ENESAR CONSULTANTS PTY LTD

Browns Oxide Project

Groundwater Assessment

Batchelor, NT

B18183/01-G

1 November 2005

B18183/01-G GP/LT
1 November 2005

ENESAR Consultants Pty Ltd
124 Camberwell Road
Hawthorn East, VIC 3123

Attention: Ms Tara Halliday

Dear Ms Halliday,

RE: BROWNS OXIDE PROJECT
GROUNDWATER ASSESSMENT

Coffey Geosciences are pleased to provide the following report relating to groundwater conditions and predicted impacts at the Browns Oxide Project.

This final report has taken into account further comments from both the client (Compass) and comments provided by Mr Peter Jolly of the Northern Territory Department of Natural Resources, Environment and the Arts, Water Resources Division and supersedes report number B18183/1-G.

Please do not hesitate to contact the undersigned on (07) 3274 4411 should you have any questions in regard to this report or any other hydrogeological matter.

For and on behalf of

COFFEY GEOSCIENCES PTY LTD

Ross Best

ROSS BEST

Senior Principal

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1. INTRODUCTION

Compass Resources NL (Compass) is proposing to develop a mining operation called the Browns Oxide Project in the Northern Territory, 65 km south of Darwin and 7 km northwest of the Batchelor township.

The scope of the project is to mine and process a polymetallic oxide ore (copper, cobalt and nickel) over a project life of up to 4 years. The oxide deposit averages 20 to 25 m deep, with two pockets to a maximum depth of 57 m and overlies a stratabound sulphide deposit in Proterozoic graphitic shales, calcareous sediments, and dolostone.

The position of the proposed mining operation is shown in Figure 1. This report supersedes an earlier version (B18183/1-F of September 2005) and takes into account background materials and advice received from Mr Peter Jolly of the Water Resources Division of the Department of Natural Resources, Environment and the Arts.

1.1 Previous Investigations

The deposit is located 1 km west of the old Whites Mine and the centre of the Browns Oxide Pit is some 300 m from the Intermediate open cut. The Whites Pit and Intermediate Pit remain from earlier mining activities carried out at Rum Jungle 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.

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 for the proposed Browns Polymetallic mine was excavated in October 1999. The pit encountered groundwater and was 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).

A summary of the main findings of the three previous Water Studies investigations is given in Appendix A.

1.2 Scope of This Investigation

This investigation presents an evaluation of groundwater implications associated with the proposed Browns Oxide deposit. The implications are similar to results presented in Water Studies (2002a & b) but the mining is shallower and additional monitoring data, that sheds new light on previous results, is available.

a) Describe the existing groundwater system

This will be done with particular reference to Batchelor's potable and irrigation water supply bores, which are some 10 km away and in dolostone, and groundwater aquifers and will include the following points:

- Significance
- Current uses
- Flows
- Water quality
- Interactions with surface water bodies (e.g., East Finniss River)
- Impact of historic mining activities.

b) Assess potential impacts on groundwater quantity

This section will assess potential impacts on the volume of water in local or related aquifers including:

- Local aquifer resources
- Batchelor's groundwater resource.

c) Describe potential impacts on groundwater quality

- Discuss pollution pathways from the project to regional groundwater systems with potential connection to Bachelor's aquifer and Darwin River Dam catchment.
- Discuss the potential for contamination of the groundwater system by acid mine drainage, radionuclides or other chemicals or pollutants.
- Consider and discuss the risks associated with the proximity of the proposed project to:
    - Borefields or aquifer recharge zones that may supply potable water.
    - The Rum Jungle site.

d) Evaluate mitigation options

- Outline any safeguards or management strategies that may be used to reduce the impacts of construction and operation on the groundwater system.
- Describe predicted residual impacts after management measures have been implemented and after mining has been completed.

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 Finniss River and its tributaries. The Finniss River catchment drains initially to the north, then turns sharply west at the Old Crossing. 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 300 m from Rum Jungle Intermediate mine-void that is to the north and on the opposite side of the East Finniss River. The project area is 400 m from the Intermediate mine waste dump which is on the same side of the river as Browns Oxide Project. These position relationships are shown in Figure 1.

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 wet season starts in November and ends in March, the average rainfall distributed as shown in Figure 2.

The rainfall has distinct seasonality because of the monsoonal climate. An example from the BOM Silo rainfall data for Browns Oxide deposit over approximately the past 20 years is shown in Figure 4. In Section 2.4 it will be seen that groundwater levels are strongly influenced by this seasonality.

A method of rainfall analysis referred to as *rainfall residual analysis*, which compares current rainfall with long term average values has been used to identify rainfall trends in terms of above average (excess) or below average (deficit) periods. Values above average suggest excess rainfall, during which groundwater levels might be expected to rise, values below average suggest the opposite and groundwater levels might be expected to fall. For the Browns Oxide area a plot of cumulative rainfall residual is presented in Figure 3.

The rainfall residual suggests that rainfall in the area has been predominantly below average since about 1918, with short periods above average in 1950's and 1970's/1980's insufficient to create an excess. The result is a long period of deficit rainfall during which groundwater levels could be expected to have been depressed. In recent years (through the 1990's), rainfall has consistently been above average, to the extent that the cumulative graph is now in excess. Under these conditions, groundwater levels could be expected to have risen.

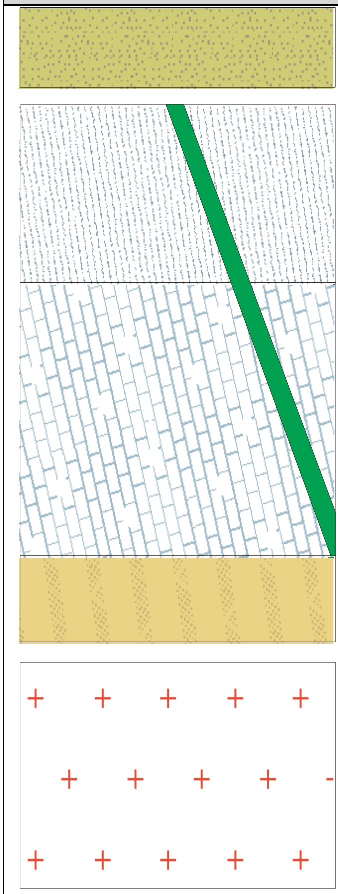
2.3 Geology

The geology of the project area as mapped by Lally (2003) in the context of the geology of the Rum Jungle mineral field is shown in Figure 1. Reference should be made to Lally for details of the geology, which shows that 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.

A NW to SE geological section through the Browns oxide area (along line A-A' in Figure 1) is shown in Figure 5.

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. The same symbols are used on Figures 1 and 5.

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	Mount Partridge
	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	
	Arkosic arenite, quartz arenite, and conglomerate	Crater Formation	
	Granitoid		Rum Jungle Complex

Water Studies (2002b) state that mineralisation in the Whites Formation is confined between the contact zone with Coomalie Dolostone and terminates against the Giants Reef fault.

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 and sulphide minerals have been oxidised. 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.

Groundwater levels have been irregularly monitored in 5 bores since 1983. The hydrographs for these bores are presented in Figures 6 to 8 over the same time interval as the rainfall record shown in Figure 3.

The rapid cyclic groundwater response to rainfall is evidence that the aquifers, in the project area, are unconfined. The regular recessions are also evidence of a dynamic groundwater system in which groundwater is discharging to creeks or is being used, for example by transpiration. Evaluation of the rainfall shows that there is potential for a high proportion of rainfall to recharge the aquifers during the wet season. A long term average suggests that recharge could be 47% of rainfall during November to March.

Water Studies (2002b) repeat many of the observations presented in the Water Studies (2000) relating to the nature of the aquifers (see Appendix A) 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 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 developing on the steel casing. Bore RN22107 located 150m north-west of Whites Pit produced an 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.

2.4.3 Groundwater Yields

Airlift yields were tested after construction of the trial pit observation holes. These and other indicators of yield are listed in Table 3.

TABLE 3: AQUIFER YIELD

Bore	*Air Lift Yield (L/s)*	*Pumping Rate (L/s)*
TPB1	8	12.5
TPB2	8	9.5
TPB3	30	20
Trial Pit		20 (initial) 9 (average)
Other Bores - Max	40	
Other Bores - Mode	0.1	
Other Bores - Average	9.5	

Note: "Other bores" refers to registered bores of which 16 record airlift yields.

Compass' mineral exploration bore logs note the presence and depths of karstic or fracture zones. In some holes groundwater inflow was so high that it prevented further drilling. The karstic zones were studied spatially by Water Studies (2000).

For this project, the cavernous intersection in the exploration holes has been classified into groups and plotted spatially in Figure 9, the classification plot shows a tendency of deep permeable zones which appear to be associated with the shale (Whites Formation), and high yield bores to plot along a fault line (referred to in the geological mapping of Lally (2004) as a shear zone with normal throw). The association of high yielding bores with the fault is expected to influence groundwater inflow in parts of the excavation that intersect the fault. Drawdown, from mine dewatering, might expand more widely in the direction of the fault.

Aquifer boundaries and the extent of connectivity are unknown but the shallow aquifer appears to be connected in the form of a continuous porous zone and connectivity may also be enhanced by fracturing. It appears that the aquifer may reasonably be regarded as a single unit, rather than separate shallow and deep aquifers. It would appear likely that under high stress some separation in groundwater levels between individual water bearing features would occur. Compass advise that during bulk sampling from the trial pit inflows were observed from the footwall carbonates, faulted ground and from hanging wall amphibolites.

Compass have advised that groundwater inflows to the Whites Open Cut averaged approximately 23L/s over the life of the mine with comparable groundwater inflows experienced into the Intermediate Pit and that no major pumping problems were experienced during these former mining operations. This experience is considered to provide a guide to the groundwater inflows that may be experienced in the proposed Browns Oxide Project.

2.4.4 Groundwater Elevation and Groundwater Flow Direction

Insufficient data is available to prepare a groundwater surface map (watertable contours). Such a map requires detailed study of groundwater level changes as, under this dynamic groundwater system, the water table would fluctuate with time. Despite this, the general trend in groundwater flow can be predicted from the conceptual model of the groundwater system.

Under unconfined conditions, in relatively high hydraulic conductivity formations, the groundwater surface would be a flat version of the surface topography. Groundwater would therefore move towards the major creeks where it may sustain baseflow following the wet season or may sustain water in pools (billabongs) in otherwise dry creek beds. Potential groundwater flow paths in the area around Browns Oxide deposit based on the topography are shown in Figure 10.

Groundwater was intercepted by the trial pit (excavated to 31 m depth) at approximately 8 m below surface. Water was pumped out of the pit at an average rate of approximately 740 m^3/day (8.8 L/s) for 71 days. Records show that the pumping rate was sustained at approximately 10.3L/s for the later half of the test, presumably to sustain the drawdown within the pit. The evidence therefore shows that groundwater might be intercepted by the mine excavations at between 4 and 8 m below surface. The deepest mine excavations will go to 57 m below surface.

2.4.5 Long -Term Groundwater Elevation

From the 5 longer term hydrographs (Figures 6, 7 and 8), there is some evidence that groundwater levels have increased over the period during which monitoring has taken place. The hydrographs are based on manually recorded water levels and are not continuous. Manually recorded levels may not capture the highest water level attained in the bore and the observed trends are subject to confirmation from more continuous automated methods.

It is possible that the apparent rising trends over the period shown in Figures 6 to 8 are due to the increased rainfall residual discussed in Section 2.2 and shown in Figure 4.

2.5 Groundwater Observations from the Dewatering Trial

Impacts from the trial pit dewatering were evaluated by Water Studies (2002c) who noted drawdowns in all bores that were used for monitoring during the trial. They evaluated the bores in terms of distance from the centre of the trial pit and in terms of lithology and their conclusion was that responses were influenced by lithology or geological structure.

The evidence they present shows that 3 bores (TPB1, 2, and 3) that show clear responses to pumping, are between 130 m and 240 m from the centre of the trial pit. Bore RN 23516 is 360 m from the trial pit and shows a small impact of 0.23 m, of which 0.18 m may be due to the trial dewatering. Most of the bores monitored during the trial dewatering showed drawdowns as summarised in Table 4.

TABLE 4: CHANGE IN GROUNDWATER LEVEL AT BORES MONITORED DURING TRIAL PIT DEWATERING

Bore ID	*Surface Elevation (mAHD)**	*Collar Height (m above ground)*	*Distance from Trial Dewatering (m)*	*Drawdown during trial (m in 71 days)*
TPB2	60.67028	0.45	140	**3.3**
TPB1	63.41141	0.5	150	**3.0**
TPB3	69.56539	0.48	240	**0.8**
RN23137	68.57073	0.75	250	**Increased in level by 2.4m**
RN23516	57.91182	0.9	360	**0.14**
RN22085	59.84417	0.95	640	**No apparent impact**
RN22084	61.3117	0.4	1120	**No apparent impact**
RN22544	59.44085	0.9	1340	**No apparent impact**
RN23511	58.59597	1.33	1470	**No apparent impact**
RN23140	57.96405	0.55	1500	**No apparent impact**
RN24130	62.50652	0	2500	**No apparent impact**
RN22548	72.71493	0.15	2500	**No apparent impact**
Day Sect. Bore	73.0734	1.07	3200	**No apparent impact**
RN28747	65.97597	0.92	4800	**No apparent impact**
Earthrowl Bore	67.15279	0.2	5000	**0.8**
Crater Lake	**68.80237**	**0.5**	**11700**	**No apparent impact**

Longer term monitoring shows that the change in water level recorded in many of the bores monitored over the trial dewatering period is due to the natural recession that is evident in groundwater in this area and is not due to the trial dewatering. Examples of the responses are given in Figures 11 and 12.

Many of the observation points monitored during the trial period do not have longer term monitoring and the response is assessed taking account of the natural dry season groundwater recession. Taking this into account no response is apparent for many of the bores monitored.

RN23516 is 360 m from the trial dewatering, from the geological mapping it appears to be linked to the trial pit by a fault (see Figure 9). The response in this hole of 0.18 m drawdown may therefore not be characteristic of the aquifer at that distance from the dewatering trial because of the possible more direct connection to the trial pit via the fault. No response was apparent for bores at greater distance than 360m from the centre of the pit except for the apparent response of 0.8m from the Earthrowl Bore. Given that this bore is some 5km from the test pit it is considered that the apparent response is coincidental and relates to some external influence.

Bore RN23137 showed an increase in groundwater level in response to the trial dewatering. It is assumed that this relates to the effects of discharge of the pumped water from the trial dewatering.

A distance drawdown plot based on the four bores that responded to the dewatering trial is presented in Figure 13.

From this evaluation of the trial pit dewatering, it is evident that four bores exhibited drawdown response to pumping. The drawdown response is clearly affected by the irregular form of the trial pit and the large volume of storage within the pit so that conventional pump test interpretation is not possible. The test demonstrated that dewatering of the pit could be sustained (during the dry season) by groundwater extraction at 10.3 L/s and that groundwater impacts to dewatering over a three month period were limited to a distance of about 400m from the centre of the pit along the strike of the major geological features.

