R E P O R T

Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources

Prepared for

Iluka Resources Limited

PO Box 96
CAPEL WA 6271

3 July 2002

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URS

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3 July 2002
Project No. 44047-021-562

Iluka Resources Limited
PO Box 96
CAPEL WA 6271

Attention: Mr Alan Mason

Dear Sir,

Subject: WAROONA DEPOSIT
IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

Please find following our report for the above mentioned project.

Thank you for the opportunity to be involved in this project. If you have any queries or require any further information, please do not hesitate to contact the undersigned.

Yours faithfully,
URS AUSTRALIA PTY LTD

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Iluka Resources Limited (Iluka) is presently undertaking mining feasibility studies for the development of the Waroona Deposit. The deposit forms a significant mineral sands resource adjacent to the Township of Waroona approximately 110 kilometres south of Perth, Western Australia (Figure 1).

Mining tenure is provided by several mining leases; M70/735, M70/797, M70/798 and M70/1089. These tenements are shown on Figure 2.

Project commencement is expected within the next five years. As a result of the proximity of the town of Waroona and numerous nearby landowners, Iluka recognises that various environmental and conservation issues need to be addressed as part of the mining feasibility studies. Several of the environmental issues involve the local groundwater resources, and in particular:

- impacts on the shallow aquifer zones of groundwater abstraction during mining;
- loss of amenity for nearby users of the shallow groundwater resources; and
- riparean rights of nearby landowners associated with surface water resources of the Nanga Brook and other surface water features in proximity to the project area.

A shallow groundwater resource investigation programme has been implemented to develop an understanding of the project area hydrogeology. This programme has incorporated:

- Reverse-circulation reconnaissance drilling to broadly define the local stratigraphic and lithological profiles.
- Two test production bores that intersect the Yoganup Formation and weathered Archaean bedrock, in areas to the east of the Darling Fault.
- Three test production bores that intersect the Yoganup Formation within the western orebody, west of the Darling Fault, in areas where mining is expected to extend at least 20m below the water table.
- Two test production bores that intersect the Leederville Formation below the deepest areas of the western orebody.
- Twelve new multipiezometer bores, which together with the exiting multipiezometer sites provide hydrogeological data on the superficial formations, Leederville Formation and weathered Archaean bedrock profiles throughout the project area. Available data include:
    - a groundwater level and groundwater quality baseline throughout the proposed mine site;
    - drawdown responses during aquifer tests in the proposed test production bores; and
    - records that will enable appropriate and informed management of the local groundwater and surface water resources and evaluation of any impacts of mining on the superficial formations, Leederville Formation and the weathered Archaean bedrock profiles.

- Upgrades to the existing W10, W12 and W13 piezometer sites to provide information on the lower portions of the superficial formations and shallow Leederville formation along the western perimeter of the project area.
- Aquifer tests in each of the test production bores. These tests provide data on:
  - the characteristics and hydraulic parameters of the superficial formations, Leederville Formation and weathered Archaean bedrock profiles;
  - the vertical leakage and drawdown of the potentiometric heads in the Leederville Formation that would be induced by groundwater abstraction from the overlying Yoganup Formation; and
  - the yield and supply potential of groundwater abstracted during mining.
- Short-term constant-discharge pumping tests in each of the multipiezometer bores.

The results of the shallow groundwater resource investigation have been applied to develop a representative groundwater flow model of the project area. The developed model has been applied to:

- predict the impacts of mining on the local shallow groundwater resources;
- define potential environmental and conservation issues linked to the potential impacts of mining on the local water resources; and
- develop a monitoring programme and operating strategy that outline commitments to the conservation and protection of the local water resources and other users of these resources.

This report defines the project area hydrogeology, potential impacts on the local water resources due to mining and appropriate monitoring and management protocols. The report incorporates all of the results of the site investigations, details of mining plans and water resources assessments based on groundwater flow modelling. It is intended for the report to support an application to the Department of Environment, Water and Catchment Protection for a Groundwater Well Licence (abstraction) for local dewatering of the superficial formations during mining. Accordingly, it also incorporates monitoring and management strategies appropriate for the project area and planned mining developments.

2.1 Local Setting

The Waroona Deposit is located immediately adjacent to the northeastern side of the Waroona township (Figure 1).

The deposit occurs on the footslopes of the Darling Scarp with ground elevations ranging between 35m AHD in the west to 95m AHD along the escarpment to the east. Footslope areas are termed the Ridge Hill Shelf and comprise undulating terrain of palaeo-shoreline and colluvial outwash from the escarpment.

Most of the landholdings directly above the mineral sands deposits are owned by Iluka. The majority of properties within the project area consist of cleared rural holdings used for pasture and grazing/agistment. However, the eastern portions of the project area typically consists of uncleared steep slopes and in the southeast occur immediately adjacent to urban and semi-rural land-users.

Three small gauged streams transect the project area (Figure 3). The southernmost Nanga Brook is aligned parallel to the southern boundary of mining tenement M70/735 and transects numerous urban and semi-rural landholdings. Streamflow is generally non-perennial, although monitoring of Nanga Brook indicates small flows can often be sustained through the summer months. All three streams have been modified to the west of the project area to form drains linked to the main irrigation channels that serve the Waroona Irrigation Area.

No environmentally protected wetlands are located within 5km of the Waroona Deposit. The nearest protected wetland is located approximately 10km northwest of the deposit, beyond the South Western Highway (DOLA, Swan Coastal Plain Lakes, Miscellaneous Plan No. 1851, Sheet 17 of 27). Hill et al (1986) identified four damplands (seasonally waterlogged basins) and one sumpland (seasonally inundated basin) within the Waroona Deposit, and an area of sumplands approximately 2km west of the deposit, across South Western Highway.

2.2 Climate

The project area has a Mediterranean-type climate with hot dry summers and cool wet winters. Data recorded at the Waroona Post Office since 1935 indicates a mean annual average rainfall of 1,023 mm. Average monthly rainfall data are presented in Table 1. Evaporation generally exceeds rainfall during the period from October to April.

Table 1
Mean Monthly Rainfall
(1935 to 2001)

Month	January	February	March	April	May	June	July	August	September	October	November	December	Total
Rainfall (mm)	12.6	16.1	22.8	54.8	148.8	212.9	198.9	154.7	91.2	59.1	36.6	13.9	1,023

2.3 Geology and Stratigraphy

The project area occurs on the eastern fringe of the Southern Perth Basin; the Darling Fault forms the eastern limit of the basin and underlies the Waroona Deposit.

Eastern portions of the deposit overlie Archaean bedrocks of the Yilgarn Shield. Western portions overlie sediments of the Southern Perth Basin. The exact location of the Darling Fault beneath the project area is uncertain. The typical shallow geological profiles and interpreted locations of the Darling Fault are shown in a regional context on Figure 4, and based on local drilling on Figure 5. The key elements of the regional geomorphology and geological profile include:

- Darling Escarpment and Plateau:
  - Archaean basement consisting of crystalline granitic and gneissic rocks, with minor dolerite intrusion.
  - Tertiary laterite profiles that occur extensively over the plateau areas.
  - Thin Quaternary deposits of coarse alluvial and colluvial material within present drainage lines.
- Ridge Hill Shelf:

  Superficial formations of Quaternary age, including:
  - Yoganup Formation, comprised of sands and clayey sands of fluvial and aeolian origins bedded with mineral sands. Beneath the project area the sequence of Yoganup Formation sediments approximately ranges from 15 to 25 m in thickness.
  - Mixed assemblages of predominantly silty clays and lateritic gravelly clays in colluvial deposits.
- Pinjarra Plain:
  - Superficial formations that predominantly comprise the Guildford Formation and are mainly sandy clay and clay deposits.

The stratigraphy of the Southern Perth Basin between Mandurah and Bunbury has been broadly defined from the drilling of stratigraphic, groundwater exploration and oil exploration drillholes. The stratigraphy is outlined in Table 2 and on Figure 6.

Table 2
Regional Stratigraphy

Stratigraphic Unit	Age	Approximate Thickness (m)
Yoganup Formation	Quaternary	10
Unconformity		
Guildford Formation	Quaternary	25
Unconformity		
Leederville Formation	Cretaceous	100
Unconformity		
Cattamarra Coal Measures Eneabba Formation	Jurassic	>1,000

The superficial formations are underlain by the Leederville Formation, part of the Warnbro Group deposited in the Cretaceous age. The Leederville Formation is locally uppermost in the Southern Perth Basin sedimentary pile that extends to depths in excess of a thousand metres. Unconformably underlying the Leederville Formation are the Cattamarra Coal Measures and Eneabba Formation of Jurassic age. Both of these formations form lateral equivalents of the Yarragadee Formation. The extent and distribution of these formations are influenced by post-depositional faulting and erosion (Figure 6).

2.4 Management of Water Resources

The water resources of the project area are managed by the Department of Environment, Water and Catchment Protection (DEWCP) under:

- the Harvey Basin Surface Water Allocation Plan; and
- the Murray Groundwater Area Allocation Plan.

These management plans have been designed to enable sustainable development of the available surface water and groundwater resources whilst preserving ecological and environmental water provisions for the local water-dependent ecosystems.

2.4.1 Surface Water

The project area occurs within the Harvey River Basin. Surface water resources occur in streams from the Darling Scarp. Runoff from rainfall is the major component of streamflow, particularly in the upper

catchment areas. The flows in the larger streams are also supported by baseflow from shallow groundwater resources. Water quality in the upper catchment areas is usually of low salinity, ranging up to about 300 mg/L Total Dissolved Solids (TDS) concentrations.

The local surface water resources are used extensively for irrigation supply, town water supply, environmental and recreational purposes. Figure 7 presents the major surface water features of the Harvey River Basin, notably the current network of dams and the Waroona and Harvey irrigation areas.

Historically, the demand for irrigation water has averaged 60,000 ML/annum in the Harvey Irrigation Area, and about 16,000 ML/annum in the Waroona Irrigation Area (Water &Rivers Commission, 1998). Town water supply demand from surface water resources within the Harvey River Basin is currently about 2,000 ML/annum.

Use of surface water resources for industrial projects has been limited. The main industrial demand has been by Alcoa for its Willowdale Mine and Wagerup Alumina Refinery. The Wagerup Alumina Refinery sources surface water from the South Yalup Dam and Chasede Dam (on a tributary of Samson Brook). Both Alcoa and Cable Sands Pty Ltd have purchased small proportions of their water requirements from the Water Corporation and South West Irrigation, the two main existing water service providers in the region.

