Woodside Energy Limited
Proposed Blacktip Development
Wadeye, Northern Territory

ACID SULPHATE SOIL INVESTIGATION

- Final (Version 02)
- 9 February 2005

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Contents

Document History and Status

Version	Date issued	Reviewed by	Approved by	Date approved	Version type
01a	10/12/04	D. Donovan	D. Oulton	10/12/04	Draft for internal review
01	10/12/04	D. Donovan	D. Oulton	10/12/04	Draft for external review
01b	27/01/05	C. Morgan	D. Oulton	08/02/05	2nd draft for external review
02	09/02/05	D. Donovan	D. Oulton	09/02/05	Final

Distribution of Copies

Version	Copy no	Quantity	Issued to
01a	1	1	Sinclair Knight Merz (Mr. David Donovan)
01	1	1	Woodside Energy Limited (Mr. Ceri Morgan)
01b	1	1	Woodside Energy Limited (Mr. Ceri Morgan)
02	1	2	Woodside Energy Limited (Mr. Ceri Morgan)
02	2	2	Sinclair Knight Merz (File and Library Copies)

Printed:	9 February 2005
Last saved:	9 February 2005 11:12 AM
File name:	I:\WVES\Projects\WV02732\Deliverables\Reports\R01sjsCM (V02).doc
Author:	Stephanie Sneyd / Dion Oulton
Project manager:	Dion Oulton
Name of organisation:	Woodside Energy Limited
Name of project:	Proposed Blacktip Development, Wadeye, Northern Territory
Name of document:	Acid Sulphate Soil Investigation
Document version:	02
Project number:	WV02540.500

Executive Summary

Woodside Energy Limited (WEL) proposes to develop the Blacktip Gas Project (Blacktip Development), located approximately 15km from Wadeye in the Northern Territory (NT). The proposed project involves an offshore gas production well, an incoming wet gas pipeline, an onshore plant site, and gas export facilities.

Sinclair Knight Merz (SKM) completed a desktop assessment in January 2004 identifying the possible presence of Acid Sulphate Soils (ASS) or Potential Acid Sulphate Soils (PASS) in areas of the proposed Blacktip development. In recognition of the potential impact exposure of ASS or PASS soils could have on the environment and site infrastructure, WEL commissioned SKM to investigate the presence or absence of ASS and PASS soils in the Blacktip Development project area.

Prior to completion of the investigation activities a sampling and analysis plan (SAP) was developed based on the level of risk posed by ASS in the proposed development areas. Where risks were identified as high, the sampling program was in accordance with regulatory guidelines. Where risks of ASS conditions were identified as low to moderate, a reduced sampling program was undertaken.

A field program based on the SAP was completed, including field tests and collection of samples for analysis. Samples were collected across three areas, selected during a desktop investigation undertaken by SKM in 2004 (SKM, March 2004), and based on the anticipated level of risk posed by ASS. The selected areas included: Area A (landfall and beach-crossing portion of proposed pipeline route), Area B (proposed plant site and portions of the pipeline route) and Area C (near-shore zone of proposed pipeline route, from lowest astronomical tide to approximately 10 m water depth). Samples were selected for analysis based on field observations and were analysed for the Suspended Peroxide Oxidation Combined Acidity and Sulphate (SPOCAS) suite of analytes.

Based on the result of this investigation SKM conclude that:

- Based on the findings of the 'acid trail' and 'sulphur trail' lines of evidence for all samples selected for laboratory analysis, ASS or PASS are not expected to be encountered during construction activities in Areas A, B or C (where maximum depth of disturbance is understood to be 2 mbg).
- Based on field data and laboratory data, the shallow sandy soils encountered in Area A have a high buffering capacity. All other soils encountered have a low to nil buffering capacity. Buffering capacity refers to the intrinsic nature of a soil to resist changes in pH, where a high buffering capacity indicates a good resistance to change.
- The clays encountered at depth within Area A are acidic in nature. Disturbance of these acidic clays may have a negative impact on the environment by introducing an acidic medium to the naturally alkaline marine environment, although the potential risk is considered to be Nil to Very Low due to the small exposure time and rapid tidal changes in the area. Disturbance of

the acidic clays in Area A may also have a negative impact on infrastructure exposed to those clays, therefore consideration should be given to the materials used during construction, in accordance with recommendations in the report entitled *Blacktip Gas Project Nearshore Geotechnical Investigation* (WEL document number B3330RU1790079).

- Due to the alternative sample handling methods undertaken in Area C as a result of access and timing constraints, field tests and laboratory results may be biased, although still broadly indicative of the presence or absence of ASS or PASS.
- A detailed ASS management plan to remove, remediate or manage the presence of ASS or PASS is not required.

Although ASS and PASS were not identified in the areas of investigation, naturally acidic soils which may have pipeline integrity issues were noted. Due to the presence of these acidic soils, SKM recommends the following:

- Consideration should be given to the design and materials of any infrastructure that may be exposed to acidic soils across Areas A, B and C. Design should minimise disturbance of naturally acidic soils at depth and materials, should they be potentially in contact with naturally acidic soils, should be acid-resistant where possible.
- Any dredging or excavation management plans for Areas A and C should consider the effects of low pH (acidic) soils and their potential impacts on the environment.

1. Introduction

Woodside Energy Limited (WEL) proposes to develop the Blacktip Gas Project, located approximately 15km from Wadeye in the Northern Territory (NT) (the site). The proposed project involves an offshore gas production well, an incoming wet gas pipeline, an onshore plant site, and gas export facilities.

Sinclair Knight Merz (SKM) completed a desktop investigation, including an assessment of potential risks, in January 2004 identifying the possible presence of Acid Sulphate Soils (ASS) or Potential Acid Sulphate Soils (PASS) in proposed Blacktip Development project area (SKM, March 2004).

During the development of the proposed project, sub-surface soils will be disturbed and ASS or PASS may be encountered. In recognition of the potential impact exposure of these soils could have on the environment and site infrastructure, and as required in the Draft Environmental Impact Statement (EIS) guidelines produced by the Office of Environment and Heritage, Department of Infrastructure, Planning and Environment (DIPE), NT Government, WEL commissioned SKM to investigate the presence or absence of ASS and PASS soils in the Blacktip Development project area.

Please note that for the purposes of this investigation the word 'sulphate' is considered interchangeable for 'sulfate', being a simple variant in spelling. Certain guideline materials refer to 'sulphate' while others refer to 'sulfate'. 'Sulphate' is the spelling chosen for this report, although the alternative spelling is retained in report and document references.

2. Background

SKM was commissioned in January 2004 to conduct a desktop assessment to determine the potential occurrence of ASS in areas of the proposed Blacktip Development onshore plant site that will be disturbed during development activities. Results of the desktop assessment are detailed in the following report:

- *Blacktip Development Onshore Plant Site and Gas Pipeline Route, Wadeye/Port Keats, Northern Territory – Desktop Assessment of Acid Sulfate Soils* – Version 03 – 5 March 2004 (WV02540.500 R01dadUP).

Areas included in the desktop assessment (SKM, March 2004) comprised the pipeline landfall area, approximately two kilometres (km) of incoming wet gas onshore pipeline and the proposed plant site. These areas are collectively identified in this report as 'areas of the proposed development'.

The objective of the desktop assessment was to conduct a preliminary appraisal of ASS risk associated with soils in the areas of the proposed development that will be disturbed during development activities. Based on the results of the desktop assessment, SKM (March 2004) concluded the following:

- there is a moderate to high risk of ASS conditions in soils associated with the landfall and beach-crossing portion of the proposed pipeline route; and
- there is a low to nil risk of ASS conditions in soils associated with the proposed plant site and portions of the proposed pipeline route.

Based on the conclusions derived from the desktop assessment, SKM recommended that soil investigations be conducted to determine the actual presence of ASS in areas of the proposed development that will be disturbed during development activities.

Subsequent to the completion of the desktop assessment and SKM's recommendation, discussions with the NT Government identified the need to undertake an assessment of ASS conditions in the near-shore zone of the proposed development, being from lowest astronomical tide (LAT) to approximately 10 m water depth. The NT Government identified sediments within this zone as having a potentially high risk of ASS conditions if disturbed.

Geotechnical works within the near-shore zone had been completed when the sampling and analysis program for the investigation was developed. Originally the collection of samples for ASS analysis was to occur simultaneously with geotechnical works within the near-shore zone, however time and practical constraints meant that SKM was not present during these works. Preliminary information from geotechnical drilling activities indicated the presence of shallow bedrock in the near-shore zone. The presence of shallow bedrock suggests that the risk of ASS conditions might be reduced from high to 'low to moderate'. Based on this preliminary assessment, an alternative approach to ASS assessment in the near-shore zone was developed and is detailed in this report.

3. Acid Sulphate Soil Investigation

3.1 Objectives

The objectives of this ASS investigation are to:

- determine whether actual ASS are present beneath the areas proposed to be disturbed during construction activities;
- determine whether PASS are present beneath the areas proposed to be disturbed during construction activities; and
- determine whether a detailed ASS management plan is required.

3.2 Scope of Work

In order to achieve the objectives, SKM's scope of work included the completion of:

- a sampling and analysis plan;
- shallow test pits and soil bores;
- collection of soil samples;
- field testing of soil samples for pH_F and pH_{FOX};
- submission of soil samples for laboratory analysis; and
- reporting of analytical results.

3.3 Nominated Investigation Criteria

Based on discussions with Sandra Pidsley (Environmental Assessment Officer (Marine), Office of Environment and Heritage, DIPE, NT Government), the investigation of ASS conditions at the proposed Blacktip Development was conducted using the following reference:

- *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland 1998* (Ahern *et al.*, October 1998 - Revision 4.0).

These guidelines are part of the *Queensland Acid Sulfate Soil Technical Manual - Soil Management Guidelines* (Department of Natural Resources and Mines, 2002), which outlines a risk-based approach to best practice management of ASS.

3.4 Investigation Activities

Prior to completion of the investigation activities a sampling and analysis plan (SAP) was developed based on the level of risk posed by ASS in the proposed development areas. Where risks were identified as high, the sampling program is in accordance with regulatory guidelines. Where risks of ASS conditions were identified as low to moderate, a reduced sampling program was undertaken. The SAP was submitted to WEL for approval. Details of the SAP have been incorporated into this report.

3.4.1 Investigation Areas

Based on results of the desktop assessment (SKM, March 2004) and subsequent discussions with NT Government, the site was subdivided into three areas based on the risk of ASS conditions and sampling constraints. The three areas and associated sample locations are illustrated in **Figures 1** and **2, Appendix A** and are described below.

Area A – the landfall and beach-crossing portion of the proposed pipeline route, which was identified as having moderate to high risk of ASS conditions.

Area B – the proposed plant site and portions of the proposed pipeline route, which was identified as having low to nil risk of ASS conditions.

Area C – the near-shore zone of the pipeline route, within the dredge zone from LAT to 10 m water depth (estimated), which was identified as having a high risk of ASS conditions. However, preliminary review of geotechnical information obtained from this area indicated the presence of shallow bedrock, therefore a reduction to a low to moderate level of risk of ASS conditions is appropriate.

3.4.2 Sampling Density

In general, the nominated investigation criteria require the following sampling regime:

- 1 sample location per 50 metres (m) of pipeline;
- 2 sample locations per hectare (ha) of disturbed land;
- investigation of soils to at least 1 m below the depth of the proposed disturbance or to at least 2 m below the land surface, whichever is greater;
- field testing of soil samples at 0.25 m vertical intervals; and
- laboratory analysis of soil samples at 0.5 m vertical intervals.

WEL advised SKM that the maximum depth of soil disturbance associated with the proposed development is 2 metres below grade (mbg).

