coffey geotechnics
SPECIALISTS MANAGING THE EARTH

BELLVISTA 2 – PRECINCT 1
BELLVISTA BOULEVARD, CALOUNDRA

ACID SULFATE SOILS INVESTIGATIONS

BROWN CONSULTING (QLD) PTY LTD

GEOTKPAR01560AA/B (Rev3)
30 November 2010

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
1/36 Kerryl Street Kunda Park QLD 4556 Australia
PO Box 5537 Maroochydore South QLD 4558 Australia

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

30 November 2010

Brown Consulting (Qld) Pty Ltd
P.O. Box 997
Buddina Qld 4575

Attention: Mr Brent Thomas

Dear Sir,

RE: **Bellvista 2 – Precinct 1**
Bellvista Boulevard, Caloundra
Acid Sulfate Soils Investigations

Coffey Geotechnics Pty Ltd (Coffey) was commissioned by Mr Brent Thomas of Brown Consulting (Qld) Pty Ltd on behalf of Stockland Caloundra Downs Pty Ltd to undertake acid sulphate soils investigations and assessments for the proposed subdivision of Precinct 1 of the Bellvista 2 Estate in Bellvista Boulevard at Caloundra. The investigations and assessments are set out in this report.

Should you wish to discuss any aspect of this report, please contact Ron McMahon in our Kunda Park office.

For and on behalf of Coffey Geotechnics Pty Ltd

Ron McMahon

Principal Engineer

Figures

Appendices

1 INTRODUCTION

Coffey Geotechnics Pty Ltd (Coffey) was commissioned by Mr Brent Thomas of Brown Consulting (Qld) Pty Ltd (Browns) on behalf of Stockland Caloundra Downs Pty Ltd to undertake acid sulphate soils (ASS) investigations and assessments for the proposed subdivision of Precinct 1 which is part of the Bellvista 2 Estate at Bellvista Boulevard, Caloundra.

2 PROPOSED DEVELOPMENT

Precinct 1 of the proposed development covers some 45.1 hectares. The development involves some 21.0 hectares of mixed use residential precinct and 14.4 hectares of open space. The works will include the placement of imported fill on the lots, the construction roads and the installation of services. Open drains between 2 and 4 metres deep will be constructed along the northern side of Precinct 1. The proposed layout is shown in the development plan provided by Browns, a copy of which is attached.

3 FIELDWORK

Fieldwork was undertaken between 17 April and 5 May 2009 under the direction of a principal engineer from Coffey's Kunda Park office. A total of 18 boreholes were drilled to a depth of 6 metres, 18 boreholes to a depth of 4 metres and 20 boreholes to a depth of 3 metres on the site. In addition, 18 boreholes were drilled immediately adjacent to Precinct 1 on the southern side. Dynamic cone penetrometers (DCP) testing to depths up to 1.5 metres was conducted adjacent to each borehole. Borehole logs and DCP blow counts are attached in **Appendix A** together with explanation sheets defining the terms and symbols used. Borehole locations are shown in **Figure 1**.

Soils samples were collected at 0.25 metre depth intervals to depths between 3 and 4 metres in all boreholes. Samples were placed in resealable plastic bags and chilled in the field. Selected samples were packed into oxygen impermeable bags for transport to the analytical laboratory.

A walkover inspection was conducted by engineers and soil scientists from Coffey's Kunda Park office. The topography and surface features were noted.

4 LABORATORY TESTING

Laboratory testing for ASS was undertaken at the analytical laboratories of BioTrack Pty Ltd at Highvale. Samples were taken at 0.25 metre depth intervals from fifteen boreholes in Precinct 1. In addition, samples from seven boreholes in Precinct 2 were sent for screen testing. The screen test method used was the peroxide oxidation method set out in the QASSIT Guidelines (1998). A total of 240 samples from within or immediately adjacent to Precinct 1were tested by this method. In addition, 104 samples from Precinct 2 were also screen tested. The test certificates showing all results are attached in **Appendix B**.