A fundamental aspect in allocation planning of the surface water resources is that the highest priority is given to ecological water requirements. Ecological water requirements are the spatial and transient waters needed to adequately sustain dependent ecosystems with a low level of risk. In addition, environmental water provisions secure resources for aesthetic, heritage and recreational aspects.

The environmental water provisions are currently negotiable. The diverting of surface water resources for consumptive uses is a lesser priority.

2.4.2 Groundwater

The project area is located within the eastern portion of the Waroona Subarea of the Murray Groundwater Area (Figure 8).

Historical demand for the groundwater resources has been primarily from private domestic users of the superficial formations and for domestic and stock purposes from the shallow Leederville Formation.

Industrial demand for groundwater resources within the region is limited. Current industrial demand within a 10km radius of the project area is limited to two supply borefields operated by Alcoa for their Wagerup Alumina Refinery. These borefields are located about 8km southwest of the project.

There are no known users of the deeper Cattamarra Coal Measures groundwater resources of the region. Local knowledge of these resources is largely based upon the government-funded drilling investigation conducted between the coast and the Darling Scarp along the Harvey Borehole Line (Deeney, 1989) transect, approximately seven kilometres south of Waroona (Figure 6). These data indicate that the Cattamarra Coal Measures are low-yielding and contain groundwater resources of salinities typically in excess of 5,000 mg/L TDS.

Details of current Groundwater Well Licences (GWL) allocations within a ten kilometre radius of the project area are summarised in Table 3 and on Figure 9.

Within the Murray Groundwater Area, groundwater abstraction of less than 1,500 kL/annum for domestic or stock purposes does not require a GWL. Consequently, the GWL data summarised in Table 3 do not represent the full allocation and use of the shallow groundwater resources.

Table 3

Summary of Groundwater Well Licence Allocations[1]

(December 2001)

Aquifer System	Approximate Distance from Project Area[2]					
	Within 1 km of Project Area		Between 1 km and 3 km of Project Area		Between 3 km and 10 km of Project Area	
	Number of GWLs	Total Allocation (kL/annum)	Number of GWLs	Total Allocation (kL/annum)	Number of GWLs	Total Allocation (kL/annum)
superficial formations	16	22,500	6	63,900	21	1,186,300
Leederville Formation	2	23,800	1	1,500	5	38,000
Cattamarra Coal Measures	0	0	0	0	0	0

Notes: 1 Includes current, expired, and applied - for groundwater licences held by DEWCP.
2 Project area approximated by the region 399000 mE to 400800 mE; 6366700 mN to 6368500 mN.

2.5 Mining Plans

The current schedule for the mining of the Waroona Deposit is shown on Figure 10. This schedule outlines mining from July 2007 to October 2112.

The mining schedule will be varied to allow for additional reconnaissance drilling results. The schedule will also be dependant on market requirements and completion of mining at the preceding minesite. Mining pre-development is likely to commence 12 months prior to mining.

Comprehensive investigations of the Waroona Deposit have been completed to develop an understanding of the local aquifer systems, groundwater resources and the potential impacts of the mine development. The site investigations were completed from November 2000 to April 2001. The completed investigations included:

- reconnaissance drilling by RC methods to characterise the lithological profiles and define the key aquifer zones at selected investigation sites; and
- groundwater exploration drilling to construct:
  - two shallow test production bores that investigate the Yoganup Formation and weathered Archaean bedrock, in areas to the east of the Darling Fault;
  - three shallow test production bores that investigate the Yoganup Formation within the western orebody, west of the Darling Fault;
  - two test production bores that intersects the upper 50 m of the Leederville Formation below the deepest areas of the western orebody;
  - twelve multipiezometer bores that comprise up to six discrete standpipes and monitoring intervals, predominantly within the superficial formations and weathered bedrock profile, but also intersecting the shallow Leederville Formation at four sites;
  - upgrades to three existing multipiezometer sites along the western perimeter of the project area to provide standpipes and monitoring intervals within the lower superficial formations and shallow Leederville formation.
  - aquifer tests in each of the test production bore; and
  - short-term Constant-Discharge aquifer tests in each multipiezometer bore.

Detailed descriptions of the completed site investigations are outlined below.

3.1 Reconnaissance Drilling

Reconnaissance drilling to investigate the local aquifer profiles within the vicinity of the Waroona Deposit was undertaken during 30 October and 1 November 2001. A suite of twelve holes was drilled using air-core methods. Each hole was sampled and lithologically logged at one metre intervals. The sites of the reconnaissance drilling are broadly compatible with those of the multipiezometer bores. Details of the reconnaissance drilling are outlined in Table 4.

Table 4

Summary of Reconnaissance Drilling

Site	Approximate AMG Co-ordinates		Ground Elevation (mAHD)	Depth (m)	Stratigraphy
	mN	ME			
W5	6366934	400562	83.63	30	Colluvium/Yoganup
W7	6367270	400027	70.04	30	Colluvium/Yoganup
W9	6366765	399804	53.69	30	Colluvium/Yoganup/
W10	6366722	399065	39.72	39	Colluvium Yogunup/Top of Leederville
W12	6367100	399074	36.86	40	Surficial Sand/Guildford/
W13	6367796	398966	33.34	18	Surficial Sand/Guildford/
W15	6367295	399439	37.74	30	Surficial Sand/Yogunup/Top of Leederville
W16	6366891	399422	43.02	30	Colluvium/Guildford/Yoganup/Top of Leederville
W17	6366898	399715	50.13	30	Colluvium/Guildford/Yoganup
W18	6366852	400508	62.05	15	Colluvium/Yoganup/Top of Bedrock
W19	6366833	400753	72.01	2.1	Colluvium/Top of Bedrock
W20	6367768	399592	40.31	29.9	Colluvium/Yoganup/Leederville
W21	6367683	399893	48.56	24	Colluvium/Yoganup
W22	6367525	400602	68.19	16.2	Colluvium/Yoganup/Top of Bedrock
W23	6367743	400451	50.21	12.5	Colluvium/Yogunup/ Top of Bedrock
W24	6367897	400448	57.49	11.6	Colluvium/Yogunup/ Top of Bedrock
W25	6367895	400604	61.86	8.9	Colluvium/Yoganup/Top of Bedrock
W26	6368683	400518	68.22	11.8	Colluvium/Yoganup/Top of Bedrock
WSB1	6366924	399424	42.81	33	Colluvium/Guildford/Yoganup/Leederville
WSB2	6366856	400480	61.82	15	Colluvium/Top of Bedrock
WSB3	6367763	399572	40.07	32	Colluvium/Yoganup/Leederville
WSB4	6367903	400468	59.11	12	Colluvium/Top of Bedrock
WSB5	6367320	399452	38.07	30	Surficial Sand/Yoganup/Leederville
WLB1	6366892	399450	43.46	80	Colluvium/Yoganup/Leederville
WLB2	6367764	399617	42.81	80	Colluvium/Yoganup/Leederville

Results from the reconnaissance drilling have been applied to:

- broadly define the bottom elevation of the superficial formations;

- broadly define the weathered bedrock profile;
- design the screen intervals for multipiezometer bores at each site; and
- determine the locations of superficial formations and weathered bedrock shallow test production bores.

3.2 Groundwater Exploration Bores

The groundwater exploration programme was completed by Wintergreen Drilling during November 2000 to February 2001. Groundwater Well Licence No. 99260 (exploration) authorised this aspect of the site investigations. A copy of the licence is included as Appendix A.

The drilling was completed using mud-rotary techniques.

Construction details of the completed test production bores and multipiezometer bores are summarised in Table 5. Locations of the bores are shown on Figure 11. Diagrams of each bore, providing construction details and lithological profiles, are shown in Appendix B.

Table 5

Summary Details - Groundwater Exploration Bores

Bore	AMG Co-ordinates		Collar Elevation (mAHD)	Depth (m)	Hole Diameter (mm)	Bore Casings		
	mN	mE				Material	Slotted Interval (m)	Gravel Interval (m)
SUPERFICIAL FORMATIONS TEST PRODUCTION BORES								
WSB1	6366924	399424	43.0	36.29	311	195mm Cl.9 uPVC	3-36	2-33
WSB2	6366856	400480	62.6	15.67	215	125mm Cl.9 uPVC	4-15	2-15
WSB3	6367763	399572	40.3	32.95	311	195mm Cl.9 uPVC	3-32	2-32
WSB4	6367903	400468	60.0	10.34	215	125mm Cl.9 uPVC	6-12	2-12
WSB5	6367320	399452	38.3	30.19	311	195 mm Cl.9 uPVC	1-30	0.5-30
WSB5(U/S)	6367322	399446	37.9	32.35				
LEEDERVILLE FORMATION TEST PRODUCTION BORES								
WLB1	6366892	399450	43.7	80	311	195mm Cl.9 uPVC	32-80	30-80
WLB2	6367764	399617	40.8	80	311	195mm Cl.9 uPVC	36-80	32-80
NEW MULTIPIEZOMETER BORES[1]								
W15S	6367295	399439	38.5	10.0	150	80mm Cl.9 uPVC	4-10	3-10
W15M1	6367296	399439	38.4	15.0	150	80mm Cl.9 uPVC	12-15	11-15
W15M2	6367298	399439	38.4	25.0	150	80mm Cl.9 uPVC	16-26	15-26
W15D	6367298	399441	38.5	34.0	150	80mm Cl.9 uPVC	28-35	26-35
W16S1	6366889	399422	43.6	6.0	150	80mm Cl.9 uPVC	3-6	2-6
W16S2	6366891	399422	43.6	15.0	150	80mm Cl.9 uPVC	9-15	8-15
W16M1	6366894	399423	43.4	27.0	150	80mm Cl.9 uPVC	24-28	23-28
W16M2	6366892	399423	43.6	66.0	150	80mm Cl.9 uPVC	60-66	58-66
W16D	6366890	399412	43.5	80.0	150	80mm Cl.9 uPVC	72-80	70-80
W17S	6366898	399715	50.7	8.0	150	80mm Cl.9 uPVC	2-8	1-8

Table 5 (continued)