The sampling rationale followed in this investigation was based on consideration of the level of risk each of the proposed areas of development poses to the environment as well as specific constraints placed on sampling in some areas. The sampling rationale for each of the investigation areas is described below:

Area A

The landfall and beach-crossing portion of the proposed pipeline route were identified as having a moderate to high risk of ASS conditions (SKM, March 2004). These areas represent the highest risk to the environment (ie. near-shore marine). The sampling program in this area, including lateral and vertical sampling density, was undertaken in accordance with regulatory requirements.

A total of six boreholes were sampled within Area A (OSA12 through OSA17).

Area B

This portion of the proposed pipeline route and the proposed plant site were identified as having a low to nil risk of ASS conditions (SKM, March 2004). These areas are located away from the near shore marine environment. Based on the identified low risk and the distance from sensitive environmental receptors, the sampling program in this area was reduced with regard to lateral sampling density.

The reduction in lateral sampling density for Area B equates to one sampling point for every 500 metres of proposed pipeline and the completion of six sampling points in the area of the proposed plant site. Sampling locations at the proposed plant site were confined to the area of the site that will be disturbed during development activities (ie. building footprint areas).

Field testing of soil samples in Area B was undertaken at the recommended vertical intervals of 0.25 m. However, based on the identified reduced risk of ASS conditions in Area B, only one sample per sample location was selected for laboratory analysis. Samples selected for laboratory analysis were based on field observations and field testing. All samples collected during these works were stored for future analysis if required.

A total of four boreholes were sampled along the pipeline portion of Area B (OSB18, OSB20, OSB22 and OSA24) and six boreholes were sampled within the proposed plant site (OSB23 and OSB25 through OSB29).

Area C

The near-shore zone was identified as having a high risk of ASS conditions, therefore SKM initially proposed no reduction in sampling requirements. However, geotechnical works (comprising the drilling of ten boreholes) commenced in the near-shore zone prior to SKM reaching the site. With this constraint in mind, SKM utilised sample cores collected as part of the geotechnical works for this ASS investigation.

It should be noted that cores obtained from the near-shore zone geotechnical investigation were not collected in accordance with the general standards required for ASS analysis (ie. samples were not frozen immediately following collection and field testing for ASS was not undertaken). As such, the analytical results for these samples will provide an indication only of the potential presence of ASS and, based on discussions with laboratory personnel and marine experts, may result in a bias of results, with acidity values biased high and sulphur values biased low. However analysis of samples collected as part of the geotechnical component should provide sufficient qualitative and quantitative data to allow assessment of ASS conditions.

Based on the expected bias of laboratory results and reduced risk of ASS conditions due to the presence of shallow bedrock, a reduced sampling program was conducted in Area C. The sampling program comprised the collection and analysis of one sample (minimum) from half (five) of the ten geotechnical borehole cores completed in this area.

3.4.3 Sampling Depths

Sampling depths were based on the anticipated depth of disturbance and consideration of regulatory requirements. With an anticipated depth of disturbance of 2 mbg and a requirement to sample at least one metre below the depth of disturbance, most locations were sampled to a depth of 3 mbg. However, due to variations in site conditions, investigation depths varied in some locations as follows:

- the sampling depths were reduced at OSB20 (1.0mbg), OSB22 (1.0mbg) and OSB24 (2.75mbg) within Area B due to the presence of shallow rock; and
- sampling depths were increased to 6.0 mbg at OAS16 and OSA17 within Area A due to topographic variations and advice from Mr. Paul Hefer (Advanced Geomechanics) that the pipeline installation would be at an increased depth at these locations.

3.4.4 Sampling Procedures

As described in **Section 3.4.2**, core material had been collected as part of the geotechnical investigation in Area C prior to SKM's arrival on site. Separate sampling procedures are therefore described for Areas A and B (where samples were collected as per ASS regulatory requirements) and for Area C (where samples were not collected as per ASS regulatory requirements).

Areas A and B

ASS investigation activities within Areas A and B were conducted in association with the geotechnical works being completed for the Blacktip Development Project. On shore sampling was conducted using the equipment available (e.g. drill rig or backhoe), as detailed below:

- OSA12 to OSA17, OSB23 and OSB25 to OSB29 were completed using a drill rig equipped with a hollow flight auger with split sampler.
- All other sampling locations within Areas A and B were completed using a backhoe to complete test pits.

The sampling methodology within Areas A and B was in accordance with regulatory requirements and is described below.

- Bore logs were completed for all sample locations (included within **Appendix C**).
- Australian Map Grid (AMG52) coordinates for each sampling location was recorded on bore logs.
- Soil samples were collected at 0.25 m intervals or at changes in soil horizons, except where core losses occurred and no sample was available.
- Sampling and field testing equipment was decontaminated between sampling points using a high pressure washing system and a phosphate free detergent.
- Sampling included the recording of depths below ground level and field descriptions of texture, colour, mottling, presence of jarosite, shell or carbonate material (including abundance and size).

- Where the presence of carbonate material was confirmed in the field by a positive reaction (effervescence) with hydrochloric acid (HCl), an attempt was made to remove all visible shell material from the laboratory sample.
- Field pH tests were conducted on all field samples and included measurements of field pH (pH_F) using a field pH meter and deionised water, field peroxide pH (pH_{FOX}) using 30% hydrogen peroxide and mono-sulfides using HCl.
- Samples collected for laboratory analysis were immediately placed in sealable polyethylene containers appropriately identified using a waterproof marking pen. Air was excluded from the sampling containers and the containers were immediately placed into a portable freezer.
- The samples were kept frozen until ready for insulated transport to the laboratory using chain of custody documentation.

SKM understands that groundwater will not be dewatered during development in Areas A and B, therefore no groundwater investigations were conducted. Groundwater was not encountered during ASS investigation activities.

Area C

As identified within **Section 3.4.2**, geotechnical works in the near-shore zone, including the collection of geotechnical cores, were completed prior to SKM's arrival at the site. Information provided by Advanced Geomechanics indicates that undisturbed sample material was sealed immediately after collection to prevent moisture loss and was transported to Perth for geotechnical analysis.

SKM employed following sampling procedure for ASS in Area C soils.

- SKM was present when core/sample boxes were opened and cores were unsealed.
- Sampling included the recording of depths below ground level and field descriptions of texture, colour, mottling, presence of jarosite, shell or carbonate material (including abundance and size).
- Where the presence of carbonate material was confirmed in the field by a positive reaction (effervescence) with hydrochloric acid (HCl), an attempt was made to remove all visible shell material from the laboratory sample.
- pH tests were conducted using a field test kit on all samples and included measurements of pH (pH_F) using a pH meter and deionised water, peroxide pH (pH_{FOX}) using 30% hydrogen peroxide solution and mono-sulfides using HCl.
- Sampling and testing equipment was decontaminated between samples/tests where required.
- Samples collected for laboratory analysis were immediately placed in sealable polyethylene containers appropriately identified using a waterproof marking pen. Air was excluded from the sampling containers and the containers will be transport to the laboratory using chain of custody documentation.

As noted, initial sample handling procedures for material collected from Area C is not in accordance with regulatory requirements. As such, analytical results will provide an indication only of the potential presence of ASS.

3.4.5 Field Tests

Based on the nominated investigation criteria, to determine PASS in the field the following factors need to be considered:

- strength of the reaction with peroxide;
- the difference between pH_F and pH_{FOX}; and
- absolute pH_{FOX} values.

In addition, a simple matrix to aid in the determination of ASS and PASS in the field has been established by the former Acid Sulfate Soils Management Advisory Committee of New South Wales (ASSMAC, 2000) and is detailed below.

pH measurement type	ASS	PASS	Neither ASS or PASS
pH_F	<4	>4	>4
pH_{FOX}	<4	<4	>4

The amount of carbonate material present in a soil may be indicative of the pH buffering capacity of that soil and is estimated in the field by observing the strength of the reaction of the soils with dilute hydrochloric acid (HCl). Stronger reactions are recorded with increasing carbonate content.

3.5 Analysis Program

The laboratory analysis of samples, including those collected from Areas A, B and C, was conducted by Marine and Freshwater Research Laboratory (MAFRL). MAFRL is located at Murdoch University in Perth, Western Australia and is a NATA-accredited facility (accreditation no. 10603).

Samples were selected for analysis based on field observations, including soil type and field pH tests. All soil samples selected for analysis were analysed for the Suspended Peroxide Oxidation Combined Acidity and Sulphate (SPOCAS) suite of analytes, as detailed below:

- pH(KCL) - KCL extractable pH;
- pH(OX)- Peroxide oxidised pH;
- TAA - Total Actual Acidity;
- TPA - Total Potential Acidity;
- S(KCL) - KCL extractable sulphur;
- S(P) - Peroxide sulphur;
- S(RAS) - Residual acid soluble sulphur;

- Ca(KCL) - KCL extractable calcium;
- Ca(P) - Peroxide calcium;
- Mg (KCL) - KCL extractable magnesium;
- Mg (P) - Peroxide oxidisable magnesium; and
- ANC - Acid neutralising capacity.

In order to compare the analytical results to the action criteria specified in the regulatory guidelines, several calculations were performed. Total Sulphidic Acidity (TSA), Peroxide Oxidisable Sulphur S(POS) and pH difference were calculated.

All sample material sent to the laboratory for analysis was dried and stored appropriately at MAFRL in the event that future analysis is required.

ASS and PASS assessment of SPOCAS results is based on 2 lines of evidence: the 'acid trail' and the 'sulphur trail'. The 'acid trail' considers pH(KCL), TAA, TPA and TSA results and the 'sulphur trail' considers pH(OX), S(KCL), S(P), S(RAS) and S(POS). Ca(KCL), Ca(P), Mg (KCL) Mg (P) and ANC are used to assess buffering capacity of the soils should ASS or PASS be detected.

ASS or PASS are identified to be present when *both* the 'acid trail' *and* the 'sulphur trail' lines of evidence show indicative concentrations. If either the 'acid trail' or the 'sulphur trail' lines of evidence are incomplete (ie. below detection or action criteria) then ASS or PASS are not present.

3.6 Investigation Results

3.6.1 Field Observations

Geological bore logs for investigation locations are included within **Appendix C**. Site photographs are included within **Appendix E**.

3.6.2 Geology

Area A

The geology underlying Area A is generally characterised as light brown, fine- to medium-grained sands containing a large percentage of shell fragments to approximately 2.0 mbg, underlain by red, yellow and grey motley clays with a high plasticity to the extent of the investigation.

Area B

For the purposes of a generalised geological description, Area B is divided here into the plant site and the pipeline route.

The geology underlying the plant site portion of Area B is generally characterised as red-brown, fine- to medium-grained silty sands, becoming clayey at depth.

The geology underlying the pipeline route is generally characterised as red-brown fine- to medium-grained silty sands, becoming clayey at depths ranging from 0.75 mbg to 2.25 mbg. This material overlies gravelly sands containing pisolitic laterite to depths ranging from 0.75 mbg to 2.75 mbg, which in turn overlies cemented ferricrete. The vertical extent of the ferricrete is unknown, as the equipment available was unable to penetrate this layer.

Area C

The geology underlying Area C is generally characterised as iron-rich clay, light grey with red, brown, yellow mottles to the maximum depth of ASS investigation. It should be noted that boreholes in Area C were continued as part of the geotechnical investigations.

3.6.3 Field Tests

Field test results indicate the following:

- Based on consideration of the three factors and the matrix outlined in **Section 3.4.5**, none of the soils tested exhibited characteristics of ASS or PASS.
- Based on this assessment tool, sandy soils encountered at all sampling locations in Area A exhibited a medium to high buffering capacity, all other soils sampled exhibited a low to nil buffering capacity.

3.6.4 Analytical Results

Analytical results are included in **Table 1** through **3, Appendix B.** Laboratory certificates and chain of custody documentation is included in **Appendix D**.

