clumping or surface crusting of particulate lime which can reduce the level of effectiveness in neutralising water or soil.

4.4.4 General Site Management

All natural soils within the excavation zones must be treated as ASS material until such a time as the material is demonstrated to be non-ASS material or treatment effectively reduces the risk associated with the material and validation results meet the relevant specifications.

ASS/PASS materials that have been excavated (or otherwise brought to the ground surface) should be separated from the non-ASS material and immediately transferred to the treatment area as soon as practicable to minimise the quantity of soil and/or groundwater requiring treatment and the risk of environmental harm to the site and/or down-gradient receptors.

Bunding, diversion drains, contaminated water treatment/containment etc may be used to contain surface water run-off from PASS disturbance zones and subsequent storage and treatment areas. However, PASS materials must not be used in the construction of bunds and other diversion devices.

Equipment used in the treatment of ASS shall be washed with an alkaline solution at the completion of each work period to minimize corrosion of equipment.

4.4.5 Excavation Works

Excavation works should be undertaken in the following manner:

- Any material identified as non-ASS (as determined through additional investigations as detailed in **Section 4.2**) is to be removed from within the ASS zone footprint and treatment area;
- Natural soils or materials identified as ASS or suspected to comprise physical properties indicative of ASS should be assumed to be ASS unless demonstrated otherwise. All excavated natural soil material brought to the ground/water surface should be transferred immediately to the treatment area;
- Works including disturbance of natural soils will be subject to field testing upon initial exposure of each natural soil horizon. Field testing will include pH_f and post peroxide pH_{fox}, with both required to meet the validation criteria of pH 6 to be considered non-ASS soil. Alternatively, dependent upon the scheduling of the excavation works, laboratory pre-testing of soils from this zone may be undertaken using sPOCAS or S_{Cr} methods. If either the field criteria or laboratory analysis results indicate the material is considered to be ASS, then the material will require treatment as discussed in the following section;
- At the completion of the day's activities, where excavation works result in the exposure of known or suspected ASS, a guard layer of fine ag lime will be applied to the base of the excavation at a rate of 5 kg lime/m^2 of exposed soil. If the base of the excavation is to remain exposed for an extended period (i.e. more than three days) the lime coating should be checked and re-limed as necessary. Alternatively, the lime may be covered with a layer of compacted non-ASS material at least 0.3 m in thickness. It is noted that this will not be required during piling works;
- All cut batters/exposed faces potentially including ASS, (i.e. faces at the edge of excavation faces, etc), shall be coated with fine ag lime at a rate of 5 kg/m^2 and the lime coating should be checked and re-limed as necessary on a daily basis during periods of dewatering, whilst the faces are temporarily exposed and/or following wet weather events.

4.4.6 Treatment of Excavated PASS Material

Treatment of ASS soils will comprise the addition of sufficient quantities of finely ground neutralising agent to treat all oxidisable S% and actual acidity and provide a factor of safety to compensate for potential impurities in the neutralising agent, non-homogenous mixing and limitations to the solubility of the neutralising agent. This will need to be determined on the basis of analysis data collected as per **Section 4.2**.

The excavated ASS material will be immediately transferred to the treatment area and placed either in a stockpile within the pre-treatment stockpile area or immediately on the treatment pad. Treatment of excavated material should occur within one day of excavation of the material.

If stockpiled, the material should be formed into a conical stockpile to minimise the exposure of the material to air. In the event of significant wet weather periods, the stockpiles should be covered with builder's plastic or similar to limit the infiltration of rainfall into the stockpiles.

The excavated ASS material should be treated as soon as practicable and within one day of excavation.

If site conditions require the stockpiling of material for longer than 24 hours, the stockpiles should be treated with a guard layer of ag lime of 5 kg lime/ m^2 per vertical metre of soil in the stockpile. This would result in a two-metre-high stockpile requiring an application of 10 kg lime/m^2 surface area. The stockpile should then be covered with an impervious surface (i.e. builder's plastic) that

covers the top and sides of the stockpile to minimise drying by wind and sun and to prevent rainfall entering the stockpile.