Bore	AMG Co-ordinates		Collar Elevation (mAHD)	Depth (m)	Hole Diameter (mm)	Bore Casings		
	mN	mE				Material	Slotted Interval (m)	Gravel Interval (m)
W17D	6366901	399715	50.9	17.0	150	80mm Cl.9 uPVC	14-17	12-16
W18S	6366852	400508	62.7	10.0	150	80mm Cl.9 uPVC	4-10	2-10
W18D	6366851	400509	62.7	15.0	150	80mm Cl.9 uPVC	12-15	11-15
W19	6366833	400753	72.7	2.0	150	80mm Cl.9 uPVC	1-2	0.5-2
W20S1	6367768	399594	41.1	6.0	150	80mm Cl.9 uPVC	3-6	2-6
W20S2	6367768	399592	41.0	12.0	150	80mm Cl.9 uPVC	9-12	8-12
W20M1	6367769	399596	41.1	26.0	150	80mm Cl.9 uPVC	20-28	18-28
W20M2	6367769	399598	41.1	32.0	150	80mm Cl.9 uPVC	28-33	27-33
W20D1	6367768	399590	41.0	50.0	150	80mm Cl.9 uPVC	40-50	38-50
W20D2	6367767	399598	41.1	80.0	150	80mm Cl.9 uPVC	70-80	68-80
W21S	6367683	399893	49.4	6.0	150	80mm Cl.9 uPVC	3-6	2-6
W21M	6367683	399892	49.3	12.0	150	80mm Cl.9 uPVC	8-12	7-12
W21D	6367683	399890	49.2	24.0	150	80mm Cl.9 uPVC	18-24	16-24
W22S	6367525	400602	68.9	10.0	150	80mm Cl.9 uPVC	7-10	6-10
W22D	6367523	400604	68.9	16.0	150	80mm Cl.9 uPVC	12-16	11-16
W23S	6367743	400451	51.0	5.0	150	80mm Cl.9 uPVC	2-5	1-5
W23M	6367744	400450	51.0	8.0	150	80mm Cl.9 uPVC	6-8	5-8
W23D	6367745	400449	50.9	13.0	150	80mm Cl.9 uPVC	9-13	8-13
W24	6367897	400448	58.4	12.0	150	80mm Cl.9 uPVC	6-12	5-12
W25S	6367895	400604	62.6	1.5	150	80mm Cl.9 uPVC	0.5-1.5	0-1.5
W25D	6367894	400604	62.4	9.0	150	80mm Cl.9 uPVC	6-9	5-9
W26S	6368683	400518	68.8	9.0	150	80mm Cl.9 uPVC	6-9	5-9
W26D	6368682	400518	69.0	12.0	150	80mm Cl.9 uPVC	10-12	9-12
UPGRADE EXISTING MULTIPIEZOMETER BORES [1]								
W10S	6366876	399217	40.6	9	150	80mm Cl.9 uPVC	3-9	2-9
W10M	6366877	399215	40.6	25	150	80mm Cl.9 uPVC	19-25	18-25
W10D	6366876	399224	40.6	40	150	80mm Cl.9 uPVC	37-40	35-40
W12D[2]	6367101	399074	37.5	25	150	80mm Cl.9 uPVC	13-25	11-25
W12S[2]	6367100	399074	37.5	40	150	80mm Cl.9 uPVC	30-40	28-40
W13S	6367796	398965	34.1	25	150	80mm Cl.9 uPVC	5-10	3-10
W13D	6367796	398966	34.1	40	150	80mm Cl.9 uPVC	14-18	12-18

Notes: 1. S - denotes shallow, M denotes middle, D denotes deep.
2. W12S and W12D are labelled in reverse on the collar.

3.3 Aquifer Tests

Aquifer tests have been completed in all of the groundwater exploration bores. Most tests were completed during March 2001.

In the test production bores, the design aquifer testing programme incorporated:

- 30-minute step-drawdown tests;
- 24-hour constant-discharge tests;
- 2-hour recovery test; and

- observation of aquifer responses to pumping in nearby piezometer bores.

The design protocols were followed except in circumstances where very low yields compromised the tests.

In the multipiezometer bores, the aquifer tests were conducted over 10 to 20 minute durations using a Grundfos MP1 sampling pump.

Details of the aquifer tests are summarised in Table 6 (test production bores), Table 7 (multipiezometer bore responses to tests in the test production bores) and Table 8 (tests in the multipiezometer bores).

Plots of the observed drawdown responses in the test bores are shown in Appendix C (test production bores) and D (multipiezometer bores).

Table 6

Summary of Aquifer Tests in Test Production Bores

Bore	Test Type	Test Duration (minutes)	Discharge Rate (kL/day)	Drawdown (m)	Comments
WSB1	Step-Drawdown	30	86	4.77	
		30	130	7.48	
		30	173	9.34	
		30	216	11.89	
	Constant-Discharge	1440	130	5.81	
	Recovery	120	(129.6)	0.80	
WSB2	Step-Drawdown	30	8.64	2.83	
		30	17.28	6.91	
		15	25.92	9.5	Pump stopped
	Constant-Discharge	1440	8.64	6.82	
	Recovery	120	(8.64)	3.69	
WSB3	Step-Drawdown	30	17.28	8.11	
		30	25.92	15.75	
		35	34.56	26.95	
	Constant-Discharge	660	8.64	23.65	Test stopped, water level too low
	Recovery	120	(8.64)	13.37	
WSB4	Constant-Discharge	2.5	8.64	1.35	Test stopped, water level too low
	Recovery	120	(8.64)	1.10	
WSB5	Constant-Discharge	1440	1089	10.75	
	Recovery	120	(1089)	0.32	

Table 6 (continued)

Bore	Test Type	Test Duration (minutes)	Discharge Rate (kL/day)	Drawdown (m)	Comments
WLB1	Step-Drawdown	30	43.2	13.56	
		30	86.4	31	
		30	129.6	49	
	Constant-Discharge	1440	43.2	27.26	
	Recovery	120	(43.2)	6.4	
WLB2	Constant-Discharge	25	43.2	28.9	Test stopped, water level too low
	Recovery	120	(43.2)	21.31	

Table 7

Multipiezometer Bore Responses to

Aquifer Tests in the Test Production Bores

Bore	Test Type	Test Duration (mins)	Discharge Rate (kL/day)	Observed Drawdowns		
				Piezometer	Radial Distance (m)	Drawdown (m)
WSB1	Constant-Discharge	1440	130	W16S1	35	0.01
				W16S2	35	0.084
				W16M1	35	4.183
				W16M2	35	No response
				W16D	35	Not monitored
WSB2	Constant-Discharge	1440	9	W18S	28	No response
				W18M1	28	0.025
WSB3	Constant-Discharge	660	9	W20S1	22	0.165
				W20S2	22	0.06
				W20M1	22	0.095
				W20M2	22	0.22
				W20D1	22	Not monitored
				W20D2	22	Not monitored
WSB4	Constant-Discharge	2.5	9	W24	22	Not monitored
				W25S	22	Not monitored
				W25D	22	Not monitored
WSB5	Constant-Discharge	1140	1089	W15S	28	0.31
				W15M1	28	0.44
				W15M2	28	0.355
				W15D	28	0.36
				P2	28	0.59

Table 7 (continued)

Bore	Test Type	Test Duration (mins)	Discharge Rate (kL/day)	Observed Drawdowns		
				Piezometer	Radial Distance (m)	Drawdown (m)
WLB1	Constant-Discharge	1440	43	W16S1	28	0.09
				W16S2	28	0.21
				W16M1	28	0.29
				W16M2	28	1.94
				W16D	28	2.34
WLB2	Constant-Discharge	25		W20S1	24	Not monitored
				W20S2	24	Not monitored
				W20M1	24	Not monitored
				W20M2	24	Not monitored
				W20D1	24	Not monitored
				W20D2	24	Not monitored

Table 8
Aquifer Tests in Multipiezometer Bores

Bore	Test Period	Test Type	Test Duration (mins)	Discharge Rate (kL/day)	Drawdown (m)	Comments
W10S	November 30, 2000	Constant-Discharge	20	4	4.86	
W10S	February 9, 2001	Constant-Discharge	13.45	6	4.63	Dry at 13 minutes
W10M	November 30, 2000	Constant-Discharge	20	8	16.7	Rate slowing towards the end
W10M	February 9, 2001	Constant-Discharge	20	6	11.91	
W10D	February 9, 2001	Constant-Discharge	20	13	22.62	
W12S	February 9, 2001	Constant-Discharge	20	15	3.9	
W12D	February 9, 2001	Constant-Discharge	20	24	3.09	
W13S	February 9, 2001	Constant-Discharge	4.5	24	6.99	Rate too High. Reduced to lower rate.
W13S	February 9, 2001	Constant-Discharge	8	12	6.7	
W13D	February 9, 2001	Constant-Discharge	20	13	3.13	
W15S	February 12, 2001	Constant-Discharge	20	28	1.29	
W15S	November 30, 2000	Constant-Discharge	2	NA	0.42	Test Stopped to Increase Rate
W15S	November 30, 2000	Constant-Discharge	3	21	0.74	Test Stopped to Increase Rate
W15S	November 30, 2000	Constant-Discharge	20	22	1.09	
W15M1	February 12, 2001	Constant-Discharge	20	23	4.72	
W15M2	February 12, 2001	Constant-Discharge	20	23	0.34	
W15M2	February 12, 2001	Constant-Discharge	3	NA	0.28	Test Stopped to Increase Rate
W15M2	November 30, 2000	Constant-Discharge	20	26	0.38	
W15D	February 12, 2001	Constant-Discharge	20	33	26.91	
W16S1	September 2, 2001	Constant-Discharge	5	7	2.77	Dry at 5 minutes
W16S2	September 2, 2001	Constant-Discharge	13.23	7	9.13	Dry at 13 minutes
W16M1	September 2, 2001	Constant-Discharge	20	7	11.77	
W16M2	September 2, 2001	Constant-Discharge	20	4	13.05	
W16D	September 2, 2001	Constant-Discharge	20	10	25.31	
W17S	November 30, 2000	Constant-Discharge	20	9	3.96	

Table 8 (continued)

