COMPASS RESOURCES NL

Browns Oxide Project - Groundwater Modelling

Location

B18183/2-AC

13 April 2006

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Compass Resources NL
Level 5, Eastern Valley Way
ROSEVILLE NSW 2069

Attention: Mr Rod Elvish

Dear Mr Elvish,

RE: BROWNS OXIDE PROJECT - GROUNDWATER MODELLING

This report provides the results of a groundwater modelling study of the proposed Browns Oxide Project.

It was commissioned to provide the groundwater modelling part of the "further information" required from Compass Resources NL by the NT EPA and takes into account aspects raised by the EPA's groundwater consultant. The report sets out an assessment of inflows to the proposed mine pit, their sources (and therefore water quality) and the extent of drawdown impacts on existing groundwater levels.

If you have any questions in relation to this report or if you require further assistance please contact the undersigned in our Sydney office on (02 9911 1000) or Dr Detlef Bringemeier in our Brisbane office on (07 3274 4411).

For and on behalf of

COFFEY GEOSCIENCES PTY LTD

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1. INTRODUCTION

This report sets out the results of numerical groundwater modelling of the proposed Browns Oxide Project which would involve production of copper, cobalt and nickel from an oxide orebody. The purpose of the modelling was to provide an assessment of groundwater inflows to the mine pit and predictions of the extent of impact of mining on groundwater levels in the vicinity of the mine.

This work follows an earlier groundwater assessment present in a report by Coffey Geosciences (2005).

The deposit is located 1 km west of the old Whites Mine and the centre of the Browns Oxide Pit is some 700 m from the Intermediate open cut. The Whites Pit and Intermediate Pit remain from earlier mining activities carried out prior to 1971. Data from groundwater monitoring and investigation associated with the Rum Jungle site has been used, with site specific data, by Water Studies (2000 & 2002b) in developing an understanding of the hydrogeology of the area. Background hydrogeological information provided by Jolly *et al* (2000) and Lawton (1996) was also taken into account as was water inflow data to the Browns shaft during 1976.

Previous investigation of hydrogeological conditions and possible groundwater impacts for the proposed Browns Polymetallic mine was presented by Water Studies (2000 & 2002b). The proposed Browns Polymetallic mine differed from the current proposal by proposing to mine deeper sulphide deposits, the mine would have been significantly deeper and potentially covered a larger area than the current proposal. Details of the proposed mining were provided in Compass (2004).

A pit to obtain bulk ore samples for metallurgical test-work was excavated in October 1999. The pit encountered groundwater. After mining an initial sample the pit was allowed to fill with water. It was again dewatered in June 2000 by pumping from the pit, this pumping constituted a dewatering trial. To observe the impacts on groundwater, water levels were monitored in surrounding bores, and pumping rates were recorded. Pumping records exist from 25 June to 11 September 2002, groundwater levels at 19 monitoring bores were recorded between 19 June and 26 September 2002, and a few water levels were monitored in the excavation. A report covering this dewatering test was presented as Water Studies (2002c).

This report was commissioned by Mr Rod Elvish on behalf of Compass Resources NL (Compass).

2. PHYSICAL SETTING

2.1 Drainage

The region is characterised by gently undulating hills at an elevation of between 40 and 100 mAHD drained by the East Finniss River and its tributaries. The East Finniss River is an ephemeral stream that drains to the northwest where it meets the Finniss River some 8 km downstream from the project area.

The Project area is located south of the East Finniss River near the top of a local watershed drained by other small creeks that drain toward the East Finniss River.

The Browns Oxide Project is approximately 700 m from Rum Jungle Intermediate mine-void that is to the north-east and on the opposite side of the East Finniss River. The project area is some 400 m from the Intermediate mine waste dump which is on the same side of the river as the Browns Oxide Project. Water quality has been monitored since 1968 in creeks and bores in this area because of a past history of contamination from Rum Jungle Mine.

2.2 Climate

The area experiences a monsoonal climate with average rainfall of 1400 mm/year. The bulk of this rain falls during the wet season which starts in November and ends in March.

