APPENDIX 5: GEOTECHNICAL ASSESSMENT FOR AN EVAPORATION POND - MYAMBA - SOIL AND ROCK ENGINEERING (2004)

TRILOGY
WATER STORAGE FACILITY
GEOTECHNICAL ASSESSMENT
PHILLIPS RIVER PROJECT

Report prepared for:

TECTONIC RESOURCES NL
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Our ref: **PS5720.03-AG WSF Geotech**
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Project no: ps5720/03 5 October, 2004
Our ref: PS5720.03-AG WSF Geotech

PROJECT: TRILOGY AND KUNDIP WATER STORAGE FACILITIES

CLIENT: TECTONIC RESOURCES NL

LOCATION: RAV 8 MINE

SUBJECT: GEOTECHNICAL ASSESSMENT

1.0 INTRODUCTION

This report presents the results of a geotechnical assessment carried out for the proposed water storage facilities (WSF) at the Trilogy and Kundip Mine Sites for Tectonic Resources NL.

The purpose of the geotechnical investigation is to report on:

(i) Soil, rock and groundwater conditions within the foundation zone for the containment embankment and adjacent reservoir area.

(ii) Suitable geotechnical parameters for embankment design.

(iii) Seepage characteristics of the reservoir area.

(iv) Stability assessment of the embankment geometry.

(v) Construction considerations pertinent to the proposed development, including suitability of materials for fill, compaction control and groundwater control during construction.

The study was commissioned by Tectonic Resources NL owner of the Trilogy and Kundip Projects via Purchase Order R08448.

This report is prepared and is to be read subject to the terms and conditions contained in our proposal which was accepted on 16 January 2004. Our advice is based on the information stated and on the assumptions expressed herein. Should that information or the assumptions be incorrect then Soil & Rock Engineering, a division of Coffey Geosciences Pty Ltd shall accept no liability in respect of the advice whether under law of contract, tort or otherwise.

2.0 INFORMATION SUPPLIED

The following information was supplied by the client:

(i) A contour plan of the area around the Trilogy Pit.

(ii) A copy of the report by Rockwater Pty Ltd entitled, *'Trilogy Gold and Base Metal Project Hydrogeological Investigation: Results of Exploratory Drilling, Construction of a Test Production Bore, Test Pumping and Numerical Modelling'*, dated March 2004.

(iii) A copy of the report by Rockwater Pty Ltd entitled, *'Kundip Copper & Gold Project Hydrogeological Investigation: and Monitoring Bore Completion Report'*, dated March 2004.

Based on this information and discussion with the client we understand the proposed development will comprise water storage facilities to accommodate mine dewatering from the Trilogy Pit. Hydrogeology studies indicate a likely dewatering rate of 250m^3/day to 37m below ground level and a likely dewatering rate of 2,500m^3/day to lower the groundwater to 100m below ground level.

The water storage facilities at the Kundip Pit will be relatively small as the hydrogeological studies indicated most bores were dry, the maximum flow being approximately 60m^3/day from one bore. Requirements for mine water for dust suppression and other uses may exceed the available supply of water from dewatering activities.

3.0 SITE CONDITIONS

The Trilogy site is located on grazing land approximately 18kms south southwest of the Rav 8 Mine. Kundip is located approximately 12kms southwest of the Rav 8 Mine.

At the time of the investigation fieldwork, 16 March 2004, site features at Trilogy comprised cleared land with a gently fall to the south estimated at 1 in 100.

At the time of the investigation fieldwork, 16 March 2004, site features at Kundip comprised a clearing within a drainage line which had previously been used as a water storage dam as part of the previous mining operations. The valley with a gently fall to the southwest estimated at 1 in 80, with the valley sides, which were covered in trees and shrubs having slopes estimated at 1 in 30. It is understood that given the small size of water storage required that the site assessed may not be the final site for the Kundip water storage and that a compacted clay liner or HDPE lined storage may considered.

The site is located near Ravensthorpe, Western Australia which, according to AS1170.4-1993, has an acceleration coefficient of 0.08.

4.0 DESCRIPTION OF FIELDWORK

4.1 General

Fieldwork was carried out under the supervision of a Principal Geotechnical Engineer from Soil & Rock Engineering on 16 March 2004. The requirements of Australian Standard AS 1726-1993 were used as a guide for the investigations.

4.2 Test Pitting

A total of 10 test pits were excavated by a JCB 3CX backhoe at the Trilogy Site to depths varying from 2.8m to 3.3m below the existing ground surface at the approximate locations shown on Figure 1.