Bore	Test Period	Test Type	Test Duration (mins)	Discharge Rate (kL/day)	Drawdown (m)	Comments
W17D	November 30, 2000	Constant-Discharge	9	11	10.28	Dry at 9 minutes
W18S	November 30, 2000	Constant-Discharge	20	6	2.46	
W18D	November 30, 2000	Constant-Discharge	20	12	4.62	
W20S1	February 12, 2001	Constant-Discharge	4.5	6	1.86	
W20S2	February 12, 2001	Constant-Discharge	20	6	5.76	
W20M1	February 12, 2001	Constant-Discharge	20	18	1.91	
W20M2	February 12, 2001	Constant-Discharge	20	10	17.6	
W20D1	February 12, 2001	Constant-Discharge	20	23	25.29	
W20D2	February 12, 2001	Constant-Discharge	15	24	37.46	
W21S	February 8, 2001	Constant-Discharge	3	NA	2.13	Dry at 3 minutes
W21M	February 8, 2001	Constant-Discharge	20	7	6.34	
W21D	February 8, 2001	Constant-Discharge	20	7	17.83	
W22S	November 23, 2000	Constant-Discharge	20	5	1.58	
W22D	November 23, 2000	Constant-Discharge	20	14	1.32	
W23S	November 23, 2000	Constant-Discharge	11	13	3.25	Dry at 11 minutes
W23S	November 24, 2000	Constant-Discharge	20	6	2.03	
W23M	November 23, 2000	Constant-Discharge	12	NA	5.66	Pumping problems, stopped at 12 minutes
W23M	November 24, 2000	Constant-Discharge	8	17	6.54	Dry at 8 minutes
W23D	November 24, 2000	Constant-Discharge	20	16	3.63	
W24	November 24, 2000	Constant-Discharge	20	10	4.13	
W25D	November 24, 2000	Constant-Discharge	20	7	5.83	
W25D	February 12, 2001	Constant-Discharge	8	11	6.51	Dry at 7 minutes

Note: NA - Not available

3.4 Groundwater Sampling and Quality Analyses

Groundwater sampling was undertaken during the aquifer tests in most test production bores and multipiezometer bores. Samples were not collected from W19, W25S and W26D.

All samples were submitted to the Australian Government Analytical Laboratories (AGAL) and Australian Reference Laboratory (ARL) for analyses of dominant, common ions. The analyses form a baseline for groundwater quality at the Waroona Deposit. Laboratory analyses reports are provided in Appendix E.

3.5 Water Resources Census

A water resources census of residents nearby to the Waroona Deposit was conducted from 2 to 4 May 2002. The census was undertaken by Sharon McDonald (Community Relations Officer, Iluka) and Ian Brunner (Principal Hydrogeologist, URS) and essentially involved discussions with nearby residences. A total of 26 residences were visited, of which 5 were not available for interviewing. The locations of the nearby residences are shown on Figure 12.

A summary of the water resources census is contained in Appendix F. The key findings of the census are as follows:

- Stock and irrigation water is derived by the local residents to the southwest of the Waroona Deposit from groundwater and surface water (Nanga Brook) resources.
- Residents situated along McDowell St (closer to Waroona townsite) are interpreted to be sourcing groundwater from a different flow system to the mine area. Residents closer to the mine are likely to be sourcing groundwater from a similar flow system to the mine area.
- Groundwater level data suggest that there is a groundwater baseflow component to the observed stream flow of Nanga Brook.
- Surface water that outflows from springs on the western perimeter of the dunal terrain (Figure 3) is used for domestic and stock watering by the Mullins residents.
- Water users of Nanga Brook experience some supply and water quality issues, particularly in warmer months.
- Ferraro Brook flows through the Waroona Deposit. No nearby downstream users of Ferraro Brook were identified during the census.

Accordingly, the mining plans for the Waroona Deposit should incorporate provisions to protect the Nanga Brook and dunal fringe springs, preserving the local settings and streamflow quality. These provisions include:

- limiting drawdown impacts in the vicinity of the Nanga Brook, thus sustaining baseflow contributions to the streamflow from shallow groundwater resources;
- preserving streamflow qualities by strictly limiting runoff from disturbed areas discharging straight into Nanga Brook, other streams and dunal fringe springs;
- retention of comparatively poor quality (sediment laden and turbid) surface water during the mining and rehabilitation phases; and
- provision should be made to supplement users of the Nanga Brook surface water, in the event that mining and dewatering operations cause adverse impacts on the streamflow quantity and quality.

It is also interpreted that the springs located on the western dunal fringe would be impacted by mining. Agricultural activities have already had some impacts downstream of the springs, on the Mullins property. Provision should be made to artificially recharge the spring, so to preserve the local ecology. The springs should be retained in the post-mining setting.

Drawdown of the water table due to groundwater abstraction during mining has the potential to impact on nearby groundwater users, particularly those to the west and south of the proposed mine area. Provisions should be made to supplement shallow groundwater users in these areas if necessary to make-up shortfalls in routine supply demands. Management and conservation provisions should be continued until after mining, until such time that the groundwater environment recovers to near baseline conditions.

Drawdown of the local water table also has the potential to adversely impact on vegetation that uptakes shallow groundwater. Nearby vegetation should be monitored and provisions should be made to remediate any vegetation stress caused by reductions in available water resources.

Numerous mineral exploration, reconnaissance drilling and groundwater exploration bores provide lithological data in the project area. These data have been applied, with regional mapping, to define the geological and stratigraphic profiles.

4.1 Lithological Mapping and Profiles

Formations and formation boundaries have been defined by mineralogy, lithology, colour, sorting, clayey fines content and heavy mineral occurrence. Most data have been sourced from the geological model of the Waroona Deposit, with model parameters sorted based on eleven key lithological descriptions that comprise:

- clay;
- clay/sand;
- rock;
- sand_1 with clay fines content <10% and coarse sand fraction >30%;
- sand_2 with clay fines content <10% and coarse sand fraction >30%;
- sand_3 with clay fines content >10% and <15%;
- sand_4 with clay fines content >15% and <20%;
- sand_5 with clay fines content >20%;
- sand/rock;
- clay/rock; and
- sand/clay/rock.

These data have been supported by reconnaissance drilling lithological logs that enable more definitive interpretation of:

- occurrence of weathered bedrock and fresh bedrock contacts;
- shallow Leederville Formation distribution; and
- base of the superficial formations (basal sands tend to have a lower clay content).

Surface mapping (Figure 13) shows the project area is predominantly underlain by Yoganup Formation. Guildford Formation occurs to the west. Deposits of colluvium and gravel occur on the upper footslope in areas east of the Darling Fault and terminate further east again where Archaean bedrock commonly

outcrops. On streams, the Yoganup Formation has been incised by erosional activity and the clayey Guildford Formation forms valley-floor deposits in these areas.

4.1.1 Superficial Formations

The Yoganup Formation locally forms a succession of sandy clay and clayey sands, with minor amounts of moderately sorted sand. The thickness of the Yoganup formation is variable, ranging from a few metres in the eastern areas up to about 40m in the western areas Based on review of selected geological drillhole logs, the Yoganup Formation can be generally locally subdivided into the following units:

- an uppermost sequence of clay and sandy clay that generally varies in thickness from 5 to 15m;
- a lower sandy sequence consisting of sand, clay, clayey sand and sandy clay that generally varies in thickness up to 20 m; and
- a basal unit comprising discontinuous sandy beds, typically less than two metres thick, that may represent colluvial and erosional deposits that rest unconformably on the Leederville Formation.

Along the western margin of the project area, the Yoganup Formation is overlain by brown and grey mottled clays and sandy clays of the Guildford Formation (Figure 5). In these areas, the Guildford Formation is approximately 10m thick, and is believed to progressively increase in thickness further to the west.

Throughout the central and eastern portions of the project area thin colluvial deposits occur as erosional beds above the Yoganup Formation. These shallow beds are typically formed of silty and clayey sands, with variable amounts of gravel, and often become more abundant closer to the escarpment. The deposits are poorly sorted (including some high-energy gravel beds) and non-uniform in thickness.

The entire superficial formations profile is interspersed with iron-cemented ferricrete or laterised beds. These beds occur over broad areas but are not uniformly distributed vertically or laterally. Usually, the occurrence of iron-cementation is linked to historical water tables (perched and permanent) and/or preferred groundwater flow paths.

The interpreted bottom elevations of the superficial formations are shown on Figure 14. Typical geological cross-sections, based on the collation of all available reconnaissance drilling lithological data, are shown on Figures 15a and b. These figures show that there is considerable lateral and vertical variation in the lithologies of the Yoganup Formation. Typical plan views of the lithological distribution based on the available reconnaissance drilling lithological data are shown on Figure 15c.

4.1.2 Leederville Formation

The Leederville Formation has locally been investigated by two holes to a depth of 80 m. Mineral resource and reconnaissance drilling has typically penetrated only the upper few metres of the formation.

Locally, the upper beds of the Leederville Formation are variable, being comprised of:

- dark grey-blue mudstones and shales, with textural variations from puggy to hard slatey characteristics, variably interbedded with sandy horizons;
- variably weathered clay/silt and sands which contain ferruginised zones; and
- minor granite boulders.

4.1.3 Bedrock

Outcrop of Archaean bedrock is evident on the escarpment to the east of the project area. Weathered bedrock profiles also overlie fresh bedrock, as observed at reconnaissance drilling sites W18, W19, W22, W23, W24, W25 and W26.

The weathered bedrock profiles vary considerably within the project area, incorporating:

- kaolinitic clays;
- granitic quartzose sands with some iron staining, commonly just above the fresh bedrock contact;
- quartzose and feldspathic sands, also commonly just above the fresh bedrock contact;
- green-brown mottled clays and ironstone gravels; and
- green-brown gritty clays.

The distributions of weathered bedrock and the fresh bedrock contact are poorly defined.

The location of the Darling Fault is not closely defined.

4.2 Stratigraphy

The stratigraphy of the project area is outlined in Table 9.

Table 9

Local Stratigraphy

Age	Stratigraphy		
	Unit	Group	Formation
Quaternary	Superficial formations	Kwinana	Guildford Formation Yoganup Formation
Quaternary	Colluvium	-	Colluvium and Laterite
Unconformity			
Cretaceous	Leederville Formation	Warnbro	Leederville Formation
Archaean	Granites, Gneisses and Dolerite	Yilgarn Shield	Bedrock

The Waroona Deposit occurs within the Murray Groundwater Area of the Southern Perth Basin and overlaps Archaean terrain of the Yilgarn Shield. The major aquifer zones that occur locally are limited to the superficial formations (including colluvial outwash from the Darling Scarp). The crystalline rocks of the Yilgarn Shield locally form minor limited-extent aquifers.

The project area occurs in the recharge zone for the Southern Perth Basin aquifer systems.

