Title:
Difference Plot 2003 - 2004 & 2004 - 2005

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

Filepath: \B18625\L.mja_Seaaway\DRG\DRG_008_111129_Difference_Plot_2003-2005.wor

FOR INFORMATION ONLY
Title: Difference Plot 2007 - 2008 & 2008 - 2009

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

Filepath: \B18625_L.mja_Seaway\DRG\DRG_010_111129_Difference Plot 2007-2008.wor
Title: Difference Plot 2009 - 2010 & 2010 - 2011

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
Title: Difference Plot 2001 - 2002 & 2001 - 2011

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant guarantee or make representations regarding the currency and accuracy of information contained in this map.

Filepath: N:\B18625.L.mja_Seaway\DRG\DRG_012_111129 Difference Plot 2011.wor
4 GEOTECHNICAL ASSESSMENT

An assessment of the current factor of safety for the rock training walls, based on the most recent cross sectional survey (2011), was carried out by Coffey Geotechnics Pty Ltd. The full report is contained in Appendix A and the major conclusions are summarised below.

All five surveyed cross sections of the Training Walls were assessed and it is considered that two of the sections have the most critical profiles. The two sections are:

- CH00 – Breakwater section; and
- CH375 – Revetment section.

The shallow surface failures have been ignored in the assessments. The critical FOS values are of the order of 1.0 with the failure surfaces limited to the sand batter and the toe of the embankment (see Figure 1 and Figure 2 in Appendix A of Appendix A). Deeper critical circle failures pass through the rock batter and indicate FOS values of 1.15 and 1.14.

The above values indicate marginal stability unless remedial measures are carried out.
5 FUTURE MONITORING

It is recommended that monitoring surveys be continue to be undertaken at least annually as at present and the following actions be taken after each survey:

- Continue plotting the existing sections from CH 00 to Ch 500 and assess the maximum slope angle and note sections which are getting steeper (around 32 degrees is critical);
- Use the contour plan of the survey to check that the spatial extent of the hole is covered and that the maximum slope angle is captured;
- Assess the volume of the entrance and determine whether scouring or accretion has occurred (optional); and
- Use video monitoring of the maximum slopes near the southern wall as a visual reference in conjunction with diving inspections of the bypassing pipeline.
CONCLUSIONS

There is evidence that the entrance channel is continuing to scour. However, since the early 1990's this has been spatially rather than deepening of the existing holes. The rate of scour appears to be decreasing and is currently about 20,000 m³/year. It is likely that the channel will increase in area, i.e. scour, until an area proportionate with the tidal prism is reached. At the current rates of change this could take another 5-10 years under current conditions. This could be extended by events which may increase the tidal prism such as canal development, channel dredging and sea level rise.

With regard to the training wall stability, the geotechnical assessment has indicated that the factor of safety has reduced to around 1.0 in some areas near the scour holes. These values indicate marginal stability unless remedial measures are carried out.

An investigation of remedial actions is recommended. These may include rock protection of the bank slopes, channel flow re-balancing or possible re-design of the training wall sections.
APPENDIX A: GEOTECHNICAL REPORT
Fax Transmission

To: Malcolm Andrews
Fax No: E-mail
From: Zen Ng
Date: 11 November 2011
Company: BMT WBM Pty Ltd
Reference: GEOTNEWS20895AA-AB-01
cc: BMT WBM Pty Ltd
Pages: 1 of 9
Subject: Stability Assessment of the Gold Coast Seaway Entrance

1 INTRODUCTION

Coffey Geotechnics Pty Ltd (Coffey) has been commissioned by BMT WBM Pty Ltd (BMT WBM) to assess the stability of the Training Walls and the likely failure scenario at Seaway Entrance located at the Gold Coast, Queensland.

This fax discusses the assumptions adopted for the analysis and presents the assessment results.

2 GEOLOGICAL MODEL & ADOPTED PARAMETERS

The adopted geometry of the Training Walls and the river channel has been based on the survey information provided by BMT WBM. Representative cross sections have been developed from the survey information incorporating the design cross sections.

