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REPORT
ON
ACID SULPHATE SOIL ASSESSMENT

PROPOSED RESIDENTIAL SUBDIVISION
LOTS 682, 705 AND 810 MANYANA DRIVE
MANYANA

Prepared for:
JWA ENTERPRISES PTY LTD

JUNE 2007
PROJECT 40809

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5 June 2007

REPORT ON ACID SULPHATE SOIL ASSESSMENT
PROPOSED RESIDENTIAL SUBDIVISION
LOTS 682, 705 AND 810 MANYANA DRIVE
MANYANA

1. INTRODUCTION

This report presents the results of an acid sulphate soil assessment undertaken for a proposed residential subdivision at Lots 682, 705 and 810 Manyana Drive, Manyana. The work was requested by and undertaken in liaison with Mr David Cannon of Watkinson Apperley Pty Ltd, consulting surveyors and project managers acting on behalf of the developer, JWA Enterprises Pty Ltd.

It is understood that the proposed subdivision comprises the creation of 71 residential building lots (Lots 2 – 11 and 101 – 151) together with the construction of associated residential pavements. Site investigation was undertaken to profile the subsurface conditions within the mapped area of concern and immediate surrounds in order to assess the acid sulphate potential of the underlying soils.

The investigation comprised test pit excavation and sample collection followed by laboratory testing of selected samples, engineering analysis and reporting. Details of the work undertaken and the results obtained are given herein together with comments relating to acid sulphate potential. A draft report was forwarded to the client in a facsimile transmission dated 29 May 2007. This report supersedes all previous correspondence.

2. SITE DESCRIPTION AND REGIONAL GEOLOGY

The overall site, which consists of Lot 682 in DP 568678, Lot 705 in DP 613881 and Lot 810 in DP 247285, comprises an irregular shaped area of some 9.5 ha with maximum north-south and east-west dimensions of 384 m and 530 m respectively (refer Drawing 1). It is bounded to both the north and west by existing residential development and to both the south and east by vacant, undeveloped land. The mapped area of concern is located in the north eastern corner of the overall site where site levels typically fall in the northerly, southerly and westerly directions (refer Drawing 1). At the time of the field work, the area of investigation was typically heavily vegetated with the exception of several cleared access tracks formed in connection with recent sewer main construction works. An un-named watercourse was also noted to traverse the northern portion of the investigation area in an approximate east-west direction.

Reference to the Ulladulla 1:250 000 Metallogenic Sheet (Ref. 1) indicates that the overall site is underlain by Quaternary alluvium overlying Undifferentiated Sediments of Tertiary Age. The alluvium comprises gravel, swamp deposits and sand dunes whilst the Undifferentiated Sediments comprise gravel, sand, clay, quartzite, sandstone and conglomerate.

Additional reference to the 1:25 000 Acid Sulphate Risk Map for Milton – Cunjurong Point (Ref. 2) indicates that whilst the mapped area of concern is classified as *'Estuarine Plain of Elevation 1 – 2 m'* (refer Drawing 1), the remainder of the site and its immediate surrounds are classified as having *'No known occurrences of acid sulphate soil materials'*. Whilst the online Shoalhaven City Council State of the Environment (SCC SOE) Acid Sulphate Map (Ref. 3) is generally consistent with the above for the overall site, the mapped area of concern is classified as having a *'Low probability of encountering acid sulphate soils within 1 m of the ground surface'*.

3. FIELD WORK

3.1 Methods

The field work comprised eight test pits (Pits 1 – 8) excavated to depths of 2.0 – 2.5 m with a Kubota KX41-3V mini-excavator fitted with a 350 mm wide bucket.

The field work was undertaken by a geotechnical engineer and incorporated the collection of representative disturbed samples to assist in strata identification and for laboratory testing. The soil samples collected were placed in plastic bags immediately upon collection and stored in an esky on ice for transportation to the Douglas Partners (DP) laboratory.

The locations of the test pits are shown on Drawing 1 in Appendix A. The easting and northing coordinates shown on the test pit logs were determined on-site using a Garmin 12 Channel (hand-held) GPS. The surface levels also shown on the test pit logs were determined by Watkinson Apperley Pty Ltd and were forwarded to DP in an email transmission dated 5 June 2007.

3.2 Results

The test pit logs are included in Appendix A and should be read in conjunction with the notes defining classification methods and descriptive terms. In summary, the field investigation encountered relatively uniform subsurface conditions underlying the investigation area with the principal succession of strata observed broadly summarised as follows:

TOPSOIL:	Brown and dark brown silty clay, sandy silty clay, clayey silt and sandy clayey silt with some roots and rootlets to depths of 0.2 – 0.7 m in Pits 1 and 3 – 8;
ALLUVIUM / CLAY:	Firm to very stiff (typically firm to stiff) grey, light grey, dark grey, brown orange brown, red brown and grey brown clay, silty clay and clayey silt to the limit of investigation in Pits 1 – 6 at depths of 2.3 – 2.5 m, and to depths of 1.8 m and 1.7 m in Pits 7 and 8 respectively;
RESIDUAL SOIL:	Very stiff to hard, light grey mottled red brown slightly gravelly silty clay and gravelly silty clay to the limit of investigation in Pits 7 and 8 at depths of 2.0 m respectively.

Different initial conditions were encountered in Pit 2 with the presence of uncontrolled, poorly compacted silty clay filling to a depth of 0.2 m overlying soft to firm remnant silty clay topsoil to a depth of 0.4 m thence the natural alluvial soil profile thereafter.

Groundwater seepage was observed in Pits 1, 3, 5 and 6 at depths of 0.3 – 2.4 m. No free groundwater was observed in any of the remaining pits whilst they remained open. It is noted however, that the pits were backfilled immediately following excavation and sampling, thus precluding any longer-term monitoring of groundwater levels. It is further noted that groundwater levels are affected by preceding climatic conditions and soil permeability and can therefore vary with time.

4. LABORATORY TESTING

Laboratory testing for acid sulphate soils was undertaken in two stages, with reference made to the ASSMAC *'Acid Sulphate Soil Manual'* (Ref. 4) and QASSIT (Ref. 5). Selected samples from the test pits (a total of 52 samples) were initially tested in the DP laboratory for measurement of pH in H_2O (pH_F) and pH after oxidation with H_2O_2 (pH_{FOX}) using a calibrated pH meter.