A total of 3 test pits were excavated by a JCB 3CX backhoe at the Kundip Site to depths varying from 1.0m to 2.7m below the existing ground surface.

Disturbed samples of representative soil types were taken from testpit locations at Trilogy for laboratory examination and testing.

The records of the test pit logs from the Trilogy Site showing the detailed descriptions of the major strata intersected, the depths at which the samples were taken and insitu tests carried out and the results of these tests are presented in Appendix A. The Method of Soil Classification and Notes and Abbreviations on the Logs precede the logs as Figures A1 and A2.

No testpit logs are provided for the Kundip site as the actual final position of the water storage dam had not been chosen at the time of the investigation. A description of the materials encountered is provided in Section 6.0.

5.0 DESCRIPTION OF LABORATORY TESTING

Laboratory testing was carried out in accordance with the general requirements of the latest edition of AS 1289. Where a test was not covered by an Australian standard, a local or International standard was adopted and noted on the laboratory test certificate. The testing was carried out by, Coffey Geosciences Soil Laboratory, a NATA registered Testing Authority.

The extent of testing carried out to provide the geotechnical parameters required for this study is presented in Table 1.

Table 1 Laboratory Testing

Type of Test	Number
Particle size distribution	5
Atterberg limits	5
Linear shrinkage	5

Test certificates for the above mentioned tests are attached in Appendix B.

6.0 RESULTS OF INVESTIGATION

6.1 Geological Setting

The site of the Trilogy WSF is located over a shallow surface covered of sandy clay / clayey sand in an area of phyllitic schist and carbonaceous shale (with minor quartzite) of the Proterozoic Mount Barren Beds. These sediments unconformably overlie the Archaean succession of the southern part of the Yilgarn Block.

The Kundip area is characterised by a very shallow colluvial (clay, gravel and cobble mix) overlying steeply dipping mafic to intermediate volcanic rocks of Archaean age with some mafic schists.

6.2 Ground Conditions

6.2.1 Trilogy WSF

The ground conditions intersected by the testpits can be generalised according to the following subsurface sequence:

TOPSOIL .... loose, grey silty sand, fine to medium grained with gravels and organic material (grass cover and root zone) extending to depths of between 0.05m to 0.3m overlying.

SANDY CLAY (CI) .... very stiff to hard, orange / brown / yellow, moisture content less than the plastic limit, medium plasticity, extending to depths of 3.0m, overlying.

PHYLLITE .... very low strength, extremely weathered, light grey to reddish yellow to the terminal depth of the pit, where encountered.

It should be noted that Testpit 8 encountered silty sand beneath the topsoil, clayey gravel and gravely sandy clay over a ferruginous cemented sand/gravel hardpan at 2.0m depth, which extended to 2.7m

For a detailed description of the ground conditions investigated, the reader is referred to the logs presented in Appendix A. There are always some variations in subsurface conditions across the site which cannot be fully defined by investigation. It is therefore unlikely that the measurements and values obtained from sampling and testing undertaken as part of this investigation of the Trilogy Site will represent the extremes of conditions which exist within the site.

The site shows some variability between the testpits. After topsoil removal and prior to commencement of construction further investigation of near surface areas by ripping watering and compaction is required to more fully delineate the extent of the clayey gravel similar to that encountered in Testpit 8. Compaction of 500mm of clay over these areas will be required.

6.2.2 Kundip

All 3 testpits excavated at Kundip encountered a mixture of clay gravel and cobbles (colluvial materials) over rock, with the depth of colluvial materials varying from 1.0m to 2.7m. It is therefore unlikely that the measurements and values obtained from sampling and testing undertaken as part of this investigation of the Kundip Site will represent the extremes of conditions which exist within the site.

6.3 Groundwater

No groundwater was encountered during the testpit excavations at Trilogy or Kundip.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 General

Based on the above results of this study, the following conclusions have been determined and recommendations have been provided. It should be noted that the ground encountered by the testpits represent the ground conditions at the location where the tests have been undertaken and as such are an extremely small proportion of the site to be developed. Accordingly, variations to the ground conditions are likely and allowance should be made for variability in the design and construction budgets.

Whilst, to the best of our knowledge, the information contained in this report is accurate at the date of issue, ground conditions including groundwater levels can change in a limited time or due to seasonal fluctuations. For example fill could be added to a site or surface materials removed from a site which will therefore change the thickness of surface materials and depth to the underlying

materials. The potential for change in ground conditions should be recognised particularly if this report is used after a protracted delay.