Regional groundwater flow is westward toward the coast. Broad aspects of the regional hydrogeology are outlined in the following references:

- Deeney, A.C. (1988) - Geology and Groundwater Resources of the Superficial Formations between Pinjarra and Bunbury, Perth Basin. Western Australian Geological Survey, Professional Papers, Report 26, pp. 31-57.
- Deeney, A.C. (1989) - Hydrogeology of the Harvey Borehole Line, Perth Basin. Western Australian Geological Survey, Professional Papers, Report 26, pp.59-68.

Based on these references, together with data from local drillholes, it is evident that the Waroona Deposit is underlain by the following vertical succession of aquifer systems:

- superficial formations (to approximately 30 m maximum);
- Leederville Formation (from 10 to 30 m, to approximately 130 m depth); and
- Cattamarra Coal Measures/Eneabba Formation (below about 130 m depth).

The local hydrogeology of the shallow aquifer systems has been defined based on:

- lithological profiles and local stratigraphy;
- data collected from the installed multipiezometer bores;
- results of aquifer tests in test production bores and multipiezometer bores; and
- terrain characterisation based on observed site geomorphology, streamflow and aquifer settings.

These aspects have been integrated to develop the knowledge and understanding of the local aquifer systems.

5.1 Aquifer Profiles

Locally, the most significant aquifer system is formed by sand beds within the Yoganup Formation and the underlying unconformity surface. Laterally, this water table aquifer is in hydraulic connection with aquifer zones formed upstream and downstream within the weathered bedrock profile and the Guildford Formation.

Within the Yoganup Formation, the typical range of fines contents broadly indicates that the saturated portions of the Yoganup Formation would generally form a comparatively low-permeability aquifer. However, locally in the western areas of the deposit, the fines contents are comparatively low and indicative of the occurrence of preferred flow paths (lateral and vertical) that form zones of higher transmissivity.

Groundwater discharge from the Yoganup Formation occurs in a spring on the western perimeter of the dunal terrain. In this dunal perimeter area, the contact between the dunal Yoganup Formation and Guildford Formation on the Pinjarra Plain coincides with the footslope and toe of the dunal terrain (Figure 5). In this setting, the clayey units of the Guildford Formation form confining layers.

At the base of the Yoganup Formation, the unconformity surface on the Leederville Formation contact is discontinuous in its extent and variable in its characteristics. Typically, the most transmissive beds are characterised by granitic sand deposits with pebbles and cobbles of weathered to fresh bedrock. The surface is also variably cemented with ferricrete, promoting the likely occurrence of preferred flow paths.

The thin colluvial deposits which occur as discontinuous erosional beds above the Yoganup Formation are poorly sorted and non-uniform in thickness. It is anticipated that the erosional beds would form a variable, anisotropic aquifer – with groundwater flow occurring along preferred paths predominantly formed by the sand and gravel beds.

The Leederville Formation comprises a multiple-layer confined aquifer system of regional extent. Shallow Leederville Formation beds form a comparatively poor low-yielding aquifer in areas close to the escarpment and the Darling Fault. The test production bores constructed within the shallow Leederville Formation confirm the low-yielding nature of the aquifer in these areas.

Within the weathered and fresh bedrock profile, the most significant aquifer zones occur as:

- quartzose, feldspathic and granitic sands marginally above the fresh bedrock; and
- relic fractures or structures in the weathered or fresh rocks.

These aquifer zones are of limited extent, influence both topography and surface drainage features and may form local perched or ephemeral groundwater flow paths.

5.2 Groundwater Levels

Groundwater level data in the project area are derived from the installed multipiezometer bores. These data represent a pre-mining environment baseline.

Historical groundwater level data collected between November 1992 and August 1999 are provided as hydrographs on Figures 16 to 18. These data generally indicate:

- Seasonal fluctuations in water table elevations in the superficial formations vary considerably depending on proximity to the escarpment and aquifer characteristics. Fluctuations of two to three

metres are typically observed in the western areas (Figure 16) and closely correspond to recharge by winter rainfall. Groundwater level fluctuations in the eastern areas are of the order of 0.5 to 2m.

- Seasonal fluctuations within the shallow Leederville Formation and weathered Archaean bedrocks (Figure 18) are of the order of one to four metres and similar to that within the overlying superficial formations.

The recently available groundwater level data from the entire multipiezometer network have been collated to evaluate water table elevations, groundwater flow directions and the vertical stratification of heads within the shallow aquifer systems. Groundwater levels were measured on 31 May 2001 and are shown on Figures 19 and 20 for the water table and deeper profile potentiometric levels.

The groundwater level data broadly indicate:

- Water table elevations of 35 to 70 mAHD within the project area.
- General westward groundwater flow from the escarpment.
- Localised groundwater flow that subtly reflects the surface topography, with slight mounding of the water table in central areas of the deposit that have low topographic relief.
- Local streams incise the water table, providing a discharge zone for both the superficial formations and the shallow Leederville Formation (due to upward leakage into the superficial formations). Recharge would predominantly occur on the local crests and uplands.
- Varied vertical flow-gradients between the water table and lower superficial formations profile, though typically with downward gradients from the superficial formations to the Leederville Formation and Archaean bedrock. Observed vertical head differences range from approximately 0 to 7 m. The vertical head differences indicate areal differences in the hydraulic characteristics and local vertical flow within the superficial formations and underlying strata.
- Hydraulic gradients are generally steeper beneath the escarpment and flatten towards the west, probably reflecting increasing transmissivity towards the west.

The available data are interpreted to represent near-seasonal-low water table elevations. It is expected that seasonal-lows would usually occur in April or May of each year.

5.3 Hydraulic Parameters

Data on the hydraulic parameters for the superficial formations, Leederville Formation and bedrock profiles are provided by the aquifer tests completed in the test production bores and multipiezometers. The aquifer tests in the test production bores provide observed drawdown responses in the pumping bore and also within the nearby multipiezometer bore. In order to evaluate the drawdown responses in the multipiezometer bores, an understanding of the potential yields from the various aquifer profiles and

systems intersected by the test production bore is required. Estimates of the potential yield of the different aquifer profiles have been evaluated based on:

- drawdown responses observed and specific capacities (kL/day/m) calculated from the aquifer tests in each piezometer; and
- observed drawdowns in each multipiezometer screen interval and comparisons to the observed drawdowns in the test production bore.

Apportioned yields based on this methodology are outlined in Table 10. The results are semi-quantitative and when applied probably provide upper-bound values for hydraulic parameters. Results of the aquifer tests are summarised in Table 11 (from the production bores) and Table 12 (from the multipiezometers).

Table 10

Apportioning of Test Production Bore Yields

Piezometer Bore	Piezometer Bore Specific Capacity (kL/day/m)	Drawdown in Representative Interval in the Test Production Bore (m)	Specific Capacity Multiplied by Drawdown (kL/day)	Apportioned Yield (kL/day)
CONSTANT-DISCHARGE TEST IN WSB1				
W16S1	2.6	3.3	8.6	55
W16S2	0.7	5.8	4.0	26
W16M1	0.6	5.8	3.5	22
W16M2	0.3	5.8	1.7	11
W16D	0.4	5.8	2.3	15
Aggregate			20	x 6.5
WSB1 Yield			130	
CONSTANT-DISCHARGE TEST IN WSB2				
W18S	2.5	6.8	17.0	4
W18D	2.6	6.8	17.7	4
Aggregate			34	x 0.23
WSB2 Yield			8	
CONSTANT-DISCHARGE TEST IN WSB3				
W20S1	3.1	2.3	7.1	0.2
W20S2	1.1	8.1	8.9	0.2
W20M1	9.6	23.65	227.0	7
W20M2	0.5	23.65	11.8	0.3
Aggregate			254	x 0.03
WSB3 Yield			8	
CONSTANT-DISCHARGE TEST IN WSB5				
W15S1	9.8	8.6	84.3	101
W15M1	4.8	10.7	51.3	61
W15M2	67.8	10.7	725.4	870
W15D	1.2	10.7	12.8	15
Aggregate			873	x 1.2
WSB5 Yield			1089	

Table 10 (continued)

Piezometer Bore	Piezometer Bore Specific Capacity (kL/day/m)	Drawdown in Representative Interval in the Test Production Bore (m)	Specific Capacity Multiplied by Drawdown (kL/day)	Apportioned Yield (kL/day)
CONSTANT-DISCHARGE TEST IN WLB1				
W16S1	2.6	3.3	8.6	7
W16S2	0.8	11.8	9.4	8
W16M1	0.6	22.8	13.7	12
W16M2	0.3	27.2	8.1	7
W16D	0.4	27.2	10.9	9
Aggregate			50	x 0.86
WLB1 Yield			43	

Table 11

Hydraulic Parameters Interpreted from Aquifer Tests in Test Production Bores

Piezometer Bore	Hydraulic Parameters								
	Transmissivity (m^2/day)						Theis Recovery	Hydraulic Conductivity (m/day)	Storativity (dimensionless)
	Cooper Jacob			Theis					
	Early-Time	Late-Time	Best Fit	Early-Time	Late-Time	Best Fit			
CONSTANT-DISCHARGE TEST IN WSB1									
WSB1	9	31	19	-	-	16	14	0.3 - 0.95	4.87×10^{-6}
W16S1	-	-	-	-	-	-	-	-	-
W16S2	-	-	110	-	-	50	-	8-18	$9.1x\ 10^{-10}$
W16M1	4	14	5	-	-	5	2	0.5-3	$7.36x10^{-9}$
W16M2	-	-	-	-	-	-	-	-	-
W16D	-	-	-	-	-	-	-	-	-
CONSTANT-DISCHARGE TEST IN WSB2									
WSB2	-	-	0.8			0.8	0.6	0.05 - 0.10	2.99×10^{-4}
W18S	No response								
W18M1	Very minor response (0.02m)								
CONSTANT-DISCHARGE TEST IN WSB3									
WSB3	1	0.1	0.35	-	0.2	1	0.2	0.003 - 0.04	1.58×10^{-2}
W20S1	-	0.33	0.74	-	0.32	-	-	0.1 - 0.2	1.07×10^{-6}
W20S2	Very minor response (0.06m)								
W20M1	Very minor response (0.095m)								
W20M2	-	0.15	0.64	-	-	4	-	0.03 - 0.1	2.20×10^{-5}

Table 11 (continued)