The detailed results of the screening tests (pH_F and pH_{FOX}) are included in Appendix A. Positive indicators of actual and potential acid sulphate soils (eg: $pH_F < 4.0$, lowering of pH by at least one unit following peroxide oxidation, or $pH_{FOX} < 3.5$) were found in 10 samples and as such, confirmation of acid sulphate potential was required and assessed via the undertaking of Full Chromium Suite tests.

Six soil samples were selected for Full Chromium Suite testing, which was carried out by ALS Environmental. The method includes measurement of pH in potassium chloride (KCl), sulfidic – Titratable Actual Acidity (s-TAA) and Chromium Reducible Sulphur (S_{CR}) in order to determine Net Acidity (%S). The detailed laboratory test report sheets are included in Appendix A with the results summarised in Table 1.

The results indicate pH in potassium chloride values in the range of 3.9 – 4.4 with Net Acidity values in the range of 0.08 – 0.16%S for the soil samples tested from Pits 1, 3 – 6, 8. The results further indicate that whilst all Net Acidity values exceed the action criteria for greater than 1000 tonnes of soil disturbed (0.03%S), the soil samples tested from Pits 5 and 6 (0.08%S and 0.09%S respectively) do not exceed the action criteria for 1 – 1000 tonnes of soil disturbed.

Table 1 – Results of Full Chromium Suite Testing

Pit No	Depth (m)	RL	pH KCl	s-TAA (%S)	S_{CR} (%S)	S_{NAS} (%S)	Net Acidity
1	1.9		4.1	0.14	<0.02	<0.02	**0.14**
3	2.4		4.2	0.13	<0.02	<0.02	**0.13**
4	1.9		3.9	0.16	<0.02	<0.02	**0.16**
5	1.5		4.4	0.08	<0.02	<0.02	**0.08***
6	0.5		4.4	0.09	<0.02	<0.02	**0.09***
8	1.0		4.3	0.14	<0.02	<0.02	**0.14**
Action Criteria[1] for >1000 tonnes of soil disturbed (Ref. 3)							0.03
Action Criteria[2] for 1 – 1000 tonnes of soil disturbed (Ref. 3)							0.10

Where: s-TAA = sulphidic – Titratable Actual Acidity
S_{CR} = Chromium Reducible Sulphur
S_{NAS} = Net Acid Soluble Sulphur
Net Acidity = s-TAA + S_{CR} + S_{NAS}

0.14 Exceeds Action Criteria[1]

0.08* Exceeds Action Criteria[1] But Does Not Exceed Action Criteria[2]

5. PROPOSED DEVELOPMENT

Based on the development details provided by the client, it is understood that the proposed development comprises subdivision of existing residue Lots 682, 705 and 810 to form an 'infill' development and hence complete residential development in the south eastern corner of the Manyana village. It is further understood that the subdivision comprises the creation of 71 residential building lots (Lots 2 – 11 and 101 – 151) together with the construction of associated residential pavements and accessways.

Additional development details provided by the client also indicate that the area of existing bushland to the south of proposed Lots 2 – 10 and east of proposed Lots 12 – 22 (ie: area containing Estuarine Plain) will be largely retained as part of the development and will remain predominately undisturbed with only minor clearing for asset protection zones required together with a possible detention basin in the north-west corner (ie: near Lots 10 – 12). No other development details were available at the time of the investigation.

6. COMMENTS

6.1 General

The following comments are based on subsurface conditions encountered at the time of the investigation, the results of laboratory testing from within the investigation area and DP experience with similar projects. This report is aimed at assisting in conceptual planning of the development and will be submitted as part of the Environmental Assessment Report to the NSW Department of Planning.

6.2 Acid Sulphate Soil Assessment

Based on the laboratory test results and the ASSMAC (Ref. 4) and QASSIT (Ref. 5) guidelines, the following interpretations are made with respect to acid sulphate potential.

Screening Tests

- The results of the initial screening tests for pH in H_2O (pH_F) were generally in the range of 4.1 – 5.8, indicating that the soils are acidic. Different results were however, obtained from the samples tested from Pit 3 (2.4 m) and Pit 4 (1.3 m, 1.6 m, 1.9 m, 2.2 m) with pH_F values in the range of 3.7 – 3.9, indicating that Actual Acid Sulphate Soils (AASS) are present. This interpretation is based on the ASSMAC/QASSIT guidelines which suggest that oxidation of pyrite has occurred in the past when pH_F is less than 4;
- The results of the initial screening tests for pH following addition of H_2O_2 (pH_{FOX}) were generally in the range of 3.7 – 5.3 with measured pH drops typically in the range of 0.1 – 0.9 when compared to respective pH_F values. Different results were however, obtained from the samples tested from Pit 1 (1.6 m, 1.9 m, 2.2 m), Pit 2 (0.6 m) and Pit 4 (1.3 m, 1.6 m, 1.9 m, 2.2 m, 2.5 m) with pH_{FOX} values typically in the range of 3.3 – 3.5 and corresponding pH drops in the range of 0.4 – 1.4. The results indicate some potential for forming acidic conditions upon oxidation in the above samples, based on ASSMAC/QASSIT guidelines which suggest that Potential Acid Sulphate Soils (PASS) are present where pH in H_2O_2 is less than 3.5, or where the difference between pH_F and pH_{FOX} is greater than 1.

Full Chromium Suite Tests

- The results of the full chromium suite testing indicate Net Acidity values in the range of 0.08 – 0.16%S for the soil samples tested with all results exceeding the action criteria for greater than 1000 tonnes of soil disturbed during development (0.03%S), and all results (with the exception of Pits 5 and 6) also exceeding the action criteria for 1 – 1000 tonnes of soil disturbed (0.10%S). The results therefore confirm the presence of acid sulphate conditions in the underlying site soils.

In summary, the results of the limited testing undertaken to date indicate the presence of actual and potential acid sulphate soils of possible erratic lateral distribution within the eastern portion of the proposed development area, and generally below depths of 0.5 – 2.5 m. The act of disturbing or exposing these soils through construction activity shall necessitate the production of an acid sulphate soil management plan.

Whilst the area of existing bushland to be retained as part of the development may remain essentially undisturbed, future disturbance of the underlying acid sulphate soils is anticipated in order to facilitate subdivision construction with further investigation and the preparation of an acid sulphate soil management plan (ASSMP) considered necessary as detailed design of the development proceeds.

DOUGLAS PARTNERS PTY LTD

C R Wing
Geotechnical Engineer

Reviewed by:

PP: **Dr T J Wiesner**
Principal

References:

1. NSW Department of Mines (1974), *'Geology of Ulladulla 1:250 000 Metallogenic Sheet'* No. S1 56-13.

2. NSW Department of land and Water Conservation (1997), *' Milton – Cunjurong Point Acid Sulphate Soil Risk Map'*, No. 8927N2.