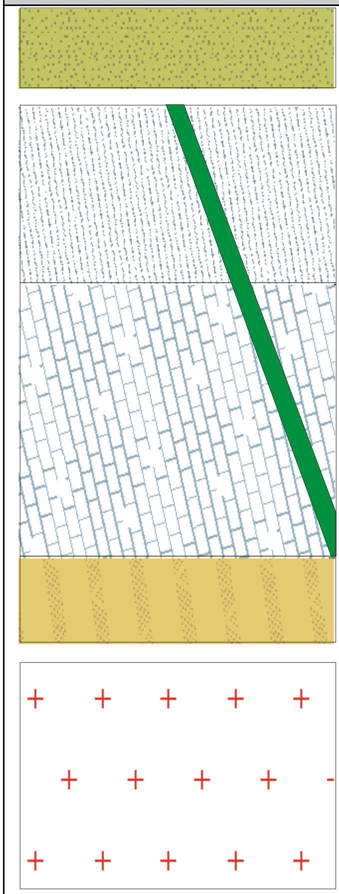
The rainfall has distinct seasonality because of the monsoonal climate. The strong seasonal character of the rainfall influences groundwater levels measured in the area which are typically 4 to 8m higher at the end of the wet season than at the end of the dry season.

2.3 Geology

The geology of the project area is described by Lally (2003). The project area is underlain by metasedimentary sequences of the Mount Partridge Group, comprising dolostones conformably overlain by carbonaceous pellites. The rocks have been deformed and metamorphosed to green schist facies during the Barramundi Orogen (McCready, *et. al.* 2004). Brittle failure associated with deformation, has produced a number of faults, some of which follow the northeast to southwest structural trend. The Browns Oxide project area is on the northern limb of a northeast -southwest trending, gently plunging syncline with dips of about 60º to the south east.

The geological summary provided above is consistent with geological exploration records provided by Compass. A summary of the geology and stratigraphy is presented in Table 1.

TABLE 1: SIMPLIFIED STRATIGRAPHY AND LITHOLOGICAL DESCRIPTIONS

Graphic	*Lithology*	*Formation*	*Group*
	Hematitic quartzite breccia	Geolsec Formation	
	Calcareous and carbonaceous pyritic pelites, marl, amphibolite dykes, and quartzite	Whites Formation	
	Stromatolitic dolostone and magnesite, minor interbeds of metapelite and para amphibolite Brecciated zones are associated with faulting, Vuggy recrystalised zones (from metamorphic recrystallisation?) occur through the rock and karstic zones are present near the surface.	Coomalie Dolostone	Mount Partridge
	Arkosic arenite, quartz arenite, and conglomerate	Crater Formation	
	Granitoid		Rum Jungle Complex

Water Studies (2002b) state that mineralisation in the Whites Formation occurs at the contact zone with Coomalie Dolostone and terminates against the Giants Reef fault. Review of the results of resource evaluation studies provided by Compass also indicates the presence of mineralisation within the margin of the Coomalie Dolostone against the Whites Formation.

The Browns Oxide mine proposes to excavate the upper parts of these deposits, referred to as the oxidised ore horizon where some supergene enrichment has taken place, sulphide minerals have been oxidised and sulphur has been removed by natural processes. The oxidised ore horizon is up to about 50 m deep in the project area but oxidised depths in rocks around the area are usually less than 30 m deep (Water Studies, 2000).

2.4 Description of the Groundwater System

2.4.1 Nature of the Aquifers

Groundwater occurs at between 2 and 12 m below surface in the project area with an average of about 4 m. The groundwater levels fluctuate seasonally by up to 8 m (in RN23137), generally the fluctuation is over a smaller range with average of 5 m. Groundwater hydrographs coincide with the monsoonal climate, groundwater levels start to rise in about December and peak in February, the peak is followed by recession that continues until the annual rise starts again in December. Hydrographs are presented in a report by Water Studies (2005).

Water Studies (2002b) repeat many of the observations presented in the Water Studies (2000) relating to the nature of the aquifers and add observations based on Appleyard (1983) and Salama & Scott (1986) regarding a shallow and deep aquifer. The shallow aquifer is reported to be only a couple of meters deep in the shallow lateritic soil and is reported to be responsible for most of the contaminant migration from the old Rum Jungle dumps. The deeper aquifer is reportedly a fractured system that is poorly connected. The conceptual model presented by previous investigators suggests that there is little groundwater movement through the deeper system. Evidence from hydrographs, presented in this study, shows dynamic recharge and discharge in deep and shallow bores. The uniformity of the responses suggests that similar groundwater processes such as recharge and discharge are occurring over a wide area and through a deep, relatively continuous saturated zone.

Investigation by Water Studies (2000) of aquifer parameters showed that the aquifers have relatively high hydraulic conductivity and that karstic zones may be found in the dolostone. Their conclusion based on evidence from pumping tests was that the aquifers are predominantly unconfined although some pumping tests suggested that the aquifers may be semi-confined. The monitoring evidence suggests that if confining conditions exist they are probably local (at a pumped bore) and are unlikely to have an influence at more regional scales.