7.2 Geotechnical Parameters for Embankment Design

7.2.1 Trilogy WSF

The design concept for the Trilogy WSF (TWSF) incorporates perimeter embankments constructed with sandy clay sourced from the surface of the Trilogy Pit or within the facility and a compacted clay liner on the 'floor' of the facility.

Stage 1 of the facility will have a maximum evaporation area of 7.3ha and the perimeter embankments will have a maximum height of 4m. The TWSF will be constructed in stages with cells added to cater for the expected increase in dewatering flows. The facility could have an ultimate area of approximately 80ha.

Based on the low embankment height batter slopes adopted in the design are 1:2 (vertical:horizontal) upstream and 1:2.75 (vertical:horizontal) downstream. The slope geometry has been checked by conducting stability analyses of the embankment design concept, ref to Section 7.3.

7.2.2 Kundip WSF

The proposed Kundip WSF is relatively small sized turkeys nest dam with a capacity of approximately 2,500m^3. It will be constructed from completely weathered overburden materials such as schist or similar, compacted to achieve a low permeability. No stability or seepage assessment has been made of this structure as it may be located upstream of and adjacent to mine waste dumps.

7.3 Stability Analyses Trilogy WSF

7.3.1 Method of Stability Analysis

Stability analyses of the design concept (refer to the Notice of Intent document) have been carried out using a computer model which analyses the stability of potential circular slip planes within the mass of the water storage embankment by the Bishop's method. The computer programme "SlopeW" was used for this purpose.

7.3.2 Material Input Parameters

The design parameters adopted in the stability analyses for each of the different material types are summarised on the plots presented in Appendix C. These parameters have been assumed based on classification testing.

The following cases have been considered as part of the stability analyses of the design concept presented in this Notice of Intent:

Case 1 The perimeter embankments, maximum height 4m and assuming 'worst' case operating conditions (ie 'high' phreatic surface).

Case 2 As for Case 1, but subject to an earthquake loading. An acceleration coefficient of 0.08 was adopted (a 1 in 500 year event (approximately) for "rock" conditions in accordance with AS1170.4-1993).

7.3.3 Results of Stability Analyses

A copy of the computer printouts showing the results of the analyses are attached to this report in Appendix C. The results are summarised in Table 2, below.

Table 2 Results of Stability Analyses

Case Number	Factor of Safety	Recommended Minimum Factors of Safety for each Case
Case 1	1.72	1.50
Case 2	1.37	1.10

The slope stability analyses indicate that Cases 1 and 2 have adequate factors of safety when compared with recommended minimum factors of safety (ANCOLD (1999)[3]). The material parameters adopted in the analyses should be confirmed during Stage 1 construction, by additional sampling and triaxial testing.

7.4 Seepage Characteristics of the Water Storage Area

7.4.1 Trilogy WSF

The site of the proposed Trilogy is underlain be sandy clay of medium plasticity and it is expected than with compaction of a 500mm layer of mine water overburden the hydraulic conductivity of the base with be in the order of 1.0×10^{-9}m/sec. Testing during construction is recommended to confirm this assumption.

7.5 Construction Considerations

7.5.1 General

There are a number of activities that must be undertaken during construction to ensure compliance with design and to ensure the smooth running of the project. The following activities should be carried out during the contract.

7.5.2 Site Preparation

All organic materials should be stripped and stockpiled as instructed by the Superintendent or his nominated representative.

The investigation intersected organic material to depths varying from 0.05m to 0.30m at Trilogy. Variations to this depth range may be present over the site. The site at Kundip had previously been disturbed and no topsoil was present.

The organic material is not suitable for use as filling. It is only suitable for landscaping purposes.

It should be noted that ground conditions and particularly groundwater levels may vary with the seasons. As such, site preparation procedures may differ from the above if development proceeds during winter months.

7.5.3 Proof Compaction

After the site for the water storage facilities has been stripped, scarified and watered to the satisfaction of the Supervising Engineer, the site should be proof compacted using a heavy, self-propelled, vibrating roller, capable of operating in variable frequency modes. A Dynamic CA 251D, or equivalent, is recommended.

7.5.4 Fill Selection Requirements

For this study, fill shall comprise mine waste or insitu materials defined as fill satisfying the following criteria:

(i) Containing more than 35% by weight of soil fractions finer than 0.075mm.