3. Shoalhaven City Council Website, *'http://gis.shoalhaven.nsw.gov.au/soemaps/'.*

4. ASSMAC (1998), *'Acid Sulphate Soils Manual*'.

5. QLD Department of Natural Resources and Mines (2002), 'Queensland Acid Sulfate Soil Technical Manual – Soil Management Guidelines'.

APPENDIX A

Notes Relating to This Report
Test Pit Logs (Pits 1 – 8)
Results of Acid Sulphate Screening Tests (4 no)
Laboratory Test Report Sheets (5 no)
Drawing 1

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NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all, of course, are necessarily relevant to all reports.

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

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, Geotechnical Site Investigations Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00 mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Undrained Shear Strength kPa
Very soft	less than 12
Soft	12—25
Firm	25—50
Stiff	50—100
Very stiff	100—200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT "N" Value (blows/300 mm)	CPT Cone Value (q_c — MPa)
Very loose	less than 5	less than 2
Loose	5—10	2—5
Medium dense	10—30	5—15
Dense	30—50	15—25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

Sampling is carried out during drilling to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing with a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling are given in the report.

Drilling Methods.

The following is a brief summary of drilling methods currently adopted by the Company and some comments on their use and application.

Test Pits — these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils if it is safe to descent into the pit. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) — the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling — the hole is advanced by pushing a 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers — the hole is advanced using 90—115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and in sands above the water

table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling — the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling — similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling — a continuous core sample is obtained using a diamond-tipped core barrel, usually 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" — Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7

  as 4, 6, 7
  N = 13

- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm

  as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil.

Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch cone — abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australian Standard 1289, Test 6.4.1.

In the tests, a 35 mm diameter rod with a cone-tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20 mm per second) the information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: —

- Cone resistance — the actual end bearing force divided by the cross sectional area of the cone — expressed in MPa.
- Sleeve friction — the frictional force on the sleeve divided by the surface area — expressed in kPa.
- Friction ratio — the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0—5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0—50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1%—2% are commonly encountered in sands and very soft clays rising to 4%—10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:—

q_c (MPa) = (0.4 to 0.6) N (blows per 300 mm)

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:—

q_c = (12 to 18) c_u

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Hand Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150 mm increments of penetration. Normally, there is a depth limitation of 1.2 m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer — a 16 mm diameter flat-ended rod is driven with a 9 kg hammer, dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as the Scala Penetrometer) — a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). The test was developed initially for pavement subgrade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

Bore Logs

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

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

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems;

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

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

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

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

- unexpected variations in ground conditions — the potential for this will depend partly on bore spacing and sampling frequency
- changes in policy or interpretation of policy by statutory authorities
- the actions of contractors responding to commercial pressures.

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

Site Anomalies

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

Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section

is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

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

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DESCRIPTION AND CLASSIFICATION OF ROCKS FOR ENGINEERING PURPOSES

DEGREE OF WEATHERING

Term	Symbol	Definition
Extremely Weathered	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - i.e. it can be remoulded and can be classified according to the Unified Classification System, but the texture of the original rock is still evident.
Highly Weathered	HW	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decreased compared to the fresh rock usually as a result of iron leaching or deposition. The colour and strength of the original fresh rock substance is no longer recognisable.
Moderately Weathered	MW	Rock substance affected by weathering to the extent that staining or discolouration of the rock substance usually by limonite has taken place. The colour of the fresh rock is no longer recognisable.
Slightly Weathered	SW	Rock substance affected by weathering to the extent that partial staining or discolouration of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable.
Fresh Stained	Fs	Rock substance unaffected by weathering, but showing limonite staining along joints.
Fresh	Fr	Rock substance unaffected by weathering.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index ($I_{S(50)}$) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by Australian Standard 4133.4.1 - 1993.

Term	Symbol	Field Guide*	Point Load Index $I_{S(50)}$ MPa	Approx Unconfined Compressive Strength q_u ** MPa
Extremely low	EL	Easily remoulded by hand to a material with soil properties	<0.03	< 0.6
Very low	VL	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; too hard to cut a triaxial sample by hand. SPT will refuse. Pieces up to 3 cm thick can be broken by finger pressure.	0.03-0.1	0.6-2
Low	L	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150 mm long 40 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.	0.1-0.3	2-6
Medium	M	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.	0.3-1.0	6-20
High	H	Can be slightly scratched with a knife. A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken with pick with a single firm blow, rock rings under hammer.	1 - 3	20-60
Very high	VH	Cannot be scratched with a knife. Hand specimen breaks with pick after more than one blow, rock rings under hammer.	3 - 10	60-200
Extremely high	EH	Specimen requires many blows with geological pick to break through intact material, rock rings under hammer.	>10	> 200

Note that these terms refer to strength of rock material and not to the strength of the rock mass, which may be considerably weaker due to rock defects.

* The field guide assessment of rock strength may be used for preliminary assessment or when point load testing is not able to be done.

** The approximate unconfined compressive strength (q_u) shown in the table is based on an assumed ratio to the point load index of 20:1. This ratio may vary widely.

STRATIFICATION SPACING

Term	Separation of Stratification Planes
Thinly laminated	<6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	>2 m

DEGREE OF FRACTURING

This classification applies to diamond drill cores and refers to the spacing of all types of natural fractures along which the core is discontinuous. These include bedding plane partings, joints and other rock defects, but exclude known artificial fractures such as drilling breaks. The orientation of rock defects is measured as an angle relative to a plane perpendicular to the core axis. Note that where possible, recordings of the actual defect spacing or range of spacings is preferred to the general terms given below.

Term	Description
Fragmented	The core consists mainly of fragments with dimensions less than 20 mm.
Highly Fractured	Core lengths are generally less than 20 mm - 40 mm with occasional fragments.
Fractured	Core lengths are mainly 40 mm - 200 mm with occasional shorter and longer sections.
Slightly Fractured	Core lengths are generally 200 mm - 1000 mm with occasional shorter and longer sections.
Unbroken	The core does not contain any fracture.

ROCK QUALITY DESIGNATION (RQD)

This is defined as the ratio of sound (i.e. low strength or better) core in lengths of greater than 100 mm to the total length of the core, expressed in percent. If the core is broken by handling or by the drilling process (i.e. the fracture surfaces are fresh, irregular breaks rather than joint surfaces) the fresh broken pieces are fitted together and counted as one piece.