2.4.2 Aquifer Parameters

Aquifer parameters determined by Water Studies (2000) are presented in table format in the summary of that document in Appendix A. The original report presented a discussion about responses of monitoring bores to pumping, since these monitoring bores were relatively close to the test bores it is assumed that the observations are largely valid although in some cases the recessionary trends may be responsible for some of the observations.

Aquifer parameters are summarised in Table 2.

TABLE 2: AQUIFER PARAMETER SUMMARY (From Water Studies, 2000)

Bore	*Aquifer Type*	*Depth to Water (mBGL)*	*Transmissivity T (m^2/d)*	*Permeability K (m/d)*	*Storage S*
TPB1	Weathered carbonate aquifer	5.34	180	30	0.01
TPB2	Weathered zone Whites Fm. Carbonate Contact	6.08	40-100	4-10	0.001 to 0.01
TPB3	Fault zone	7.43	55	10	0.001 to 0.0001

Interpretation of the results of trial pit dewatering resulted in assessment of aquifer permeability of approximately 30m^3/d at the lower end of the earlier assessments.

An assessment of shallow aquifer parameters in the vicinity of White's waste rock heap developed by Appleyard (1983) indicated a transmissivity of $12m^2/d$ for a shallow aquifer found within lateritic soils. Drilling by the Department of Transport and Works (Appleyard, 1983) within a the deeper aquifer in the vicinity of the Rum Jungle minesite produced airlift yields from 1L/s to 60L/s in the dolostone. Transmissivity of the dolostone was not assessed but from the yields produced from airlift testing it is clear that transmissive features are present within the deeper fresh to slightly weathered dolostone aquifer. Such features do not appear to be present in the weathered shallow soils.

Construction records for Borehole RN22108 (May 1983) located some 50m to the west of the Intermediate Pit (about 200m north east of the north-eastern limit of the proposed Browns Oxide pit) produced separate inflows of 40L/s at 27m depth, 30L/s at 41m depth and 60L/s at 60m depth indicating the presence of highly transmissive zones within the slightly weathered to fresh Coomalie Dolostone. A cavity containing ferruginised medium grained sand was logged at 57m depth. The water quality encountered below the cavity was noted as of different chemical character to that above the cavity with copper plating noted as developing on the steel casing. An airlift yield of 30L/s was noted for Bore RN22107 located 150m north-west of Whites Pit produced airlift yield of 30L/s from the Coomalie Dolostone at a depth of 16m. Subsequently the hole blew out to a nearby pilot hole and air return was lost. These results demonstrate the present of transmissive karstic features within the fresh to slightly weathered Coomalie Dolostone.

Testing of the Coomalie Dolostone aquifer for water supply purposes at the township of Batchelor some 7km to south-west of the Browns Oxide Project site was reported by Jolly (1982). Based on the results of test pumping the transmissivity of the Coomalie Dolostone aquifer system was assessed to be approximately $2000m^2/d$. The borefield developed at the site has provided a reliable groundwater supply to the township. Mr Jolly of the Department of Natural Resource, Environment and the Arts advises that the borefield installed in the 1980's continues to provide good service.

3. MODELLING APPROACH

Establishment of the calibrated groundwater model involved the following activities:

- Review of background information;
- Selection of a model domain;
- Identification of the location and nature of aquifer boundaries;
- Selection of aquifer properties;
- Implementation of the interpreted model using the MODFLOW finite difference groundwater program;
- Trial of model parameters to achieve reasonable agreement with observations.

4. BACKGROUND INFORMATION

The modelling parameters which are significant in the groundwater model are summarised in Table 2 together with sources of information used for their assessment. Data from Compass has been progressively provided to the EPA.

TABLE 2 : MODELLING PARAMETERS

Parameter	Significance	Information Sources
Extent of aquifers	Control zone of potential influence	Regional geological material (Lally, geological map) Local geological mapping
Groundwater levels	Basis for evaluation of model performance Baseline conditions	Monitoring records for RN series bores and TBP1, TPB2, TPB3
Ground surface levels	Limits the level to which groundwater can rise prior under the influence of recharge	Survey of borehole collars, level surveys and broad scale topographic information sources
Aquifer transmissivity	Influences flow quantities and extent of drawdown impacts	Test pumping for bore TPB1, TPB2, TPB3 NT Government test pumping records for RN23140, RN23137, RN23304, RN22458
Aquifer storage parameters (specific yield)	Influences the timing of response to stresses on the groundwater system	Response of groundwater level to recharge events Experience
Recharge from rainfall infiltration	Influences the seasonal aquifer performance and the extent of aquifer impacts	Response of groundwater level to recharge events Experience
Discharge zones (rivers creeks)	Act to limit groundwater levels during the wet season	Survey data for bed levels Groundwater response in the vicinity of discharge zones
Discharge zones (mine voids)	Dampen groundwater level fluctuations in the vicinity of the voids	Survey data for water levels during wet and dry seasons

Aquifer assessment from interpretation of test pumping records has occurred. Water Studies (2000) discussed the results of test pumping of Bores TPB1, TPB2, TPB2 and records for test pumping of bores RN23140, RN23137, RN23304, RN22458 were provided by Mr Peter Jolly, government consultant to the EPA. The data is presented in Appendix C and results of these tests are summarised in Table 3.