Laboratory results indicate the following:

- Calculated TSA values ranged from 0 to 11 equivalent moles of hydrogen per tonne (mol H/t) with the highest levels associated with two samples from Area B and a shallow near-shore sample collected close to LAT in Area C. All calculated TSA values are below the action criteria provided in the nominated investigation criteria.
- Calculated S(POS) values ranged from <0.001 to 0.110 kilograms of hydrogen sulphide per tonne of soil (kg H_2SO_2/t of soil) with the highest levels associated with the shallow sandy soils encountered in Area A. All other S(POS) values were below the action criteria given in the nominated investigation criteria or established as effectively 0 mol H/t.
- Calculated pH differences ranged from 0 to 2.9 with the largest difference associated with the shallow sandy soils encountered in Area A.
- pH (KCl) vales ranged from 4.3 to 10.1 with the lowest pH values associated with the clays encountered in Area A and the highest pH values associated with the shallow sandy soils encountered in Area A.
- A comparison of quality control duplicate samples and their corresponding primary samples indicates an overall acceptance of field sampling techniques and analytical results.

4. Discussion of Results

Calculated TSA results above 0 mol H/t, although not exceeding action criteria within the nominated investigation criteria, were reported in two deep samples from Area B (OSB18-3.0 and OSB29-3.0) and two shallow near-shore samples in Area C (NS6-2.8 and NS10-0.1), indicative of acidic conditions. These conditions are reflected in the low field and laboratory measured pH values from those samples. The S(POS) results for the corresponding samples do not exceed the action criteria set in the nominated investigation criteria. The determination of the presence of ASS or PASS requires both the 'acid trail' and 'sulphur trail' lines of evidence to be complete (see **Section 3.5**). Based on the analytical results of this investigation, ASS and PASS are not present in Areas B or C.

Laboratory S(POS) results were recorded above the action criteria in shallow sandy soils encountered within Area A (OSA12-0.0, 0.5, 1.0; OSA13-0.5, 1.0; OSA14-0.0, 0.5, 1.0; OSA15-0.5, 1.0, 1.5, 2.5; OSA16-1.0 to 5.0 and OSA17-0.5). TSA results for the corresponding samples do not exceed the action criteria set within the nominated investigation criteria. Based on the analytical results of this investigation and the incomplete lines of evidence, ASS and PASS are not present in Area A.

The natural pH of the soils analysed is best represented by the pH (KCL) value. Based on results measured in this investigation, shallow sandy soils encountered in Area A can be broadly described as alkaline while deeper clays in Area A are acidic. Soils in Area B are slightly acidic and soils within Area C are neutral to alkaline at the surface, becoming slightly acidic at depth.

The alkalinity of the shallow sandy soils in Area A is indicative of shallow marine sediments, which interact with the naturally alkaline marine environment. Although not indicative of ASS or PASS, the acidity of the deeper (approximately 2.5 mbg) underlying clays in this area should be noted as there may be associated pipeline integrity issues. SKM understand that material excavated during construction operations will be deposited alongside the trench and used as backfill material.

Area A is located within the intertidal zone, therefore there may be environmental consequences should acidic soils be exposed to an un-buffered environment, such as exposure during low tide events. Such an occurrence could result in the leaching of acids from these soils during rainfall events and the exposure of acidic waters to the marine environment. However, given the small exposure time and rapid tidal changes in the area, the potential risks are considered to be Nil to Very Low.

Should acidic clays be exposed in Area C, the high natural buffering capacity of seawater should be sufficient to neutralise the acidity and protect the environment.

As noted in **Section 3.4.4**, initial sample handling procedures for material collected from Area C were not in accordance with regulatory requirements due to timing and access constraints during testing. Discussions with laboratory personnel and marine experts prior to analysis identified that analysis of such samples produces biased results, where acidity values are biased high and sulphur values are biased low. The data produced from analysis of samples from Area C is considered sufficient to allow both a qualitative and quantitative assessment of ASS and PASS conditions.

Correlation between field and laboratory analysed samples is sufficient for the purposes of this investigation.

5. Conclusions

Based on the result of this investigation SKM conclude that:

- Based on the findings of the 'acid trail' and 'sulphur trail' lines of evidence for all samples selected for laboratory analysis, ASS or PASS are not expected to be encountered during construction activities in Areas A, B or C (where maximum depth of disturbance is understood to be 2 mbg).
- Based on field data and laboratory data, the shallow sandy soils encountered in Area A have a high buffering capacity. All other soils encountered have a low to nil buffering capacity. Buffering capacity refers to the intrinsic nature of a soil to resist changes in pH, where a high buffering capacity indicates a good resistance to change.
- The clays encountered at depth within Area A are acidic in nature. Disturbance of these acidic clays may have a negative impact on the environment by introducing an acidic medium to the naturally alkaline marine environment, although the potential risk is considered to be Nil to Very Low due to the small exposure time and rapid tidal changes in the area. Disturbance of the acidic clays in Area A may also have a negative impact on infrastructure exposed to those clays, therefore consideration should be given to the materials used during construction, in accordance with recommendations in the report entitled *Blacktip Gas Project Nearshore Geotechnical Investigation* (WEL document number B3330RU1790079).
- Due to the alternative sample handling methods undertaken in Area C as a result of access and timing constraints, field tests and laboratory results may be biased, although still broadly indicative of the presence or absence of ASS or PASS.
- A detailed ASS management plan to remove, remediate or manage the presence of ASS or PASS is not required.

6. Recommendations

Although ASS and PASS were not identified in the areas of investigation, naturally acidic soils which may have pipeline integrity issues were noted. Due to the presence of these acidic soils, SKM recommends the following:

- Consideration should be given to minimising or avoiding the disturbance of clay material in Area A.
- Consideration should be given to the design and materials of any infrastructure that may be exposed to acidic soils across Areas A, B and C. Design should minimise disturbance of naturally acidic soils at depth and materials, should they be potentially in contact with naturally acidic soils, should be acid-resistant where possible.
- Any dredging or excavation management plans for Areas A and C should consider the effects of low pH (acidic) soils and their potential impacts on the environment.

7. References

Ahern, C.R., Ahern, M.R. and Powell, B. (1998) *Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland 1988.* QASSIT, Department of Natural Resources, Resource Sciences Centre, Indooroopilly.

ASSMAC (2000) *Acid Sulfate Soils - Keys to Success*. New South Wales Acid Sulfate Soils Management Advisory Committee.

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Sinclair Knight Merz (March 2004) *Blacktip Development Onshore Plant Site and Gas Pipeline Route, Wadeye/Port Keats, Northern Territory – Desktop Assessment of Acid Sulfate Soils* – Version 03 – 5 March 2004 (WV02540.500-R01dadUP).

Woodside Energy Limited, *Blacktip Gas Project Nearshore Geotechnical Investigation* (WEL document reference B3330RU1790079).

8. Statement of Limitations

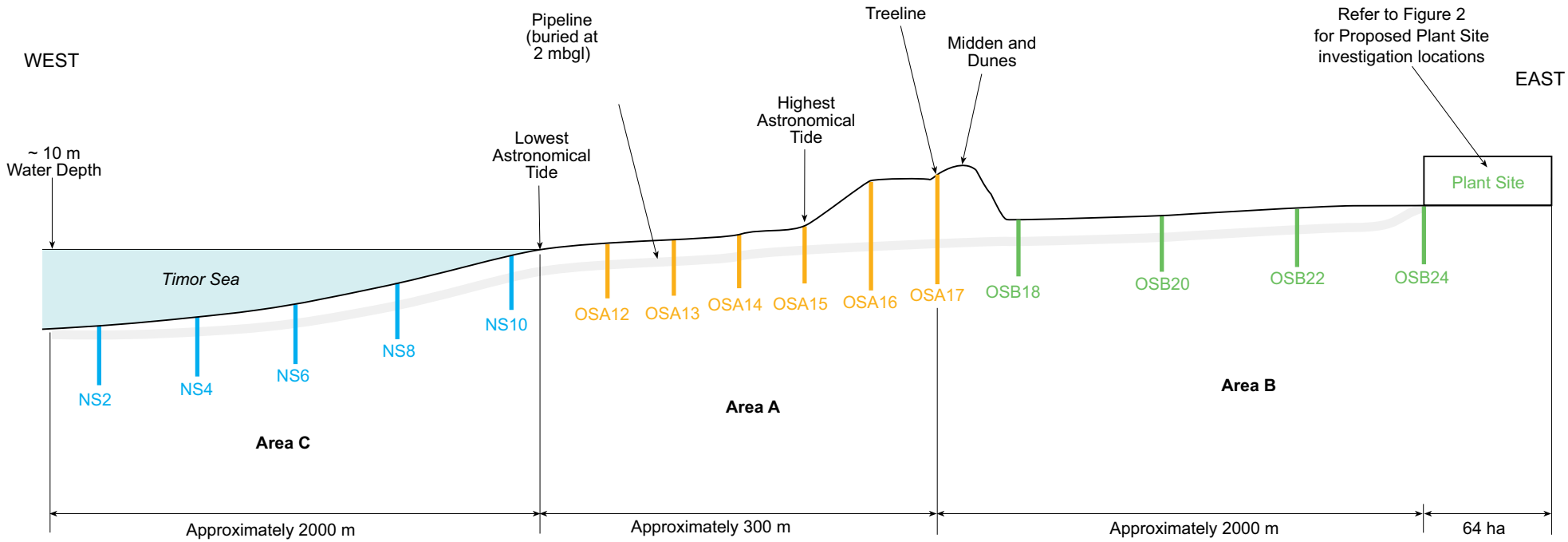
This report presents the results of this investigation, which was prepared for the purpose of this commission. The information provided herein relates only to the project of this commission and must be reviewed by a competent engineer/scientist before being used for any other purpose. SKM accepts no responsibility for other use of the information.

Where investigations have been performed and recorded by others, the data is included and used in the form provided. The responsibility for the accuracy of such data remains with the issuing authority, not with SKM.

The advice tendered in the report is based on information obtained from the locations identified in the report and is not warranted in respect to the conditions that may be encountered across the site at other than these locations.

An understanding of the site conditions depends on the integration of many pieces of information, some regional, some site specific, some structure specific and some experience based. Hence this report should not be altered, amended or abbreviated, issued in part or issued incomplete in any way without prior checking and approval by SKM. SKM accepts no responsibility for any circumstances, which arise from the issue of the report, which has been modified in any way as outlined above.

Appendix A Figures



KEY

NSX	Nearshore bore
OSAX	Onshore Area A bore
OSBX	Onshore Area B bore

- Bores OSA16 and OSA17 completed to 6 mbgs.
- All other bores completed to 3 mbgs.
- Bore logs provided in **Appendix C**.
- WEL bore nomenclature for Areas A and B included on bore logs.
- Relative locations of ASS investigation boreholes are illustrated in Figure 2.