Irrespective of whether the material is placed within a skip bin or a treatment pad, mixing of the lime and soil mixture may be undertaken by harrowing, rotary hoeing, using an excavator shaker bucket to blend the material, the use of a pug mill or similar equipment. Care shall be taken to ensure that mixing occurs throughout the depth of the layer/throughout the binned material. The soil must be managed to achieve a consistency that will allow for thorough mixing of the soil and neutralising agent to ensure that the effective neutralisation occurs.

This may require mechanical turning of material and breaking up of soil to provide for adequate mixing of soil particles and lime. In some instances, drying of the disturbed material (with associated management of any acidic leachate and other resulting contaminants) may be required for the material to be workable. Drying should not be undertaken during foreseeable wet weather events due to the increased risk of runoff flushing acid from the material and into uncontrolled areas. It is noted that given the material does not comprise marine clay soils and dewatering will be required during excavation; additional drying of the material is not expected to be necessary during the works.

Following mixing, ag lime shall be spread at a rate of approximately 5 kg lime/m^2 around the toe of the treated soil, around a 1 m perimeter between the toe of the material and across the exposed face of the bund to neutralise any leachate released from the soil. Once the soil has sufficiently dried that no more leachate is being released, the material should be turned to ensure that all leachate is released from the treatment area.

On completion of mixing the soil and lime, field testing can be undertaken approximately 48 hours following. If neutralisation has occurred and been confirmed, soil samples can be collected for confirmation from the laboratory that the ASS/PASS material has been sufficiently neutralised. Soil can then be to be placed back within the excavation or disposed of offsite as waste.

4.4.7 Water Management During Treatment

Surface drainage and groundwater that comes into contact with ASS materials has the potential to become acidic and contaminated with heavy metals leached from the acidified soil. Sources of water may include ground surface drainage associated with rainfall, dewatering product produced during the excavation works, leachate produced during treatment of excavated soils, and groundwater inflow into open excavations.

Additional water holding tanks may be necessary in the vicinity of the treatment works zones to store collected water prior to treatment. The water holding capacity directly related to the acid sulfate soil excavation and treatment areas should be maintained at a minimum quantity associated with a 1 in 10-year rainfall event to ensure that sufficient capacity is available to store all potentially acidic water that may be generated during site works.

Water will be neutralised, where required by the addition of lime (or equivalent alkaline product) within a dedicated treatment tank or lined detention basin. Lime shall be added incrementally and thoroughly mixed within the treatment vessel. Approximate lime application rates based on initial pH are provided in **Table 4.1**.

Table 4.1 Treatment of Acidic Dewater

Water pH	Agricultural Lime / 1000L Water
0.5	11.7kg
1.0	3.7kg
1.5	1.2kg
2.0	0.37kg
2.5	0.12kg
3.0	37g
3.5	12g
4.0	4g
4.5	1.2g
5.0	0.37g
5.5	0.12g

Lime addition and mixing shall continue until the pH of the water is within the range of 6.5 – 8.5.

In the event water volumes greater than the capacity of the water treatment holding capacity are produced during the acid sulfate soil management activities, consideration should be given to off-site disposal of water via a licensed contractor or treatment of water using neutralisation chemical dosing within holding tanks prior to re-irrigation of open excavations once the pH of the water has been demonstrated to be suitable.

4.4.8 Validation of Treated PASS Material

Following the application and mixing of lime to the ASS, the material can be immediately sampled for field testing. The soil would be assessed to establish post neutralisation conditions and establish whether the following performance criteria have been achieved:

- Post neutralisation, the soil pH is greater than pH 5.5 (and preferably less than 9);
- The neutralising capacity of the treated soil must exceed the sum of the TAA and TPA of the soil, i.e. there is no net acidity in the soil as measured by sPOCAS / S_{Cr} < 0.03%S; and
- Excess neutralising potential should remain in the soil as all acid generation reactions may not be complete and so the soil may still have further capacity to generate acidity.

Validation testing using field tests to measure the soil/water pH shall be undertaken at a rate of ten samples per treatment batch (to a maximum quantity of 100 m^3, or a rate of 1 sample per 20 m^3). Field testing will include pH_f and post treatment peroxide pH_{fox}, with both required to meet the post neutralisation criteria noted above for all samples per treatment batch.