TABLE 3 : RESULTS FROM TEST PUMPING

Bore Number	Material	Pumping Rate (L/s)	Interpreted Transmissivity (m^2/d)	Comment
TPB1	Coomalie Dolostone	12.5	180	Interpretation by Water Studies
TPB2	Whites Formation	9.5	40 to 100	Interpretation by Water Studies
TPB3	Whites Formation	20	55	Interpretation by Water Studies
RN23140	Coomalie Dolostone	8.0	420 to 1050	Interpretation by Coffey from NT Govt data
RN23137	Amphibolite	2.9	18 to 30	Interpretation by Coffey from NT Govt data
RN23304	Tremolite shist	4.6	15 to 40	Interpretation by Coffey from NT Govt data
RN22548	Quartz breccia	18.8	140 to 370	Interpretation by Coffey from NT Govt data

These results were recognised in the adoption of initial trial values for aquifer parameters. An initial value of 1300m^2/d was adopted for Coomalie Dolomite. It is recognised that higher transmissivity values (1000m^2/d to 3500m^2/d) were assessed by Mr Peter Jolly for the Coomalie Dolostone near Batchelor as part of groundwater resource evaluation studies. For the present study emphasis was given to the results of local testing.

5. MODEL GEOMETRY AND BOUNDARIES

The extent of aquifers was assessed on the basis of regional geological information presented by Lally (2002) and the 1:100,000 Geology of the Rum Jungle Uranium Field (1984), Northern Territory Bureau of Mineral Resources, Geology and Geophysics, Department of Resources and Energy.

Figure 1 shows the extent of model boundaries and aquifer extents based on these sources. The grid over the model region shows the adopted finite difference grid. The grid structure is refined in the vicinity of the proposed mine to improve resolution in that area. The northern and southern model boundaries coincide with the presence of the Crater Formation (conglomerate, sandstone and shale expected to be of low permeability) and the granite of the Rum Jungle Complex. For the purposes of modelling these are considered to represent barriers to groundwater flow and are taken as no-flow boundaries. The western model boundary is considered to be sufficiently far from the proposed mine site to be influenced by mining operations. It is taken as a boundary of stable groundwater level. Groundwater levels along this boundary were assessed from results of monitoring of regional bores together with ground levels.

The East Finniss River and tributaries are also modelled as drain boundaries which provide a zone of discharge. The pits associated with the former mining operations of the Whites Pit and the Intermediate Pit are modelled as constant head zones with head levels set at 60mAHD and 58mAHD consistent with measurements of typical levels within these features quoted by Lawton (1996).

The proposed mine will be largely excavated within the Whites Formation which is expected to be of significantly lower transmissivity than the Coomalie Dolostone which is present over much of the model domain. The extent of the Whites Formation is taken from surface geological mapping records presented in Compass Resources NL Drawing EL 4880 (Rum Jungle – Embayment Prospect, September 1991). The Coomalie Dolomite is taken as occupying the remainder of the model domain. For the purposes of this assessment localised zones described as quartz heamatite breccia have not been modelled. For the purposes of modelling these quartz heamatite breccia zone are treated as Coomalie Dolostone.

Figure 2 presents the adopted ground surface contours employed in the model based on limited borehole level data, surface survey records and regional topographic information sources. It is recognised that these levels are crude in a regional sense. These contours do not take account of localised mounding associated with features such as waste dumps.

6. CALIBRATION FOR RECHARGE AND TRANSMISSIVITY

Figure 3 presents the results of a steady state calibration after a series of trial to obtain infiltration and transmissivity values for the Whites Formation and the Coomalie Dolostone regions to provide a reasonable match to measured groundwater levels. The aquifer parameter values adopted to achieve this result are transmissivity values of $1000m^2/d$ transmissivity and $40m^3/d$ for the Coomalie Dolostone and the Whites Formation respectively with recharge of 300mm/yr and 200mm/yr for these formations respectively. It is recognised alternate model parameters could have been used to obtain this calibration outcome. For example, doubling of the transmissivity and recharge values would have resulted in similar steady state calibration results. In adopting the values chosen, emphasis has been placed on the results of test pumping at the site in the Coomalie Dolomite and Whites Formation.