The strength parameters of the material used in the Training Walls are developed based on the information provided by BMT WBM, including the descriptions, weights and photos of the materials. The parameters adopted in the analysis are summarized in Table 1 below. A sensibility check of the parameters indicates that these are within the expected range for the material types based on description provided by BMT WBM.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Density (kN/m³)</th>
<th>c' (kPa)</th>
<th>Φ (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beach Sand</td>
<td>16</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>Rocky Fill</td>
<td>22</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>Core Material</td>
<td>22</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>Concrete Block</td>
<td>22</td>
<td>0</td>
<td>40</td>
</tr>
</tbody>
</table>

The sea level through the embankment was kept at the same level as the sea level.
3 ASSESSMENT RESULTS

All five surveyed cross sections of the Training Walls have been assessed and it was assessed that two of the sections have the most critical profiles. The two sections are:

- CH00 – Breakwater section
- CH375 – Revetment section

The shallow surface failures have been ignored in the assessments. The critical FOS values are of the order of 1.0 with the failure surfaces limited to the sand batter and the toe of the embankment (see Figure 1 and Figure 2). Deeper critical circle failures pass through the rock batter and indicate FOS values of 1.15 and 1.14 (see Figure 3 and Figure 4) for the sections analysed. The above values indicate marginal stability unless remedial measures are carried out.

The survey information also shows that the profiles along the channel is variable and the area in adjacent to both the northern and southern Training Walls has been scoured to about RL-20m, which is similar to the profile of the selected sections in the analysis.

4 RECOMMENDATION & CLOSURE

Based on the assessment results, it is assessed that both the northern and southern Training Walls having low FOS indicating marginal stability. It is recommended that remedial measures be undertaken to stabilise the walls.

If you have any questions regarding this fax please contact Zen Ng or the undersigned in our Brisbane Office (+61 7 3608 2500).

For and on behalf of Coffey Geotechnics Pty Ltd,

Jay Ameratunga
Senior Principal

Attachments:

Important Information about your Coffey Report
Attachment A: Analysis Outputs
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.
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.
FOR INFORMATION ONLY
Slope Stability – Circular Failure (CF)

File Name: CH375-2.gz
Last Edited By: Zen Ng
Date: 11/11/2011
Method: Morgenstern-Price

Name: Beach Sand
Model: Mohr-Coulomb
Unit Weight: 16 kN/m³
Cohesion: 0 kPa
Phi: 28 °
Piezometric Line: 1

Name: Rocky Fill
Model: Mohr-Coulomb
Unit Weight: 22 kN/m³
Cohesion: 0 kPa
Phi: 38 °
Piezometric Line: 1

Name: Core material
Model: Mohr-Coulomb
Unit Weight: 22 kN/m³
Cohesion: 0 kPa
Phi: 40 °
Piezometric Line: 1

Description:

• Section CH375
• Southern Wall
• Revetment Section

FOR INFORMATION ONLY

FOR INFORMATION ONLY
FOR INFORMATION ONLY

Description
- Section CH00
- Northern Wall
- Breakwater Section

File Name: CH00-2.gzsz
Last Edited By: Zen Ng
Date: 11/11/2011
Method: Morgenstern-Price

Name: Beach Sand
Model: Mohr-Coulomb
Unit Weight: 16 kN/m³
Cohesion: 0 kPa
Phi: 28°
Piezometric Line: 1

Name: Rocky Fill
Model: Mohr-Coulomb
Unit Weight: 22 kN/m³
Cohesion: 0 kPa
Phi: 38°
Piezometric Line: 1

Name: Core material
Model: Mohr-Coulomb
Unit Weight: 22 kN/m³
Cohesion: 0 kPa
Phi: 40°
Piezometric Line: 1

Name: Concrete block
Model: Mohr-Coulomb
Unit Weight: 22 kN/m³
Cohesion: 0 kPa
Phi: 40°
Piezometric Line: 1

FOR INFORMATION ONLY
Description
- Section CH375
- Southern Wall
- Revetment Section

File Name: CH375-2.gsz
Last Edited By: Zen Ng
Date: 11/11/2011
Method: Morgenstern-Price

drawn: ZN
approved: JA
date: 11/11/2011
scale: As Shown
original size: A4

client: BMT WBM Pty Ltd
project: Stability Assessment of Seawall Entrance
title: Slope Stability – Circular Failure (CF)
project no: GEOTNEWS20895AA
figure no: 4