2.6 Other Groundwater Users

The registered bore data for this area contains 116 registered bores within a 3 km radius of the proposed mine, of these 15 appear to be production bores and 10 are at the groundwater irrigation area located south west of the mine. These bore details are summarised in Table 5.

The high yield recorded in some parts of the aquifer suggest that it is a useful resource.

TABLE 5: OTHER GROUNDWATER USE

BoreID	*Easting (GDA 94 Z52)*	*Northing (GDA 94 Z52)*	*Name*	*Distance from Browns Oxide Project (m)*
RN024109	715028.673	8561760.593	Goyder4	1390
RN031479	714937.674	8561903.591	About-Time	1390
RN024131	715078.673	8561610.594	Goyder6	1460
RN030843	714777.675	8561555.595	Goyder8	1710
RN024130	714598.677	8561430.596	Goyder5	1940
RN021951	714578.677	8561410.596	Goyder1	1970
RN021952	714578.677	8561410.596	Goyder2	1970
RN021953	714578.677	8561410.596	Goyder3	1970
RN000259	718440.646	8564282.581	Army1	2090
RN024641	714468.678	8561310.597	Goyder7	2130
RN000261	718668.644	8564276.583	Army2	2270
RN009799	715128.674	8560260.608	UranerZ	2590
RN031234	715105.674	8560180.609	Goyder9	2670
	716163	8559573	Day Sect. Bore	3200
RN28747	713042	8559474	At irrigation area	4800
	713388	8558926	Earthrowl Bore	5000

Groundwater is used for town water supply, agricultural and domestic purposes at Batchelor some 7km to the south east of the Browns Oxide Project site (Jolly, 1981, Department of Transport and Works, 1989, Jin Foo, 1996 and advice from Mr Peter Jolly of the Department of Natural Resources, Environment and the Arts). The Coomalie Dolostone in this area is characterised by high groundwater yields. Sustainable yield in the Batchelor area is assessed as 1,000 GL between recharge events. Water quality has remained stable allowing continuing use for town water supply purposes.

Coffey

2.7 Summary of the Groundwater System

- Aquifer is unconfined;
- Moderately transmissive;
- Groundwater is dynamic, groundwater levels respond to recharge and natural discharge, groundwater levels fluctuate by between 2 and 8 m over the wet and dry season;
- There is some evidence that groundwater levels may have risen in recent years due to large scale cycles in weather conditions, the area is presently experiencing above average rainfall;
- Groundwater yields vary from low (0.1 L/s) to high (60L/s) with average about 9 L/s. This is relatively high suggesting that parts of the aquifer system are a good resource and indicating the potential for high groundwater inflows from karstic features within the Coomalie Dolostone.

2.8 Groundwater Quality

In a discussion relating to the “shallow” and “deep” aquifer models of Salama & Scott (1986) and Appleyard (1983), Water Studies (2002b) present data from other sources that show:

- The “shallow aquifer” water quality is influenced by leachate from the Rum Jungle waste dumps. Typical concentrations of indicator parameters in shallow groundwater show 10 mg/L to 100 mg/L copper, manganese, nickel, and cobalt, pH 3 to 4, and EC 2,000 µS/cm to 13,000 µS/cm and elevated sulphates.
- Monitoring up to 1986 of the “deep aquifer” was confined to the vicinity of the Rum Jungle waste heaps and open cuts. Water quality near Whites Waste Dump had an EC greater than 30,000 µS/cm and pH of about 4. It was assumed, due to lack of connectivity that contaminant transport in the “deep aquifer” was restricted compared with the “shallow aquifer”. Records from registered monitoring bores in Rum Jungle area show that groundwater sulphate could be as high as 22000 mg/L. These results clearly show the effects of oxidation of sulphide material and contrast with the results of groundwater quality monitoring adjacent to the trial pit set out below.

Groundwater quality was measured in the trial pit observation bores, the results are summarised in Table 6.

TABLE 6: GROUNDWATER QUALITY IN MONITORING BORES AT THE TRIAL PIT

Bore	*Aquifer*	*pH*	*ECa (µS/cm)*
TPB1	Weathered carbonate aquifer	7.1	235
TPB2	Weathered Whites Fm./Carbonate Contact	5.9	3550
TPB3	Fault Zone	6.9	260

Water Studies (2000) states that groundwater in the weathered zone of the Whites Formation is poorer quality and slightly acidic compared with the deeper water reported in Table 6. This may be a local phenomenon as discrimination in water quality in a rapidly recharged, unconfined system with dynamic water level variations is difficult to explain.

Recent monitoring has included measurement of pH in the trial pit (27 March and 8 May 2005), at both times the water was acid with pH of just over 3. Sulphide ore (partially oxidised on the dump) previously stockpiled near the trial pit has been pushed back into the pit. This is the likely cause of the low pH values. Compass advise that the pit water was circumneutral or alkaline until the ore was pushed back into the pit about four years after excavation.

Groundwater quality at the irrigation area is fresh (200 mg/L TDS) but may have high dissolved iron (up to 26 mg/L).

3. IMPACTS

3.1 Impacts of Groundwater Inflow on Mining

Even at the shallow depths for the oxide excavation karstic/fractured rock may be intersected giving rise to high initial rates of groundwater inflow, although it is anticipated by Compass that this will only occur in the footwall and that there is little evidence of it there. The initial rates are expected to decrease over time to lower values. Inflows will be subject to seasonal impacts as the local groundwater system is influenced by rapid groundwater recharge during the wet season with gradual recession over the dry season.

Water from the Finniss River and water stored within the Intermediate Pit and the Whites Pit would provide recharge to the groundwater system during mining of the proposed Browns Oxide Project.

Initial groundwater will be intercepted from between 4 to 8 m below surface, depending on the time of year, and groundwater inflow will increase as the excavation is deepened. Water will be encountered in the base of the excavation making trafficability difficult but inflows will also occur from the sides of the benches and may fluctuate seasonally.

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[a] Water Studies (2000) state that samples were collected from each bore for detailed laboratory analysis however this may never have happened. There are minor discrepancies in the results presented in Water Studies (2000) and Water Studies (2002b), Water Studies (2000) was the original source so results from that source have been used in this report.

Predictions of inflow rates can be made using analytical methods. These contain uncertainty as they cannot consider time variations such as, progressive enlargement and deepening of the excavation, they therefore assume that the excavation is emplaced at once. Analytical methods suggest that inflow may be between 600 and 2000 m^3/day (7 to 23 L/s) depending on the stage of excavation. This translates to about 0.3 and 1.1 m^3/m/day of excavation perimeter. It is noted that mining will take place up and down the fault and so it is possible that higher inflows may occur.

It is likely that high transmissivity features are present within the slightly weathered to fresh Coomalie Dolostone and that these were not engaged during the pump out test from the trial pit. It is possible that such features may be encountered during mining operation resulting in substantial increases to pit inflows. Based on experience at the Whites Pit and the Intermediate Pit where groundwater inflows averaging of the order of 23L/s were experienced it is assessed that inflows of this magnitude may be expected. Based on discussions with staff of Compass it is understood that mining is to be restricted to the weathered oxide carbonate and is not planned to take place in the fresh Coomalie Dolostone where high airlift yields have been recorded. Nevertheless it is possible that high yielding zones may be encountered at the base of the mine pit where it intersects or comes close to the fresh Coomalie Dolostone. For this reason it is recommended that provision be made to address groundwater inflows up to 60L/s. Should groundwater inflows in excess of 30L/s occur during mining it is recommended that the services of an experienced hydrogeologist or groundwater engineer be engaged to provide advice in relation to management of groundwater inflow.

Drawdown influences associated with high groundwater inflows are assessed as likely to be largely limited to the Coomalie Dolostone and the faulted zone to the north east of the proposed mine. Groundwater loss from the Intermediate Pit to the north east of the proposed mine may occur. The chemistry of groundwater inflows would be expected to be influenced by groundwater chemistry within the Intermediate Pit. Water quality in the Intermediate Pit is understood to be managed by diversion of fresh water flow from the Finniss River through the Intermediate Pit during the wet season.

Groundwater inflow to the excavation will cause difficult mining conditions including poor trafficability, some areas may be inaccessible due to water, wet blasting conditions, and slope stability may be influenced by high water tables. The position of the water table is expected to vary seasonally so that any of these issues may not occur at certain times of the year but may become significant at other times.

Groundwater inflows and levels will have to be controlled to minimise these predicted impacts and to manage the seasonal range. Options include:

- Dewatering pumping from bores around the perimeter of the excavation;
- Curtain grouting of particular features;
- A cut-off trench around the perimeter of the excavation, the trench would have to be designed to drain to a sump(s) from where the water can be pumped;
- In-pit dewatering, for this option, the excavation is progressed in such a way that it drains to a sump from where the water can be pumped; and,
- Even with dewatering bores or a cut-off trench all the groundwater seepage may not be captured and some in-pit drainage and pumping is likely to be necessary.

3.2 Impacts of Groundwater Quality on Mining

Groundwater quality collected by the mine may be influenced by seepage from Rum Jungle mine dumps particularly Intermediate and Whites. Previous investigations have suggested that all contaminated groundwater moves in a shallow aquifer zone and that deep migration of pollutants is limited. However this study indicates that a single aquifer is operating in the area and so as groundwater is drawn down by dewatering the contaminated groundwater will move downward and may join deeper, fresher groundwater that is moving toward the mine. This means that groundwater quality may deteriorate during dewatering. It is noted that the Rum Jungle Mine pits are located on the far side of the East Finniss River, which is an ephemeral stream. Given the relatively shallow depth of the proposed oxide pit the risk of ground water movement under the river is low, assuming that there is a relict water mound beneath the river. Wet season recharge from this river together with wet season recharge to the groundwater system in the vicinity of the Browns Oxide Project will tend to limit potential for migration of groundwater from the Rum Jungle mine dumps.

Groundwater quality tested during the trial pit dewatering suggested that the groundwater in the deeper aquifer is fresh to slightly saline (depending on lithology) and slightly acid to neutral. During dewatering the quality of some inflows is expected to become slightly saline, TDS may rise above 3000 mg/L, and the water may be acidic. Acidic groundwater conditions with pH values as low as 2.7 were measured in groundwater samples collected by the Department of Transport and Works in the vicinity of the waste rock dumps from the Whites Pit and the Intermediate Pit. Groundwater quality in the weathered carbonate were typically above pH 6.5 with values as low as pH 4.9 measured in groundwater taken from cavities within the fresh dolostone.

Depending on the water control measures adopted, the water quality may vary according to the location of the point of collection. For example, if dewatering is done using perimeter bores the water quality on the north-western, south-western and south-eastern perimeters is expected to remain relatively constant while on the north-eastern perimeter it is expected to deteriorate as polluted water is drawn in from the Rum Jungle Mine area. In contrast, if water inflows are managed with in-pit methods the water will be mixed in a sump so that the pumped water quality will become uniform.

The quality of groundwater inflow to the pit will need to be monitored and treatment will need to be carried out as necessary to achieve adequate discharge standards. Water quality also has potential to influence the rate of corrosion of mining and pumping equipment.

3.3 Impacts of Mining on Groundwater Quantity

Removal of groundwater will impact the aquifers by lowering groundwater and changing groundwater flow directions. Predicting the extent to which this may happen will require additional monitoring data and further groundwater modelling.

For this evaluation expected impacts have been extrapolated from the dewatering trial results, drawdowns have been predicted using analytical methods and have been applied regionally around the proposed mine using the trial dewatering results. The predicted drawdown distance curve is shown in Figure 13. A section (along line A-A' Figure 1) with possible mining drawdowns is given in Figure 14.

The drawdowns will be influenced by geological boundaries and recharge sources such as rivers. Some of these controls are based on the conceptual model that is based on information available at the time of this investigation. Additional investigation would assist in the evaluation of the influence of these boundaries. Therefore these predictions would have to be investigated further by modelling or by monitoring during mining.

Drawdown impacts will be greatest adjacent to the mine and will reduce with distance influenced by geological boundaries and recharge sources. An initial appraisal of the extent of drawdown impacts was made using analytical methods assuming radial homogeneity with no boundary conditions imposed. Based on this analysis drawdown impacts are calculated to extend to between 1000 and 1500 m around the mine excavation (see Figure 13). It is likely that wet season recharge and the presence of the Finniss River will restrict impacts compared with the analytical model results. Analytical models of the kind used do not address seasonal recharge. Monitoring results show strong recharge to the groundwater system each wet season and also showed the absence of measurable drawdown impacts beyond 500m from the trial pit during a three month dewatering period. Taking these factors into account it is considered unlikely that drawdown impacts will be greater than predicted using the analytical model described above.

If boundaries such as the East Finniss River or the catchment boundary constrain groundwater drawdown it is expected to extend to the East Finniss River on the north-eastern side. This is expected to influence dry season flows and billabongs in the river. If the catchment boundary constrains drawdown, it will widen somewhat at the boundary but will not extend beyond the boundary. If the boundaries do not influence drawdown, it could continue beyond the boundaries. Drawdown extents are shown in Figure 15, as estimated above, and considering possible boundary conditions. As discussed above impacts may be suppressed below those shown in Figure 15 as a result of wet season recharge to the groundwater system.

River flows during the wet season are not expected to be influenced but low flows and dry season conditions may be impacted. It is noted that the river is already ephemeral. To determine the scale of impact would require additional investigation including analysis of flow gauging records for the river.

Figure 15 does not include the influence of faults however it shows the position of mapped faults. The association of high aquifer yield with faults discussed in Section 2.4.3 suggests drawdowns could extend in the direction of faults. Responses recorded during the trial dewatering operation are assessed to indicate that drawdown impacts on the irrigation area in the vicinity of bore BN24130 would not be significant though it is possible that some impact could develop along preferential flow paths associated with geological features including faults. It is recommended that groundwater monitoring be carried out during operation to assess development of groundwater drawdown impacts.

Other bores in the vicinity of the proposed mine including RN28747, Earthrowl Bore, Day Sect Bore and Batchelor township bores, are between 3 and 7 km from the mine and are not expected to be influenced by dewatering.

3.4 Impacts of Mining on Groundwater Quality

On the eastern side of the mine drawdowns are not expected to be significant at the waste dumps of Intermediate and Whites mines though it is possible than mine dewatering could have some influence on the direction of contaminated water migrating from those sources. The mine will act as a collector of groundwater and this may include some groundwater which is affected by infiltration from the waste dumps. Impacts on the volume of contaminated groundwater that migrates to the East Finniss River are considered likely to be small though there may be some reduction to the volume of contaminated groundwater migrating to the river.

Geochemical testwork has been undertaken on 16 drill core samples of near-surface rock that will be mined over the life of the Browns Oxide Project (EGi, 2005). This waste rock will consist of either oxidised sulfidic shales or carbonate-rich sediments. The different lithologies have been categorised on the basis of acid-forming potential (i.e., either non-acid forming (NAF) or potentially acid forming (PAF)). The black shales with sulfide content greater than 1% are classified PAF. Black shales with negligible sulfide content (<0.02%) are considered to have negligible potential for acid generation. The carbonate waste rock samples are considered unlikely to acidify, although it is possible that sulfidic dolomite may generate sulfate rich drainage over time.