Having obtained this steady state calibration a transient simulation was carried out for a twelve month period taking the rainfall records for 2002 to obtain monthly modelled groundwater levels at the location of monitoring bores. Figure 4 presents a comparison between modelled and measured groundwater levels for this period. The calibration is not perfect but was considered to provide an adequate basis for assessment of mine impacts. A specific yield value for the Coomalie Dolostone of 0.05 was adopted and a value of 0.01 was adopted for the Whites Formation to obtain this result.

7. TRIAL PIT TEST CALIBRATION

Calibration using the measured groundwater response following construction of a trial pit within the proposed mine area was carried out. The pit was dewatered for a period of approximately 71 days with groundwater flows of up to 12L/s. Figure 5 presents the groundwater contours modelled at the end of the 71 day period. The results showed a poor match to the measured groundwater response as TPB1 (3.0m), TPB2 (3.3m) and TPB1 (0.8m). After several trials it was clear that with the actual boundary between the Whites Formation and the Coomalie Dolostone that it would not be possible to match the measured groundwater response at TPB1.

Advice provided by Compass (Appendix A) has indicated that exploration drilling covering the area of the proposed mine did not encounter areas where groundwater inflow prevented reverse circulation drilling operations, not did any hole require auxiliary air compressors or boosters. It is also noted in sections of mineralisation for the Whites and Intermediates pits that a zone of mineralisation to the north of the main mineralisation zone was present. Experience at the other sites is that groundwater flow within mineralised areas is not high. Taking these factors into account a further material zone was introduced to facilitate calibration of the groundwater response to the trial pit dewatering. After several trials it was found that reasonable agreement to the measured response was obtained after setting the transmissivity of this zone (referred to in Figure 6 as 'Impregnated Coomalie Dolostone') to have properties equal to those adopted for the Whites Formation.

The calibrated contours at the end of the period of dewatering of the trial pit (September 2002) are shown in Figure 6. Again the results do not provide a perfect match to the measured values with modelled groundwater levels slightly lower that measured values. This was considered to provide an adequate basis for production analysis recognising that changes to provide a better match would likely result in lower transmissivity values and therefore reduce predicted groundwater inflows to the mine pit. Adoption of the calibrated model is therefore considered conservative in relation to mine inflow assessment.

8. ADOPTED PARAMETERS

Table 4 summarises the parameters adopted following calibration studies discussed above.

TABLE 4 : ADOPTED MODEL PARAMETERS

Parameter	Adopted Value	Comment
Transmissivity (m^2/d)		
Coomalie Dolostone	1000	Based on test pumping results modified to achieve calibration match.
Whites Formation	40	
Impregnated Coomalie Dolostone	40	
Recharge (mm/yr)		
Coomalie Dolostone	300	Based on steady state calibration.
Whites Formation	200	
Impregnated Coomalie Dolostone	200	
Specific Yield		
Coomalie Dolostone	0.05	Based on assessment of seasonal response and matching of piezometer response to test pit dewatering.
Whites Formation	0.01	
Impregnated Coomalie Dolostone	0.01	

9. RESULTS OF MODELLING

Modelling was carried out to assess the groundwater level changes and the groundwater inflows associated with the development of the proposed Browns Oxide Project.

Modelling was carried out for average groundwater conditions using a steady state analysis. The modelled head contours therefore represent average conditions over which natural seasonal variation would apply. Similarly modelled flow rates represent average conditions and seasonal variations would apply. The East Finniss River has been taken as being capable of sustaining infiltration to the groundwater system. It is recognised that the East Finniss River does not flow during the dry season. For the purposes of modelling it is assumed that water discharge from the mine would be returned to the East Finniss River and that this would maintain the capacity of the river to provide a source of groundwater recharge. It is considered that this is a reasonable assumption where mine inflows are high (greater than say 100L/s).

For the purposes of modelling, it is assumed that the mine pit is fully excavated and dewatered from the outset. In practice, deep pockets within the main mine pit and at the satellite pits may be allowed to fill with water following completion of mining of the relevant area. The modelling assumption of sustained drawdown of the entire mine pit is considered to be conservative in relation to assessment of the total groundwater flow to the mine pit and in relation to modelled drawdown impacts.