In the presence of positive field validation tests, laboratory analysis of validation samples may be employed to determine the level of net acidity and confirm that the treatment has been successful or provide an indication of the quantity of further ag lime application necessary to neutralise the soil.

Confirmatory laboratory analysis (pH and sPOCAS / S_{Cr}) will be undertaken at a rate of one sample per treatment batch (to a maximum quantity of 100 m^3, or a rate of 1 sample per 100 m^3 for larger quantities). The samples obtained for laboratory analysis may be obtained by compositing three subsamples obtained from the treatment material to provide a broader indication of net acidity levels. All samples will be obtained from no less than 0.1 m below the stockpile surface at the time of sampling to ensure representative samples are obtained for field testing/laboratory analysis.

Following receipt and logging of the successful laboratory validation results, the stockpile may then be released for beneficial reuse of material at the site, or alternatively, for off-site disposal. In the event that the laboratory results indicate that the stockpile requires further treatment, the material should be returned to the treatment pad as a unique treatment batch and treated as required prior to re-sampling.

If negative field tests occur but the confirmatory laboratory analysis results indicate that there is still net acidity, a further application of ag lime will be mixed with material to ensure additional neutralisation capacity, prior to further confirmatory analysis.

Following receipt and logging of the successful laboratory validation results, the material may then be released for beneficial reuse of material at the site, or alternatively, for off-site disposal. In the event that the laboratory results indicate that the stockpile requires further treatment, the material should be treated as required prior to re-sampling.

4.4.9 Site Condition Monitoring

It is anticipated that monitoring of conditions will be undertaken by both the site contractors and an appropriately qualified consultant to ensure that the appropriate environmental controls are in place and the treatment strategy is minimising the environmental risk associated with the ASS materials.

The following inspection/monitoring regime will be implemented during the site works period and documented as appropriate to demonstrate compliance with this ASSMP:

- Stockpiles of material will be inspected daily by the site contractors with pH measurements of any retained leachate taken and recorded where required. In the event that leachate is significantly acidic (pH < 5.0), the stockpiled material may require further treatment; and
- All treated excavation faces to be retained for more than three days will be inspected on the third morning and lime reapplied as necessary each following morning.

Regular inspection of all excavation and treatment areas will be undertaken to identify potential indications of ASS oxidation. These inspections should note:

- Unexplained scalding, corrosion or degradation of onsite steel equipment and concrete paved surfaces;
- Formation of the mineral jarosite or other acidic salts in exposed or excavated soils;
- Areas of surface water blue-green, blue-white in colour or extremely clarified indicating high concentrations of aluminium; and
- Rust coloured deposits on excavation faces, in drainage paths, on bunds, channels, etc indicating iron precipitates.
- Such inspections should also identify the presence of unusual odours, including strong organic or sulphurous smells (i.e. rotten egg gas).

4.4.10 Removal of Neutralised ASS Material from the site

Only material confirmed to be below the criteria listed in **Section 4.4.8** will be considered as stabilised ASS material for potential reuse within or removal from site. Once stabilised, the material will be provided a final waste classification as per the requirements of EPA (2014) for off-site disposal to a lawful facility. A final round of field pH testing should be undertaken prior to loading of the trucks to ensure that pH levels remain above 6. Should material continue to have a high moisture content, consideration may be given to off-site removal as liquid waste as per EPA (2014).

5. Responsibilities

The selection of samples for environmental analysis as per **Section 4.2** shall be undertaken by a suitably qualified and experienced environmental or geotechnical consultant. Results of analysis shall be assessed and evaluated by a suitably qualified and experienced consultant.

Implementation of the physical treatment, material management and environmental controls portions of this ASSMP will be the responsibility of the site contractor engaged to complete remediation and/or construction works within the site. The monitoring of conditions, unless otherwise specified in the monitoring sections will be the responsibility of a suitable qualified environmental consultant who will regularly inspect the site, the treatment area and treatment activities and implement the validation assessments to document compliance with this ASSMP.