Uranium is reportedly at insignificant concentrations and radiogenic contamination from the deposit is not expected but radiogenic contamination may enter the system via contaminated groundwater so should not be excluded from monitoring.

Mine wastes from the Browns Oxide Project should be studied to assess their potential to leach contaminants from soluble minerals in the waste rocks, tailings, or from contaminated water that may be co-disposed with the mine wastes. Management measures should be undertaken to address leachate from mine tailings or other waste.

3.5 Summary of Impacts on Groundwater

Some changes to dry season flows in the East Finniss River may occur as a result of dewatering for the Browns Oxide Project. This impact is considered likely to be low. It is recommended that gauging records be monitored during mine operation to assess the level of this potential impact. It is also possible that minor reductions to the volume of contaminated groundwater reaching the East Finniss River could occur as a result of dewatering for the Browns Oxide Project.

Samples from the Browns Oxide deposit show insignificant Uranium content and some potential for acid generation.

Salinity and acid generation should not be discounted because the ore is oxidised, more comprehensive testing may be required.

3.6 Mitigation

Groundwater drawdowns have been predicted from the available information using analytical estimation that is largely time independent, this means that it calculates the impact for an essentially infinite mine life. The mining is proposed to occur for up to 4 years, over this relatively short period impacts are likely to be lower than assessed based on the analytical methods adopted.

The potential for high rainfall and rapid groundwater recharge suggests that impacts generated during the dry season may recover during the wet season in which case mitigation may not be necessary. Evaluation of long term climatic trends suggests that the area is entering a period of excess residual rainfall during which groundwater recharge will take place.

The extent and duration of impacts is uncertain and additional investigation and monitoring is required to refine the predictions made in this report. If, and only if, impacts on neighbouring groundwater users are shown to be significant mitigation will be necessary. Mitigation possibilities include:

a) Reinjection of groundwater. Ideally this should be done across the catchment boundary, but reinjection would only be possible if the water quality was good and remained unaffected by mining. The possibility that dewatering might draw poor quality water to the mine suggests that this option may not be acceptable. Reinjection would be complicated by the presence of low permeability zones that may occur in heterogeneous rock units. For example groundwater removed from an aquifer zone with high permeability could not be returned to another aquifer zone with low permeability.

b) Groundwater barrier (such as curtain grouting). This would be very costly if the whole mine were targeted, indications are that high yield zones exist at the mine, these may contribute the bulk of the groundwater inflow. Barriers could be targeted at the high yield zones to reduce costs but not control all groundwater inflow.

The selection of appropriate measures should be determined only once adverse impacts are observed and should take into account conditions observed. Additional monitoring bore locations may be necessary to provide an adequate understanding of the effects of the mining on the groundwater.

Waste containment facilities should include clay barriers or liners and underdrains to prevent leachate leakage and capture any leachate that might leak.

3.7 Monitoring

A proposed monitoring program was presented in Water Studies (2002a) in which 15 bores were identified for monitoring, these bores have been monitored at approximately monthly intervals since January 2002. In addition, water chemistry (pH) has been measured in the trial pit since March 2005 this should continue, EC should also be measured and water depth, relative to a reference position, should be noted.

These monitoring points cover groundwater conditions in the mine area, on the north east and to the southeast. There are no positions on the northwest or southwest of the mine; monitoring points in these areas should be established. The positions should be chosen to provide maximum information to add to understanding of the hydrogeology and obtain information to reduce uncertainties identified by the conceptual model. These would include in particular identifying the nature of the aquifer boundaries, investigation of the supposed upper and lower aquifer and possible anisotropy in the direction of the irrigation area.

Boundary positions should be determined with more certainty from a more accurate topographic survey (the current investigation used a 1:250,000 topographic map). Monitoring of pump testing across the boundaries should identify the potential for impacts to cross the boundaries. All tests should be carried out during the dry season.

As the purpose of monitoring is to define the existing environment (background condition), water chemistry should be included. The groundwater monitoring program presented in Water Studies (2002a) lists the following parameters and frequencies:

"It is proposed that groundwater levels be monitored in all bores listed in Table 1 on a monthly basis. Groundwater from each of these bores will also be sampled on a quarterly basis and laboratory analysed for the following chemical parameters:

- ***General Parameters*** – pH and electrical conductivity;
- ***Major Ions*** – calcium, magnesium, sodium, potassium, chloride, sulphate, carbonate and bi-carbonate;
- ***Selected Metals*** – iron, manganese, aluminium, cobalt, copper, lead, nickel, uranium and zinc; and,
- ***Radiological Parameters*** - gross alpha and beta (in a sub-set of four (4) bores only).

From the initial round of groundwater sampling, a full multi-element scan will be conducted on a selection of samples to ensure that all metals of environmental concern are identified.

A number of key landholder's bores in which pumping equipment is installed will also be sampled and these samples analysed for the chemical parameters listed above. A selection of any non-equipped landholders bores will be made, and these bores included in the monthly groundwater level monitoring program. The use of private bores as long term groundwater monitoring facilities will need to be negotiated with landholders, once appropriate bores are identified.

This investigation supports the Water Studies (2002a) approach but would add arsenic and selenium to the list of selected metals.

4. CONCLUSIONS AND RECOMMENDATIONS

Groundwater in the project area occurs at relatively shallow depth that varies sharply with the monsoonal seasons. The dynamic groundwater regime is interpreted as an unconfined aquifer system that is rapidly recharged by rainfall and discharges to rivers or other environmental use.

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 up to 60L/s be made (approximately twice that understood to have been encountered in the nearby Whites Mine). During operation should groundwater inflows in excess of 30L/s be encountered it is recommended that the services of an experienced hydrogeologist or groundwater engineer be engaged to reassess potential future inflows and to provide advice in relation to mitigation measures.

Dewatering will lower groundwater levels adjacent to the mine and as a result groundwater will be drawn from surrounding areas towards the mine, changing groundwater flow directions in some cases.

While contaminated groundwater from the Rum Jungle mine area is not considered likely to form a significant contribution to groundwater dewatering inflows some capture of contaminated groundwater is considered possible.

Impact prediction is uncertain due to lack of evidence. It is considered unlikely that groundwater drawdowns resulting from mine dewatering would impact upon the irrigation area some 1.5 km southwest of the mine though the potential for minor impacts cannot be ruled out due to the existence of geological faults that extend from the mine through the irrigation area. These faults could create an anisotropic drawdown that extends preferentially in the direction of the irrigation area. Should adverse impacts occur mitigation measures would be put in place involving supply of the irrigator with suitable alternative water from dewatering bores.

Recommendations

- Groundwater recharge is an important feature of the local hydrogeology. It is recommended that continuous groundwater level monitoring be established on a network of monitoring bores to track recharge behaviour during mine dewatering.
- Monitoring of mine dewatering flows (quality and flow rate) is recommended to provide the basis of assessment of changes in groundwater and likely source areas.
- The dewatering trial results be used to evaluate aquifer parameters, this will give a broader indication of average aquifer parameters as opposed to values obtained from relatively short term (1 day) pumping tests.
- Bore hydrographs be evaluated in terms of responses to rainfall to define possible spatial differences in the aquifer.

- Consideration should be given to improving the understanding of the hydrogeological conditions by undertaking more detailed numerical modelling.
- Monitoring should continue at the current monitored points (these were recommended in Water Studies, 2002a), and should include water quality monitoring at some points to establish background conditions.
- Additional monitoring points are required on the south-western side to define conditions between the mine and the irrigation area.

For and on behalf of

COFFEY GEOSCIENCES PTY LTD

ROSS BEST

Senior Principal

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Information

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 the 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.

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 have incorporated 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

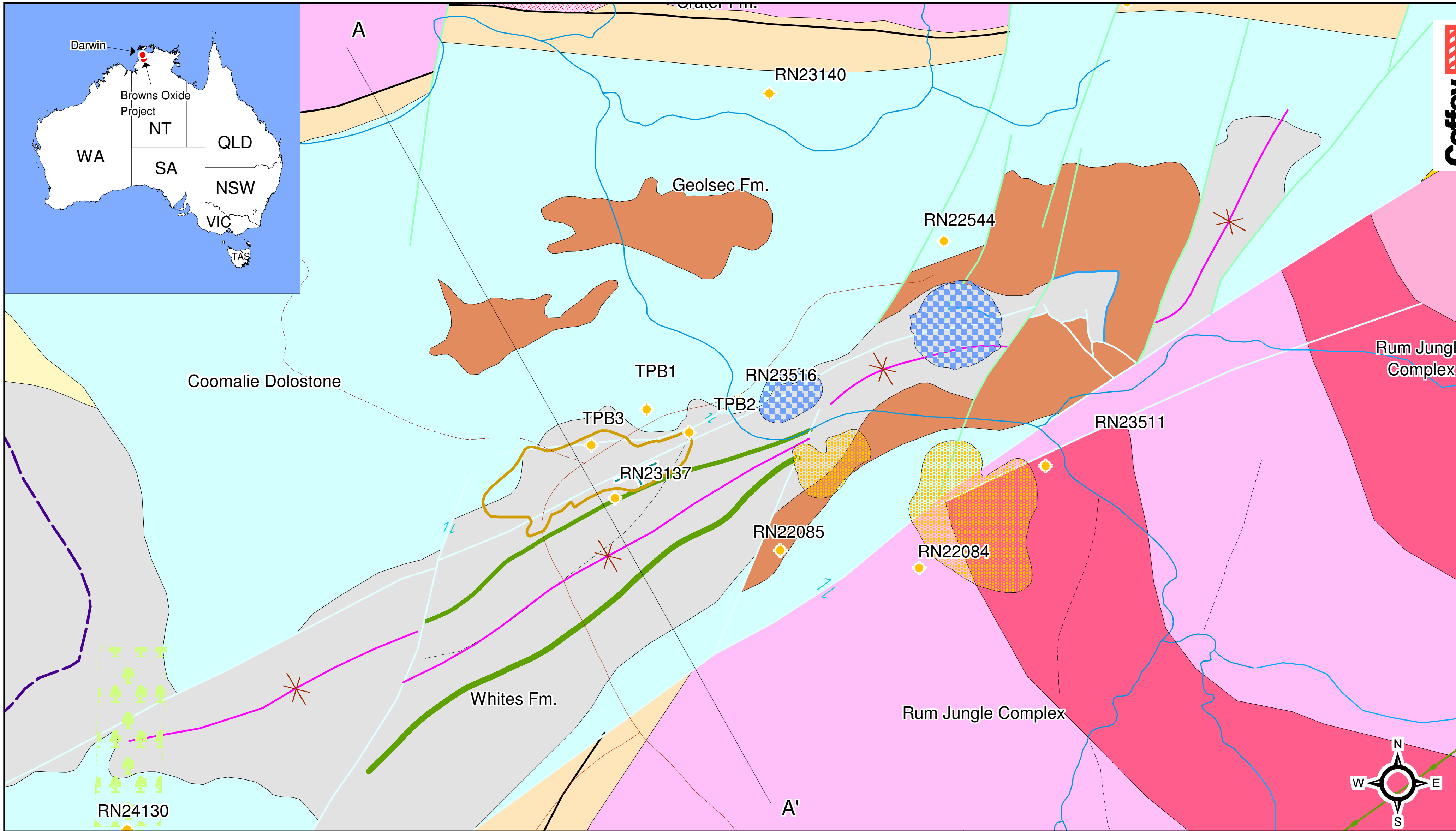
Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design toward 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.*

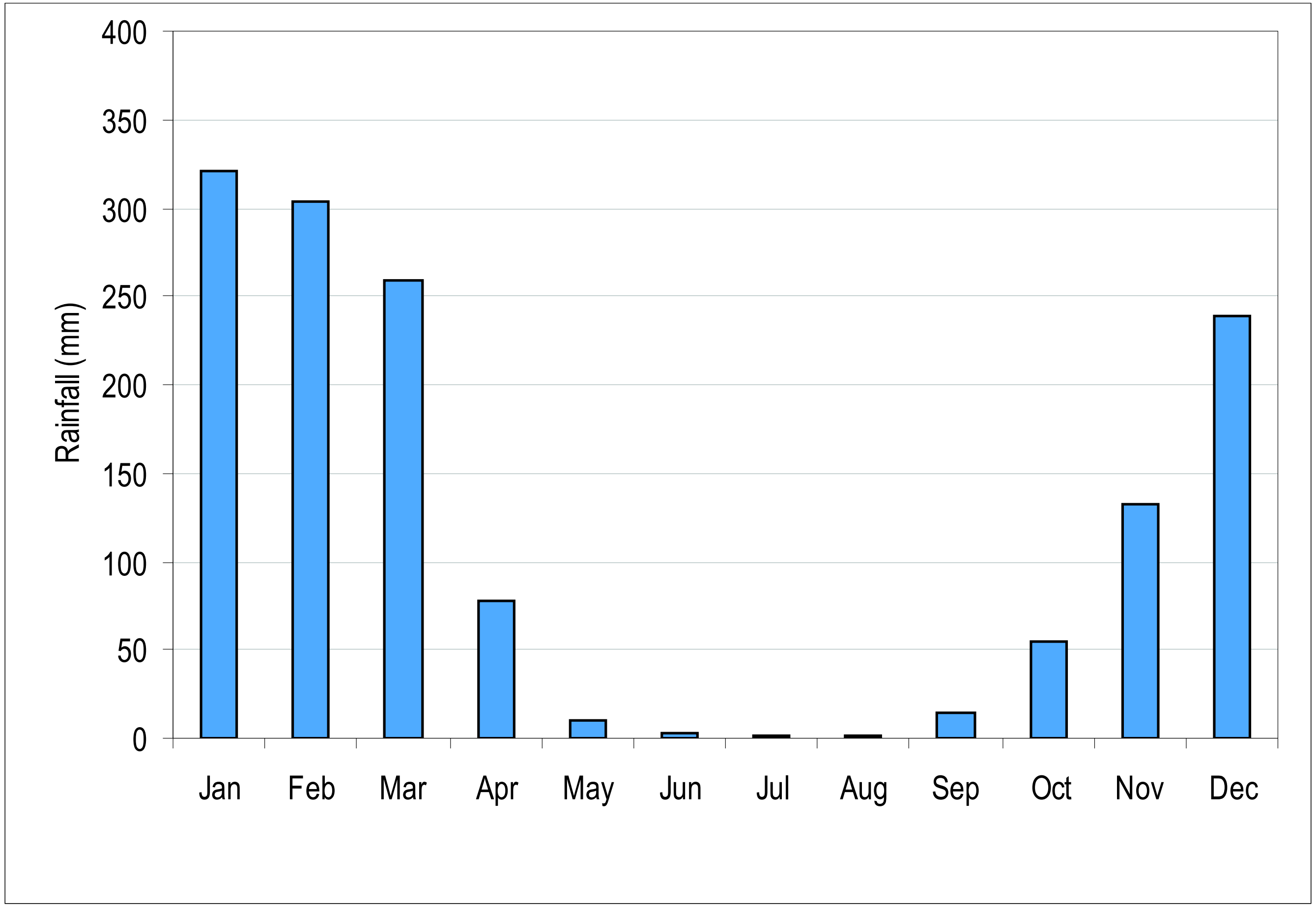
FIGURES



Trial Pit Monitoring Points
Browns Oxide Mine
Rum Jungle Mine Dumps
Rum Jungle Mine Pits
Road
Dirt Road
East Finniss River
Irrigation Area