(ii) Having a liquid limit of not less than 35% and not greater than 50% and a plasticity index equal to or greater than 25%, (i.e. medium plasticity).

It is recommended that a 25 kg representative sample(s) of the proposed fill be delivered to a N.A.T.A. registered Testing Authority at least one week before approval is required.

7.5.5 Compaction Requirements

The fill shall be compacted to achieve a dry density not less than 95% of the standard maximum dry density, as determined from AS 1289.5.1.1, with the materials placed at optimum moisture content +/-2%.

The Contractor shall determine his loose lift thicknesses appropriate to his compaction plant to achieve the above compaction requirements.

It is recommended that the Contractor submits, in writing with his tender, details of his compaction plan including methods of compaction to achieve the specified level of compaction and his experience with similar materials.

Compliance with compaction requirements should be checked by carrying out field density tests, sand replacement, AS 1289.5.3.1 and/or nuclear density meter test AS 1289.5.8.1, and comparing the field results with the results of the laboratory modified compaction test AS 1289.5.2.1.

7.5.6 Site Drainage

Runoff from upslope of the site should be collected and diverted away from the storage.

7.5.7 Monitoring Water Levels

It is recommended that where containment embankment heights exceed 7.5m piezometers be installed to monitor phreatic water levels within the embankments. The siting of these monitoring points will depend on the final shape and construction procedure.

8.0 UNEXPECTED VARIATIONS IN GROUND CONDITIONS

This report has been prepared for the use of Tectonic Resources NL for the Trilogy and Kundip Projects in accordance with generally accepted consulting practice. No other warranty, expressed or implied, is made as to the professional advice included in this report. This report has not been prepared for the use by parties other than Tectonic Resources NL and their respective consultants. This report may not contain sufficient information for the purposes of other parties or for other uses.

It should be noted that the ground investigated represents an extremely small proportion of the site to be developed and there are always some variations in subsurface conditions across a site which cannot be fully defined by investigation. Hence it is unlikely that the measurements and values obtained from sampling and testing during the investigation will represent the extremes of conditions which exist within the site. Accordingly, variations to the ground conditions are likely and allowance should be made for variability in the design and construction budgets.

Whilst, to the best of our knowledge the information contained in this report is accurate at the date of issue, ground conditions including groundwater levels can change in a limited time. For example fill could be added to a site or surface materials removed from a site. The potential for change in ground conditions should be recognised particularly if this report is used after a protracted delay.

If the ground conditions encountered during construction are significantly different from those described in this report and on which the conclusions and recommendations were based, then this office must be notified immediately.

9.0 RECOMMENDATIONS FOR FURTHER GEOTECHNICAL INVESTIGATIONS

On the basis that the final site for the Kundip Water Storage Facility had not been selected it is recommended that a geotechnical assessment be made of the final site prior to construction to ensure the construction considerations detailed above are appropriate for the selected site.

10.0 STANDARDS AND REFERENCES

The following standards and references were used in the preparation of this report.

The Figures and appendices referred to herein are attached and complete this report.

1. AS 1726-1993 SAA Geotechnical Site Investigations.

2. AS 1289 Method of Testing Soils For Engineering Purposes.

3. Australian National Committee on Large Dams ANCOLD (1999), *'Guidelines on Tailings Dam Design, Construction and Operation'*.

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PROJECT: **TRILOGY AND KUNDIP WATER STORAGE FACILITIES**

CLIENT: **TECTONIC RESOURCES N.L.**

LOCATION: **RAV 8 MINE**

SUBJECT: **APPENDIX A - FIELDWORK**

This appendix contains the following Figures:

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PROJECT: **TRILOGY AND KUNDIP WATER STORAGE FACILITIES**

CLIENT: **TECTONIC RESOURCES N.L.**

LOCATION: **RAV 8 MINE**

SUBJECT: **APPENDIX B - LABORATORY TESTING**

This appendix contains the following Figures:

Laboratory Test Certificates FIGURES B1 to B5

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PROJECT: **TRILOGY AND KUNDIP WATER STORAGE FACILITIES**

CLIENT: **TECTONIC RESOURCES N.L.**

LOCATION: **RAV 8 MINE**

SUBJECT: **APPENDIX C – STABILITY ANALYSES**

This appendix contains the following Figures:

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GEOTECHNICAL INVESTIGATION

PRELIMINARY

FACTUAL
&
EVALUATION
REPORT

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