NOT TO SCALE

Version:	2
Date Drawn:	08/12/2004
Date Printed:	09/02/2005
Project Ref:	WV02540.500

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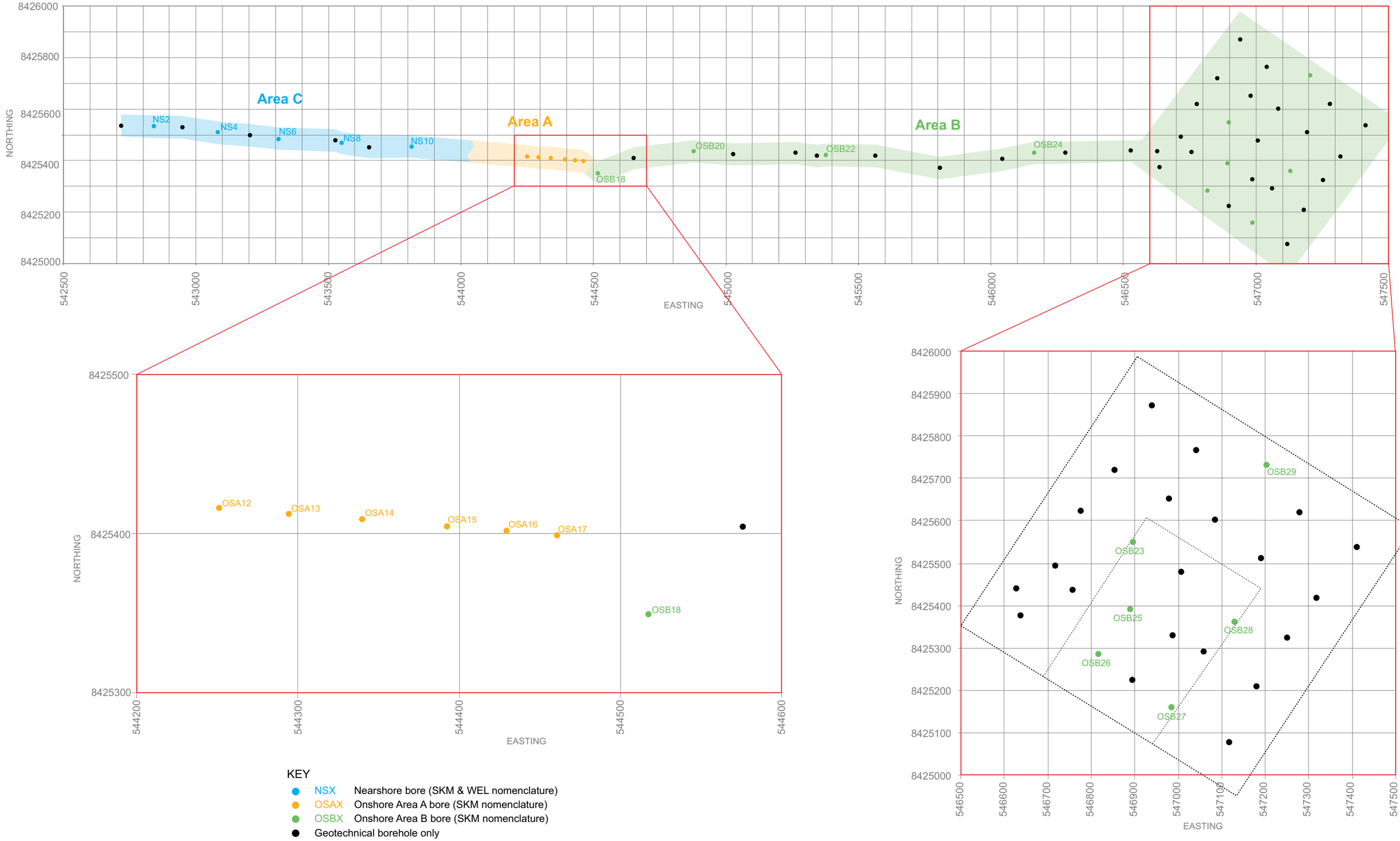
Figure 1: Conceptual Diagram Illustrating Investigation Locations
Acid Sulphate Soil Investigation
Proposed Blacktip Development



KEY

- NSX Nearshore bore (SKM & WEL nomenclature)
- OSAX Onshore Area A bore (SKM nomenclature)
- OSBX Onshore Area B bore (SKM nomenclature)
- Geotechnical borehole only

- Near shore bore locations obtained from Advanced Geomechanics bore logs
- Onshore Areas A and B locations obtained from Advanced Geomechanics Spreadsheet
- SKM bore logs provided in **Appendix C**
- WEL bore nomenclature for Areas A and B included on bore logs
- Locations provided in MGA Zone 52 format

Version:	1
Date Drawn:	10/12/2004
Date Printed:	09/02/2005
Project Ref:	WV02540.500

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Figure 2: ASS Investigation Borehole Locations
Acid Sulphate Soil Investigation
Proposed Blacktip Development

Appendix B Tables

Acid Sulphate Soils Investigation
Proposed Blacktip Development
Wadeye, Northern Territory

Table 1 - Area A SPOCAS Analytical Results (Interim)

LAB METHOD	23A	23B	23F	23Q	23G	23C	23D	23R	23V	23W	23S	23T	Calculations		
SAMPLE	pH (KCL)	pH (OX)	TAA	ANC(E)	TPA	S(KCl)	S(P)	S(RAS)	Ca(KCl)	Ca(P)	Mg(KCl)	Mg(P)	TSA	S(POS)	pH diff
			mol H/t	mol H/t	mol H/t	%S	%S	%S	%Ca	%Ca	%Mg	%Mg	(TPA-TAA)	(P-KCL)	(pH(OX)-pH(KCL))
OSA 12 0.0m	10.0	7.7	0	6200	0	0.034	0.098	0.064	0.18	10	0.052	0.44	0	0.064	2.4
OSA 12 0.5m	10.1	7.5	0	6200	0	0.031	0.096	0.065	0.16	9.9	0.060	0.44	0	0.065	2.5
QC1 (field duplicate of OSA12-0.5)	9.9	7.4	0	3700	0	0.033	0.065	0.031	0.11	5.9	0.039	0.28	0	0.032	2.5
OSA 12 1.0m	10.1	7.2	0	4200	0	0.031	0.072	0.042	0.20	6.8	0.048	0.32	0	0.041	2.9
OSA 12 1.5m	9.6	7.8	0	880	0	0.011	0.017	0.005	0.24	1.4	0.044	0.084	0	0.006	1.8
OSA 12 2.0m	7.8	7.2	0	150	0	0.011	0.005	<0.001	0.26	0.38	0.13	0.15	0	-0.006	0.6
OSA 12 2.5m	4.3	4.9	89	0	67	0.002	0.001	<0.001	0.077	0.088	0.11	0.12	-22	-0.001	-0.6
OSA 12 3.0m	4.4	4.7	112	0	92	0.003	<0.001	<0.001	0.058	0.066	0.088	0.098	-20	<0.001	-0.3
OSA 13 0.5m	10.1	7.6	0	6200	0	0.028	0.096	0.068	0.17	10	0.058	0.44	0	0.068	2.5
OSA 13 1.0m	10.1	7.7	0	8800	0	0.027	0.12	0.093	0.14	14	0.052	0.54	0	0.093	2.4
OSA 13 1.5m	9.9	7.8	0	8600	0	0.032	0.12	0.086	0.17	15	0.055	0.49	0	0.088	2.1
OSA 13 2.0m	8.9	7.4	0	470	0	0.013	0.008	<0.001	0.23	0.79	0.097	0.12	0	-0.005	1.5
OSA 13 2.5m	6.2	6.7	10	100	0	0.004	0.004	<0.001	0.24	0.29	0.14	0.16	-10	0.000	-0.5
OSA 13 3.0m	4.6	5.6	57	0	21	0.003	<0.001	<0.001	0.14	0.17	0.11	0.11	-36	<0.001	-1.0
OSA14 0.0m	9.5	8.0	0	5800	0	0.030	0.086	0.056	0.21	9.5	0.076	0.38	0	0.056	1.5
OSA14 0.5m	9.7	8.0	0	8600	0	0.026	0.12	0.091	0.18	14	0.061	0.50	0	0.094	1.7
OSA14 1.5m	9.8	8.2	0	9200	0	0.014	0.11	0.099	0.15	15	0.048	0.59	0	0.096	1.6
OSA14 2.0m	8.5	8.1	0	650	0	0.008	0.010	0.002	0.29	1.2	0.13	0.17	0	0.002	0.4
OSA14 2.5m	5.8	6.7	14	80	0	0.003	<0.001	<0.001	0.25	0.31	0.15	0.16	-14	<0.001	-0.9
OSA14 3.0m	4.8	5.8	38	0	4	0.004	0.002	<0.001	0.18	0.23	0.14	0.15	-34	-0.002	-1.0
OSA15 0.5m	10.1	7.8	0	8400	0	0.026	0.12	0.096	0.17	14	0.061	0.63	0	0.094	2.3
OSA15 1.0m	10.0	8.1	0	12000	0	0.027	0.13	0.11	0.11	20	0.052	0.54	0	0.103	1.9
OSA15 1.5m	9.9	7.9	0	12000	0	0.030	0.14	0.11	0.13	20	0.051	0.57	0	0.110	2.0
OSA15 2.5m	9.4	8.2	0	4900	0	0.026	0.066	0.040	0.18	7.4	0.071	0.34	0	0.040	1.2
OSA15 3.0m	8.3	7.6	0	170	0	0.020	0.019	<0.001	0.23	0.35	0.13	0.15	0	-0.001	0.7

KEY

1 - Laboratory methods described in *Acid Sulfate Soils, Laboratory Methods Guidelines*, Department of Natural Resources (2004)

SPOCAS - Suspended Peroxide Oxidation Combined Acidity and Sulphur

pH (KCL) - KCL extractable pH

pH (OX) - Peroxide Oxidised pH

TAA - Total Actual Acidity

ANC - Acid Neutralising Capacity

TPA - Total Potential Acidity

S(KCL) - KCL extractable Sulphur

S(P) - Peroxide Sulphur

S(RAS) - Residual Acid Soluble Sulphur

Ca(KCL) - KCL extractable Calcium

Ca(P) - Preoxide Calcium

Mg (KCL) - KCL extractable Magnesium

Mg (P) - Peroxide oxidisable Magnesium

TSA - Total Sulphidic Acidity

S(POS) - Peroxide Oxidisable Sulphur

Acid Sulphate Soils Investigation

Proposed Blacktip Development

Wadeye, Northern Territory

Table 1 - Area A SPOCAS Analytical Results (Interim)

LAB METHOD	23A	23B	23F	23Q	23G	23C	23D	23R	23V	23W	23S	23T	Calculations		
SAMPLE	pH (KCL)	pH (OX)	TAA	ANC(E)	TPA	S(KCl)	S(P)	S(RAS)	Ca(KCl)	Ca(P)	Mg(KCl)	Mg(P)	TSA	S(POS)	pH diff
			mol H/t	mol H/t	mol H/t	%S	%S	%S	%Ca	%Ca	%Mg	%Mg	(TPA-TAA)	(P-KCL)	(pH(OX)-pH(KCL))
OSA16 1.0m	10.0	8.3	0	7300	0	0.006	0.081	0.076	0.17	12	0.020	0.46	0	0.075	1.6
QC2 (field duplicate of OSA16-1.0)	9.9	7.7	0	6200	0	0.029	0.094	0.065	0.14	10	0.047	0.44	0	0.065	2.2
OSA16 1.5m	10.0	8.4	0	8600	0	0.005	0.073	0.068	0.17	11	0.026	0.43	0	0.068	1.6
OSA16 2.0m	10.0	8.2	0	7700	0	0.005	0.078	0.072	0.18	13	0.034	0.46	0	0.073	1.7
OSA16 2.5m	9.9	9.1	0	8700	0	0.006	0.099	0.093	0.15	15	0.031	0.50	0	0.093	0.9
OSA16 3.0m	9.9	8.1	0	6800	0	0.004	0.067	0.063	0.16	11	0.027	0.43	0	0.063	1.8
OSA16 3.5m	9.9	9.9	0	9400	0	0.006	0.097	0.090	0.15	16	0.039	0.54	0	0.091	0.0
OSA16 4.0m	9.9	9.8	0	11000	0	0.008	0.11	0.11	0.12	19	0.038	0.51	0	0.102	0.1
OSA16 4.5m	9.8	9.2	0	5600	0	0.010	0.037	0.027	0.12	9.5	0.023	0.23	0	0.027	0.6
OSA16 5.0m	9.9	8.9	0	6400	0	0.012	0.046	0.034	0.13	11	0.030	0.28	0	0.034	1.0
OSA16 5.5m	9.9	9.7	0	7900	0	0.012	0.037	0.025	0.16	14	0.026	0.28	0	0.025	0.2
OSA16 6.0m	8.8	7.2	0	150	0	0.006	0.003	<0.001	0.29	0.38	0.14	0.15	0	-0.003	1.5
OSA17 0.5m	9.9	9.0	0	5900	0	0.004	0.062	0.058	0.13	9.9	0.010	0.25	0	0.058	0.9
OSA17 1.0m	10.0	8.3	0	2200	0	0.004	0.019	0.015	0.15	3.2	0.010	0.091	0	0.015	1.7
OSA17 1.5m	10.0	8.0	0	2600	0	0.003	0.023	0.019	0.17	3.8	0.016	0.16	0	0.020	2.0
OSA17 2.0m	9.9	7.7	0	1700	0	0.002	0.010	0.007	0.18	2.6	0.013	0.055	0	0.008	2.2
OSA17 2.5m	9.8	8.5	0	2200	0	0.003	0.014	0.011	0.17	3.3	0.017	0.12	0	0.011	1.3
OSA17 3.0m	9.9	9.2	0	2700	0	0.003	0.017	0.015	0.18	4.1	0.020	0.15	0	0.014	0.8
OSA17 3.5m	9.9	9.4	0	3300	0	0.004	0.021	0.017	0.17	5.2	0.019	0.13	0	0.017	0.5
OSA17 4.0m	9.9	9.1	0	2300	0	0.003	0.015	0.013	0.16	3.6	0.017	0.12	0	0.012	0.8
OSA17 4.5m	9.8	9.5	0	7900	0	0.003	0.012	0.009	0.16	14	0.010	0.19	0	0.009	0.3
OSA17 5.0m	9.9	8.1	0	2900	0	0.003	0.005	0.002	0.13	4.8	0.007	0.080	0	0.002	1.8
OSA17 5.5m	9.5	8.2	0	3200	0	0.003	0.006	0.003	0.15	5.2	0.007	0.076	0	0.003	1.3
OSA17 6.0m	8.5	6.8	0	140	0	0.002	<0.001	<0.001	0.47	0.59	0.086	0.098	0	<0.001	1.7