The contractor should appoint a foreman or other responsible employee to undertake the appropriate monitoring activities as designated in this ASSMP. This person should be appropriately trained by the environmental consultant in all actions to be completed by the contractor. Where doubt arises concerning the results of the inspections or of field test validity, the environmental consultant should be contacted for verification of appropriate actions.

The contractor is not authorised to make any changes to this ASSMP or implement unapproved variations to the treatment and/or monitoring protocols outlined in this document unless explicit written approval is obtained from the environmental consultant prior to implementation of the changes.

Where ambiguity or conflicts in procedures arise, it is the contractor's responsibility to seek clarification on appropriate actions from the environmental consultant.

ASS mitigation measures should be documented as they apply to all individual works activities to be undertaken at the site. All persons responsible for the works activities should be made aware of their responsibilities in writing and suitable ASS management training should be provided to those persons to ensure that the responsibilities can be achieved.

Where contingency actions are necessary, or in the event that non-compliance with the ASSMP is identified by the contractor, the environmental consultant should be immediately informed in writing. The environmental consultant will then be obliged to provide a timely response documenting the necessary corrective actions.

6. Contingencies

In the event of unexpected events at both Frank Gray and Mike Pawley Ovals and Passmore Reserve, including the identification of additional PASS zones at the site, or the failure of management measures as described in this ASSMP, the associated environmental risk will be managed by the evaluation and implementation of the contingency procedures and mitigation strategies.

6.1.1 Additional Acid Sulfate Soil Identification

In the event that site excavation works encounter the potential for additional acid sulfate soil areas at the site, identified by visual cues, field testing or laboratory analysis, the additional areas will be treated as per the PASS material treatment protocols. If the material is to be excavated as part of the development works, the excavation will be undertaken in stages with suitable volumes to allow for the completion of the neutralisation treatment process prior to excavation of the next stage (each of the light pole footings).

If the proposed works do not require excavation of the identified material, exposed surfaces will be treated with a guard layer of lime upon exposure. Groundwater seepage will be monitored, and neutralising agents added as necessary to manage the potentially acidic leachate produced.

6.1.2 Failure of Initial Acid Neutralisation Treatment

As described in **Section 4.4.8,** following the treatment of materials within the treatment area, validation sampling will be completed to assess the success of the neutralisation process prior to removal of the material from the holding area. In the event that the validation testing indicates that neutralisation of the material is incomplete (i.e. pH<6), a further application of lime and repeat of the treatment procedure will be undertaken prior to further validation assessment. If the proposed techniques fail, further consideration may be given to alternative management strategies as outlined in **Section 4.3**.

7. Conclusions

Site characterisation assessment data available for subsurface conditions across the site has identified the occurrence of ASS/PASS material in three of five locations submitted for analysis, primarily situated within fill black sandy silt soils at varying depths across the site lithology. Given similar material types identified to be widespread across the site, at proposed development depths there is the potential that these conditions may extend across the site area and at variable depths.

Where existing and future assessment data identifies the presence of ASS/PASS materials within or areas these materials may be disturbed, the measures identified in this acid sulfate soil management plan (ASSMP) provide appropriate procedures to manage the risks associated with the proposed activities. If successfully implemented, these measures will minimise the environmental risks associated with disturbance of the PASS materials.

8. Limitations

This report has been prepared for use by the client who has commissioned the works in accordance with the project brief only and has been based in part on information obtained from the client and other parties.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

JBS&G accepts no liability for use or interpretation by any person or body other than the client who commissioned the works. This report should not be reproduced without prior approval by the client or amended in any way without prior approval by JBS&G, and should not be relied upon by other parties, who should make their own enquiries.