The samples taken at 0.5 metre depth intervals from sixteen boreholes in or immediately adjacent to Precinct 1 and seven boreholes in Precinct 2 were sent for quantitative analyses. The quantitative test method was:

- the measurement of total actual acidity (TAA) and preoxidation sulfur (S kcl) to assess the nature and severity of the pre-existing acidity.

- the measurement of chromium reducible sulfur (S_{Cr}) and residual acidity (s–NAS) to determine acid generating potential.

A total of 120 samples from within Precinct 1 or from the immediately adjacent areas were tested by this method. Test certificates showing all results are attached in **Appendix B**.

5 SITE CONDITIONS

5.1 Topography and Site Description

Precinct 1 is a more or less triangular area off the south eastern side of Bellvista Boulevard at Caloundra. It adjoins the Caloundra airport property in the northeast.

The lot is at an elevation of about RL 5 to 6 metres AHD along the Bellvista Boulevard frontage and slopes down to the southeast and southwest away from the boulevard frontage with an average gradient less than 1% to an elevation of about RL 2 metres in the southern parts of the site. A natural drainage line flows to the south around the south western end of the precinct.

Precinct 1 has been previously cleared of the endemic vegetation. A dense exotic grass cover is established over the site. Larger woody vegetation within Precinct 1 precinct was generally in the form of regrowth and limited to areas along the existing drainage lines. Tree species identified included *Pinus radiate, Acacia melanoxylon, Lophostemon suaveolens, Melaleuca quinquenervia* and various Eucalyptus species.

5.2 Geology and Geomorphology

According to the 1:100 000 Geological Series mapping, sheet 9444 and part 9544, prepared by the Department of Mines and Energy Queensland, the site is underlain by Quaternary alluvium (mapping unit Qa). This unit consists predominantly of sands and silty sands in this area. The alluvium is underlain at shallow depth by residual soils derived from the Late Triassic to Jurassic Landsborough Sandstones (mapping unit RJl). This sequence is predominately sandstone in this area.

5.3 Subsurface Profile

The subsurface profile was inferred from the Coffey boreholes on the site. The soil profile generally consists of upper alluvial sand and silty sand strata overlying residual clayey sands and sands underlain by stiff residual sandy clays. Sandy clay/clayey sand fill soils between 200 mm and 600 mm deep were noted in three boreholes. The compaction history of the fill is not known. The upper sandy profile

consists of a silty sand topsoil 200 mm to 300 mm thick overlying the subsoils. Organic matter was present in the topsoils but was a relatively small percentage of the soil mass at depths greater than 200 mm. The subsoils are medium dense to very dense sands and clayey sands. In some areas the subsoils are indurated. The depth of the upper sand strata varies from 0.6 metres deep to more than 3 metres deep overlying the residual clay soils.

The underlying sandy clays are derived from the in situ weathering of the Landsborough Sandstones and grade to sandstone with depth. The clays are stiff to very stiff in consistency. Laboratory testing was not undertaken but Coffey's experience with these clays and visual classification indicates that they have a high plasticity and are moderately reactive.

5.4 Hydrology

Groundwater was recorded at depths generally between 0.5 and 1 metre in boreholes on the site. The groundwater appeared to be a perched water table in the upper sand profile which is underlain by the residual clay soils.

Investigations were undertaken during periods of higher than average rainfall and it may be that during drier periods, the groundwater trapped in the upper sands is transpired out of the profile or seeps vertically or laterally off the site. During period of prolonged dry weather, it is expected that the groundwater in the upper parts of the site will not be present.

However, the site is relatively flat with slow surface drainage and the profile consists of sandy soil overlying low permeability clays. It should be anticipated that, during periods of prolonged heavy rainfall, the water table may be higher than that recorded in boreholes during these investigations. All structure and drain design and construction planning should anticipate the possibility of high groundwater levels.