KEY

1 - Laboratory methods described in *Acid Sulfate Soils, Laboratory Methods Guidelines*, Department of Natural Resources (2004)

SPOCAS - Suspended Peroxide Oxidation Combined Acidity and Sulphur

pH (KCL) - KCL extractable pH

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S(P) - Peroxide Sulphur

S(RAS) - Residual Acid Soluble Sulphur

Ca(KCL) - KCL extractable Calcium

Ca(P) - Preoxide Calcium

Mg (KCL) - KCL extractable Magnesium

Mg (P) - Peroxide oxidisable Magnesium

TSA - Total Sulphidic Acidity

S(POS) - Peroxide Oxidisable Sulphur

Acid Sulphate Soils Investigation

Proposed Blacktip Development

Wadeye, Northern Territory

Table 2 - Area B SPOCAS Analytical Results (Interim)

LAB METHOD[1]	23A	23B	23F	23Q	23G	23C	23D	23R	23V	23W	23S	23T	Calculations		
SKM SAMPLE REF	pH (KCL)	pH (OX)	TAA	ANC(E)	TPA	S(KCl)	S(P)	S(RAS)	Ca(KCl)	Ca(P)	Mg(KCl)	Mg(P)	TSA	S(POS)	pH diff
			mol H/t	mol H/t	mol H/t	%S	%S	%S	%Ca	%Ca	%Mg	%Mg	(TPA-TAA)	(P-KCL)	(pH(OX)-pH(KCL))
OSB18 3.0m	6.6	6.0	0	0	3	0.003	0.001	<0.001	0.052	0.052	0.007	0.008	3	-0.002	0.6
OSB20 1.0m	5.7	5.9	8	0	2	0.005	0.005	<0.001	0.007	0.007	0.011	0.013	-5	0.000	-0.2
OSB22 1.0m	6.2	5.3	3	0	0	<0.001	0.001	<0.001	0.017	0.021	0.009	0.009	-3	<0.001	0.9
OSB23 3.0m	5.8	6.4	5	0	5	0.004	<0.001	<0.001	0.011	0.007	0.015	0.016	0	<0.001	-0.5
OSB24 3.0m	5.8	5.8	5	0	3	0.006	0.005	<0.001	0.005	0.012	0.023	0.025	-3	-0.001	0.0
OSB25 3.0m	5.9	6.1	5	0	3	0.005	0.003	<0.001	0.006	0.012	0.024	0.026	-3	-0.002	-0.2
duplicate of OSB25-3.0)	6.8	6.3	0	0	2	0.003	<0.001	<0.001	0.024	0.042	0.018	0.020	2	<0.001	0.4
OSB26 3.0m	5.6	5.9	7	0	4	0.004	0.002	<0.001	0.007	0.006	0.023	0.026	-3	-0.002	-0.4
OSB27 3.0m	5.9	6.2	4	0	3	0.004	0.002	<0.001	0.007	0.006	0.021	0.023	-1	-0.002	-0.3
OSB28 3.0m	5.6	6.2	6	0	3	0.004	0.003	<0.001	0.002	0.006	0.021	0.022	-3	-0.001	-0.6
OSB29 3.0m	5.8	6.2	4	0	5	0.006	0.002	<0.001	0.002	0.007	0.020	0.021	1	-0.004	-0.4

KEY

1 - Laboratory methods described in *Acid Sulfate Soils, Laboratory Methods Guidelines*, Department of Natural Resources (2004)

SPOCAS - Suspended Peroxide Oxidation Combined Acidity and Sulphur

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Ca(KCL) - KCL extractable Calcium

Ca(P) - Preoxide Calcium

Mg (KCL) - KCL extractable Magnesium

Mg (P) - Peroxide oxidisable Magnesium

TSA - Total Sulphidic Acidity

S(POS) - Peroxide Oxidisable Sulphur

Acid Sulphate Soils Investigation
Proposed Blacktip Development
Wadeye, Northern Territory

Table 3 - Area C SPOCAS Analytical Results (Interim)

LAB METHOD	23A	23B	23F	23Q	23G	23C	23D	23R	23V	23W	23S	23T	Calculations		
SAMPLE	pH (KCL)	pH (OX)	TAA	ANC(E)	TPA	S(KCl)	S(P)	S(RAS)	Ca(KCl)	Ca(P)	Mg(KCl)	Mg(P)	TSA	S(POS)	pH diff
			mol H/t	mol H/t	mol H/t	%S	%S	%S	%Ca	%Ca	%Mg	%Mg	(TPA-TAA)	(P-KCL)	(pH(OX)-pH(KCL))
NS4 0.2	8.9	7.15	0	80	0	0.024	0.021	<0.001	0.082	0.095	0.038	0.049	0	-0.003	1.7
NS6 2.8	6.1	6.14	3	0	3	0.008	0.002	<0.001	0.007	0.009	0.018	0.019	1	-0.006	-0.1
NS8 0.8	7.3	6.12	0	0	0	0.021	0.017	<0.001	0.016	0.017	0.038	0.039	0	-0.004	1.2
NS10 0.1	8.1	6.95	0	80	11	0.025	0.022	<0.001	0.071	0.10	0.12	0.14	11	-0.003	1.2
NS2 2.6	7.1	6.17	0	0	0	0.024	0.021	<0.001	0.013	0.014	0.034	0.035	0	-0.003	0.9

KEY

1 - Laboratory methods described in *Acid Sulfate Soils, Laboratory Methods Guidelines*, Department of Natural Resources (2004)

SPOCAS - Suspended Peroxide Oxidation Combined Acidity and Sulphur

pH (KCL) - KCL extractable pH

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TAA - Total Actual Acidity

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TPA - Total Potential Acidity

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Ca(P) - Preoxide Calcium

Mg (KCL) - KCL extractable Magnesium

Mg (P) - Peroxide oxidisable Magnesium

TSA - Total Sulphidic Acidity

S(POS) - Peroxide Oxidisable Sulphur

Appendix C Soil Borelogs

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSA12** (Geotechnical Bore ID: P/BH4)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: A

Date: 1/10/2004
Job No: WV02540.500
Location: Proposed Blacktip Developmer
Easting: 544251
Northing: 8425416

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
▽surface	OSA12-0.0	SAND, red, fine to coarse grained, moderately sorted with some	xxx	8.26	6.98	
		shell fragments				
0.25	OSA12-0.25	Increased percentage of shell fragments, decreased sand percentage	xxx	8.47	7.07	
0.5	OSA12-0.5	SAND, brown, fine grained, well sorted	xxx	8.29	7.05	
0.75	OSA12-0.75		xxx	8.11	6.75	
1	Core Loss		-	-	-	
1.25	OSA12-1.25		xxx	8.55	6.65	
1.5	OSA12-1.5	SAND, gravelly, yellow/orange, medium grained poorly sorted with some	xxx	8.21	6.63	
		iron piezolites				
1.75	OSA12-1.75	CLAY, pink with red yellow grey brown mottles, high plasticity, some	x	8.62	6.21	
		laterites in vein formations within clay				
2	OSA12-2.0		-	8.23	6.37	
2.25	OSA12-2.25		-	9.12	7.21	
2.5	OSA12-2.5		-	8.75	7.17	
2.75	OSA12-2.75		-	9.21	7.25	
3	OSA12-3.0		-	9.27	7.45	
		EOH at 3mbgs as per scope of work				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSA13** (Geotechnical Bore ID: P/BH3)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: A

Date: 1/10/2004
Job No: WV02540.500
Location: Proposed Blacktip Developmer
Easting: 544294
Northing: 8425413

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
▽		shell				
		fragments				
0.25	Core Loss		xxx	8.36	6.95	
		SAND light brown, fine to coarse grained, moderately to poorly sorted with				potable water added to maintain
0.5	OSA13-0.5	increased % of shell fragments	xxx	8.41	7.01	hydrostatic equilibrium
0.75	OSA123-0.75		xxx	8.58	7.19	
1	OSA13-1.0		xxx	8.84	7.02	
1.25	OSA13-1.25		xxx	8.71	8.62	
1.5	OSA13-1.5		xxx	8.72	7.01	
1.75	OSA13-1.75		xxx	8.51	6.69	
2	OSA13-2.0	CLAY, grey with red and yellow mottles, high plasticity, minor silt content	-	8.79	6.71	
2.25	OSA13-2.25		-	8.83	6.92	
2.5	OSA13-2.5		-	8.91	7.03	
2.75	OSA13-2.75		-	8.82	7.41	
3	OSA13-3.0		-	8.83	6.79	
		EOH at 3mbgs as per scope of work				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSA14** (Geotechnical Bore ID: P/BH2)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: A

Date: 1/10/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 544340
Northing: 8425409

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
▽	OSA14-0.0	SAND, light brown, fine to medium grained, well sorted, very small shell	-	8.49	7.05	
		content				
0.25	OSA14-0.25	Increased % of shell fragments, poorly sorted	xx	8.44	7.17	
0.5	OSA14-0.5		xxx	8.41	7.03	
0.75	OSA14-0.75		xxx	8.49	7.23	
1	Core Loss		-	-	-	
1.25	OSA14-1.25		xx	8.61	6.3	
1.5	OSA14-1.5		xxx	8.47	6.41	
		CLAY, red with grey and yellow mottles and stripes, partially stratified, high				
1.75	OSA14-1.75	plasticity, some laterite pieces, moderately sorted	-	8.18	6.72	
2	OSA14-2.0		-	8.21	6.37	
2.25	OSA14-2.25		-	8.71	7.11	
2.5	OSA14-2.5	CLAY, red, well sorted, high plasticity	-	8.61	6.49	
2.75	OSA14-2.75		-	8.27	7.65	
3	OSA14-3.0		-	8.49	7.08	
		EOH at 3mbgs as per scope of work				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSA15** (Geotechnical Bore ID: P/BH1)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: A

Date: 31/9/04
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 544393
Northing: 8425405