Coffey Geosciences Pty Ltd ACN 056 335 516 Geotechnical | **Resources** Environmental | **Technical** Project Management

Drawn	**RS**	ENESAR CONSULTANTS BROWNS OXIDE PROJECT GROUNDWATER ASSESSMENT	**FIGURE 1**
Approved			
Date	**June 2005**		
Scale	**1:20000**	**LOCATION AND GEOLOGY MAP**	**Ref: B18183/01-B**



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Geotechnical | **Resources** | Environment | **Technical** | Project Management

Drawn	RS
Date	June-05
Scale	Shown on Axes
Approved	

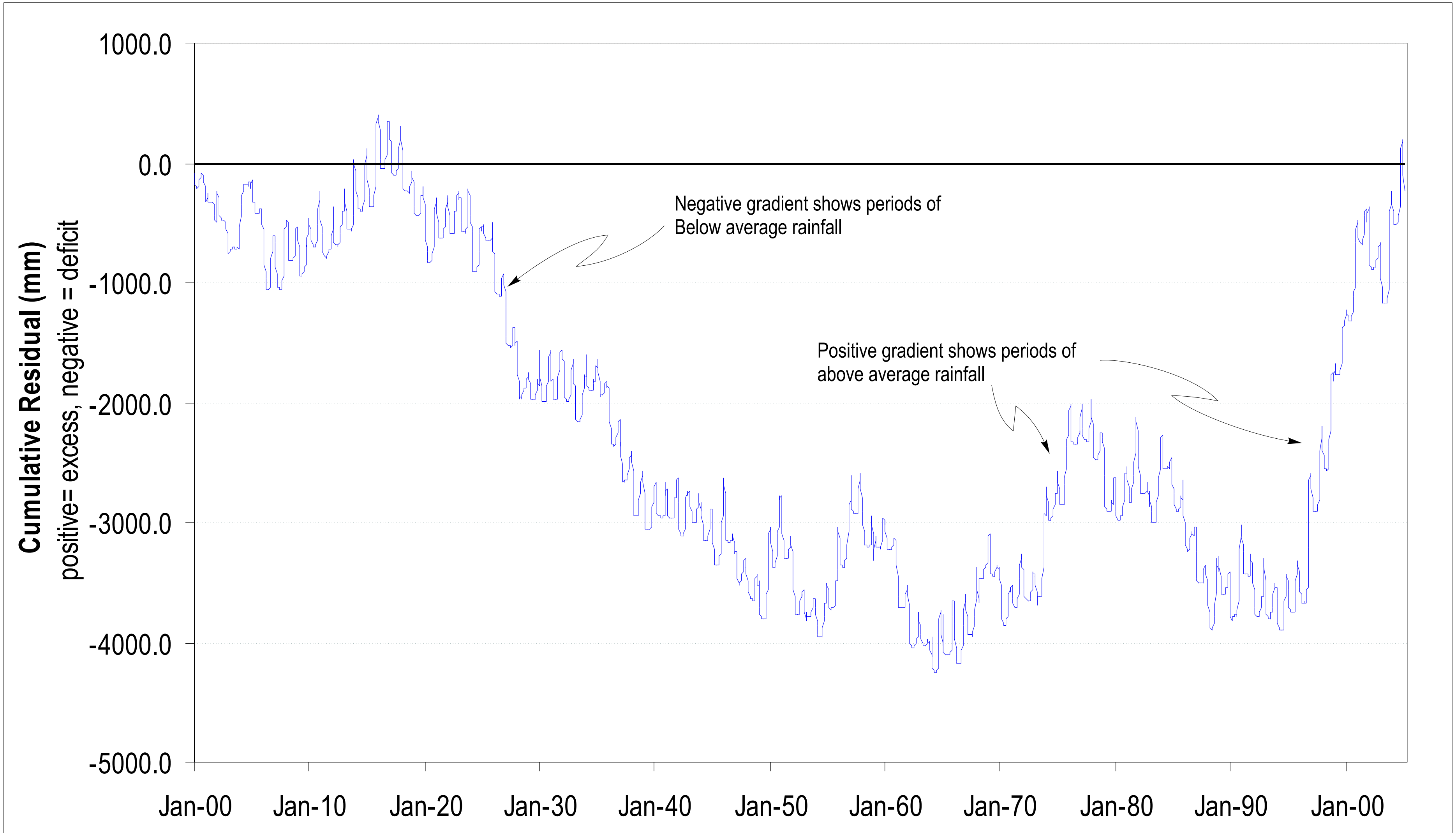
ENESAR CONSULTANTS
BROWNS OXIDE PROJECT
GROUNDWATER ASSESSMENT

AVERAGE RAINFALL AT BROWNS OXIDE DEPOSIT (FROM BOM SILO DATA)

FIGURE 2

B18183/01-B

Coffey



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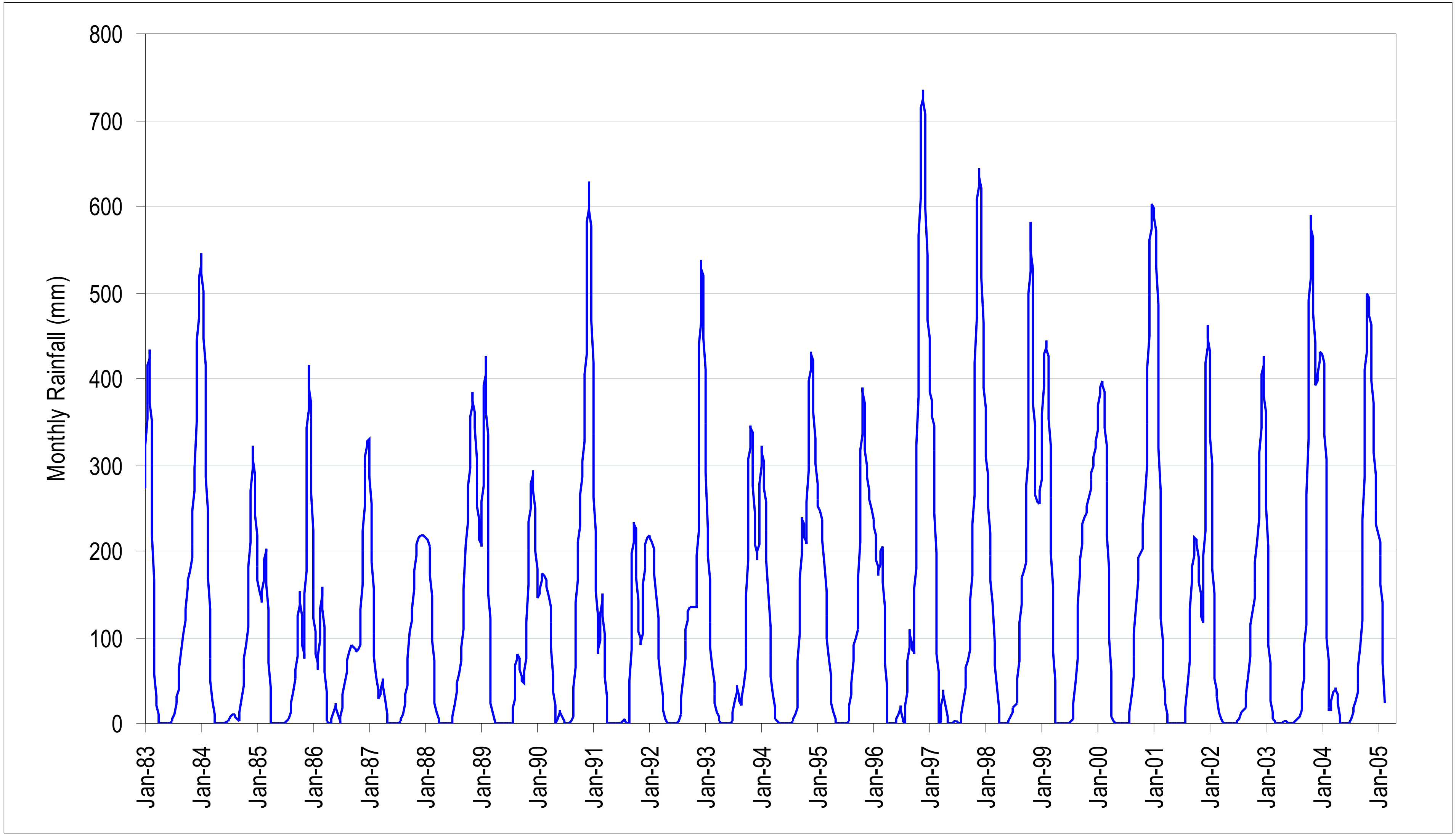
Drawn	**RS**
Date	**June-05**
Scale	**Shown on Axes**
Approved	

ENESAR CONSULTANTS
BROWNS OXIDE PROJECT
GROUNDWATER ASSESSMENT

CUMULATIVE RAINFALL RESIDUAL AT BROWNS OXIDE DEPOSIT JANUARY 1900 TO MAY 2005

FIGURE 3

B18183/01-B



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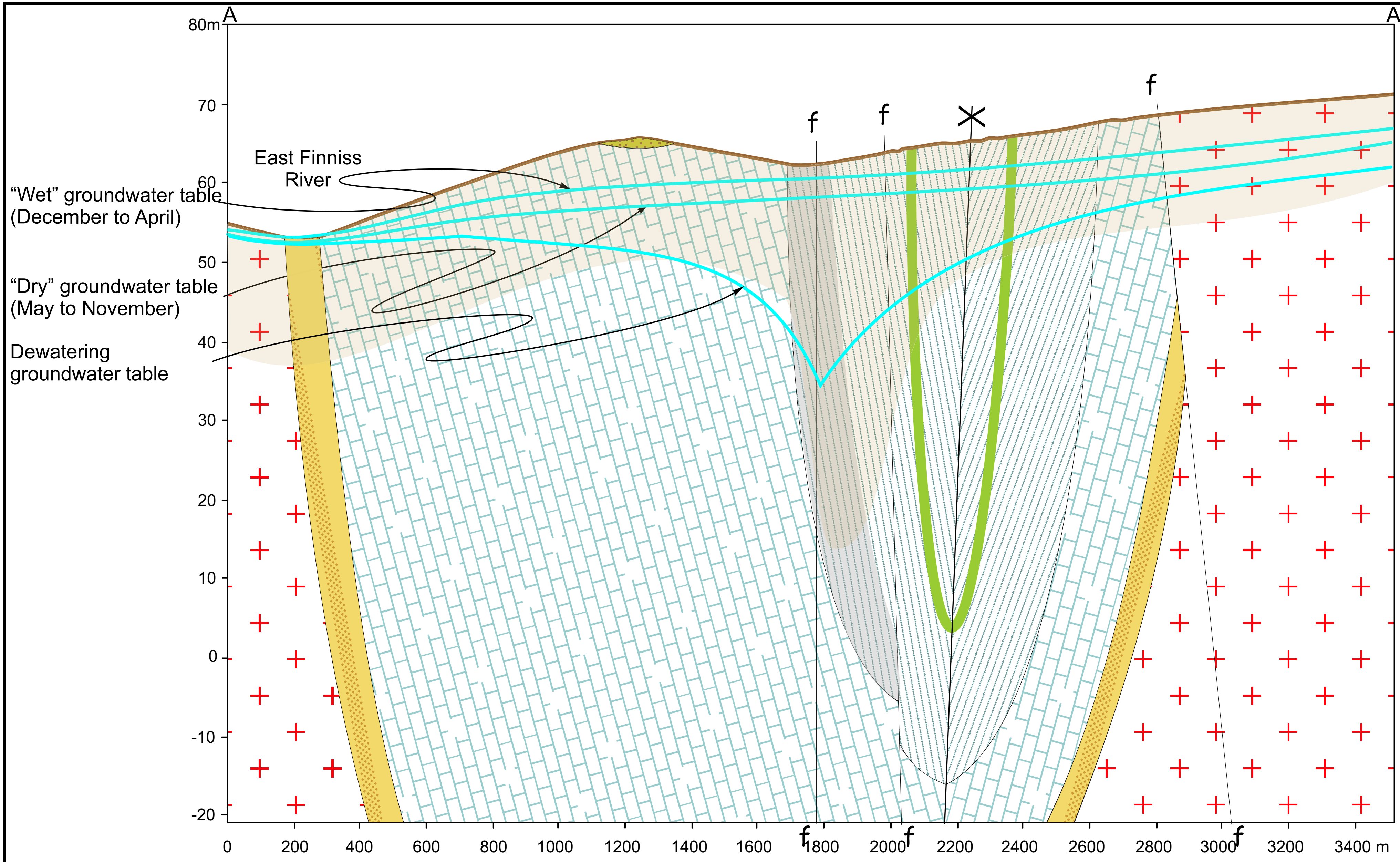
Coffey Geosciences Pty Ltd ACN 056 335 516	Geotechnical | **Resources** | Environment | **Technical** | Project Management	
Drawn RS	ENESAR CONSULTANTS BROWNS OXIDE PROJECT GROUNDWATER ASSESSMENT	**FIGURE 4**
Date June-05		
Scale Shown on Axes		
Approved	MONSOONAL WET AND DRY SEASON RAINFALL RECORD AT BROWNS OXIDE DEPOSIT SINCE 1983	B18183/01-B



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Geotechnical | Resources | Environment | Technical | Project Management