SEDIMENTARY ROCK TYPES

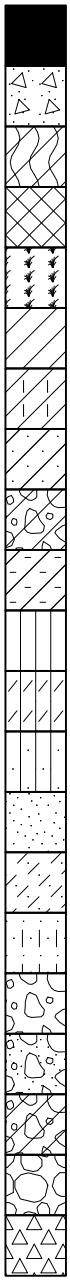
This classification system provides a standardised terminology for the engineering description of sandstone and shales, particularly in the Sydney area, but the terms and definitions may be used elsewhere when applicable.

Rock Type	Definition
Conglomerate	More than 50% of the rock consists of gravel-sized (greater than 2 mm) fragments
Sandstone:	More than 50% of the rock consists of sand-sized (0.06 to 2 mm) grains
Siltstone:	More than 50% of the rock consists of silt-sized (less than 0.06 mm) granular particles and the rock is not laminated.
Claystone:	More than 50% of the rock consists of clay or sericitic material and the rock is not laminated.
Shale:	More than 50% of the rock consists of silt or clay-sized particles and the rock is laminated.

Rocks possessing characteristics of two groups are described by their predominant particle size with reference also to the minor constituents, eg. clayey sandstone, sandy shale.

GRAPHIC SYMBOLS FOR SOIL & ROCK

SOIL



BITUMINOUS CONCRETE

CONCRETE

TOPSOIL

FILLING

PEAT

CLAY

SILTY CLAY

SANDY CLAY

GRAVELLY CLAY

SHALY CLAY

SILT

CLAYEY SILT

SANDY SILT

SAND

CLAYEY SAND

SILTY SAND

GRAVEL

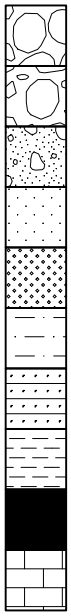
SANDY GRAVEL

CLAYEY GRAVEL

COBBLES/BOULDERS

TALUS

SEDIMENTARY ROCK



BOULDER CONGLOMERATE

CONGLOMERATE

CONGLOMERATIC SANDSTONE

SANDSTONE FINE GRAINED

SANDSTONE COARSE GRAINED

SILTSTONE

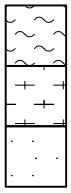
LAMINITE

MUDSTONE, CLAYSTONE, SHALE

COAL

LIMESTONE

METAMORPHIC ROCK

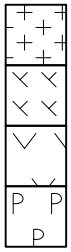


SLATE, PHYLITTE, SCHIST

GNEISS

QUARTZITE

IGNEOUS ROCK



GRANITE

DOLERITE, BASALT

TUFF

PORPHYRY

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TEST PIT LOG

CLIENT: JWA Enterprises Pty Ltd
PROJECT: Acid Sulphate Soil Assessment
LOCATION: Lots 682, 705 & 810 Manyana Drive, Manyana

SURFACE LEVEL: 5.6 m AHD
EASTING: 274017
NORTHING: 6095469
DIP/AZIMUTH: 90°/--

PIT No: 1
PROJECT No: 40809
DATE: 13 Apr 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm)
		TOPSOIL - brown and dark brown silty clay/clayey silt with some roots and rootlets, humid to damp							
	0.2	CLAY - firm, light grey mottled brown, orange brown and red brown slightly silty, high plasticity clay, humid to damp		D	0.4		pp = 100-150kPa	▽	
5				D	0.7		pp = 100kPa		
	1			D	1.0		pp = 150-180kPa		1
		- consistency becoming stiff. Colour predoninately grey and light grey mottled brown and orange brown, humid		D	1.3		pp = 200kPa		
4				D	1.6		pp = 200kPa		
				D	1.9		pp = 200kPa		
	2								2
				D	2.2		pp = 200-220kPa		
	2.3	Pit discontinued at 2.3m (limit of investigation)							
3									

Dynamic Penetrometer Test (blows per mm): 5, 10, 15, 20

RIG: Kubota KX41-3V - 350mm bucket

LOGGED: Wing

WATER OBSERVATIONS: Seepage from 0.3 - 1.1m

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

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TEST PIT LOG

CLIENT: JWA Enterprises Pty Ltd
PROJECT: Acid Sulphate Soil Assessment
LOCATION: Lots 682, 705 & 810 Manyana Drive, Manyana

SURFACE LEVEL: 4.7 m AHD
EASTING: 273966
NORTHING: 6095478
DIP/AZIMUTH: 90°/--

PIT No: 2
PROJECT No: 40809
DATE: 13 Apr 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm)
	0.2	FILLING - uncontrolled, poorly compacted, brown silty clay with some rootlets, trace sand, humid to damp							
	0.4	SILTY CLAY - soft to firm, dark brown silty clay/clayey silt with some roots and rootlets, humid (original topsoil)							
	0.7	CLAY - firm to stiff, brown grey and grey brown slightly silty, high plasticity clay, humid, trace rootlets throughout (Alluvium)		D	0.6		pp = 150kPa		
		CLAY - stiff, brown and grey brown mottled orange brown slightly silty, high plasticity clay, humid, abundant rootlets throughout (Alluvium)		D	0.9		pp = 150kPa		
				D	1.2		pp = 150kPa		
				D	1.5		pp = 150kPa		
	1.8	CLAY - stiff, grey and dark grey mottled red brown slightly silty, high plasticity clay, humid, trace fine extremely weathered gravel		D	1.8		pp = 150kPa		
				D	2.1		pp = 150-200kPa		
	2.4	Pit discontinued at 2.4m (limit of investigation)		D	2.4		pp = 150kPa		

Dynamic Penetrometer Test (blows per mm): 5, 10, 15, 20

RIG: Kubota KX41-3V - 350mm bucket

LOGGED: Wing

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

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TEST PIT LOG

CLIENT: JWA Enterprises Pty Ltd
PROJECT: Acid Sulphate Soil Assessment
LOCATION: Lots 682, 705 & 810 Manyana Drive, Manyana