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
▽	Core Loss		-			
0.25	Core Loss		-			
0.5	OSA15-0.5	SAND, light brown, medium to coarse grained, poorly sorted, contains shell fragments	xx	8.55	6.63	
0.75	OSA15-0.75	SAND, gravelly, cream colour, cemented, fine to coarse grained sand, shell fragments, stratified with some lateritic material	xxxx	8.41	6.17	
1	OSA15-1.0		xxxx	8.71	6.71	
1.25	OSA15-1.25		xxxx	8.23	6.82	
1.5	OSA15-1.5	SAND, light brown, fine grained, moderately sorted	xxx	8.61	6.83	
1.75	OSA15-1.75	GRAVEL, shell fragments, stratified, poorly sorted, some fine to coarse grained sands	xxxx	8.71	6.65	
2	Core Loss		-			
2.25	Core Loss		-			
2.5	OSA15-2.5	CLAY, grey with red and yellow mottles, high plasticity, minor silt content	-	8.45	7.11	
2.75	OSA15-2.75		-	8.71	7.23	
3	OSA15-3.0		-	7.31	5.75	
		EOH at 3mbgs as per scope of work				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSA16** (Geotechnical Bore ID: P/BH5)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: A

Date: 10/1/2004
Job No: WV02540.500
Location: Proposed Blacktip Developmer
Easting: 544430
Northing: 8425402

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
0.25	Core Loss		-	-	-	
0.5	Core Loss		-	-	-	
0.75	Core Loss		-	-	-	
		SAND, brown/yellow, medium to coarse grained, some shell fragments,				
1	OSA16-1.0	becoming coarser at depth	xxx	8.41	7.17	
1.25	OSA16-1.25		xx	8.23	7.45	
1.5	OSA16-1.5		xx	8.47	7.81	
1.75	OSA16-1.75		xx	8.17	7.62	
2	OSA16-2.0		x	8.11	7.31	
2.25	OSA16-2.25		x	8.03	7.11	
2.5	OSA16-2.5		x	7.62	7.01	
2.75	OSA16-2.75		x	8.19	7.27	
3	OSA16-3.0		x	8.27	7.35	
3.25	OSA16-3.25		x	8.72	7.03	
3.5	OSA16-3.5		x	8.89	7.77	

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSA16** (Geotechnical Bore ID: P/BH5)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: A

Date: 10/1/2004
Job No: WV02540.500
Location: Proposed Blacktip Developmer
Easting: 544430
Northing: 8425402

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
3.75	OSA16-3.75		x	8.43	7.52	
4	OSA16-4.0		x	8.52	7.47	
4.25	OSA16-4.25		x	8.24	7.73	
4.5	OSA16-4.5		x	8.15	6.68	
4.75	OSA16-4.75		x	8.61	7.91	
▽						
5	OSA16-5.0	SAND, coarse grained, semi-cemented with iron cemented pisolites	xx	8.27	7.56	
5.25	OSA16-5.25			8.32	7.41	
5.5	OSA16-5.5	CLAY, pink with yellow and grey mottles, moderate plasticity		8.91	7.63	
5.75	OSA16-5.75			8.31	6.87	
6	OAS16-6.0			8.05	6.95	
		EOH at 6mbgs as per scope of work (2m below proposed disturbance)				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSA17** (Geotechnical Bore ID: P/BH6)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: A

Date: 1/10/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 544461
Northing: 8425399

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
	Core Loss	Some organic material noted on surface				
0.25	Core Loss		-	-	-	
		SAND, yellow/brown, fine to medium grained, moderatly sorted, some				
0.5	OSA17-0.5	shell fragments, becoming coarser grained at depth	xxx	8.23	-	
0.75	Core Loss		xxx	-	-	
1	OSA17-1.0		xxx	8.41	7.17	
1.25	OSA17-1.25		xxx	8.87	8.03	
1.5	OSA17-1.5		xxx	8.37	7.06	
1.75	OSA17-1.75		xxx	8.41	7.73	
2	OSA17-2.0		xxx	8.66	7.83	
2.25	OSA17-2.25		xxx	8.77	7.61	
2.5	OSA17-2.5		xxx	8.41	7.53	
2.75	OSA17-2.75		xxx	8.36	7.19	
3	OSA17-3.0		xxx	8.21	7.14	
3.25	OSA17-3.25		xxx	8.75	6.73	
3.5	OSA17-3.5		xxx	8.34	6.71	

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSA17** (Geotechnical Bore ID: P/BH6)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: A

Date: 1/10/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 544461
Northing: 8425399

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
3.75	OSA17-3.75		xxxx	8.79	7.43	
4	OSA17-4.0		-	8.41	7.01	
		SAND, coarse grained, semi-cemented, some iron pisolites				
4.25	OSA17-4.25		-	8.81	7.65	
4.5	OSA17-4.75		-	8.13	6.83	
4.75	OSA17-4.75		-	8.31	7.67	
					7.41	
5.00	OSA17-5.0	SAND, silty, fine grained, well sorted	-	8.11	7.46	
▽ 5.25	OSA17-5.25		-	-	7.46	
5.5	OSA17-5.5	SAND, gravelly, coarse grained	-	8.11	7.46	
5.75	OSA17-5.75	CLAY, pink with yellow and grey mottles, moderate plasticity	-	-	7.46	
6	OSA17-6.0		-	7.21	6.3	
		EOH at 6mbgs as per scope of work (2m below proposed disturbance)				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSB18** (Geotechnical Bore ID: P/TP14)
Sample Method: Backhoe
Investigation Area: B

Date: 2/10/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 544517
Northing: 8425350

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
0	OSB18-0.0	SAND, silty, red/brown, well sorted, medium to fine grained	-	8.01	6.69	
0.25	OSB18-0.75		-	8.12	7.11	
0.5	OSB18.0.5		-	8.09	6.44	
0.75	OSB18.7.5	Increasing clay fraction, gravelly	-	8.97	6.48	
1	OSB18.1.0		-	8.79	7.01	
1.25	OSB18.1.25		-	8.27	7.43	
1.5	OSB18.1.5		-	8.11	7.21	
1.75	OSB18.1.75		-	8.47	7.26	
2	OSB18.2.0	CLAY with laterite	-	8.81	6.87	
2.25	OSB18.02.25		-	8.21	6.91	
2.5	OSB18.2.5		-	8.28	7.11	
2.75	OSB18.2.75		-	8.11	7.23	
3	OSB18.3.0		-	7.87	7.22	
		EOH at 3mbgs as per scope of work				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSB20** (Geotechnical Bore ID: P/TP12)
Sample Method: Backhoe
Investigation Area: B

Date: 2/10/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 544878
Northing: 8425435

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
	OSB20-00	SAND, silty, orange brown, decreasing plasticity, medium to fine grained, well sorted, homogenous	-	7.11	6.78	Violent Reaction...organics?
0.25	OSB20-0.25		-	7.27	6.13	
0.5	OSB20-0.5		-	7.41	6.43	
0.75	OSB20-0.75		-	7.35	6.51	
			-	7.02	6.67	
1	OSB20-1.0	Ferricrete, pisolitic, iron cemented				
		EOH - hardrock encountered				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				
1.25						
1.5						
1.75						
2						
2.25						
2.5						
2.75						
3						

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSB22** (Geotechnical Bore ID: P/TP8)
Sample Method: Backhoe
Investigation Area: B

Date: 2/10/2204
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 544377
Northing: 8425423

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
	OSB22-00	Some organic matter	-	7.77	6.83	Violent Reactions to H_2O_2...organics
		SAND, silty, orange/brown, decreasing plasticity				
		Medium to fine grained, homogenous				
0.25	OSB22-0.25		-	8.41	7.01	
0.5	OSB22-0.5		-	8.27	7.16	
0.75	OSB22-0.75		-	8.32	7.21	
1	OSB22-1.0		-	8.71	7.81	Violent Reactions to H_2O_2...organics?
		EOH - hardrock encountered				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				
1.25						
1.5						
1.75						
2						
2.25						
2.5						
2.75						
3						

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSB23** (Geotechnical Bore ID G/BH3)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: B

Date: 3/10/2304
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 546896
Northing: 8425548

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
	OSB23-00	SAND, silty, red brown, medium fine grained, well sorted, homogenous, dry	-	1.71	6.58	
		increasing silt fraction with depth,				
0.25	OSB23-0.25		-	7.74	6.47	
0.5	OSB23-0.5		-	7.85	7.12	
0.75	OSB23-0.75		-	7.64	6.54	
1	OSB23-1.0		-	7.32	6.36	
1.25	OSB23-1.25		-	7.42	6.95	
1.5	OSB23-1.5		-	7.34	6.75	
1.75	OSB23-1.75	Small clay percentage, decreasing plasticity when whet	-	7.23	6.77	
2	OSB23-2.0		-	7.39	6.89	
2.25	OSB23.2.25	SAND, gravelly, lateritic pisolites & ooliths, minor silty clay fraction,	-	7.45	6.82	
		some quartz pieces				
2.5	OSB23-2.5		-	7.86	6.93	
2.75	OSB23-2.75	soft cemented laterites	-	7.57	6.72	
3	OSB23-3.0		-	7.31	6.87	
		EOH at 3mbgs as per scope of work				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSB24** (Geotechnical Bore ID: P/TP15)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: B

Date: 2/10/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 546162
Northing: 8425429

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
	OSB24-00	SAND, silty, orange/red/brown, well sorted, fine to medium grained	-	7.01	6.91	
0.25	OSB24-0.25		-	7.61	7.23	
0.5	OSB24-0.5		-	7.62	7.11	
0.75	OSB24-0.75		-	7.71	7.23	
			-	6.69	6.13	
1	OSB24-1.0					
1.25	OSB24-1.25		-	7.69	6.89	
1.5	OSB24-1.5	SAND, gravelly, red/brown, some ferricrete, minor silt	-	7.09	6.89	
1.75	OSB24-1.75		-	6.75	6.03	
2	OSB24-2.0		-	6.81	6.11	
2.25	OSB24.2.25		-	7.05	6.27	
2.5	OSB24-2.5		-	7.11	6.71	
2.75	OSB24-2.75		-	7.83	6.63	
		EOH at 2.75m - hard cemented ferricrete				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				
3						

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSB25** (Geotechnical Bore ID: G/BH2)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: B

Date: 3/10/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 546891
Northing: 8925390

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
	OSB25-00	SAND, silty, some organics at surface, homogenous, red/brown, fine to medium	-	7.63	7.03	
		grained, silt fraction increasing with depth, dry				
0.25	OSB25-0.25		-	7.81	7.31	
0.5	OSB25-0.5		-	7.77	7.47	
0.75	OSB25-0.75		-	7.68	7.27	
1	OSB25-1.0		-	7.52	7.53	
1.25	OSB25-1.25		-	7.23	6.83	
1.5	OSB25-1.5		-	7.47	6.96	
1.75	OSB25-1.75		-	7.18	6.85	
2	OSB25-2.0		-	7.09	6.56	
2.25	OSB25.2.25		-	7.43	7.13	
2.5	OSB25-2.5		-	7.55	7.06	
2.75	OSB25-2.75		-	7.38	6.91	
3	OSB25-3.0		-	7.26	6.87	
		EOH at 3mbgs as per scope of work				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSB26** (Geotechnical Bore ID: G/BH5)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: B

Date: 3/10/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 546818
Northing: 8425284

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
	OSB26-00	SAND silty, medium fine grained, some organic matter on the surface, red/brown	-	7.34	6.43	
		Red @ depth. Well sorted, silt @ depth dry				
0.25	OSB26-0.26		-	7.73	6.72	
0.5	OSB26-0.5		-	7.37	6.68	
0.75	OSB26-0.75		-	7.34	6.82	
1	OSB26-1.0		-	7.54	6.56	
1.26	OSB26-1.25		-	7.48	6.93	
1.5	OSB26-1.5		-	7.97	7.18	
1.75	OSB26-1.75		-	7.95	7.05	
2	OSB26-2.0		-	7.58	6.97	
2.25	OSB26.2.25		-	7.95	7.05	
2.5	OSB26-2.5		-	7.62	6.95	
2.75	OSB26-2.75		-	7.16	6.64	
3	OSB26-3.0		-	7.05	6.49	
		EOH at 3mbgs as per scope of work				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSB27** (Geotechnical Bore ID: G/BH7)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: B