Drawn	RS
Date	May-05
Scale	As shown on axes
Approved	

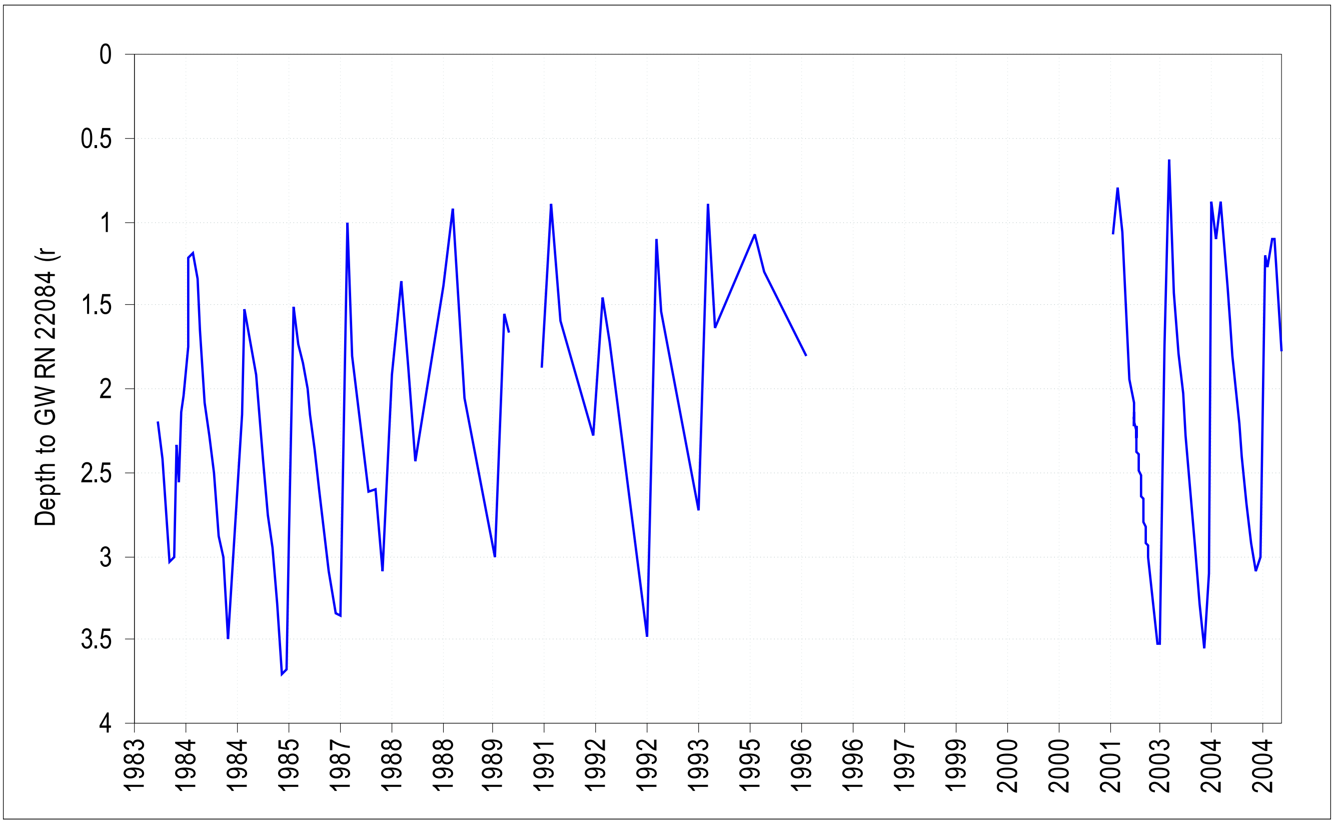
Geolsec Formation
Whites Formation
(Weathered zone/mineralised zone)
Coolambie Dolostone
Crater Formation
Rum Jungle Complex

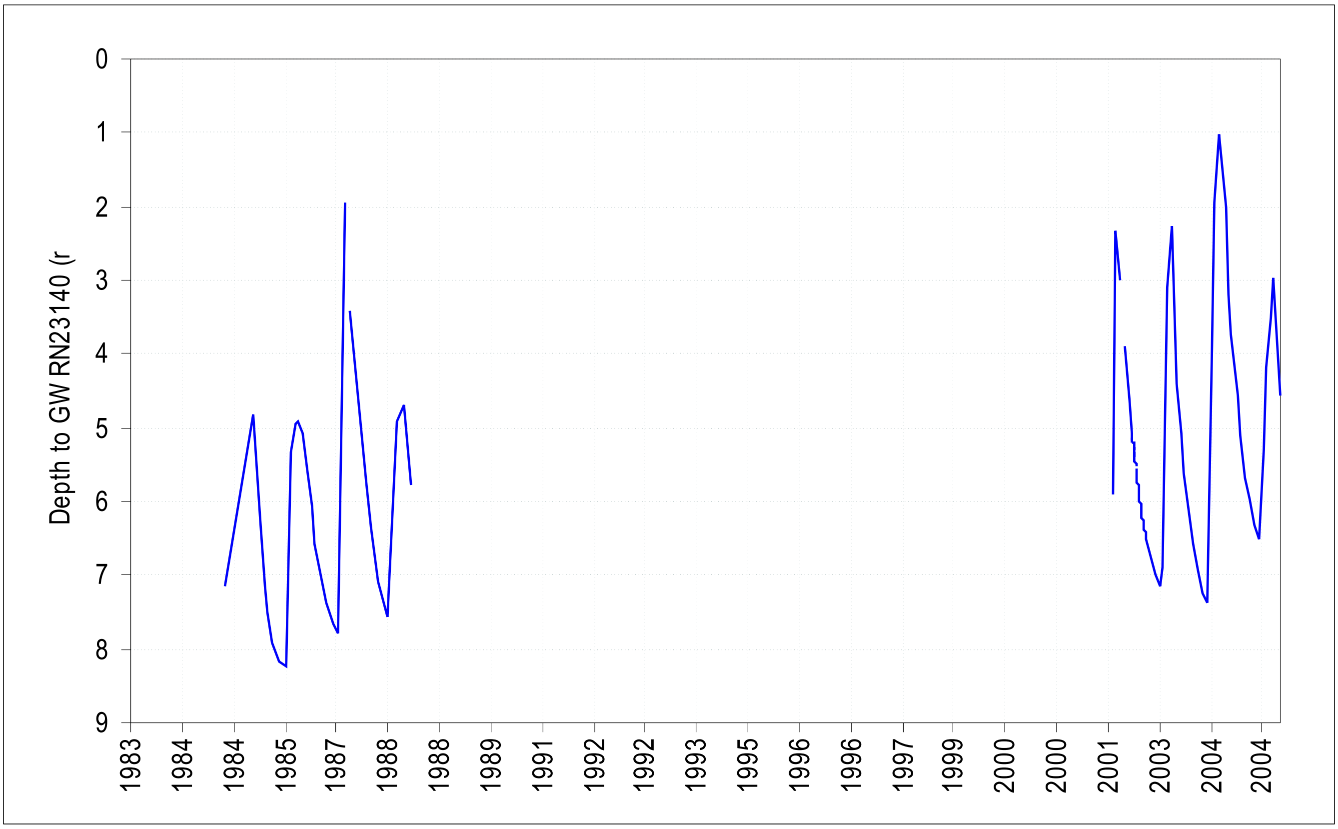
BROWNS OXIDE PROJECT
NORTHERN TERRITORY
GROUNDWATER ASSESSMENT

NW-SE GEOLOGICAL SECTION (Line A-A' Figure 1)
Based on geological mapping by Lally (2003)

FIGURE 5

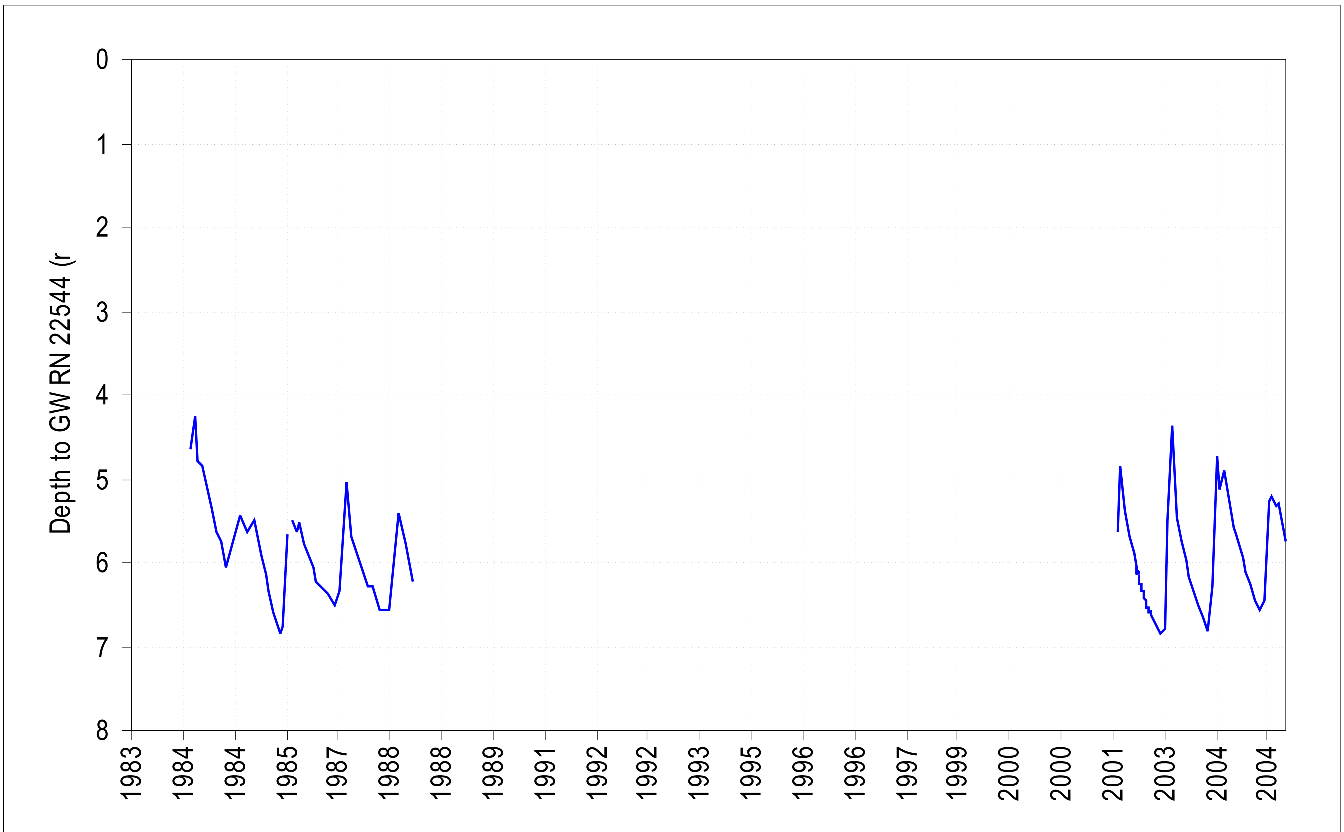
B18183-B





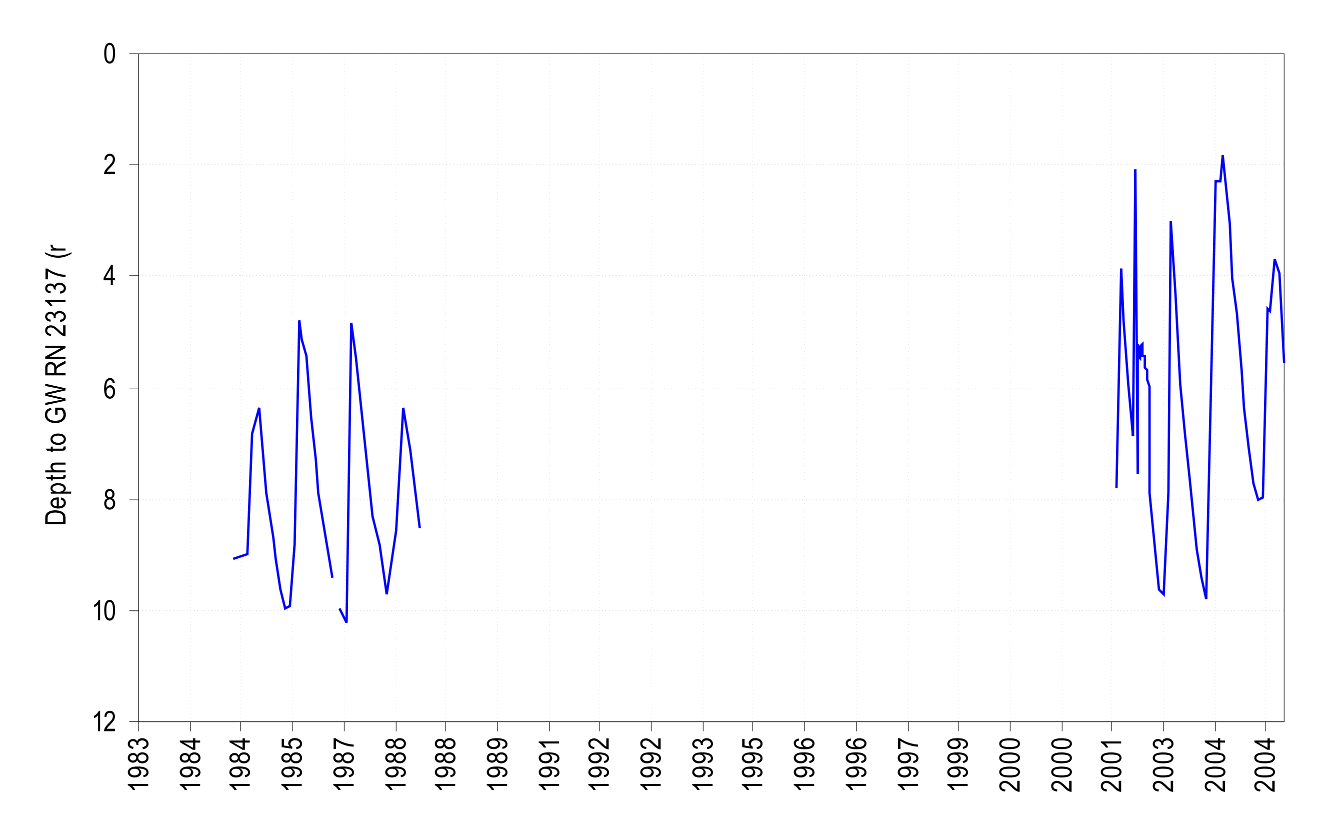
Coffey Geosciences Pty Ltd	ACN 056 335 516	Geotechnical | Resources | Environment | Technical | Project Management

Drawn	RS	ENESAR CONSULTANTS BROWNS OXIDE PROJECT GROUNDWATER ASSESSMENT GROUNDWATER HYDROGRAPHS (RN 22084 AND RN 23140)	FIGURE 6
Date	June-05		
Scale	Scale on Axes		
Approved			B18183/01-B



Coffey

Coffey Geosciences Pty Ltd ACN 056 335 516		Geotechnical | **Resources** | Environment | **Technical** | Project Management	
Drawn	**RS**	ENESAR CONSULTANTS BROWNS OXIDE PROJECT GROUNDWATER ASSESSMENT GROUNDWATER HYDROGRAPHS (RN 22085 AND RN 22544)	**FIGURE 7**
Date	**June-05**		
Scale	**Scale on Axes**		
Approved			B18183/01-B