Piezometer Bore	Hydraulic Parameters								
	Transmissivity (m^2/day)						Theis Recovery	Hydraulic Conductivity (m/day)	Storativity (dimensionless)
	Cooper Jacob			Theis					
	Early-Time	Late-Time	Best Fit	Early-Time	Late-Time	Best Fit			
CONSTANT-DISCHARGE TEST IN WSB4									
WSB4	-	-	2	-	-	-	-	0.3	1.72×10^{-4}
CONSTANT-DISCHARGE TEST IN WSB5									
WSB5	163	318	729	-	-	123	798	4 - 28	7.13×10^{-28}
W15S1	18	49	88	-	-	81	89	8 - 30	$4.80 - 6.37 \times 10^{-4}$
W15M1	-	-	58	-	-	61	356	19 - 120	$3.19 - 5.49 \times 10^{-8}$
W15M2	-	-	740	-	-	773	796	82 - 88	$5.14 - 7.69 \times 10^{-8}$
W15D	-	-	13	-	-	13	5.4	0.7 - 1.8	$6.31 - 6.56 \times 10^{-10}$
CONSTANT-DISCHARGE TEST IN WLB1									
WLB1	-	-	2	-	-	1	0.7	0.015 - 0.063	7.58×10^{-6}
W16S1	Very minor response (0.05m)								
W16S2	-	-	2	-	-	-	-	0.3	2.63×10^{-3}
W16M1	-	-	17	-	-	15	-	3.7 - 4.2	$2.02 - 3.14 \times 10^{-4}$
W16M2	7	0.45	1	-	0.40	-	-	0.06 - 1.2	$1.41 - 3.33 \times 10^{-4}$
W16D	95	0.65	1	-	0.55	-	-	0.06 - 0.6	$1.08 - 2.43 \times 10^{-4}$
CONSTANT-DISCHARGE TEST IN WLB2									
WLB2	0.7	0.4	0.5	-	-	0.3	11	0.006 - 0.25	4.56×10^{-4}

Table 12

Hydraulic Parameters Interpreted from Aquifer Tests

in Multipiezometer Bores

Piezometer	Hydraulic Parameters						Hydraulic Conductivity (m/day)	Slotted Interval (m)
	Transmissivity (m^2/day)							
	Cooper Jacob			Theis				
	Early-Time	Late-Time	Best Fit	Early-Time	Late-Time	Best Fit		
W10S	0.4	0.2	0.2	-	-	0.2	0.033	6
W10S	0.7	0.2	0.3	0.8	0.2	-	0.050	6
W10M	0.3	0.1	0.1	0.2	0.1	-	0.016	6
W10M	0.3	0.1	0.1	0.2	0.1	-	0.016	6
W10D	0.5	0.1	0.2	0.4	0.1	-	0.066	3
W12S	0.6	1.8	1.2	0.1	1.3	-	0.120	10
W12D	1.7	22.4	3.1	1.2	5.2	-	0.258	12
W13S	0.6	0.3	0.4	-	-	0.3	0.080	5
W13D	1.0	3.8	1.4	0.8	1.9	1.0	0.350	4
W15S	7.1	746.2	22.3	-	-	23.5	3.720	6
W15S	56.4	-	23.7	-	-	21.6	3.950	6
W15M1	1.1	14.8	1.8	0.8	3.5	-	0.600	3
W15M2	-	-	198.8	-	-	70.7	7.700	9
W15M2	-	-	204.5	-	-	71.8	7.000	10
W15D	0.7	0.3	0.4	-	-	0.2	0.060	7
W16S1	1.4	0.3	0.5	1.1	0.3	-	0.166	3
W16S2	0.3	0.1	0.2	-	-	0.1	0.030	6
W16M1	0.4	0.1	0.2	0.4	0.1	-	0.050	4
W16M2	0.2	0.1	0.1	0.2	0.1	-	0.016	6
W16D	0.1	0.3	0.1	0.2	0.1	-	0.013	8
W17S	0.8	-	0.6	-	-	0.6	0.100	6
W17D	0.5	0.2	0.2	0.4	0.1	-	0.060	3
W18S	-	-	0.8	-	-	0.6	0.133	6
W18D	-	-	0.9	-	-	0.8	0.300	3
W20S1	-	-	0.6	-	-	0.5	0.200	3
W20S2	-	0.4	0.3	-	-	0.2	0.100	3
W20M1	3.9	11.9	6.4	4.0	9.0	-	0.800	8
W20M2	0.3	0.1	0.1	0.3	0.1	-	0.060	5
W20D1	0.5	0.2	0.3	-	-	0.2	0.030	10
W20D2	0.4	0.1	0.2	-	-	-	0.020	10
W21M	-	-	0.3	-	-	0.2	0.075	4
W21D	0.3	0.1	0.1	-	-	0.1	0.017	6
W22S	0.7	1.3	1.0	-	-	0.8	0.330	3
W22D	7.2	-	4.9	-	-	4.4	1.220	4
W23S	1.6	-	1.1	1.2	0.9	-	0.360	3
W23S	-	-	1.3	-	-	1.0	0.430	3
W23M	0.7	0.3	0.4	0.3	0.5	-	0.200	2
W23D	3.5	0.6	0.7	3.8	0.5	-	0.175	4
W24	3.5	0.5	0.7	3.8	0.5	-	0.116	6
W25S	0.5	0.3	0.3	-	-	0.3	0.100	3
W26D	-	-	0.4	-	-	0.3	0.130	3

The results of the aquifer tests and interpreted hydraulic parameters broadly indicate:

- The aquifer tests in the test production bores generally provide higher values of transmissivity and hydraulic conductivity than the tests in the piezometers. This aspect can typically be related to the higher pumping rates from the test production bores being more able to effectively stress and drawdown the local aquifer systems.
- The Yoganup Formation forms a significantly variable aquifer system. Clayey profiles typically have measured hydraulic conductivities in the range from 0.02 to 0.5 m/day. Sand beds form the most significant aquifer zones, particularly in the vicinity of W15, W16, W11, W8 and W20. The measured hydraulic conductivities in sand beds range from 5 to 250 m/day.
- The Guildford Formation is typically characterised by mottled clays and sandy clays of low hydraulic conductivities typically less than 0.05m/day.
- The unconformity surface at the base of the Yoganup Formation is typically characterised by hydraulic conductivities in the order of 5 m/day.
- Shallow Leederville Formation profiles are of low transmissivity, with hydraulic conductivities measured in the range from 0.04 to 0.12 m/day. The poorly transmissive nature of the local beds probably significantly limits infiltration of recharge.
- Weathered bedrock profiles form a significantly variable aquifer system with measured hydraulic conductivities around 1m/day. Less transmissive aquifer zones are formed in the fresh bedrock, with measured hydraulic conductivities around 0.1m/day.

5.4 Groundwater Quality

Baseline quality data for the shallow groundwater resources of the project area are outlined in Table 13. The quality data have been subdivided to evaluate the different aquifer systems formed by the Yoganup Formation, shallow Leederville Formation and the weathered bedrock profiles.

Table 13

Groundwater Quality

Bore	Quality Parameters						
	pH	Concentration (mg/L)					
		TDS	Chloride	Sodium	Sulphate	Calcium	Magnesium
Superficial Formations							
W10S	6.2	590	130	150	120	2	4
W10M	5.6	930	360	230	38	4	15
W12S	6.0	560	210	150	28	5	10
W12D	5.7	380	150	90	11	2	8
W13S	6.4	300	100	80	22	1	7
W13D	5.8	840	420	230	36	7	25

Table 13 (continued)

Bore	Quality Parameters						
	pH	Concentration (mg/L)					
		TDS	Chloride	Sodium	Sulphate	Calcium	Magnesium
Superficial Formations							
W15S	5.8	70	22	20	14	<1	2
W15M1	5.6	70	24	20	15	<1	2
W15M2	5.2	90	35	30	19	<1	3
W15D	5.6	210	55	50	27	<1	3
W16S1	5.7	200	60	40	11	<1	2
W16S2	5.6	540	150	120	51	<1	5
W16M1	6.2	1450	680	470	91	8	31
W17S	7.6	140	39	30	16	<1	3
W17D	6.3	1140	540	360	110	9	26
W18S	5.9	620	240	130	19	21	32
W18D	6.1	660	220	130	15	25	30
W20S1	7.0	1270	300	340	110	1	15
W20S2	5.9	1300	590	410	130	5	23
W20M1	5.6	1420	710	390	65	5	31
W21S	5.9	430	80	90	79	3	5
W21M	4.9	790	170	200	240	2	6
W21D	6.2	1950	930	640	160	10	35
W22S	6.5	760	75	140	58	0.5	4.7
W23S	6.6	520	50	120	54	3.6	7.4
W26S	6.4	1010	400	300	86	8	25
Shallow Leederville Formation							
W10D	7.0	1500	740	530	31	20	38
W16M2	6.8	3130	1700	1030	15	79	45
W16D	9.2	3190	1700	1070	20	57	26
W20M2	6.8	1680	830	610	67	14	35
W20D1	6.9	2890	1300	970	120	47	72
W20D2	6.7	2390	1200	870	77	30	25
W23M	6.6	770	50	110	56	6.1	11
W23D	6.5	440	60	110	65	7.9	14
Weathered Bedrock Profile							
W22D	6.4	320	55	80	37	0.7	2.1
W24	6.5	480	130	130	26	4.8	8.9
W25D	6.1	920	340	260	90	6.3	19

The quality data indicates the local groundwater resources are fresh to brackish, slightly acid and of a sodium-chloride type. The data also provides indications of:

- Slightly lower salinity concentrations in the superficial formations compared to the Leederville Formation. This aspect may be linked to the comparably poorly transmissive nature of the shallow Leederville Formation.

- Slightly lower salinity concentrations in the weathered bedrock profile compared to the superficial formations. This aspect may be linked to recharge within the weathered bedrock and throughflow downslope to the Yoganup Formation.
- Generally lower salinity concentrations in the zones of higher hydraulic conductivity, indicative of enhanced recharge and throughflow in these preferred flow zones.
- Contamination by cement grout from drilling and piezometer installation at several sites (W10D, W16M2, W16D, W18S, W18D, W20D1, W20D2) where the groundwater characterised by is comparatively high calcium concentrations.

The development of the Waroona Deposit would raise several environmental and management issues associated with the local shallow groundwater resources. Significant portions of the Waroona Deposit occur below the water table. Consequently, mining developments will involve groundwater abstraction and result in dewatering (at least locally) of the Yoganup Formation. The depth of mining below the water table may vary from about 0 to 20m throughout the project area. Dewatering of the superficial formations may also promote depressurisation of the underlying Leederville Formation, though locally the Leederville Formation forms a very poor aquifer to depths of 80 m.