SURFACE LEVEL: 3.7 m AHD
EASTING: 273999
NORTHING: 6095396
DIP/AZIMUTH: 90°/--

PIT No: 3
PROJECT No: 40809
DATE: 13 Apr 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm)
		TOPSOIL - brown and dark brown clayey silt/silty clay with abundant roots and rootlets, humid							
	0.25	SILTY CLAY - firm to stiff, brown, grey brown and orange brown silty clay/clay, humid to damp, some rootlets throughout (Alluvium)		D	0.3		pp - *		
				D	0.6		pp = 50kPa		
				D	0.9		pp = 100kPa		
	1.2	SILTY CLAY - firm to stiff, brown and grey brown mottled orange brown, high plasticity silty clay/clay. Trace rootlets and fine extremely weathered gravel, humid to damp		D	1.2		pp = 50-100kPa	▷	
	1.5	CLAY - stiff, grey and dark grey mottled brown and orange brown slightly silty, high plasticity clay, humid		D	1.5		pp = 150-200kPa		
				D	1.8		pp = 150-200kPa		
		- trace fine extremely weathered gravel. Consistency firm to stiff		D	2.1		pp = 100-200kPa		
	2.4	Pit discontinued at 2.4m (limit of investigation)		D	2.4		pp = 50-100kPa		

RIG: Kubota KX41-3V - 350mm bucket

LOGGED: Wing

WATER OBSERVATIONS: Seepage from 1.3 - 2.1m

REMARKS: * = Could not test

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ▼ Water level

CHECKED
Initials:
Date:

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TEST PIT LOG

CLIENT: JWA Enterprises Pty Ltd
PROJECT: Acid Sulphate Soil Assessment
LOCATION: Lots 682, 705 & 810 Manyana Drive, Manyana

SURFACE LEVEL: 3.8 m AHD
EASTING: 273949
NORTHING: 6095408
DIP/AZIMUTH: 90°/--

PIT No: 4
PROJECT No: 40809
DATE: 13 Apr 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm)
		TOPSOIL -dark brown silty clay/clayey silt with abundant roots and rootlets, humid							
	0.7	CLAY - stiff, brown and grey brown mottled orange brown slightly silty, high plasticity clay, humid, trace rootlets/roots throughout		D	1.0		pp = 150kPa		
				D	1.3		pp = 150kPa		
				D	1.6		pp = 150kPa		
				D	1.9		pp = 150kPa		
		- colour predominately grey and dark grey mottled brown and orange brown		D	2.2		pp = 150kPa		
	2.5	Pit discontinued at 2.5m (limit of investigation)		D	2.5		pp = 100kPa		

Dynamic Penetrometer Test (blows per mm): 5, 10, 15, 20

RIG: Kubota KX41-3V - 350mm bucket

LOGGED: Wing

WATER OBSERVATIONS: No free groundwater observed

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧩ Water level

CHECKED
Initials:
Date:

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TEST PIT LOG

CLIENT: JWA Enterprises Pty Ltd
PROJECT: Acid Sulphate Soil Assessment
LOCATION: Lots 682, 705 & 810 Manyana Drive, Manyana

SURFACE LEVEL: 4.7 m AHD
EASTING: 273879
NORTHING: 6095450
DIP/AZIMUTH: 90°/--

PIT No: 5
PROJECT No: 40809
DATE: 13 Apr 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm)
		TOPSOIL - brown and dark brown silty clay/clayey silt with abundant roots and rootlets, humid							
	0.4	CLAYEY SILT - firm to stiff, grey and dark grey clayey silt/silty clay with some rootlets, humid (Alluvium)		D	0.6		pp = 50-80kPa		
4				D	0.9		pp = 50-100kPa		
	1.0	- colour becoming grey, light grey and light brown CLAY - stiff, grey and grey brown mottled orange brown slightly silty, high plasticity clay, some rootlets throughout, humid		D	1.2		pp = 150kPa		
				D	1.5		pp = 150-200kPa		
3				D	1.8		pp = 150-200kPa		
		- colour predominately grey mottled orange brown and red brown							
	2.4			D	2.4		pp = 150kPa	▷	
2		Pit discontinued at 2.4m (limit of investigation)							

RIG: Kubota KX41-3V - 350mm bucket

LOGGED: Wing

WATER OBSERVATIONS: Seepage at 2.4m

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep
		⧩	Water level

CHECKED
Initials:
Date:

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TEST PIT LOG

CLIENT: JWA Enterprises Pty Ltd
PROJECT: Acid Sulphate Soil Assessment
LOCATION: Lots 682, 705 & 810 Manyana Drive, Manyana

SURFACE LEVEL: 4.2 m AHD
EASTING: 273883
NORTHING: 6095358
DIP/AZIMUTH: 90°/--

PIT No: 6
PROJECT No: 40809
DATE: 13 Apr 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm)
4	0.4	TOPSOIL - brown and dark brown silty clay/clayey silt with some rootlets							
		SILTY CLAY - firm to stiff, grey and grey brown mottled orange brown high plasticity silty clay/clay, humid to damp		D	0.5		pp = 150kPa		
				D	0.8		pp = 150-200kPa		
	1			D	1.1		pp = 150-200kPa		1
3				D	1.4		pp = 150kPa		
	1.5	CLAY - firm, grey and dark grey mottled orange brown and red brown slightly silty, high plasticity clay/silty clay, humid to damp		D	1.7		pp = 100-150kPa		
	2			D	2.0		pp = 100kPa	▷	2
2				D	2.3		pp = 100kPa		
	2.4	Pit discontinued at 2.4m (limit of investigation)							

Dynamic Penetrometer Test (blows per mm): 5, 10, 15, 20

RIG: Kubota KX41-3V - 350mm bucket

LOGGED: Wing

WATER OBSERVATIONS: Seepage at 2.0m

REMARKS:

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep
		⧩	Water level

CHECKED
Initials:
Date:

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TEST PIT LOG

CLIENT: JWA Enterprises Pty Ltd
PROJECT: Acid Sulphate Soil Assessment
LOCATION: Lots 682, 705 & 810 Manyana Drive, Manyana

SURFACE LEVEL: 6.7 m AHD
EASTING: 273869
NORTHING: 6095273
DIP/AZIMUTH: 90°/--

PIT No: 7
PROJECT No: 40809
DATE: 13 Apr 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm)
6	0.35	TOPSOIL - brown silty clay with some roots and rootlets, trace fine sand, humid							
		SILTY CLAY - stiff, brown and grey brown silty clay, trace rootlets and fine gravel, humid (Alluvium)		D	0.4		pp = 150-200kPa		
	0.6	SILTY CLAY - stiff to very stiff, brown and orange brown silty clay, humid. Crumbly		D	0.7		pp = 200kPa		
	1			D	1.0		pp = *		1
				D	1.3		pp = *		
5	1.4	SILTY CLAY - very stiff, brown, orange brown and red brown silty clay with some light grey mottling, humid		D	1.6		pp = 200kPa		
	1.8	SILTY CLAY - very stiff to hard, light grey mottled red brown slightly gravelly silty clay, gravel component extremely weathered, humid (residual soil). Crumbly		D	1.9		pp > 400kPa		
	2 2.0	Pit discontinued at 2.0m (limit of investigation)							2
4									