6 ACID SULFATE SOIL ASSESSMENT

6.1 Acid Sulfate Soil Hazards

Acid sulfate soils (ASS) are soils that contain iron pyrites. The pyrite is formed under specific conditions. These conditions require the presence of iron, sulfur and organic matter and generally occur in alluvial and marine soils.

The pyrites oxidise when exposed to oxygen and will, when combined with water, form sulfuric acid. This normally occurs when soil conditions are changed from anaerobic to aerobic.

The sulfuric acid will leach out of the soil and may lower the pH of receiving waters, increase the levels of metals in the receiving waters (particularly iron and aluminium) and strip the natural neutralising capacity from the receiving waters. These consequences can have a serious impact on the receiving environment and its biosystem.

There are two basic types of ASS. These are actual acid sulfate soils (AASS) which are soils in which the pyrite has already been oxidised and sulfuric acid is present in the soil and potential ASS (PASS) where the pyrite is present but has not been oxidised. Both AASS and PASS have the potential to do environmental harm.

If ASS are present on the site, the proposed development could disturb these soils by:

- removal of ASS from below the surface to be placed in aerobic conditions above ground during the excavation of open drains along the northern and south eastern sides of Precinct 1
- removal of ASS from below the surface to be placed in aerobic conditions above ground during the stripping of topsoil on the site
- excavation of ASS during trenching for services on the site
- displacement of ASS during fill placement on the site
- lowering of the groundwater through improved drainage which may allow the oxidation of in situ PASS

The investigations undertaken were designed to evaluate the nature and extent of any ASS risk posed by these mechanisms.

6.2 Zoning Possible Acid Sulfate Soil

A desktop review of the Department of Environment and Resource Management (DERM) ASS risk mapping indicates that the site has a low probability of ASS occurrence with the land between the RL 5m AHD contour and the outer limits of Holocene, estuarine ASS. The relevant parts of the risk map are shown in **Figure 2** attached.

Topographic mapping available through the Sunshine Coast Regional Council online mapping shows that part of the site is situated above RL 5m AHD, thus ASS is not likely to be present in these soils. Most of the site however is below RL 5 m and ASS may be present.

The site is underlain by residual soils derived from the Jurassic period. It can be reasonably assumed through previous experience with these soils and their historical formation that the residual soils on the site not likely to be ASS.

The residual soils across the site are overlain by alluvial sand and silty sand and occasional intrusions of sandy clay and clayey sand. Any potential or actual acid sulfate soils, if present, are likely to be confined to soils below 5m AHD and soils within the alluvial strata.

7 ANALYSIS OF ACID SULFATE SOIL TESTING

7.1 Screen Testing Analysis

Analyses of the soils were undertaken at the analytical laboratories of BioTrack Pty Ltd at Samford. All 240 samples from within or immediately adjacent to Precinct 1 were tested by the peroxide screen test method. The qualitative screen test results indicated low to high titratable actual acidity (TAA) with preoxidation pH generally in the range 4.8 to 5.4. Screen tests results also indicated low to high titratable peroxide acidity (TPA) and low to high sulfides possible in the soil profiles. Some 120 selected samples were further tested by definitive quantitative analyses to assess the nature of the acidity and to quantify the sulfur content.

7.2 Quantitative Testing Analyses

A total of 120 samples from Precinct 1 and the immediately adjacent area were further tested for actual acidity and potential sulfuric acidity by quantitative laboratory analyses. Actual acidity was measured by the total actual acidity (TAA) plus preoxidation sulfur (S KCl) methods. Acid generating potential was measured by using the chromium reducible sulfur (S Cr) method and residual acidity (s–NAS).

7.2.1 Actual Acid Sulfate Soils (AASS)

Of the 120 samples selected for quantitative testing, the measured TAA values varied from 0 to more than 80 moles per tonne. More than half the samples showed TAA values above the QASSIT threshold of 18 moles per tonne which defines actual acidic soils. The preoxidation sulfur levels however were all below 0.01%, the limit of registration for the test method. These soils are thus mildly acidic but the acid is not sulfuric. This is common in the older leached soils derived from the weathering of the sedimentary rock in coastal Queensland. The soils are not AASS (**nonAASS**).