9.1 Mine Pit Layout

Figure 7 shows a possible mine pit layout provided by Compass. The main pit takes an elongated form aligned along strike of approximately 700m in length and up to about 250m wide. The general excavation level within the main pit varies between 35mAHD and 50mAHD with two deeper penetrations to 10mAHD. The bulk of the pit is some 10 to 25m below natural ground levels (typically 60mAHD to 68mAHD over the mine site). In addition to the main pit three satellite pits are planned to be mined to depths of 20 to 30m below ground surface.

9.2 Modelled Dewatering Results

Figure 8 presents modelled groundwater drawdown contours. Within the mine groundwater levels match the level of the deep points at the base of the pit. Groundwater head gradients are highest surrounding the deepest points in the pit. Head gradients are lower within the Coomalie Dolostone because of the comparatively high transmissivity adopted for modelling of this formation. Within the Whites Formation (to the south of the pit) drawdown of 15m or more is modelled for distances up to 500m from the pit.

Arrows illustrating the direction and relative magnitude of groundwater flows are shown in Figure 8. The northern margin of the pit is modelled as being in contact with the transmissive Coomalie Dolostone inflows in this area are substantially higher than elsewhere illustrating that flows from the Commalie Dolostone would make up the bulk of the groundwater inflow under the conditions modelled.

Figure 9 illustrates the modelled rates of groundwater inflow to various zones within the mine pit. A total of 294L/s is modelled as flowing to the mine pits. Most of this flow (226L/s = 163L/s + 63L/s) is modelled as reporting to the area at the north of the pit planned to be excavated to down to 35mAHD. This flow originates almost entirely from the Coomalie Dolostone. Groundwater flows to the deep pockets within the main pit and to the satellite pits are comparatively small (totalling 56L/s) as these are within the lower transmissivity Whites Formation or the area described as ‘impregnated dolomite’ in the calibration section of this report. Based on the groundwater contours shown in Figure 8 approximately half of the modelled groundwater flow to the deep pockets and satellite pits originates from the Coomalie Dolostone with the remainder from the Whites Formation. On this basis groundwater inflow from the Whites Formation to the south of the pit is modelled as 28L/s with the remaining 266L/s modelled originating from the Coomalie Dolostone.

A change of 218L/s is modelled in relation to seepage between the Finniss River and the groundwater system. This represents the sum of the natural groundwater inflow to the river prior to mining and losses from the river to the groundwater system during mining. Similarly a change of 103 L/s is modelled in relation to the Intermediate Pit void.

Drawdown is modelled as being less than 4m at distances greater than 2km from the proposed mine (see Figure 10).

9.3 Water Quality of Groundwater Inflows

Modelling has indicated that the bulk of groundwater inflow to the pit would originate from the Coomalie Dolostone. Results of recent water quality measurements are presented in Appendix B. Water quality within the Coomalie Dolostone measured at TPB1 shows low electroconductivity (408μS/cm), neutral pH (6.8) with nickel concentration of 51μg/L, copper concentration of 48 μg/L and cobalt concentration of 6 μg/L. Testing for groundwater samples from RN22107 and RN22108 within the Coomalie Dolostone in the immediate vicinity of the Intermediate and Whites Pits respectively show substantially higer electroconductivity (2110 μS/cm and 4700 μS/cm) with lower pH (6.0 and 6.5) and elevated metal concentrations (milligram per litre concentration for nickel, copper and cobalt). The groundwater quality at these locations is clearly influenced by chemical effects of mining in the adjacent pits.

Groundwater inflows to the Browns Oxide Project originating from the Coomalie Dolostone are expected to be initially of comparable quality to that recorded in TB1 and over time some influence from water quality influenced by conditions at the intermediate pit may occur. Modelling results indicate that groundwater seepage from the East Finniss River as a result of mine dewatering will act to limit the influence of water quality from near the intermediate pit on water quality of inflows to the Browns Oxide Pit. It should be noted that the significant seepage from the Intermediate Pit obtained from model results is in conflict with advice that groundwater inflows to the Intermediate Pit were modest during operation of this mine. On balance therefore it is anticipated that groundwater inflows modelled as originating from the Coomalie Dolostone would be comparable to the quality of water recorded from TB1 and that of the East Finniss River.

Water quality within the Whites Formation in the vicinity of the overburden dumps to the south of the Intermediate Pit is known to be degraded. Water quality measured in a sample taken from TPB3 near the south-western limits of the proposed mine is of low electroconductivity (107μS/cm), neutral pH (7.1) and low dissolved metal (Ni, Cu and Co) concentration. This provides a guide to water quality in the Whites Formation to the south-west of the proposed mine. Water quality of a sample taken from TPB2 near the north-eastern limit of the proposed pit is of high electroconductivity (2,970 μS/cm), high pH (9.3) and low dissolved metal (Ni, Cu and Co) concentration.