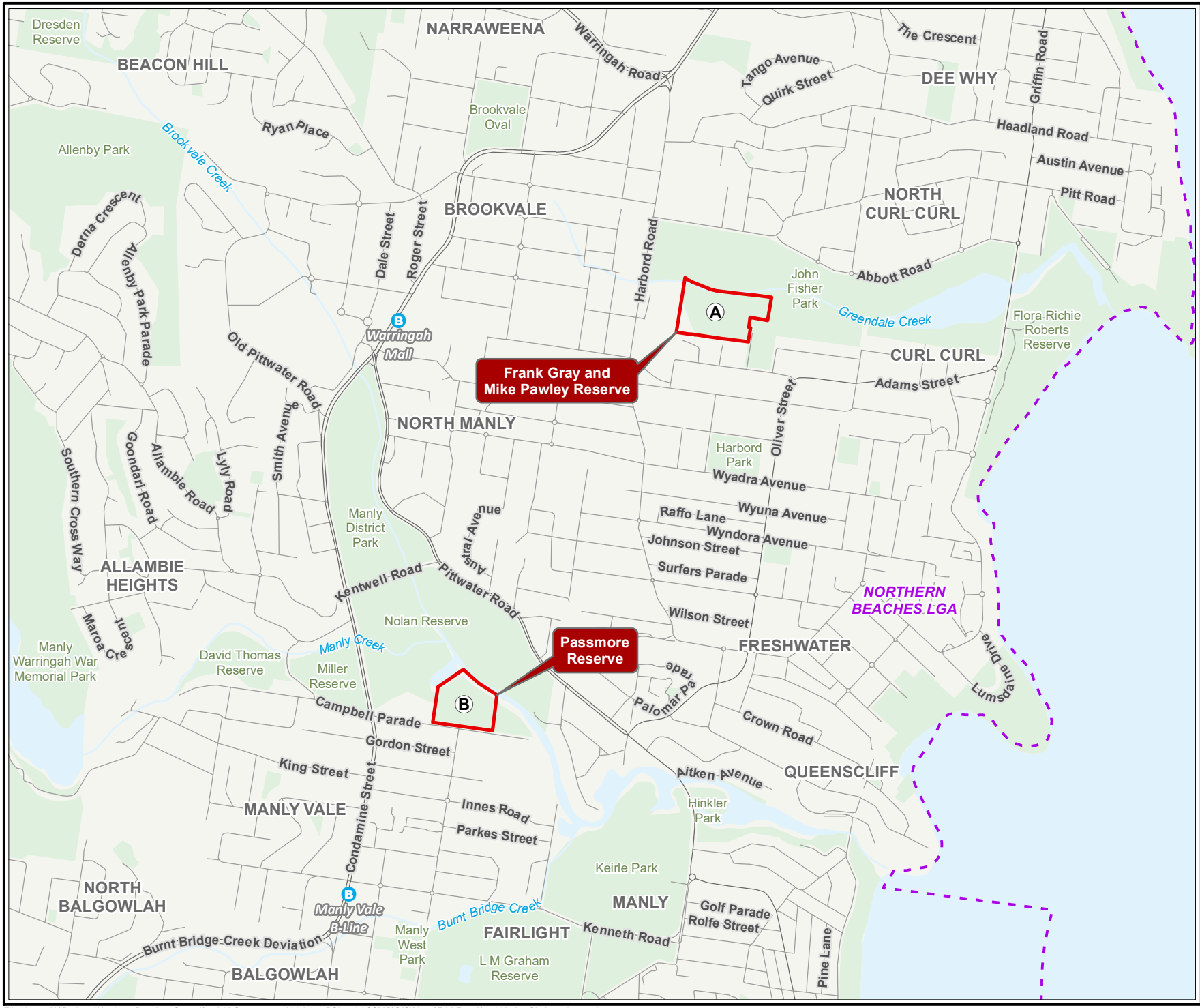
Sampling and chemical analysis of environmental media is based on appropriate guidance documents made and approved by the relevant regulatory authorities. Conclusions arising from the review and assessment of environmental data are based on the sampling and analysis considered appropriate based on the regulatory requirements.

Limited sampling and laboratory analyses were undertaken as part of the investigations undertaken, as described herein. Ground conditions between sampling locations and media may vary, and this should be considered when extrapolating between sampling points. Chemical analytes are based on the information detailed in the site history. Further chemicals or categories of chemicals may exist at the site, which were not identified in the site history and which may not be expected at the site.

Changes to the subsurface conditions may occur subsequent to the investigations described herein, through natural processes or through the intentional or accidental addition of contaminants. The conclusions and recommendations reached in this report are based on the information obtained at the time of the investigations.