Mining plans (Figure 10) show that comparatively small areas of the deposit would be developed below the water table at any one time. This aspect of the proposed mining developments will tend to limit the dewatering impacts.

Expected impacts due to the dewatering of the superficial formations during mining include:

- interception of rainfall runoff and infiltration, reducing recharge to and throughflow within the local aquifer systems;
- local drawdown and dewatering of the water table aquifer within the superficial formations;
- depressurisation of the Leederville Formation due to interception of recharge and in response to upward leakage into the mine areas;
- gravity drainage of the superficial formations and weathered Archaean bedrock aquifer zones, with associated lowering of water table elevations, in areas upgradient of those proposed to be mined;
- altering of local groundwater flow directions, with flow diverted into mining areas; and
- reductions in groundwater baseflow discharge into the local streams, and particularly the springs located on the western perimeter of the dunal terrain; and
- loss of amenity for local users of the surface waters and shallow groundwater resources.

The severity of the expected impacts would be linked to several factors, including:

- area and depth of the mining below the water table;
- the period(s) of mining below the water table and relative timing of backfilling;
- the distribution and characteristics of the aquifer systems and particularly beds of comparatively high hydraulic conductivity; and
- the location of the existing users of the streamflow and shallow groundwater resources and the nature of their water supply infrastructure.

A groundwater flow model has been developed to investigate and predict the impacts of mine development on the local surface waters and shallow groundwater resources. The model has been applied to quantify:

- groundwater abstraction during mining;
- drawdown impacts of this abstraction;
- effects on other groundwater users;
- potential effects on stream baseflow and local springs;
- appropriate groundwater and surface water monitoring and management strategies; and
- an effective Operating Strategy that would define commitments on the conservation, protection and management of the surface water resources and local shallow groundwater resources.

6.1 Groundwater Flow Model Development

Results of the site investigations within the project area have been applied to develop a groundwater flow model that simulates the local catchments and superficial formations aquifer systems. The developed model does not represent the regional aquifer system formed by the Leederville Formation.

Modelling has been completed using TARGET-3DU, a 3D finite difference groundwater flow code. This code is characterised by three-dimensional, variably saturated, density coupled, transient groundwater flow functions. The codes ability to resolve groundwater flow in variably saturated settings enables the TARGET-3DU models to effectively simulate key aspects of the project area water balance including:

- recharge due to rainfall infiltration;
- discharge on a groundwater-surface water interface within spring and valley-floor areas; and
- recharge and discharge due to seasonal water balances.

The features that are incorporated into the developed model include:

- fixed-head boundaries on the eastern and western margins of the model domain, with heads reflecting the topography and surface drainage catchments;
- fixed-head boundaries on the western margin of the model domain with heads reflecting the local topography and approximate water table elevations;
- no-flow boundaries as the northern and southern margins of the model domain;
- recharge (infiltration) based on averaged annual water balance parameters in defined catchment domains;
- multiple layers, each of uniform thickness; to simulate the variable lithology and stratigraphy of the project area;

- use of multiple material types, each with different hydraulic characteristics, to represent the different lithological and stratigraphic units; and
- variable saturation, with flow in the unsaturated zones.

6.1.1 Model Domain

The model domain incorporates all of the Waroona Deposit. Boundaries of the model extend:

- about 1 km east of the deposit and hence considerably onto granitic terrain of the Yilgarn Shield;
- about 4 km north and south of the deposit; and
- onto the Pinjarra Plain at least 3 km west of the deposit.

The finite difference mesh is orientated parallel to the AMG grid. The model domain and finite difference mesh are shown on Figure 21. The surface topography and mine pit floor are shown on Figures 22 and 23. The simulated saturated thickness of the mining blocks is shown on Figure 23b.

6.1.2 Model Layers

The TARGET-3DU model is constructed using topographical and superficial formations' lithological databases integrated into a multiple-layer form. From a bottom elevation of –48m AHD, the model is formed of 20 uniform thickness horizontal layers, as outlined in Table 14.

The bottom of the model extends into the shallow Leederville Formation.

Table 14

Model Layers

Layer	Thickness (m)	Elevation Range (mAHD)
20	32	129 to 161
19	16	113 to 129
18	12	101 to 113
17	8	93 to 101
16	8	85 to 93
15	8	77 to 85
14	8	69 to 77
13	8	61 to 69
12	8	53 to 61
11	8	45 to 53
10	8	37 to 45
9	8	29 to 37
8	8	21 to 29
7	8	13 to 21

Table 14 (continued)

Layer	Thickness (m)	Elevation Range (mAHD)
6	8	5 to 13
5	8	-3 to 5
4	8	-11 to -3
3	13	-24 to -11
2	12	-36 to -24
1	12	-48 to - 36

6.1.3 Model Material Types and Their Distribution

The lateral and vertical distribution of geological units and aquifer zones in the model has been represented by using material types with different hydrogeological properties. Different material types have been developed based on the collation of results of the site investigation, including:

- the interpreted stratigraphy (Yoganup Formation, Guildford Formation, Leederville Formation and Archaean bedrock);
- lithological mapping based on colour, mineralogy and clay contents;
- aquifer test results; and
- collation of the aquifer test results with lithological mapping to link these databases.

The model material types are shown in Table 15.

Table 15
Modelled Material Types

Material Type Number	Description
1	Air
2	Guildford Formation, clayey
3	Backfill
4	Leederville Formation
5	Yoganup Formation
6	Colluvium
7	Colluvium
8	Laterite
9	Gneiss/Granite
10	Bassendean Sand
11	Jandakot Beds
12	Sand, clean
13	Sand/Clay

Table 15 (continued)

Material Type Number	Description
14	Sand/Rock
15	Sand/Clay/Rock
16	Clay
17	Rock/Clay
18	Rock
19	Sand
20	Sand

Typical sections illustrating the material type distribution are shown on Figures 15a to 15c.

6.1.4 Hydraulic Parameters

The model hydraulic parameters for each material type have been evaluated from the results of the site investigations. The parameters defined from the aquifer tests vary over a considerable range and consequently averaged values have been applied in the model.

Each material type is assumed to be laterally isotropic. Vertical hydraulic conductivities have been estimated to be an order or magnitude less than the lateral values.

The modelled hydraulic parameters are described in Table 16.

Table 16
Hydraulic Properties of Modelled Material Types

Material Types	Horizontal Hydraulic Conductivity (m/d)	Vertical Hydraulic Conductivity (m/d)	Specific Yield (dimensionless)	Specific Storage (1/m)
Guildford Formation	1.0	0.2	0.02	1^{-6}
Backfill	1.0	0.2	0.02	1^{-6}
Leederville Formation	0.1	0.1	0.01	1^{-6}
Yoganup Formation	0.1	0.15	0.015	1^{-6}
Colluvium - Sandy Silt	1.0	0.05	0.005	1^{-6}
Colluvium - Sandy Silt	1.0	0.05	0.005	1^{-6}
Laterite	0.2	0.1	0.01	1^{-6}
Gneiss/Granite	0.0001	0.01	0.001	1^{-6}
Bassendean Sand	5.0	0.2	0.02	1^{-6}
Jandakot Beds	1.0	0.1	0.01	1^{-6}
Sand, clean	100	0.25	0.025	1^{-6}

Table 16 (continued)

Material Types	Horizontal Hydraulic Conductivity (m/d)	Vertical Hydraulic Conductivity (m/d)	Specific Yield (dimensionless)	Specific Storage (1/m)
Sand/Clay	1.0	0.15	0.015	1^{-6}
Sand/Rock	0.5	0.1	0.01	1^{-6}
Sand/Clay/Rock	0.1	0.1	0.01	1^{-6}
Clay	0.01	0.02	0.002	1^{-6}
Rock/Clay	0.001	0.05	0.005	1^{-6}
Rock	0.0001	0.01	0.001	1^{-6}
Sand	1.0	0.2	0.02	1^{-6}
Sand	1.0	0.2	0.02	1^{-6}

6.1.5 Recharge Domains

The project area is characterised by several catchment domains that are interpreted to have different seasonal and annual water balances due to variations in topography, surface lithologies, land use, depth to the water table and other factors. These factors result in spatial variations in recharge, runoff, evaporation/evapotranspiration processes and throughflow.

The suite of recharge domains applied to the simulated pre-mining environment is predominantly based on the modelled surface lithology. The domains are shown in Table 17 and on Figure 24.

Following mining, the recharge to the disturbed areas, particularly the pit, may change due to changes in the lithological profiles. These changes can only be assumed. They are considered likely to be varied from sandy tailings lithologies where recharge would be comparatively high (20% of annual average rainfall) to clay fines where recharge would be comparatively low (2% of annual average rainfall). Both values have been applied to the pit area to test model sensitivity to this aspect.

Table 17

Recharge Domains and Annual Water Balances

Recharge Domain	Annual Recharge	
	Percent of Annual Rainfall[1]	Model Flux[1] (m/year)
Yoganup Formation - Sand	20	0.18
Guildford Formation - Sandy Silt	2	0.018
Colluvium -Sandy Silt	10	0.09
Bedrock	Nil	Nil
Laterite gravel	10	0.09

Note: 1 Based on annual average rainfall of 900 mm.

6.2 Model Calibration

Calibration of the model has been an iterative process focussed predominantly on the simulation of observed water table elevations within the project area. The calibration process has been based on long-term transient simulation with average water balance fluxes.

The model calibration to observed water table elevations has occurred in discrete stages, with progressive refinement of:

- model boundary conditions, particularly the eastern boundary in steep Archaean bedrock terrain;
- recharge domains;
- annual balance fluxes in each recharge domain;
- hydraulic parameters of selected material types; particularly those of comparatively high permeability;
- starting water table elevations, particularly near the fixed-head boundaries; and
- simulated groundwater levels and comparative assessments to observed levels and the ground surface topography.

Results of the groundwater level calibration are shown on Figure 25a. The results generally show a good correlation with the observed water table elevations, particularly in valley floor areas where the local aquifers may contribute base-flow to streams and springs. It is important to reconcile that the model output is based on averaged seasonal water balance parameters. Accordingly, the model outputs should not represent seasonal-high nor seasonal-low water table elevations but a broad average of the water table.