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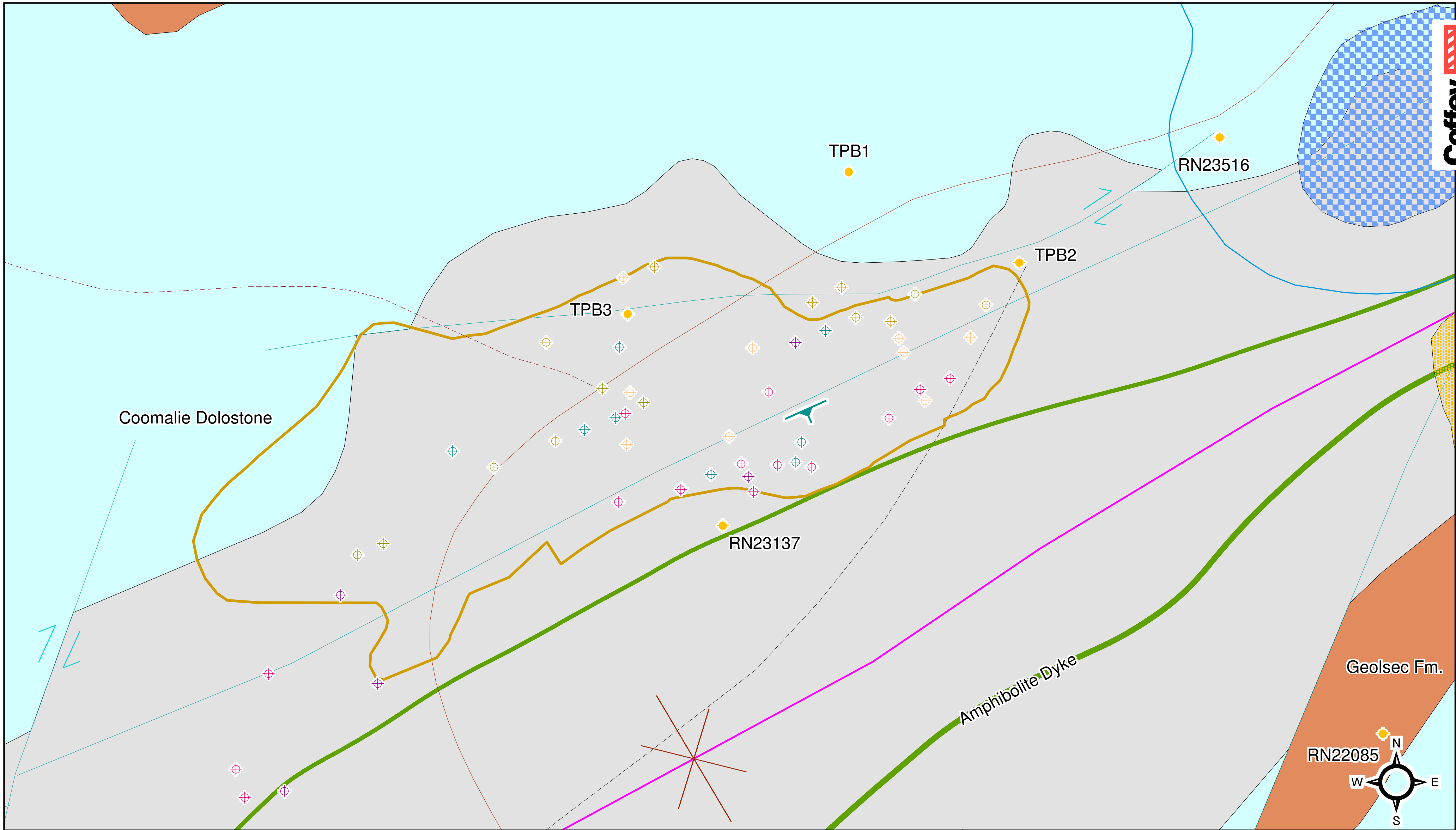
Drawn	RS	ENESAR CONSULTANTS BROWNS OXIDE PROJECT GROUNDWATER ASSESSMENT GROUNDWATER HYDROGRAPH (RN 23137)	FIGURE 8
Date	June-05		
Scale	Scale on Axes		
Approved			B18183/01-B



Browns Oxide Mine
Rum Jungle Mine Dumps
Rum Jungle Mine Pits
Fault trace
Dewatering trial monitoring bores

V thin (1-5m)
Thin (5-10m)
Thick (10-20m)
V thick (20-30m)
Extreme (>30m)
High yield cavernous/fracture

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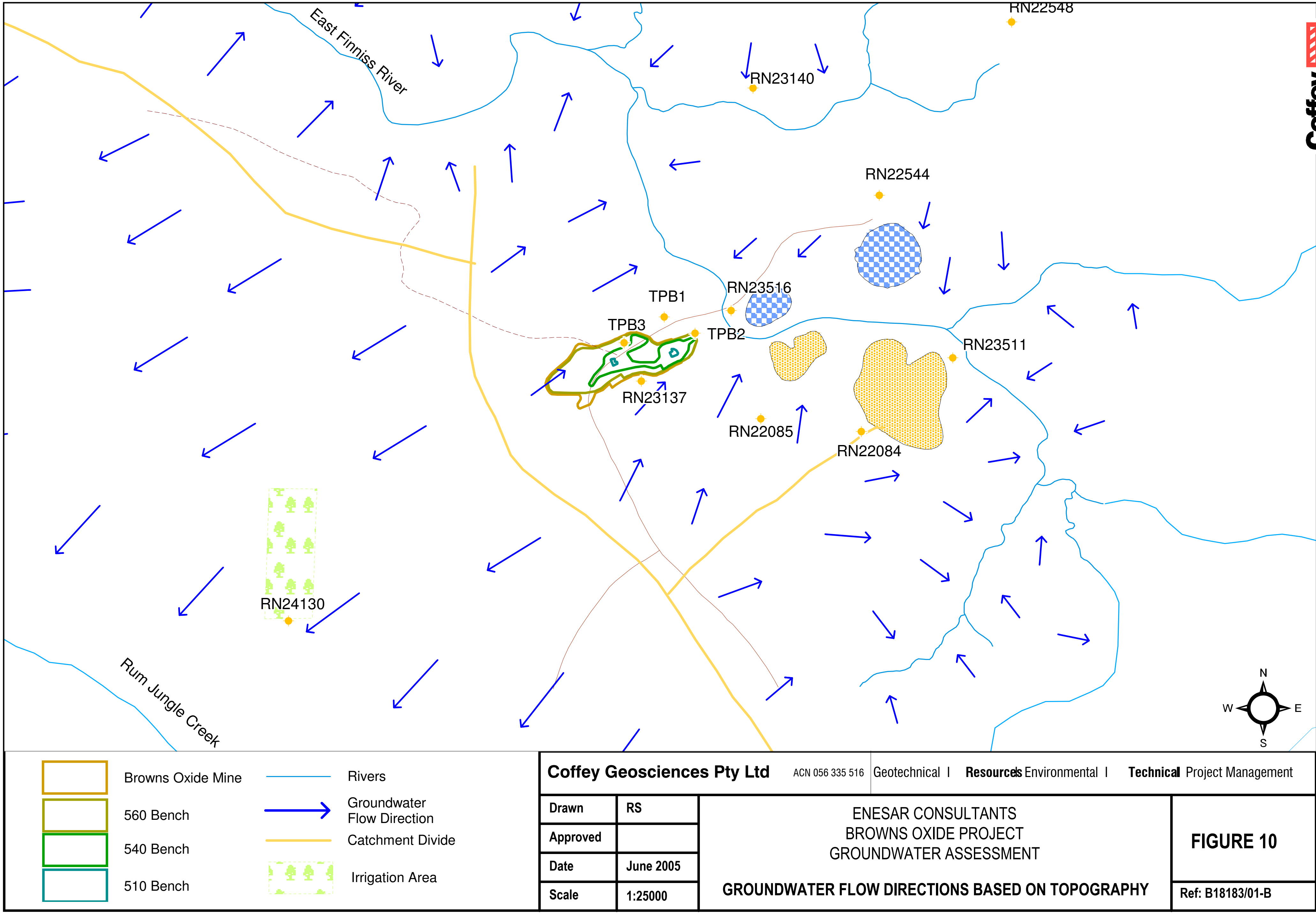
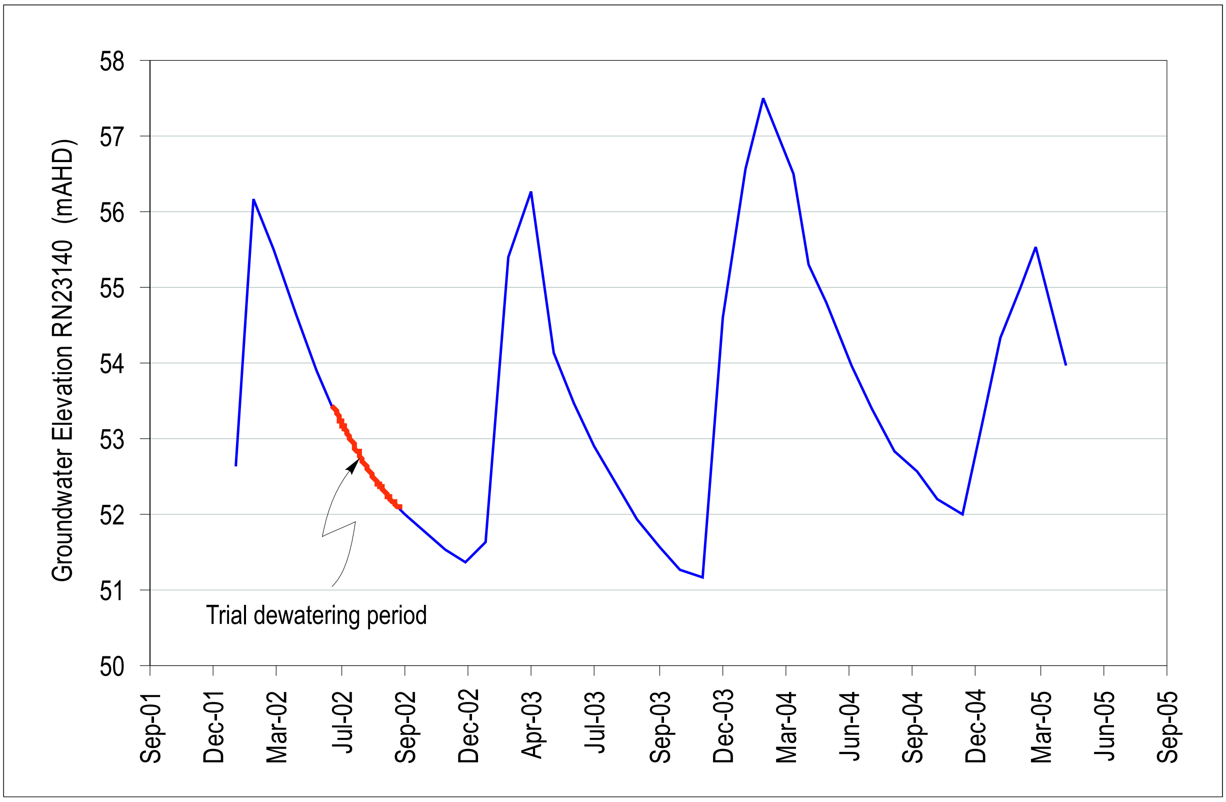
Drawn	**RS**	ENESAR CONSULTANTS BROWNS OXIDE PROJECT GROUNDWATER ASSESSMENT **CAVERNOUS ZONE CLASSIFICATION**	**FIGURE 9**
Approved			
Date	**June 2005**		
Scale	**1:5000**		**Ref: B18183/01-B**

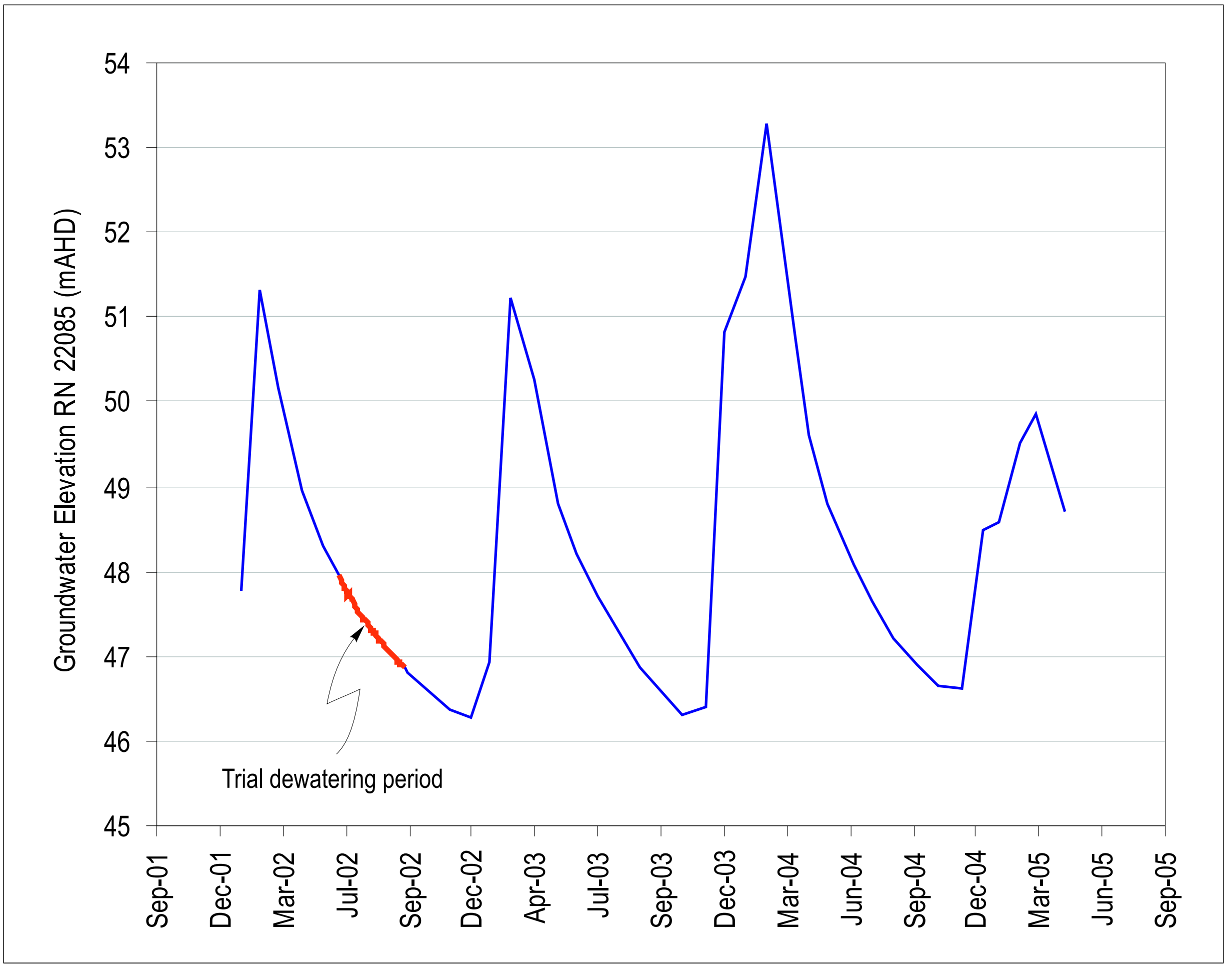


Coffey Geosciences Pty Ltd	ACN 056 335 516	Geotechnical | Resources | Environmental | Technical | Project Management
Drawn	RS	ENESAR CONSULTANTS
Approved		BROWNS OXIDE PROJECT
Date	June 2005	GROUNDWATER ASSESSMENT
Scale	1:25000	GROUNDWATER FLOW DIRECTIONS BASED ON TOPOGRAPHY