7.2.2 Potential Acid Sulfate Soils (PASS)

The oxidisable sulfur levels as measured by the chromium reducible sulfur method (S Cr) were less than or equal 0.01%, the limit of registration for the test method, for all samples. Similarly, s-NAS, a measure of the residual acidity, was below 0.01%, the limit of registration, for all samples. The QASSIT threshold for defining PASS is 0.03%S. The soils to be disturbed are thus not potential acid sulfate soils (**nonPASS**).

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Actual Acidity

Based on the laboratory results and borehole logs, all soils are nonAASS. They are thus not required to be managed as set out in the State Planning Policy SPP2/02. There is no requirement for the preparation of an ASS management plan.

However, the soils are acidic with an average natural non sulfuric acidity above the QASSIT threshold. This natural acidity left undisturbed would slowly leach out into the receiving environment causing no environmental harm (with the natural ecosystem adapted to such inputs). The Environmental Protection Act bestows a general environmental duty (GED) on all works. It is therefore recommended that some preventative treatment of excavated soils be undertaken. A draft guideline prepared by QASSIT suggests liming of the excavated soils and batters as a management tool. While the draft guideline does not require mixing of the lime and soil, Coffey suggests some mixing of the soil and lime by the excavator during digging and handling operations on the site.

The recommended liming rate for excavated soils is 4 kilograms fine agricultural lime per cubic metre. This requirement should be set out in the EMP for the site.

8.2 Potential Acidity

Based on the laboratory results and borehole logs, the soils on the site are nonPASS and are not subject to the requirements of SPP2/02.

8.3 Further Investigations

The detail of the investigation undertaken on the site is below that recommended in the QASSIT Guidelines (1998). Further investigation is not deemed necessary for the following reasons:

- A large number of boreholes (equivalent to the QASSIT Guideline recommended frequency) have been drilled on the site. These boreholes have indicated that the soil profiles are relatively consistent and no paleochannels or other potential ASS hotspots are present.

- The tested actual and potential sulphuric acidity in every sample analysed (120 in Precinct 1 and a further 52 in the adjacent Precinct 2) was below the limit or registration of the test method. The samples tested included upper alluvial sands and the underlying residual sandy clays. All samples were nonASS.

- Any excavations deeper than the depths investigated will be into residual soils derived from the in situ weathering of the underlying sandstones. Such the deeper residual soils are unlikely to be ASS and the testing has confirmed this.

- Most of the earthworks proposed for the site involve the placement of imported fill on the site. The site soils are all over consolidated with respect to likely fill and structural loads. There will thus be no significant settlement. In addition, soil shear strengths are in excess of 50 kPa and there is no risk of soil heaving adjacent to fill areas. The concerns expressed in SPP2/02 with respect to filling are thus not an issue on this site because the soils are not ASS and the mechanisms for potential harm will not occur.

- Some earthworks will involve the disturbance of on site soils for service trenching and drain excavation. All soils likely to be disturbed have been shown by investigations to be nonASS.

It is thus suggested that further ASS investigation is not necessary and that this ASS investigation report be submitted for consideration based on the data currently available.

8.4 Final Comments

Based on the assessment of geology, geomorphology, topography, hydrology and laboratory testing, the proposed works on the site will not encounter AASS or PASS and the requirements of SPP2/02 do not apply. Some of the soils in their present state are slightly acidic (non-sulfuric) and disturbance of these soils could mobilise the acidity. Coffey recommends the management of these soils as set out in Section 8.1 of this report.

For and on behalf of Coffey Geotechnics Pty Ltd

Ron McMahon

Principal Engineer

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

Important information about your **Coffey** Report

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.
Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.