Dynamic Penetrometer Test (blows per mm): 5 10 15 20

RIG: Kubota KX41-3V - 350mm bucket

LOGGED: Wing

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * = Could not test

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧗ Water level

CHECKED
Initials:
Date:

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TEST PIT LOG

CLIENT: JWA Enterprises Pty Ltd
PROJECT: Acid Sulphate Soil Assessment
LOCATION: Lots 682, 705 & 810 Manyana Drive, Manyana

SURFACE LEVEL: 5.2 m AHD
EASTING: 273932
NORTHING: 6095244
DIP/AZIMUTH: 90°/--

PIT No: 8
PROJECT No: 40809
DATE: 13 Apr 07
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm)
5	0.25	TOPSOIL - dark brown sandy silty clay/sandy clayey silt with some roots and rootlets, humid							
		SILTY CLAY - firm to stiff, light brown silty clay/clayey silt, humid (Alluvium)		D	0.4		pp = 150kPa		
				D	0.7		pp = 150-200kPa		
	0.8	SILTY CLAY - stiff, red brown mottled grey and light grey silty clay, trace fine extremely weathered gravel, humid, crumbly		D	1.0		pp = 150-200kPa		1
4	1			D	1.3		pp = 150-200kPa		
				D	1.6		pp = 150kPa		
	1.7	GRAVELLY SILTY CLAY - very stiff to hard, light grey mottled red brown gravelly silty clay, humid, crumbly (residual soil)		D	1.9		pp = *		
	2 2.0	Pit discontinued at 2.0m (limit of investigation)							2
3									

RIG: Kubota KX41-3V - 350mm bucket

LOGGED: Wing

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * = Could not test

☐ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	PID	Photo ionisation detector
B	Bulk sample	S	Standard penetration test
U_x	Tube sample (x mm dia.)	PL	Point load strength Is(50) MPa
W	Water sample	V	Shear Vane (kPa)
C	Core drilling	▷	Water seep ⧗ Water level

CHECKED
Initials:
Date:

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RESULTS OF ACID SULFATE SCREENING TESTS

Client: JWA Enterprises Pty Ltd

Project: Acid Sulphate Soil Assessment

Project Location: Lots 682, 705 and 810 Manyana Drive, MANYANA

Project No: **40809**

pH Meter: ☐ TPS with Ionode IJ46/WP80
☑ pHscan2

Calibration Buffer: ☑ pH4
☑ pH7
☑ pH10

Sample Location	Depth (m)	pH_F (in distilled water)	pH_{FOX} (oxidised in H_sO_s)			Strength of Reaction	Soil Description
		Date: 18.04.07	Date: 18.04.07	Date:	Date:	(1,2,3,4)*	
		Time:	Time:	Time:	Time:	F **	
Pit 1	0.4	4.9	4.3			1	Clay
	0.7	4.9	4.0			1	Clay
	1.0	4.3	3.8			1	Clay
	1.3	4.7	3.8			1	Clay
	1.6	4.7	3.5			1	Clay
	1.9	4.8	3.4			1	Clay
	2.2	4.9	3.5			1	Clay
Pit 2	0.6	5.5	4.5			1	Clay
	0.9	4.7	4.1			1	Clay
	1.2	4.5	3.9			1	Clay
	1.5	4.3	3.8			1	Clay
	1.8	4.7	4.2			1	Clay
	2.1	4.7	4.3			1	Clay
	2.4	4.9	4.3			1	Clay
Pit 3	0.3	5.8	5.3			1	Silty Clay

Legend: * *1 denotes no or slight effervescence*
2 denotes moderate effervescence
3 denotes vigorous effervescence
4 denotes "volcano" ie. very vigorous effervescence, gas evolution and heat
** F after reaction number indicates a bubbling/frothy reaction (organics)

Operator: JL

Date: 18 April 2007

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RESULTS OF ACID SULFATE SCREENING TESTS

Client: JWA Enterprises Pty Ltd

Project: Acid Sulphate Soil Assessment

Project Location: Lots 682, 705 and 810 Manyana Drive, MANYANA

Project No: **40809**

pH Meter: ☐ TPS with Ionode IJ46/WP80
☑ pHscan2

Calibration Buffer: ☑ pH4
☑ pH7
☑ pH10

Sample Location	Depth (m)	pH_F (in distilled water)	pH_{FOX} (oxidised in H_sO_s)			Strength of Reaction	Soil Description
		Date: 18.04.07	Date: 18.04.07	Date:	Date:	(1,2,3,4)*	
		Time:	Time:	Time:	Time:	F **	
Pit 3	0.6	5.5	4.8			1	Silty Clay
	0.9	5.5	4.7			1	Silty Clay
	1.2	5.1	4.4			1	Silty Clay
	1.5	4.9	4.2			1	Clay
	1.8	4.1	3.7			1	Clay
	2.1	4.5	3.8			1	Clay
	2.4	3.9	3.7			1	Clay
Pit 4	1.0	4.1	3.7			1	Clay
	1.3	3.8	3.4			1	Clay
	1.6	3.8	3.4			1	Clay
	1.9	3.7	3.3			1	Clay
	2.2	3.8	3.3			1	Clay
	2.5	4.1	3.3			1	Clay
Pit 5	0.6	4.3	4.2			1	Clayey Silt
	0.9	4.4	4.2			1	Clayey Silt

Legend: * *1 denotes no or slight effervescence*
2 denotes moderate effervescence
3 denotes vigorous effervescence
4 denotes "volcano" ie. very vigorous effervescence, gas evolution and heat
** F after reaction number indicates a bubbling/frothy reaction (organics)

Operator: JL

Date: 18 April 2007

Douglas Partners
Geotechnics · Environment · Groundwater

RESULTS OF ACID SULFATE SCREENING TESTS

Client: JWA Enterprises Pty Ltd

Project: Acid Sulphate Soil Assessment

Project Location: Lots 682, 705 and 810 Manyana Drive, MANYANA

Project No: 40809

pH Meter: ☐ TPS with Ionode IJ46/WP80
☑ pHscan2

Calibration Buffer: ☑ pH4
☑ pH7
☑ pH10

Sample Location	Depth (m)	pH_F (in distilled water)	pH_{FOX} (oxidised in H_sO_s)			Strength of Reaction	Soil Description
		Date: 18.04.07	Date: 18.04.07	Date:	Date:	(1,2,3,4)*	
		Time:	Time:	Time:	Time:	F **	
Pit 5	1.2	4.5	4.2			1	Clay
	1.5	4.5	4.2			1	Clay
	1.8	4.7	4.2			1	Clay
	2.1	4.3	4.0			1	Clay
	2.4	4.8	4.3			1	Clay
Pit 6	0.5	5.4	4.6			1	Silty Clay
	0.8	5.4	4.6			1	Silty Clay
	1.1	4.6	4.4			1	Silty Clay
	1.4	5.0	4.6			1	Silty Clay
	1.7	5.0	4.6			1	Clay
	2.0	5.1	4.6			1	Clay
	2.3	5.1	4.7			1	Clay
Pit 7	0.4	5.8	5.2			1	Silty Clay
	0.7	5.5	5.0			1	Silty Clay
	1.0	5.2	4.7			1	Silty Clay