FIGURE 10

Ref: B18183/01-B





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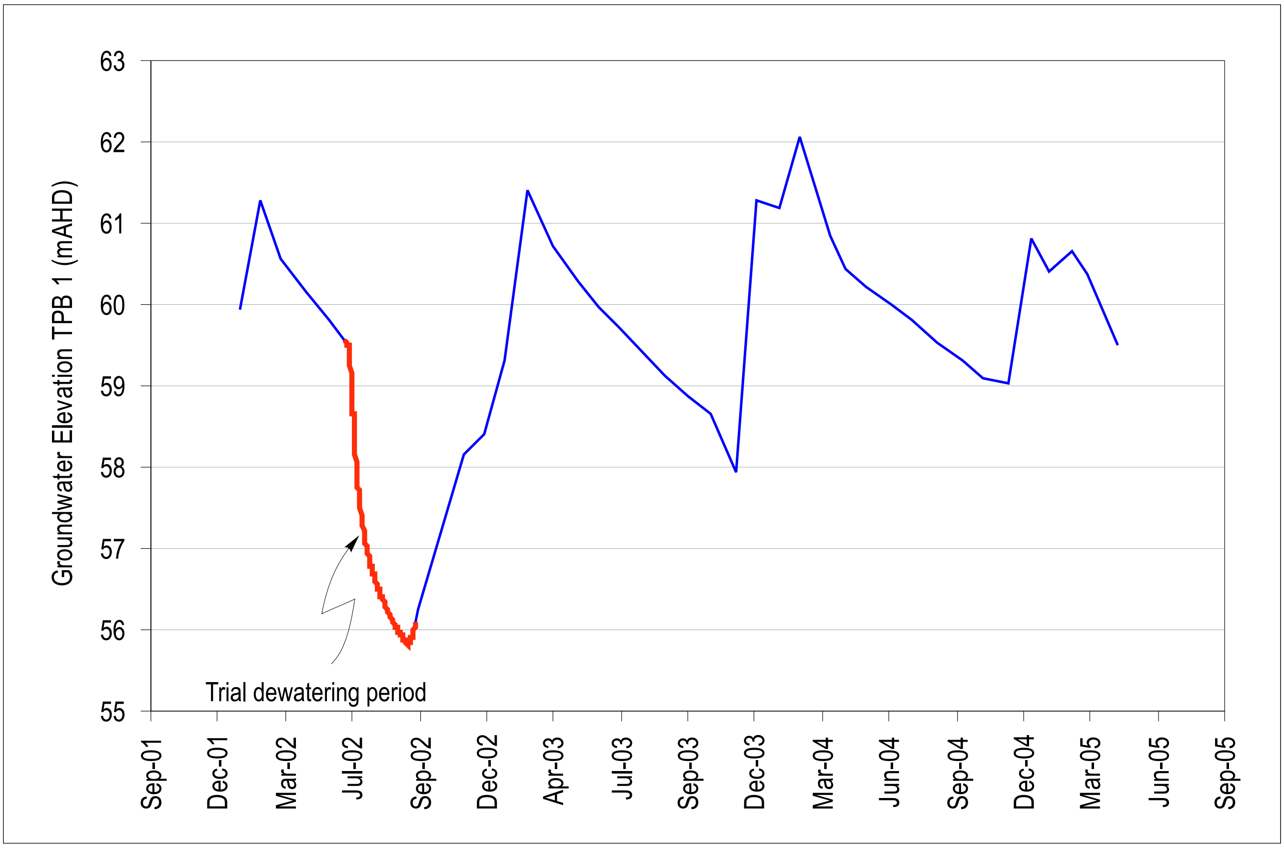
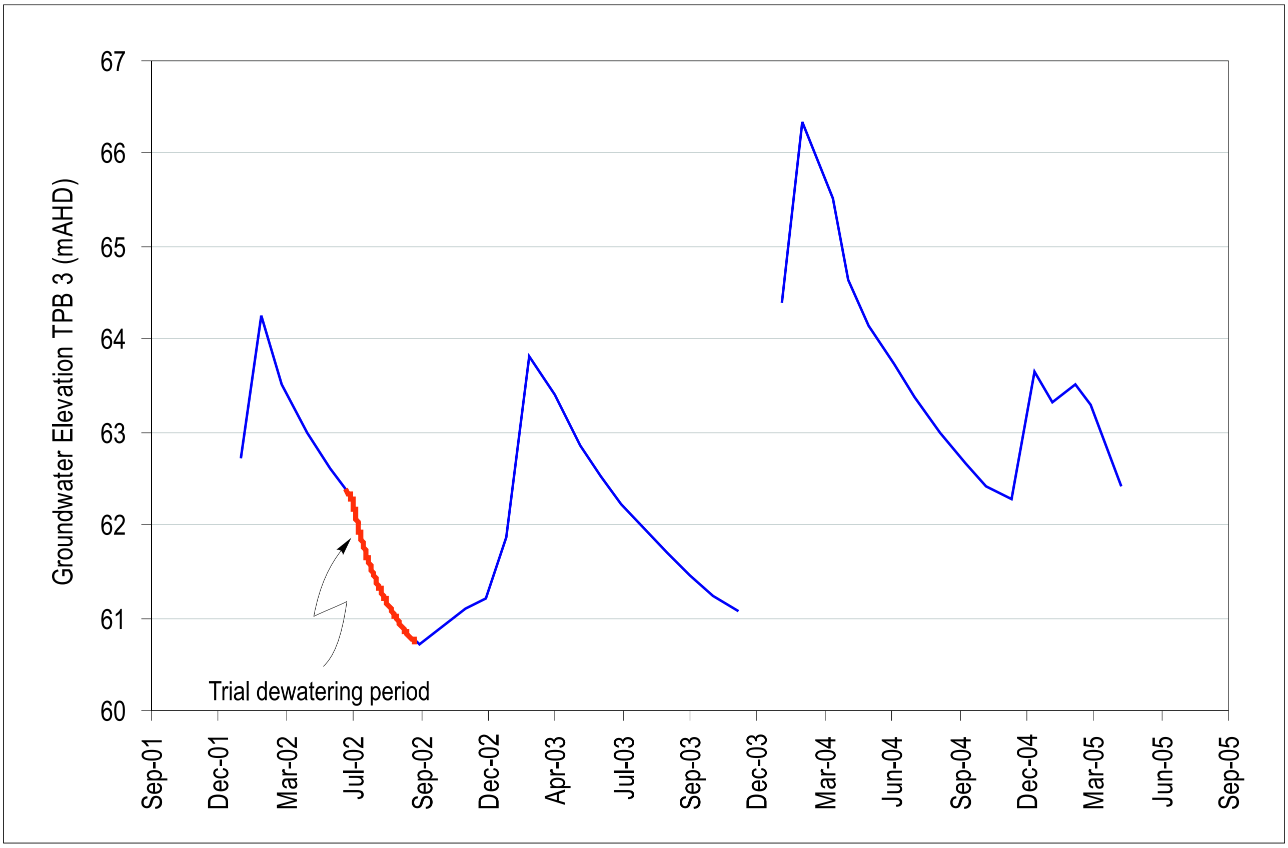
Drawn	**RS**	ENESAR CONSULTANTS BROWNS OXIDE PROJECT GROUNDWATER ASSESSMENT GROUNDWATER HYDROGRAPHS OVER TRIAL DEWATERING PERIOD (RN 23140 AND RN 22085)	**FIGURE 11**
Date	**June-05**		
Scale	**Scale on Axes**		
Approved			B18183/01-B





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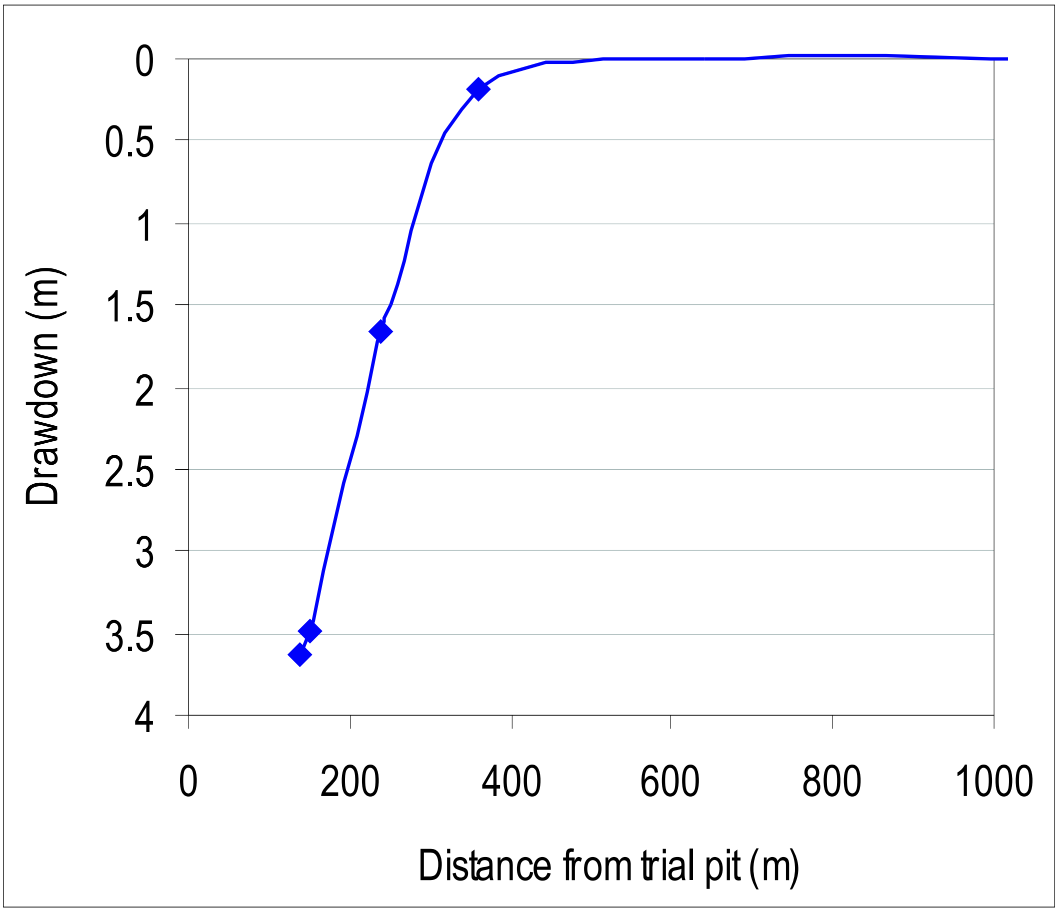
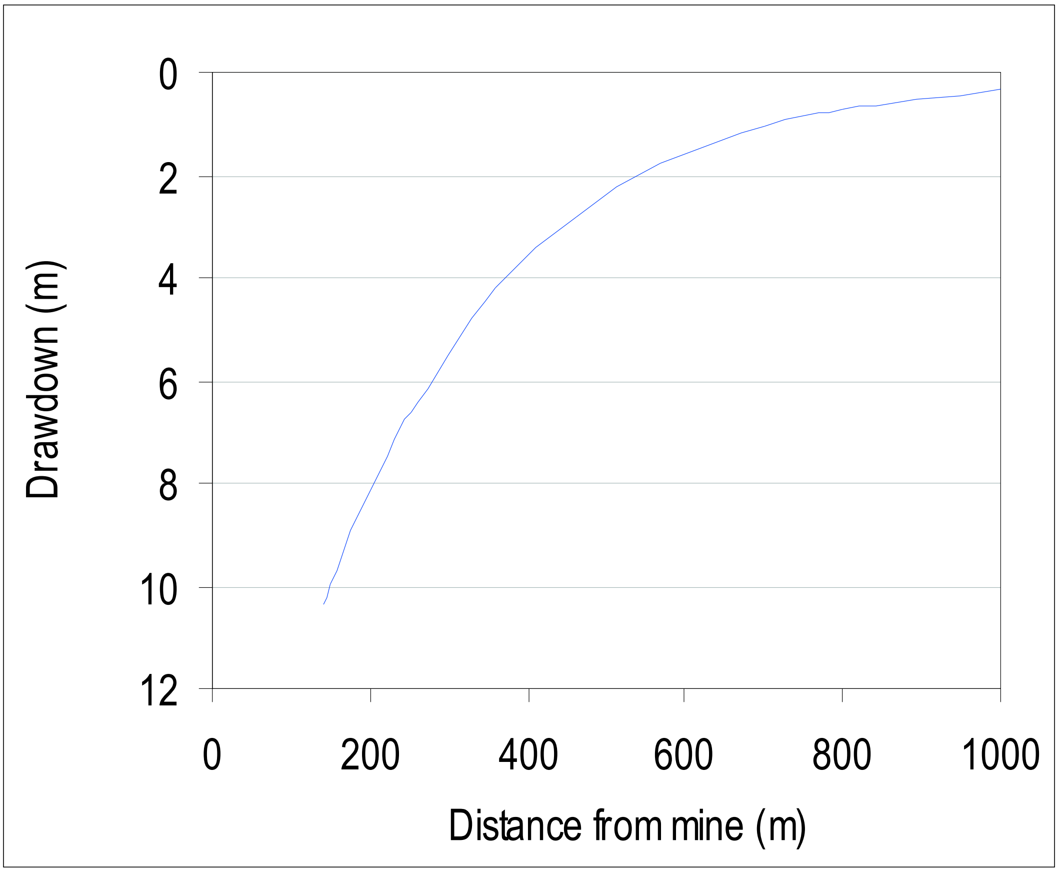
Geotechnical | **Resources** | Environment | **Technical** | Project Management

Drawn	**RS**	ENESAR CONSULTANTS BROWNS OXIDE PROJECT GROUNDWATER ASSESSMENT GROUNDWATER HYDROGRAPHS OVER TRIAL DEWATERING PERIOD (TPB 1 AND TPB 2)	**FIGURE 12**
Date	**June-05**		
Scale	**Scale on Axes**		B18183/01-B
Approved			