Date: 3/10/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 546987
Northing: 8425159

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
	OSB27-00	SAND silty medium/fine grained, red/brown homogenous	-	8.37	6.64	Violent reaction to H2O2
		silt increasing with depth, some organic matter @ surface.				Organic matter oxidising?
		Dry				
0.25	OSB27-0.25		-	8.43	6.95	
0.5	OSB27-0.5		-	7.89	7.05	
0.75	OSB27-0.75		-	8.32	7.05	
1	OSB27-1.0		-	8.26	7.18	
1.25	OSB27-1.25		-	8.34	6.31	
1.5	OSB27-1.5		-	8.11	6.92	
1.75	OSB27-1.75		-	7.93	6.56	
2	OSB27-2.0		-	7.84	6.82	
2.25	OSB27.2.25		-	7.91	6.88	
2.5	OSB27-2.5		-	7.85	6.39	
2.75	OSB27-2.75		-	7.56	6.72	
3	OSB27-3.0		-	7.66	6.93	
		EOH at 3mbgs as per scope of work				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSB28** (Geotechnical Bore ID: G/BH6)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: B

Date: 3/10/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 547131
Northing: 8425361

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
	OSB28-00	SAND silty, medium/fine grained, red brown, homogenous	-	7.79	6.93	
		silt in depth, dry				
0.25	OSB28-0.25		-	7.34	6.82	
0.5	OSB28-0.5		-	7.48	6.89	
0.75	OSB28-0.75		-	7.37	5.77	
1	OSB28-1.0	Old burnt tree? Black carbon dry fine material	-	7.89	6.65	
1.25	OSB28-1.25	SAND clayey red brown , some dry carbon pieces	-	7.82	6.75	
1.5	OSB28-1.5		-	7.73	6.95	
1.75	OSB28-1.75		-	7.56	5.36	
2	OSB28-2.0	CLAY sandy, red/brown stratified fine grained, dry	-	7.89	6.54	
2.25	OSB28.2.25		-	7.82	6.57	
2.5	OSB28-2.5		-	7.93	7.12	
2.75	OSB28-2.75		-	7.16	6.47	
3	OSB28-3.0		-	7.34	6.58	
		EOH at 3mbgs as per scope of work				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : Stephanie Sneyd
Drilled by: J & S Drilling - Advanced Geomechanics
Soil Bore ID: **OSB29** (Geotechnical Bore ID: G/BH1)
Sample Method: Hollow Flight Auger with Split Spoon Sampler
Investigation Area: B

Date: 3/10/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 547203
Northing: 8425731

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
	OSB29-00	SAND silty, medium/fine grained	-	7.64	6.37	
		No plasticity. Well sorted. Increasing silt with depth dry				
0.25	OSB29-0.25	unmeasured	-	7.95	6.43	
0.5	OSB29-0.5		-	7.97	6.89	
0.75	OSB29-0.75	SAND clayey, medium grained, low plasticity	-	8.05	6.69	
1	OSB29-1.0		-	8.18	6.32	
1.25	OSB29-1.25		-	7.31	6.26	
1.5	OSB29-1.5		-	7.92	6.34	
1.75	OSB29-1.75		-	7.56	6.11	
2	OSB29-2.0		-	7.82	6.93	
2.25	OSB29.2.25		-	7.68	6.84	
2.5	OSB29-2.5		-	7.59	6.91	
2.75	OSB29-2.75		-	7.72	6.85	
3	OSB29-3.0		-	7.93	6.56	
		EOH at 3mbgs as per scope of work				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : David Watkins
Drilled by: J & S Drilling - Advanced Geomechanics (refer to AG bore logs for full detail)
Soil Bore ID: **NS2** (Geotechnical Bore ID: NS2)
Sample Method: Core
Investigation Area: C

Date: 5/9/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 542842
Northing: 8425533

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
	Core lost	Core loss from surface down to 0.5mbgs				
0.25						
0.5	NS2-0.5	Caprock, red/brown/grey, vugs increasing to 18mm, rounded (up to 13mm), quartz	-	8.46	2.45	Volcanic reaction to H_2O_2
		pebbles cemented by iron oxides				Sample too hard for lab sampling
						reaction just oxidising fe?
0.75						
1	NS2-1.0	CLAY, sandy in a silty clay matrix, iron cemented conglomerates.	-	6.15	5.16	
1.25						
1.5		CLAY, light grey, yellow mottling, increasing plasticity				
1.75						
2						
2.25						
2.5	NS2-2.5		-	6.08	5.31	
2.75						
3						
		Hole continued for geotechnical survey, ASS investigation stopped @ 3.0mbgs				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : David Watkins
Drilled by: J & S Drilling - Advanced Geomechanics (refer to AG bore logs for full detail)
Soil Bore ID: **NS4** (Geotechnical Bore ID: NS4)
Sample Method: Core
Investigation Area: C

Date: 12/9/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 543081
Northing: 8425510

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
0.25	NS4-0.25	CLAY, light grey, mottled yellow/brown/red	-	6.85	6.17	
0.5						
0.75						
1						
1.25						
1.5						
1.75						
2						
	NS4-2.1		-	5.84	4.91	
2.25						
2.5						
2.75						
3						
		Hole continued for geotechnical survey, ASS investigation stopped @ 3.0mbgs				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : David Watkins
Drilled by: J & S Drilling - Advanced Geomechanics (refer to AG bore logs for full detail)
Soil Bore ID: **NS6** (Geotechnical Bore ID: NS6)
Sample Method: Core
Investigation Area: C

Date: 11/9/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 543311
Northing: 8425484

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
		Recovery of redrilled gravel & cobbles, black - khaki				
0.25						
0.5						
0.75						
1	NS6-1.0		-	6.84	6.81	
1.25						
1.5		CLAY with sand, grey mottled brown/red, coarse, subangular to subrounded,				
		quartz sand in highly plastic clay matrix				
1.75						
2						
2.25						
2.5	NS6-2.5		-	6.84	6.67	
2.75						
3						
		Hole continued for geotechnical survey, ASS investigation stopped @ 3.0mbgs				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by : David Watkins
Drilled by: J & S Drilling - Advanced Geomechanics (refer to AG bore logs for full detail)
Soil Bore ID: **NS8** (Geotechnical Bore ID: NS8)
Sample Method: Core
Investigation Area: C

Date: 3/10/2004
Job No: WV02540.500
Location: Proposed Blacktip Development
Easting: 543549
Northing: 8425470

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
	NS8-0.1	CLAY, light grey, mottled red/brown, iron rich	-	7.21	6.91	
0.25						
0.5						
0.75						
1						
	NS8-1.2		-	5.54	4.84	
1.25						
1.5						
1.75						
2						
2.25						
2.5						
2.75						
3						
		Hole continued for geotechnical survey, ASS investigation stopped @ 3.0mbgs				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Bore Hole Log

Logged by :	David Watkins	**Date:**	8/9/2004
Drilled by:	J & S Drilling - Advanced Geomechanics (refer to AG bore logs for full detail)	**Job No:**	WV02540.500
Soil Bore ID:	**NS10** (Geotechnical Bore ID: NS10)	**Location:**	Proposed Blacktip Development
Sample Method:	Core	**Easting:**	543815
Investigation Area:	C	**Northing:**	8425453

Depth BGL (m)	Sample Number	Lithology Description	Strength of HCL Reaction*	pH water	pH H_2O_2	Observations
	NS10-0.1	0.02m of silt gravel	-	6.57	6.52	
		CLAY, light red, mottled light grey, highly weathered, massive structure				
0.25						
0.5						
0.75						
1						
1.25						
1.5						
1.75						
2						
2.25						
2.5	NS10-2.5					
2.75						
3						
		Hole continued for geotechnical assessment, ASS investigation stopped @ 3.0m				
		* Strength of HCL reaction: '-' nil, 'x' small, 'xx' medium, 'xxx' strong				

Appendix D Laboratory Reports

MARINE AND FRESHWATER RESEARCH LABORATORY
ACID SULPHATE SOIL TESTING SPOCAS SUITE DATA

Client: Sinclair Knight Merz
Address: 7th Floor Durack centre, 263 Adelaide Terrace, WA 6001