Legend: * *1 denotes no or slight effervescence*
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Sample Location	Depth (m)	pH_F (in distilled water)	pH_{FOX} (oxidised in H_sO_s)			Strength of Reaction	Soil Description
		Date: 18.04.07	Date: 18.04.07	Date:	Date:	(1,2,3,4)*	
		Time:	Time:	Time:	Time:	F **	
Pit 7	1.3	4.9	4.6			1	Silty Clay
	1.6	4.7	4.4			1	Silty Clay
Pit 8	0.4	5.0	4.7			1	Silty Clay
	0.7	4.7	4.5			1	Silty Clay
	1.0	5.0	4.5			1	Silty Clay
	1.3	4.8	4.5			1	Silty Clay
	1.6	4.9	4.6			1	Silty Clay

Legend: * *1 denotes no or slight effervescence*
2 denotes moderate effervescence
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** F after reaction number indicates a bubbling/frothy reaction (organics)

Operator: JL

Date: 18 April 2007

ALS Environmental

CERTIFICATE OF ANALYSIS

Client	: **DOUGLAS PARTNERS PTY LTD**	*Laboratory*	: **Environmental Division Sydney**	*Page*	: **1 of 5**
Contact	: **MR CHRIS WING**	*Contact*	: **Victor Kedicioglu**	*Work Order*	: **ES0705136**
Address	: **PO BOX 486 UNANDERRA NSW AUSTRALIA 2526**	*Address*	: **277-289 Woodpark Road Smithfield NSW Australia 2164**		
E-mail	: **wingc@douglaspartners.com.au**	*E-mail*	: **Victor.Kedicioglu@alsenviro.com**		
Telephone	: **42711836**	*Telephone*	: **61-2-8784 8555**		
Facsimile	: **42711897**	*Facsimile*	: **61-2-8784 8500**		
Project	: **40809**	*Quote number*	: **EN/020/06**	*Date received*	: **20 Apr 2007**
Order number	: **54744**			*Date issued*	: **3 May 2007**
C-O-C number	: **- Not provided -**			*No. of samples*	- *Received* : **6**
Site	: **- Not provided -**				*Analysed* : **6**

ALSE - Excellence in Analytical Testing

NATA Accredited Laboratory 825

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Accredited for compliance with ISO/IEC 17025.

This document has been electronically signed by those names that appear on this report and are the authorised signatories. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory	*Position*	*Department*
Lea-Ellen Catt	**Laboratory Technician - Acid Sulphate Soils**	**Inorganics - NATA 825 (818 - Brisbane)**

Comments

This report for the ALSE reference ES0705136 supersedes any previous reports with this reference. Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

This report contains the following information:

- **Analytical Results for Samples Submitted**
- **Surrogate Recovery Data**

The analytical procedures used by ALS Environmental have been developed from established internationally-recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported herein. Reference methods from which ALSE methods are based are provided in parenthesis.

When moisture determination has been performed, results are reported on a dry weight basis. When a reported 'less than' result is higher than the LOR, this may be due to primary sample extracts/digestion dilution and/or insuffient sample amount for analysis. Surrogate Recovery Limits are static and based on USEPA SW846 or ALS-QWI/EN38 (in the absence of specified USEPA limits). Where LOR of reported result differ from standard LOR, this may be due to high moisture, reduced sample amount or matrix interference. When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for process purposes. Abbreviations: CAS number = Chemical Abstract Services number, LOR = Limit of Reporting. * Indicates failed Surrogate Recoveries.

Specific comments for Work Order **ES0705136**

Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. Conversion to liming rate in kg/m3 = kg/t x wet bulk density in t/m3.
ANC not required because pH KCl less than 6.5

ALS Environmental

Analytical Results

Analyte	CAS number	LOR	Units	Client Sample ID : PIT 1- 1.9M Sample Matrix Type / Description : SOIL Sample Date / Time : (20 Apr 2007) (15:00) Laboratory Sample ID : ES0705136-001	PIT 3- 2.4M SOIL (20 Apr 2007) (15:00) ES0705136-002	PIT 4- 1.9M SOIL (20 Apr 2007) (15:00) ES0705136-003	PIT 5- 1.5M SOIL (20 Apr 2007) (15:00) ES0705136-004	PIT 6- 0.5M SOIL (20 Apr 2007) (15:00) ES0705136-005
EA033-A: Actual Acidity								
pH KCl (23A)		0.1	pH Unit	4.1	4.2	3.9	4.4	4.4
Titratable Actual Acidity (23F)		2	mole H+ / t	91	79	102	52	56
sulfidic - Titratable Actual Acidity (s-23F)		0.02	% pyrite S	0.14	0.13	0.16	0.08	0.09
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)		0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
acidity - Chromium Reducible Sulfur (a-22B)		10	mole H+ / t	<10	<10	<10	<10	<10
EA033-D: Retained Acidity								
Net Acid Soluble Sulfur (20Je)		0.02	% S	<0.02	<0.02	<0.02	<0.02	<0.02
acidity - Net Acid Soluble Sulfur (a-20J)		10	mole H+ / t	<10	<10	<10	<10	<10
sulfidic - Net Acid Soluble Sulfur (s-20J)		0.02	% pyrite S	<0.02	<0.02	<0.02	<0.02	<0.02
KCl Extractable Sulfur (23Ce)		0.02	% S	0.05	0.04	0.06	0.04	<0.02
HCl Extractable Sulfur (20Be)		0.02	% S	0.05	0.04	0.06	0.04	<0.02
EA033-E: Acid Base Accounting								
ANC Fineness Factor		0.5		1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)		0.02	% S	0.15	0.13	0.16	0.08	0.09
Net Acidity (acidity units)		10	mole H+ / t	91	80	103	50	56
Liming Rate		1	kg CaCO3/t	7	6	8	4	4