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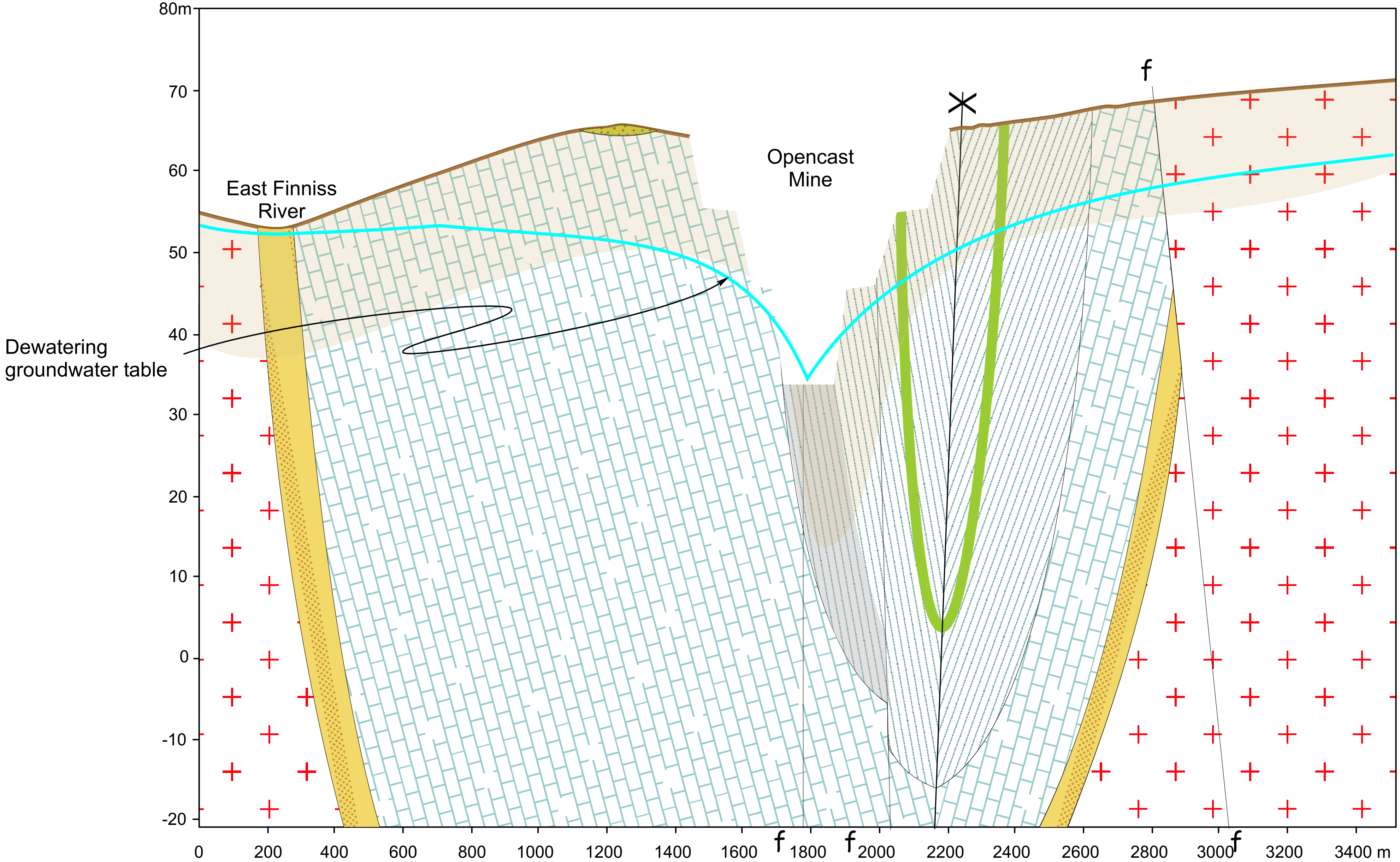
Geotechnical | **Resources** | Environment | **Technical** | Project Management

Drawn	**RS**	ENESAR CONSULTANTS BROWNS OXIDE PROJECT GROUNDWATER ASSESSMENT DISTANCE DRAWDOWN CURVES (TRIAL DEWATERING RESULTS AND PREDICTED FOR MINE)	**FIGURE 13**
Date	**June-05**		
Scale	**Scale on Axes**		
Approved			B18183/01-B



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Geotechnical | **Resources** | Environment | **Technical** | Project Management

Drawn	**RS**
Date	**May-05**
Scale	**As shown on axes**
Approved	

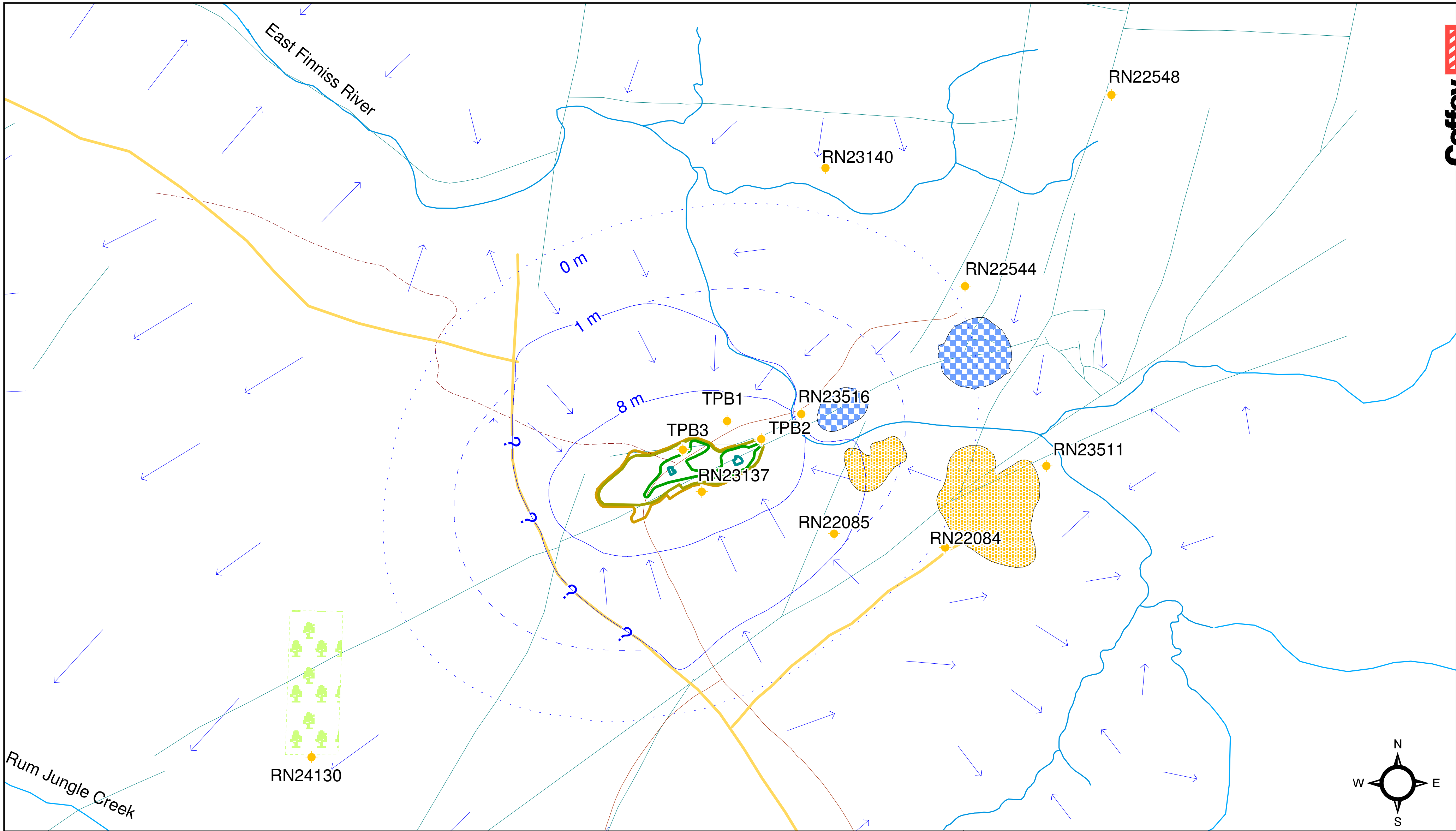
Geolsec Formation
Whites Formation
(Weathered zone/mineralised zone)
Coolambie Dolostone
Crater Formation
Rum Jungle Complex

BROWNS OXIDE PROJECT
NORTHERN TERRITORY
GROUNDWATER ASSESSMENT

NW-SE GEOLOGICAL SECTION SHOWING DRAWDOWN (LINE A-A' FIGURE 1)
Based on geological mapping by Lally (2003)

FIGURE 14

B18183-B



Groundwater flow direction
Catchment divide
Limit of influence (no boundaries)
Extent with no boundaries
Drawdown extent with boundaries
Dewatering trial monitoring points
Mine waste dumps
Mine voids
Irrigation area
Fault lines

Coffey Geosciences Pty Ltd ACN 056 335 516 Geotechnical | **Resources** Environmental | **Technical** Project Management

Drawn	RS	ENESAR CONSULTANTS BROWNS OXIDE PROJECT GROUNDWATER ASSESSMENT	**FIGURE 15**
Approved			
Date	June 2005		
Scale	1:25000	**POSSIBLE GROUNDWATER DRAWDOWNS**	Ref: B18183/01-B

APPENDIX A

SUMMARIES OF PREVIOUS REPORTS

SUMMARIES OF PREVIOUS REPORTS

1. Summary of Report Following Groundwater Investigations

WATER STUDIES PTY LTD, 2000: Browns Polymetallic Project - Preliminary Hydrogeological Assessment and Testing. Report prepared for Compass Resources NL. Report WSDJ101/2-G, November 2000.)

Conceptual Hydrogeological Model

Mineralisation is in the contact zone between Whites Formation (amphibolites/black shales) and Coomalie Dolomite. Whites Formation has relatively low groundwater potential. Coomalie Dolomite is a fractured, drusy, sometimes karstic aquifer. Interconnection is limited and it is not a widespread aquifer although initial large inflow rates are possible.

The weathered aquifer overlying less weathered rock is up to 50 m deep in the contact zone between the amphibolites/black shales and has produced significant groundwater inflows during exploration drilling and in the trial pit but elsewhere is shallower.

Groundwater may be associated with faults.

Aquifer Parameters

Three bores were pump tested results are summarised:

Bore	*Aquifer*	*Depth to Water (mbGL)*	*T (m^2/d)*	*K (m/d)*	*S (approximate)*	*Pumping Rate (L/s)*	*pH*	*EC (µS/cm)*	*Comments*
TPB1	Weathered carbonate aquifer	5.34	180	30	0.01	12.5	7.1	235	Possible barrier boundary encountered
TPB2	Weathered zone Whites Fm. Carbonate Contact	6.08	40-100	4-10	0.001 to 0.01	9.5	5.9	3550	Transmissivity increased during pumping (bore development)
TPB3	Fault zone	7.43	55	10	0.001 to 0.0001	20	6.9	260	Connection to weathered aquifers evident

Water quality was stable during tests. The report concluded that water quality was formation related.

Trial pit inflows were estimated to be 50 L/s.

Implications for mining:

- Weathered Whites formation is a major aquifer and will contribute water to the excavation during mining;
- Inflow from Coomalie Dolomite along northern face of mine are expected;
- Inflows from deeper structural features (faults, disconnected cavernous zones) are expected in deeper mining, they may be erratically encountered and contribute short term inflows;

- Wet conditions influence trafficability, effectiveness of explosives and wall stability.

Inflow control will be necessary. Possibilities include:

- Dewatering bores but these would have to be appropriately positioned and designed and are unlikely to successfully dewater faults and some non connected dolomite cavities;
- Cut off trench/drain;
- Sub-horizontal bores (collector wells).

Impacts and Recommendations

There is potential for impacts on groundwater regime and other groundwater users.

Monitoring of DLPE Rum Jungle monitoring bores, test production bores, and existing landholder bores is recommended to obtain background data as well as during the mining phase.

Additional monitoring bores will be required at the mining lease boundaries to comply with environmental requirements. These should be appropriately constructed to monitor specific hydrogeological units.

Water quality monitoring needs to be planned so that the monitoring addresses potential offsite discharge issues.

2. Summary of Groundwater Report for EIS

WATER STUDIES PTY LTD, 2002b: Browns Polymetallic Project: Review of Potential Groundwater Impacts. Report prepared for NSR Environmental Consultants Pty Ltd. Report WSDJ00283.1a. 24 May 2002.

Aquifer Characteristics

Report discussed the difference between a "shallow aquifer" formed in shallow lateritic soils (sometimes 1m deep or less). Reportedly, it acts as a conduit for seepage from waste dumps at Rum Jungle and groundwater quality is poor, it is a major source of pollution contribution to the East Finniss River. Groundwater flows radially from the waste dumps then swings to follow the surface topography and flows towards major creeks or rivers.

The deep aquifer refers to all aquifers below the shallow lateritic soils, it includes Whites Formation, Coomalie Dolomite, and structural aquifers. Water quality has been influenced close to waste dumps only and groundwater flow direction is similar to the shallow aquifer.

Summary of deeper aquifers

Aquifer	*Depth to water (m)*	*Yield (L/s)*	*pH*	*EC µS/cm*	*Comments*
Whites Formation	6	9.5	7	3350	Water quality is consistent with background, no extensive contamination due to low permeability and limited fracturing
Coomalie Dolomite	4.7	12.5	7.8	235	Contaminated near Whites and Rum Jungle waste dumps but not impacted further away. Most production bores in landholder area are in this unit impacts from mine dewatering would have to be investigated
Structural aquifers	6.6	20	7.9	235	Deeper aquifers are considered to be structural (fractured rocks and cavities) but also need to distinguish fault (line) aquifers which may connect with other shallower aquifers.

Groundwater Impacts

The report distinguishes between small, large and underground mining options:

Small Mine

Excavation will have Coomalie Dolomite as the north-western pit wall, Whites Formation as the south-eastern pit wall and will have a major fault running through the excavation. Potential impacts include:

- Drawdown in Coomalie Dolomite aquifer potentially affecting landholder domestic and irrigation bores southwest of the mine;

- Drawdown in Whites Formation may be limited by lower permeability and inferred boundary formed by Giants Reef fault. Water quality may influence use or disposal of water;
- Expect limited capture of contaminated water in shallow aquifer;
- Reduction of baseflow in East Finniss River due to removal of groundwater that would have naturally migrated towards the river;
- Waste dump leachate potentially similar to Rum Jungle;
- Final void water could contaminate Coomalie Dolomite aquifer or overtop to the East Finniss River.

Large mine

Has the same potential impacts as the small mine but in addition will capture most of the shallow aquifer contamination and will require diversion of the East Finniss River

Underground Mine

Unable to predict

Recommendations

Likely impacts are:

- Lowered levels in water bores on nearby properties as a result of mining activities;
- Contamination of groundwater from various elements of mine infrastructure (waste rock dumps, tailings dams, etc.);
- Changes to surface water flows and surface water quality.

There is insufficient data to evaluate these fully and detailed studies will be required for EIS.

Recommended work to be done for EIS and document gives details of the required tasks.

Recommended monitoring bores, frequency and water quality parameters that should be monitored.

3. Trial Dewatering Report

WATER STUDIES PTY LTD 2002c: Browns Trial Pit Dewatering Groundwater Monitoring. Report prepared for NSR Environmental Consultants Pty Ltd. Report WSDJ00283.2a. 5 September.)

Pumping at an average rate of 8.8 L/s from 29-6 to 11-9-2002 was monitored in 19 bores at different distances from the trial pit.

Groundwater levels adjacent to the trial pit declined the most (>2m) (TPB1 and TPB2). Relatively moderate falls (1-2m) in groundwater level were observed in TPB3, 22548, 23140 and 22085, and subtle declines (<1m) were observed in the remaining monitoring points (23516, 22084, 23511, 22544, Crater Lake, Earthrowl Bore, Day Sect. Bore, Thompson Bore-24130 and Roebuck Bore-28747).

During the initial stages of dewatering a rise in groundwater levels was observed in monitoring bore 23137.

It was concluded that distance and association with Coomalie Dolomite and the contact zone between the Coomalie Dolomite and Whites Formation influenced the response to pumping.