It is recognised that groundwater in the vicinity of the waste dumps to the south of the Intermediate Pit is of poor quality and this could affect the quality of a portion of the inflow to the proposed mine. Based on the modelled groundwater contours it is assessed that inflow from this region would account for 14L/s approximately than half of the flow attributed to the Whites Formation (28L/s).

9.4 Discussion of Model Results

Based on the groundwater modelling Coffey predicts a total inflow (to all pits) of approximatley 300L/s. This assessment contains several conservative assumptions:

- The entire mine operates at full depth from the outset
- The East Finniss River continues to flow all year round
- The Intermediate Pit level remain stable at present levels

The results of the model simulation also predicts that some 200L/s would seep from the East Finniss River and significant seepage would occur from the Intermediate Pit. It is recognised that the inflows to the Intermediate Pit were low during operation and that the East Finniss River does not flow in the dry season near the mine site. For the conditions modelled a high proportion of the water from the Browns Oxides pit could be returned to the East Finniss River and Intermediate Pit without affecting the natural flow regime in the river. It is expected therefore that two thirds of pit flows could be returned to the river without creating flow during the dry season.

The model development and calibration has recognised the following uncertainties which are important factors in the assessment of groundwater flow and drawdown:

- Transmissivity of the Whites Formation and Coomalie Dolostone;
- Extent of lower transmissivity 'impregnated dolomite' mineralised zone within the Coomalie Dolostone;
- Nature of interconnection between the Intermediate Pit and the groundwater system; and
- Nature of interconnection between the East Finniss River and the groundwater system.

While the representation of these factors has been guided by model calibration and review of background material, some uncertainty remains. The significance of such uncertainty is discussed in Table 5 below.

TABLE 5 : SIGNIFICANCE OF MODEL UNCERTAINTIES

Factor	Significance
Transmissivity of Coomalie Dolostone	Modelled flows derived from the Coomalie Dolostone are strongly influenced by the transmissivity of this unit. The adopted value of 1000m²/d is based on local test results. Experience at Batchelor some 7km from the site has indicated transmissivity in the vicinity of 2000m²/d. Should this transmissivity apply at the mine site inflows from the Coomalie Dolostone would be increased by a factor of approximately two though groundwater drawdown contours would not change appreciably.
Transmissivity of Whites Formation	Modelled flows derived from the Whites Formation are strongly influenced by the transmissivity of this unit. The results of calibration against the results of trial pit dewatering are considered to provide a sound basis for assessment of this parameter. It is possible that localised inflow in excess of model prediction could occur corresponding to major features such as faulted zones.
Extent of lower transmissivity mineralised zone within Coomalie Dolomite	The results of dewatering of the trial pit together with the exploration drilling records and the resource evaluation records provide a strong basis for demonstration of the existence of a low permeability zone at the fringe of the Coomalie Dolostone. It is not clear how far this zone may extend. For the purposes of modelling a conservative stance was taken assuming that the northern margin of the pit would be in contact with Coomalie Dolostone having transmissivity equivalent to the regional value. Should the lower transmissivity 'impregnated dolomite' extend beyond the circumference of the mine pit the mine inflows modelled as originating from the Coomalie Dolostone would be substantially reduced (a reduction by at least a factor of two would be expected) and the drawdown impacts within the Coomalie Dolostone would also reduce significantly (again by a factor of at least two).
Nature of connection of Intermediate Pit with groundwater system	For the purposes of modelling it is assumed that the Intermediate Pit is in hydraulic contact with the transmissive Coomalie Dolomite consistent with geological interpretation. This is considered to be a conservative assumption as the experience at the site was that inflow to the Intermediate Pit was modest. If the Intermediate Pit is separated from the transmissive Coomalie Dolostone by a zone of lower transmissivity 'impregnated dolomite' which seems likely, the seepage losses from the Intermediate Pit void modelled would be substantially reduced (by about an order of magnitude).
Nature of the connection of the Finniss River with the groundwater system	It is clear from consideration of the regional hydrogeology that the Finniss River acts as a groundwater sink. This demonstrates that in a regional sense it is hydraulically connected to the groundwater system. The model treatment of the river is therefore considered to be a reasonable representation and it follows that if groundwater levels fall the river would provide a source of recharge during the wet season. During the dry season the river may not sustain the level of recharge predicted in the model. Should this be the case groundwater levels during the dry season would be lower than during the wet season and groundwater inflows to the pit would also reduce during the dry season.

From the discussion provided in Table 5 it is clear that a conservative position has been taken in relation to most of the uncertain factors.