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Analytical Results

	Client Sample ID :	PIT 8- 1.0M				
	Sample Matrix Type / Description :	SOIL				
	Sample Date / Time :	(20 Apr 2007) (15:00)				
	Laboratory Sample ID :	ES0705136-006				
Analyte	CAS number / LOR / Units					
EA033-A: Actual Acidity						
pH KCl (23A)	0.1 pH Unit	4.3				
Titratable Actual Acidity (23F)	2 mole H+ / t	86				
sulfidic - Titratable Actual Acidity (s-23F)	0.02 % pyrite S	0.14				
EA033-B: Potential Acidity						
Chromium Reducible Sulfur (22B)	0.02 % S	<0.02				
acidity - Chromium Reducible Sulfur (a-22B)	10 mole H+ / t	<10				
EA033-D: Retained Acidity						
Net Acid Soluble Sulfur (20Je)	0.02 % S	<0.02				
acidity - Net Acid Soluble Sulfur (a-20J)	10 mole H+ / t	<10				
sulfidic - Net Acid Soluble Sulfur (s-20J)	0.02 % pyrite S	<0.02				
KCl Extractable Sulfur (23Ce)	0.02 % S	0.10				
HCl Extractable Sulfur (20Be)	0.02 % S	0.08				
EA033-E: Acid Base Accounting						
ANC Fineness Factor	0.5	1.5				
Net Acidity (sulfur units)	0.02 % S	0.14				
Net Acidity (acidity units)	10 mole H+ / t	86				
Liming Rate	1 kg CaCO3/t	6				

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Surrogate Control Limits

- **No surrogates present on this report.**

MAG
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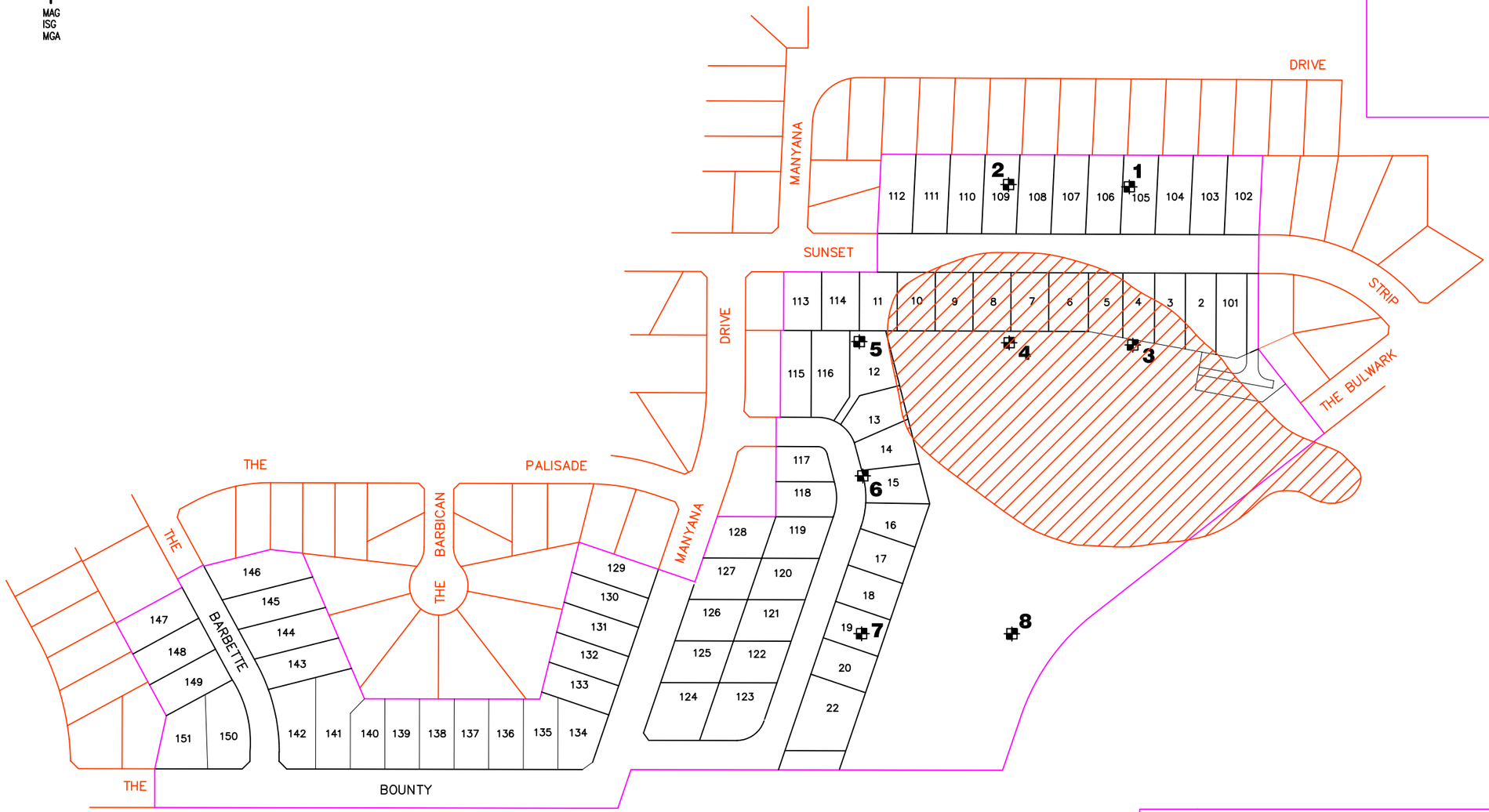

LOCALITY PLAN

LEGEND

APPROXIMATE TEST PIT LOCATION

APPROXIMATE EXTENT OF MAPPED ESTUARINE PLAIN (Ref. 2)
APPROXIMATE EXTENT OF MAPPED ACID SULPHATE ZONE (Ref. 3)

SCALE
0 100 200m
1:3000

Douglas Partners
Geotechnics, Environment, Groundwater

Sydney, Newcastle, Brisbane, Melbourne, Perth, Wyong, Campbelltown, Townsville, Canberra Cairns, Wollongong, Darwin

TITLE:
Location of Test Pits
Acid Sulphate Soil Assessment
Lots 682, 705 and 810 Manyana Drive
MANYANA

CLIENT: JWA Enterprises Pty Ltd			
DRAWN BY: CRW	SCALE: As shown	PROJECT No: 40809	OFFICE: WOLLONGONG
APPROVED BY:		DATE: 04.05.2007	DRAWING No: 1