This report does not provide a complete assessment of the environmental status of the site, and it is limited to the scope defined herein. Should information become available regarding conditions at the site including previously unknown sources of contamination, JBS&G reserves the right to review the report in the context of the additional information.

Appendix A – Figures



Legend

- Approximate Site Boundary
- LGA boundary
- Primary Road
- Local Road
- Waterway
- Waterbody area
- Parks and reserves

JBS&G

Job No: 57312	
Client: Northern Beaches Council	
Version: R02 Rev A	Date 20/09/2019
Drawn By: CA	Checked By: AF

Scale 1:20,000

0 300 600
metres

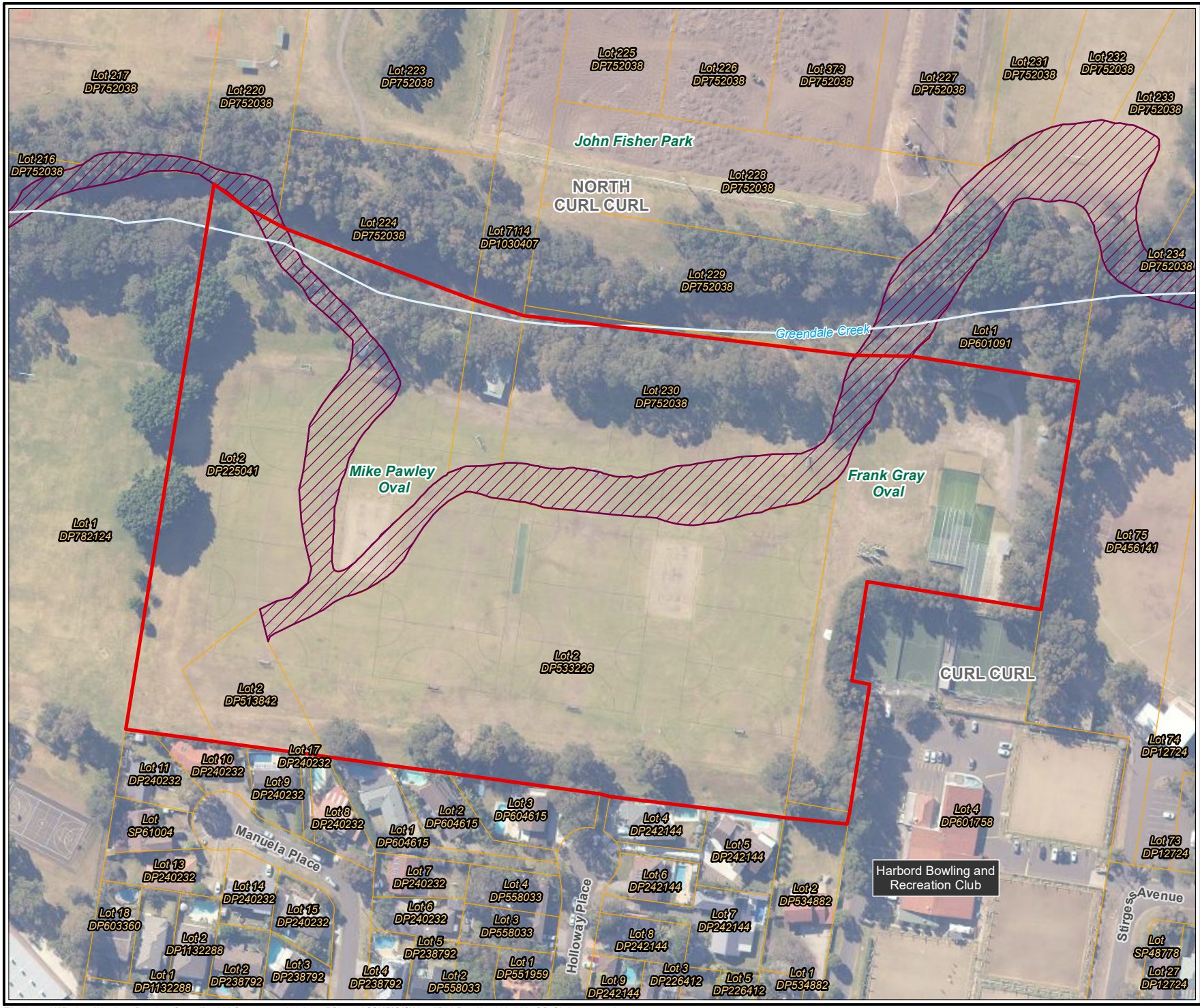
Coord. Sys. GDA 1994 MGA Zone 56

Frank Gray and Mike Pawley, and Passmore Reserves, Manly Vale and Curl Curl, NSW

SITE LOCATION

FIGURE 1

File Name: N:\Projects\Northern Beaches Council\57312 Sportsground Lighting PSI and ASSMP\GIS\Maps\R02 Rev A\57312_01_SiteLocation.mxd
Reference: NSW DFSI, 2019



Legend

- Approximate Site Boundary
- Cadastre (NSW LPI, 2019)
- Former Creek Extent (Cadastral Water Feature Corridor, NSW LPI, 2019)
- Waterway