Modelled inflows are substantially in excess of the inflow rates understood to have occurred into the Whites Pit which was substantially deeper than the proposed Browns Oxide Pit. This comparison is consistent with the conservative nature of the assessment as discussed above.

9.5 Groundwater Management

Method Of Pit Dewatering

For the purposes of modelling mine dewatering is assumed to occur from within the mine pit. Recognising that the groundwater system is strongly influenced by geological features such as fault zones it is considered that advance dewatering using perimeter groundwater bores may present practical difficulties and, subject to acceptability in relation to slope stability considerations, it is recommended that groundwater collection take place using in pit drainage trenches and sumps.

Groundwater quality varies over the site. Contaminated groundwater is known to be present in the vicinity of the overburden dumps to the south of the Intermediate Pit. This could affect the quality of groundwater entering the north-eastern slopes of the pit. It is recommended that sampling of groundwater at the point of significant ingress (greater than 5L/s) to the pit be carried out when major inflows are encountered. It is recommended that testing comprise field measurement of electroconductivity and pH with laboratory testing of metals. Measure to isolate such inflow should be carried out if testing reveals substantially degraded water quality in relation to discharge criteria. Low quality water could be used for process purposes or for dust suppression. Should inflows of low quality groundwater prove problematic control measure such as grouting may be considered. The services of an experienced hydrogeologist should be engaged to provide advice in relation to such matters.

It is recommended that periodic (six monthly) review of the rate and quality groundwater inflow be carried out with a view to separation of streams of groundwater inflow of differing quality.

Groundwater Level Monitoring

Groundwater modelling results indicate drawdown of groundwater level within the Coomalie Dolostone to 36mAHD near the northern boundary of the mine pit. The response of groundwater in the Coomalie Dolostone in response to mine dewatering will provide a useful indication of the degree of hydraulic connection between the pit and the Coomalie Dolostone. It is recommended that three groundwater monitoring bores be installed along the planned northern perimeter of the Browns Oxide Mine pit set back approximately 50m from the pit at intervals of approximately 200m. Existing exploration boreholes could be used for this purpose or new bores could be constructed. It is recommended that bores used for monitoring be tested to ensure that good hydraulic connection to the groundwater system exists. Bores showing slow recovery following air lifting are not considered suitable.

It is recommended, as part of initial mining preparation that a groundwater monitoring plan be developed which includes the following elements:

- Establishment of a network of monitoring bores to assess groundwater level response to mine dewatering within the Whites Formation and Coomalie Dolostone;
- Development of a program of water sampling check groundwater quality variation over the life of the mine;
- Measures for monitoring of the rate and distribution of groundwater inflow; and
- Regular review of monitoring data by an experienced groundwater specialist.

10. CONCLUSIONS AND RECOMMENDATIONS

Groundwater is expected to be intercepted by Browns Oxide Mine from about 4 m below surface.

Inflow control or dewatering will be required to allow mining to take place. It is recommended that provision for addressing groundwater inflows of 300L/s be made (well in excess of that understood to have been encountered in the nearby Whites Mine). This inflow is assessed to be derived predominantly from the Coomalie Dolostone (270L/s) with approximately 30L/s from the Whites Formation. The modelled inflows are substantially greater than are understood to have occurred for the deeper Whites Pit.

While contaminated groundwater from the Rum Jungle mine area is not considered likely to form a significant contribution to groundwater dewatering inflows, capture of a small proportion of contaminated groundwater is considered possible. The rate of inflow of potentially contaminated groundwater from this zone is assessed to be 14L/s based on model results.

Groundwater drawdowns of in excess of 15m are assessed for distances of less than 500m from the mine pit.

Modelling assumptions are considered to be conservative Coffey consider it likely that inflows would be lower than the modelled values. Nevertheless it is possible that higher inflows and greater drawdowns could occur in the event that conditions are less favourable than modelled.

Recommendations

It is recommended, as part of initial mining preparation that a groundwater monitoring plan be developed which includes the following elements:

- Establishment of a network of monitoring bores to assess groundwater level response to mine dewatering within the Whites Formation and Coomalie Dolostone;
- Development of a program of water sampling to check groundwater quality variation over the life of the mine;
- Measures for monitoring of the rate and distribution of groundwater inflow; and
- Regular review of monitoring data by an experienced groundwater specialist.

Subject to acceptability in relation to slope stability considerations, it is recommended that groundwater collection take place using in pit drainage trenches and sumps.

For and on behalf of

COFFEY GEOSCIENCES PTY LTD

ROSS BEST

Senior Principal

Coffey

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