Date of Issue: 3/12/04
Our Reference: SKM 04-9
Project No: WV02732

METHOD SAMPLE CODE	Date	23A pH (KCL)	23B pH (OX)	23F TAA mol H/t	23Q ANC(E) mol H/t	23G TPA mol H/t	23C S(KCl) %S	23D S(P) %S	23R S(RAS) %S	20B S (HCl) %S	20J S (NAS) %S	23V Ca(KCl) %Ca	23W Ca(P) %Ca	20E Ca(HCl) %Ca	23S Mg(KCl) %Mg	23T Mg(P) %Mg	20F Mg(HCl) %Mg
Detection Limit																	
File																	
OSA 12 0.0m		10.0	7.7	0	6200	0	0.034	0.098	0.064	0.22	0.18	0.18	10	25	0.052	0.44	1.3
OSA 12 0.5m		10.1	7.5	0	6200	0	0.031	0.096	0.065	0.22	0.19	0.16	9.9	23	0.060	0.44	1.2
OSA 12 1.0m		10.1	7.2	0	4200	0	0.031	0.072	0.042	0.15	0.12	0.20	6.8	16	0.048	0.32	0.89
OSA 12 1.5m		9.6	7.8	0	880	0	0.011	0.017	0.005	0.031	0.019	0.24	1.4	3.4	0.044	0.084	0.31
OSA 12 2.0m		7.8	7.2	0	150	0	0.011	0.005	<0.001	0.025	0.015	0.26	0.38	1.0	0.13	0.15	0.36
OSA 12 2.5m		4.3	4.9	89	0	67	0.002	0.001	<0.001	0.003	<0.001	0.077	0.088	0.22	0.11	0.12	0.28
OSA 12 3.0m		4.4	4.7	112	0	92	0.003	<0.001	<0.001	0.005	0.001	0.058	0.066	0.15	0.088	0.098	0.24
OSA 13 0.5m		10.1	7.6	0	6200	0	0.028	0.096	0.068	0.20	0.17	0.17	10	24	0.058	0.44	1.2
OSA 13 1.0m		10.1	7.7	0	8800	0	0.027	0.12	0.093	0.30	0.27	0.14	14	39	0.052	0.54	1.7
OSA 13 1.5m		9.9	7.8	0	8600	0	0.032	0.12	0.086	0.25	0.22	0.17	15	37	0.055	0.49	1.6
OSA 13 2.0m		8.9	7.4	0	470	0	0.013	0.008	<0.001	0.056	0.044	0.23	0.79	3.6	0.097	0.12	0.39
OSA 13 2.5m		6.2	6.7	10	100	0	0.004	0.004	<0.001	0.004	<0.001	0.24	0.29	0.68	0.14	0.16	0.37
OSA 13 3.0m		4.6	5.6	57	0	21	0.003	<0.001	<0.001	0.003	<0.001	0.14	0.17	0.39	0.11	0.11	0.27
OSA14 0.0m		9.5	8.0	0	5800	0	0.030	0.086	0.056	0.19	0.16	0.21	9.5	23	0.076	0.38	1.1
OSA14 0.5m		9.7	8.0	0	8600	0	0.026	0.12	0.091	0.29	0.26	0.18	14	38	0.061	0.50	1.5
OSA14 1.5m		9.8	8.2	0	9200	0	0.014	0.11	0.099	0.25	0.23	0.15	15	33	0.048	0.59	1.5
OSA14 2.0m		8.5	8.1	0	650	0	0.008	0.010	0.002	0.028	0.020	0.29	1.2	4.1	0.13	0.17	0.49
OSA14 2.5m		5.8	6.7	14	80	0	0.003	<0.001	<0.001	0.004	<0.001	0.25	0.31	0.76	0.15	0.16	0.38
OSA14 3.0m		4.8	5.8	38	0	4	0.004	0.002	<0.001	0.007	0.003	0.18	0.23	0.52	0.14	0.15	0.35
OSA15 0.5m		10.1	7.8	0	8400	0	0.026	0.12	0.096	0.22	0.20	0.17	14	28	0.061	0.63	1.5
OSA15 1.0m		10.0	8.1	0	12000	0	0.027	0.13	0.11	0.30	0.27	0.11	20	49	0.052	0.54	1.5
OSA15 1.5m		9.9	7.9	0	12000	0	0.030	0.14	0.11	0.32	0.29	0.13	20	51	0.051	0.57	1.6
OSA15 2.5m		9.4	8.2	0	4900	0	0.026	0.066	0.040	0.18	0.16	0.18	7.4	21	0.071	0.34	1.2
OSA15 3.0m		8.3	7.6	0	170	0	0.020	0.019	<0.001	0.039	0.019	0.23	0.35	0.71	0.13	0.15	0.35
OSA16 1.0m		10.0	8.3	0	7300	0	0.006	0.081	0.076	0.22	0.21	0.17	12	34	0.020	0.46	1.5
OSA16 1.5m		10.0	8.4	0	8600	0	0.005	0.073	0.068	0.22	0.21	0.17	11	33	0.026	0.43	1.4
OSA16 2.0m		10.0	8.2	0	7700	0	0.005	0.078	0.072	0.20	0.20	0.18	13	33	0.034	0.46	1.4
OSA16 2.5m		9.9	9.1	0	8700	0	0.006	0.099	0.093	0.28	0.27	0.15	15	42	0.031	0.50	1.6
OSA16 3.0m		9.9	8.1	0	6800	0	0.004	0.067	0.063	0.18	0.17	0.16	11	30	0.027	0.43	1.3
OSA16 3.5m		9.9	9.9	0	9400	0	0.006	0.097	0.090	0.22	0.21	0.15	16	36	0.039	0.54	1.5
OSA16 4.0m		9.9	9.8	0	11000	0	0.008	0.11	0.11	0.33	0.32	0.12	19	56	0.038	0.51	1.6
OSA16 4.5m		9.8	9.2	0	5600	0	0.010	0.037	0.027	0.089	0.079	0.12	9.5	22	0.023	0.23	0.65
OSA16 5.0m		9.9	8.9	0	6400	0	0.012	0.046	0.034	0.12	0.11	0.13	11	26	0.030	0.28	0.84
OSA16 5.5m		9.9	9.7	0	7900	0	0.012	0.037	0.025	0.10	0.090	0.16	14	32	0.026	0.28	0.85
OSA16 6.0m		8.8	7.2	0	150	0	0.006	0.003	<0.001	0.012	0.005	0.29	0.38	1.1	0.14	0.15	0.40
OSA17 0.5m		9.9	9.0	0	5900	0	0.004	0.062	0.058	0.17	0.17	0.13	9.9	28	0.010	0.25	0.88
OSA17 1.0m		10.0	8.3	0	2200	0	0.004	0.019	0.015	0.052	0.047	0.15	3.2	11	0.010	0.091	0.31
OSA17 1.5m		10.0	8.0	0	2600	0	0.003	0.023	0.019	0.066	0.062	0.17	3.8	13	0.016	0.16	0.61
OSA17 2.0m		9.9	7.7	0	1700	0	0.002	0.010	0.007	0.030	0.027	0.18	2.6	7.5	0.013	0.055	0.19
OSA17 2.5m		9.8	8.5	0	2200	0	0.003	0.014	0.011	0.039	0.036	0.17	3.3	10	0.017	0.12	0.42
OSA17 3.0m		9.9	9.2	0	2700	0	0.003	0.017	0.015	0.046	0.043	0.18	4.1	13	0.020	0.15	0.47
OSA17 3.5m		9.9	9.4	0	3300	0	0.004	0.021	0.017	0.054	0.051	0.17	5.2	15	0.019	0.13	0.44
OSA17 4.0m		9.9	9.1	0	2300	0	0.003	0.015	0.013	0.039	0.036	0.16	3.6	11	0.017	0.12	0.43
OSA17 4.5m		9.8	9.5	0	7900	0	0.003	0.012	0.009	0.037	0.034	0.16	14	36	0.010	0.19	0.62
OSA17 5.0m		9.9	8.1	0	2900	0	0.003	0.005	0.002	0.012	0.009	0.13	4.8	13	0.007	0.080	0.30
OSA17 5.5m		9.5	8.2	0	3200	0	0.003	0.006	0.003	0.023	0.020	0.15	5.2	17	0.007	0.076	0.33
OSA17 6.0m		8.5	6.8	0	140	0	0.002	<0.001	<0.001	0.001	<0.001	0.47	0.59	1.3	0.086	0.098	0.25
OSB18 3.0m		6.6	6.0	0	0	3	0.003	0.001	<0.001	0.002	<0.001	0.052	0.052	0.10	0.007	0.008	0.016

Signatory: JW
Date: 10/1105

MARINE AND FRESHWATER RESEARCH LABORATORY
ACID SULPHATE SOIL TESTING SPOCAS SUITE DATA

Client: Sinclair Knight Merz
Address: 7th Floor Durack centre, 263 Adelaide Terrace, WA 6001

Date of Issue: 3/12/04
Our Reference: SKM 04-9
Project No: WV02732

METHOD SAMPLE CODE	Date	23A pH (KCL)	23B pH (OX)	23F TAA mol H/t	23Q ANC(E) mol H/t	23G TPA mol H/t	23C S(KCl) %S	23D S(P) %S	23R S(RAS) %S	20B S (HCl) %S	20J S (NAS) %S	23V Ca(KCl) %Ca	23W Ca(P) %Ca	20E Ca(HCl) %Ca	23S Mg(KCl) %Mg	23T Mg(P) %Mg	20F Mg(HCl) %Mg
Detection Limit																	
File																	
OSB20 1.0m		5.7	5.9	8	0	2	0.005	0.005	<0.001	0.007	0.002	0.007	0.007	0.010	0.011	0.013	0.028
OSB22 1.0m		6.2	5.3	3	0	0	<0.001	0.001	<0.001	<0.001	<0.001	0.017	0.021	0.040	0.009	0.009	0.027
OSB23 3.0m		5.8	6.4	5	0	5	0.004	<0.001	<0.001	0.002	<0.001	0.011	0.007	0.004	0.015	0.016	0.037
OSB24 3.0m		5.8	5.8	5	0	3	0.006	0.005	<0.001	0.005	<0.001	0.005	0.012	0.008	0.023	0.025	0.059
OSB25 3.0m		5.9	6.1	5	0	3	0.005	0.003	<0.001	0.006	0.001	0.006	0.012	0.011	0.024	0.026	0.059
OSB26 3.0m		5.6	5.9	7	0	4	0.004	0.002	<0.001	0.001	<0.001	0.007	0.006	0.004	0.023	0.026	0.062
OSB27 3.0m		5.9	6.2	4	0	3	0.004	0.002	<0.001	0.002	<0.001	0.007	0.006	0.008	0.021	0.023	0.053
OSB28 3.0m		5.6	6.2	6	0	3	0.004	0.003	<0.001	0.005	<0.001	0.002	0.006	0.003	0.021	0.022	0.051
OSB29 3.0m		5.8	6.2	4	0	5	0.006	0.002	<0.001	0.004	<0.001	0.002	0.007	0.004	0.020	0.021	0.053
QC1		9.9	7.4	0	3700	0	0.033	0.065	0.031	0.15	0.11	0.11	5.9	15	0.039	0.28	0.88
QC2		9.9	7.7	0	6200	0	0.029	0.094	0.065	0.24	0.21	0.14	10	29	0.047	0.44	1.6
QC4		6.8	6.3	0	0	2	0.003	<0.001	<0.001	0.004	0.001	0.024	0.042	0.048	0.018	0.020	0.050
CARRARA		4.4	2.1	106		859	0.64	1.6	0.96	1.3	0.67	0.38	0.40	1.3	0.15	0.17	0.89

Signatory: JW
Date: 10/1/05

MARINE AND FRESHWATER RESEARCH LABORATORY
ACID SULPHATE SOIL TESTING SPOCAS SUITE DATA

Client: Sinclair Knight Merz
Address: 7th Floor Durack centre, 263 Adelaide Terrace, WA 6001

Date of Issue: 3/12/04
Our Reference: SKM 04-8

METHOD SAMPLE CODE	Date	23A pH (KCL)	23B pH (OX)	23F TAA mol H/t	23Q ANC(E) mol H/t	23G TPA mol H/t	23C S(KCl) %S	23D S(P) %S	23R S(RAS) %S	20B S (HCl) %S	20J S (NAS) %S	23V Ca(KCl) %Ca	23W Ca(P) %Ca	20E Ca(HCl) %Ca	23S Mg(KCl) %Mg	23T Mg(P) %Mg	20F Mg(HCl) %Mg
Detection Limit																	
File																	
NS4 0.2		8.9	7.15	0	80	0	0.024	0.021	<0.001	0.049	0.025	0.082	0.095	0.34	0.038	0.049	0.15
NS6 2.8		6.1	6.14	3	0	3	0.008	0.002	<0.001	0.011	0.003	0.007	0.009	0.015	0.018	0.019	0.049
NS8 0.8		7.3	6.12	0	0	0	0.021	0.017	<0.001	0.038	0.017	0.016	0.017	0.037	0.038	0.039	0.10
NS10 0.1		8.1	6.95	0	80	11	0.025	0.022	<0.001	0.047	0.022	0.071	0.10	0.17	0.12	0.14	0.37
NS2 2.6		7.1	6.17	0	0	0	0.024	0.021	<0.001	0.047	0.024	0.013	0.014	0.031	0.034	0.035	0.092
CARRARA		4.4	2.1	106		868	0.64	1.6	0.97	1.3	0.67	0.38	0.40	1.3	0.15	0.17	0.89

Signatory: JW
Date: 10/11/05

Appendix E Site Photographs

Plate 1: Drilling at location OSA12 (Geotechnical Bore ID: P/BH4).

Plate 2: Looking east from OSA13 (Geotechnical Bore ID: P/BH3) towards the beach area.

Plate 3: Core collection from OSA14 (Geotechnical Bore ID: P/BH2); 1.0 - 2.0 mbgs.

Plate 4: Core collection from OSA14 (Geotechnical Bore ID: P/BH2); 2.0 - 3.0 mbgs.

Plate 5: Logging and collection of geotechnical samples - beach area.

Plate 6: Drilling of OSA17 (Geotechnical Bore ID: P/BH6) near the tree-line.

Plate 7: View of Area C, looking west towards LAT.

Plate 8: Core collection from OSA17 (Geotechnical Bore ID:P/BH6); 5.0 - 6.0 mbgs.

Plate 9: View into test pit location OSB18 (Geotechnical Bore ID: P/TP14) along the proposed pipeline corridor of Area B.

Plate 10: Soils removed from OSB18 (Geotechnical Bore ID: P/TP14).

Plate 11: Backhoe digging test pit location OSB20 (Geotechnical Bore ID: P/TP12) within Area B.

Plate 12: Completed test pit OSB20 (Geotechnical Bore ID: P/TP12) along the proposed pipeline corridor of Area B.

Plate 13: Measurement of test pit depth at OSB20 (Geotechnical Bore ID: P/TP12).

Plate 14: Sample collection for field tests and laboratory analysis.

Plate 15: Drilling of OSB25 (Geotechnical Bore ID: G/BH2) within the proposed plant site (Area B).

Plate 16: Core collected and sampled from the proposed plant site (Area B).

Plate 17: Setup of test kit used for ASS field testing.

Plate 18: SKM Field Scientist completing field tests for ASS samples.