JBS&G

Job No: 57312

Client: Northern Beaches Council

Version: R02 Rev A	Date 20/09/2019
Drawn By: CA	Checked By: AF

Scale 1:2,000

0 20 40
metres

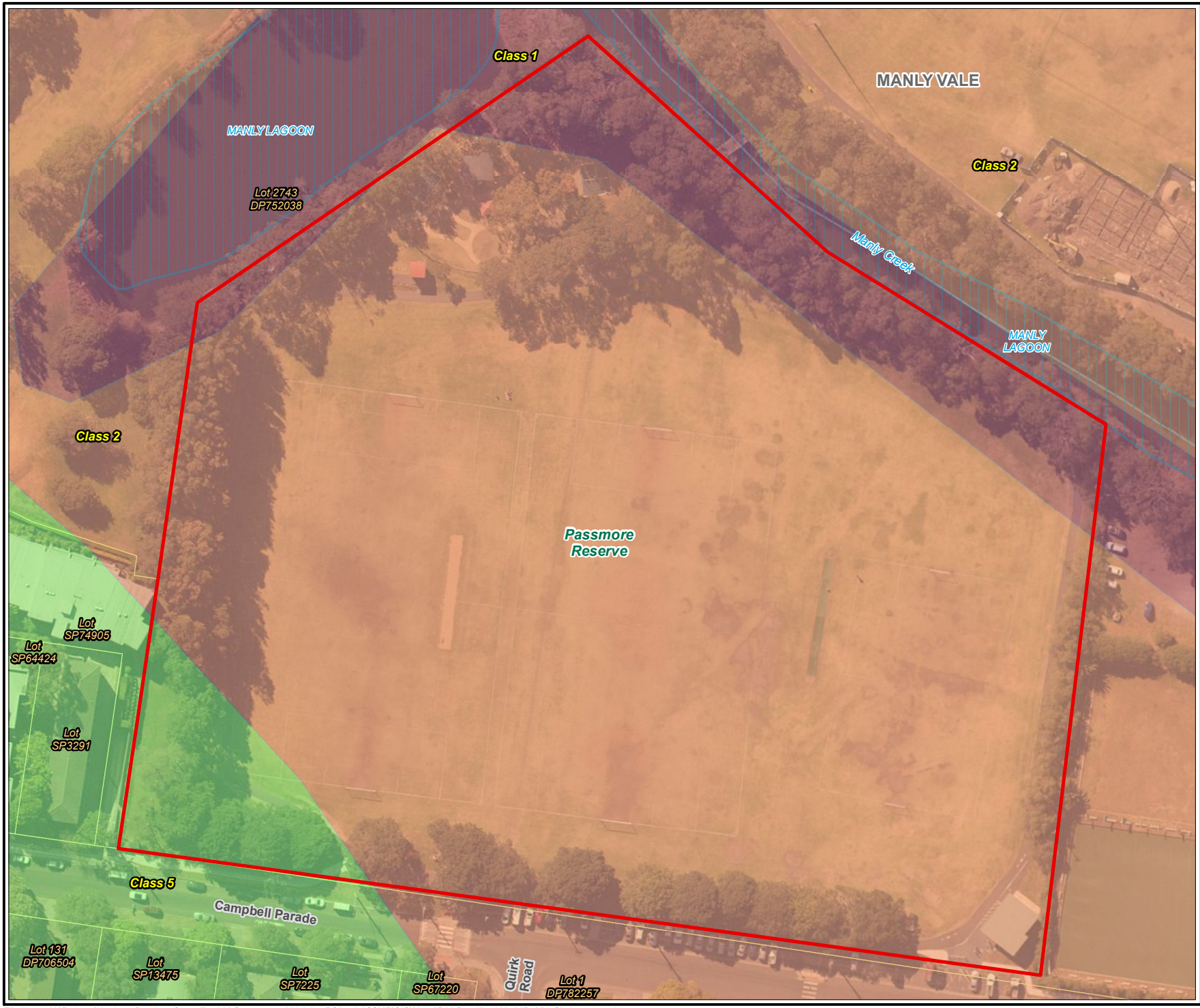
Coord. Sys. GDA 1994 MGA Zone 56

Frank Gray and Mike Pawley Ovals, Stirgess Avenue, Curl Curl, NSW

SITE LAYOUT

FIGURE 2A

File Name: N:\Projects\Northern Beaches Council\57312 Sportsground Lighting PSI and ASSMP\GIS\Maps\R02 Rev A\57312_02A_CC_SiteLayout.mxd
Reference: NSW DFSI, 2019



Legend

- Approximate Site Boundary
- Cadastre (NSW LPI, 2019)
- Waterbody area
- Waterway

Acid Sulphate Soils (NSW DPI&E EPI, 2019)

Risk Classification

- Class 1
- Class 2
- Class 5

JBS&G

Job No: 57312	
Client: Northern Beaches Council	
Version: R02 Rev A	Date 20/09/2019
Drawn By: CA	Checked By: AF

Scale 1:1,300

0 10 20
metres

Coord. Sys. GDA 1994 MGA Zone 56

Passmore Reserve,
Campbell Parade,
Manly Vale, NSW

SITE LAYOUT AND ACID SULPHATE SOILS RISK CLASSIFICATIONS

FIGURE 2B

File Name: N:\Projects\Northern Beaches Council\57312 Sportsground Lighting PSI and ASSMP\GIS\Maps\R02 Rev A\57312_02B_MV_SiteLayout.mxd
Reference: NSW DFSI, 2019

Legend

- Approximate Site Boundary
- Waterway
- Sample Locations

JBS&G

Job No: 57312

Client: Northern Beaches Council

Version: L01 Rev A	Date 20/09/2019
Drawn By: CA	Checked By: AF

Scale 1:1,750

0 20 40
metres

Coord. Sys. GDA 1994 MGA Zone 56

Frank Gray and Mike Pawley Ovals,
Stirgess Avenue,
Curl Curl, NSW

SAMPLE LOCATIONS

FIGURE 3A

File Name: N:\Projects\Northern Beaches Council\57312 Sportsground Lighting PSI and ASSMP\GIS\Maps\R02 Rev A\57312_03A_CC_SampleLocations.mxd
Reference: NSW DFSI, 2019

Legend

- Approximate Site Boundary
- Waterbody area
- Waterway
- Sample Locations

JBS&G

Job No: 57312

Client: Northern Beaches Council

Version: R02 Rev A	Date 20/09/2019
Drawn By: CA	Checked By: AF

Scale 1:1,300

0 10 20
metres

Coord. Sys. GDA 1994 MGA Zone 56

Passmore Reserve,
Campbell Parade,
Manly Vale, NSW

PROPOSED WORKS AND SAMPLE LOCATIONS

FIGURE 3B

File Name: N:\Projects\Northern Beaches Council\57312 Sportsground Lighting PSI and ASSMP\GIS\Maps\R02 Rev A\57312_03B_MV_SampleLocations.mxd
Reference: NSW DFSI, 2019

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		Name	Name	Signature	Date
A	Ryan Lill	Matthew Bennett	Matthew Bennett	*Draft for client review*	20/09/2019
0	Alex Finney	Matthew Bennett	Matthew Bennett		22/10/2019