Overall, the differences between the observed and simulated water table elevations are considered to be minor and due to local influences that would not significantly detract from the predictive outcomes derived from the model.

6.3 Predictive Simulations of Mine Dewatering

The calibrated groundwater flow model has been applied to provide predictive assessments of the impacts of groundwater abstraction during mine development. The key aspects of the predictive assessments include:

- defining the drawdown of the water table due to the groundwater abstraction during mining;
- evaluation of the reductions in groundwater baseflow into the local streams; and
- definition of the timetable for progressive recovery of the water table after mining.

Fundamental details of the modelling approach include:

- Use of the calibrated steady-state model to define pre-mining water table conditions.
- Use of transient simulations, with time-function operating.
- Application of the recharge domains and annual water balance fluxes used to define the pre-mining water table conditions.
- Introduction into the model format of a sandy material type within backfilled mined areas. This material type is moderately transmissive (hydraulic conductivity of 1.0 m/day) and is incorporated into each mine block upon the completion of mining, as defined by the mining schedules.
- Close adherence to the mine plans and development schedules outlined in Figure 10. The simulated dewatering schedule for individual mine blocks is outlined in Table 18 and shown on Figure 26.

Table 18

Simulated Mine Dewatering Schedules

Mine Block	Dewatering Period
1	July 2007 to September 2007
2	October 2007 to December 2007
3	December 2007 to March 2008
4	April 2008 to June 2008
5	June 2008 to July 2008
6	July 2008 to September 2008
7	October 2008 to December 2008
8	January 2009 to March 2009
9	April 2009 to October 2009
10	November 2009 to March 2010
11	April 2010 to July 2010
12	July 2010 to May 2011
13	May 2011 to December 2011
14	December 2011 to March 2012
15	April 2012 to June 2012
16	July 2012 to October 2012

- Simulation of the in-pit drains, sumps and mine dewatering infrastructure using constant-head nodes in the model. The constant-head nodes are set at elevations about 2 m below the bottom elevation of each mining block. The constant-head elevations in each mine block are shown on Figure 27. Individual nodes function only during designated periods compatible with the mining schedule.

6.4 Predictive Model Outcomes

The predictive outcomes from the completed modelling include:

- transient rates of groundwater abstraction for the duration of mining;
- transient distributions of drawdown during the mining period; and
- recovery of the water table during a ten-year post-mining period.

The results of the predictive outcomes are summarised below.

6.4.1 Drawdown Impacts

The simulated drawdown impacts on the water table due to mining during the period from July 2007 to October 2012 are shown on Figures 28 to 43.

Key aspects of the predicted drawdown distributions include:

- Mining occurs above the water table in Blocks 1 and 2, so no groundwater abstraction occurs in these areas.
- By March 2008, mining of Block 3 occurs close to the water table (within 2m), and consequently small-scale groundwater abstraction is likely to occur resulting in localised drawdown of the water table.
- By June. 2008, mining of Block 4 extends below the water table, resulting in small-scale groundwater abstraction and localised drawdown of the water table.
- Mining occurs close to the water table in Blocks 5, 6, 7 and 8 (within 2m), and small-scale groundwater abstraction and localised drawdown of the water table is likely to occur.
- By October 2009, as mining progresses to mining Block 9, drawdowns propagate beyond the western boundary of the mine area. Drawdowns do not extend beneath the spring located on the western perimeter of the dunal terrain, Ferraro Brook or Nanga Brook.
- By March 2010, during mining of Block 10, drawdown impacts to the west and south caused by dewatering of block 9 are reduced. Mining in Block 10 occurs partly below the water table, resulting in small-scale groundwater abstraction and localised drawdown of the water table.
- Mining in Block 11 occurs partly below the water table, resulting in small-scale groundwater abstraction and localised drawdown of the water table.
- By May 2011, the development of Block 12 induces localised drawdowns within the western portion of the mined areas. The drawdowns propagate beyond the western boundary of the mine area; drawdowns extend beneath the spring located on the western perimeter of the dunal terrain.

- By December 2011, as mining is progressed to Block 13, drawdowns propagate beyond the northwest and northern boundaries of the mine area. Drawdowns of greater than 1m extend beneath Ferraro Brook.

- By October 2012, as mining is progressed to Blocks 14 to 16, drawdowns occur within these mined areas. Drawdowns do not impact on the nearby streams. Drawdowns to the west of Block 9 and to the north of Block 13 are reduced during this time.

From the simulated drawdowns during mining it is expected that:

- Groundwater baseflow would be significantly diminished to the dunal fringe springs, and to a lesser extent to Ferraro Brook and Nanga Brook, during mining and for several years thereafter. Local streamflow may need to be seasonally artificially replenished, for the duration of mining, to provide appropriate ecological and environmental water provisions and limit adverse impacts on the local catchment.

- Drawdown of the water table occurs close to nearby residences to the southwest of the mined area, and there exists the potential for adverse impacts on groundwater users in this area.

- The existing piezometer network would be used to define actual drawdown impacts.

6.4.2 Water Table Recovery after Mining

The water table recovers after the cessation of groundwater abstraction associated with mining. Transient results showing the water table recovery are shown on Figures 44 to 48. The results show:

- Progressive recovery of the water table subsequent to mining, such that:

  - After one year the residual drawdowns are reduced, but range up to 2m beyond the western and northern pit crests. Residual drawdowns remain beneath the dunal springs and are diminished beneath the Ferraro Brook and near the Nanga Brook.

  - After two years the residual drawdowns are reduced, although are still up to 2m beyond the western and northern pit crests. Residual drawdowns remain beneath the dunal springs.

  - After five years the residual drawdowns are further reduced and are up to 2m beneath the dunal springs.

  - After ten years the residual drawdowns are mostly within the pit crests and are less than 4m. Drawdowns are further reduced beneath the dunal springs to approximately 0.5m. After twenty years, the model indicates a similar residual drawdown, suggesting mining would have a long-term impact on the western dunal fringe springs. However, our experience indicates this predicted residual drawdown is an artefact of the model and is unlikely to occur. In the model, permeable sands are removed during mining and subsequently the void is backfilled with comparatively low permeability materials, that limit recharge fluxes.

- The residual drawdowns may slightly diminish the seasonal groundwater baseflow to the local streams - otherwise, the effects of a permanently lowered water table are insignificant.

6.4.3 Forecast Process Water Supplies

Annual estimates of the mining and process water supply requirements for the Waroona Deposit are outlined in Table 19.

Table 19

Estimated Maximum Water Supply Requirements

Project Phase	Water Use	Estimated Maximum Water Supply Requirements (ML/annum per Deposit)
Development	Earthworks and construction	250
Mining	Mineral processing	2,000
Rehabilitation	Earthworks and pasture	50

These water supplies would be derived from:

- groundwater abstracted from the superficial formations during mine dewatering;
- rainfall and runoff captured within the pit and project area;
- decant from the tailings and slurries of clay fines; and
- water supply service providers.

Local divertible water resources would be preferentially used, with make-up supplies sourced from water supply service providers.

Other factors that will influence the actual quantities of water sourced from the water supply services providers include:

- rates of mining and the throughput capacity of the processing plant;
- mineralogy of each deposit, particularly clay fines content;
- evaporation losses from the solar drying dams; and
- environmental provisions required to preserve local streamflow and the shallow groundwater resources during mining.

Based on experience from existing mining operations in the southwest region, process water supply demands vary seasonally. Required water supply rates will be variable and are expected to range from

zero (at times during significant rainfall events) to about 10 ML/day (typically during the hot summer months). About 65% of the total water requirement typically occurs between November and April.

Table 20 presents the seasonal pattern of processing water use based on annual demand of 2,000 ML and experience at existing mine sites.

Table 20

Typical Seasonal Pattern of Process Water Use

Month	Process Water Supply Demand (% of total)	Indicative Monthly Water Requirements	
		Volume (ML)	Rate (ML/day)
Jan	9.8	197	6.3
Feb	12.8	257	9.2
Mar	11.5	230	7.4
Apr	11.4	228	7.6
May	9.4	187	6.0
Jun	5.8	116	3.9
Jul	5.8	116	3.7
Aug	5.1	102	3.3
Sep	5.0	100	3.3
Oct	5.2	104	3.4
Nov	8.5	170	5.7
Dec	9.7	194	6.3
	Total	2,000	-
	Minimum	-	0 to 3.3
	Maximum	-	9.2
	Average	-	5.5

Groundwater abstraction rates during mining could not be accurately quantified using the groundwater model. The coarse-layer form of the model, with 8m layer thickness prevents definitive water balance assessments of abstraction due to mining.

However, based on the model outputs, it is estimated that the quantity of groundwater abstraction will typically be minor in comparison with the process water demand. Therefore the majority of water supply demands would be met by water supply service providers. Table 21 broadly outlines where groundwater abstraction during mining will occur. In this, it has been assumed that mineral processing commences in July 2007.

Table 21

Groundwater Abstraction During Mining

Month	Indicative Monthly Water Requirement (ML/day)	Groundwater Abstraction during Mining (ML/day)	Process Water Demand (ML/day)
July 2007	3.7	negligible	3.7
August	3.3	negligible	3.3
September	3.3	negligible	3.3
October	3.4	negligible	3.4
November	5.7	negligible	5.7
December	6.3	negligible	6.3
January 2008	6.3	negligible	6.3
February	9.2	negligible	9.2
March	7.4	negligible	7.4
April	7.6	minor	<7.6
May	6.0	minor	<6.0
June	3.9	minor	<3.9
July	3.7	negligible	3.7
August	3.3	negligible	3.3
September	3.3	negligible	3.3
October	3.4	negligible	3.4
November	5.7	negligible	5.7
December	6.3	negligible	6.3
January 2009	6.3	negligible	6.3
February	9.2	negligible	9.2
March	7.4	negligible	7.4
April	7.6	minor	<6.7
May	6.0	minor	<5.1
June	3.9	minor	<3.0
July	3.7	minor	<2.8
August	3.3	minor	<2.4
September	3.3	minor	<2.4
October	3.4	minor	<2.5
November	5.7	minor	<5.2
December	6.3	minor	<5.8
January 2010	6.3	minor	<5.8
February	9.2	minor	<8.7
March	7.4	minor	<6.9
April	7.6	minor	<7.6
May	6.0	minor	<6.0
June	3.9	minor	<3.9
July	3.7	minor	<2.9
August	3.3	minor	<2.5
September	3.3	minor	<2.5

Table 21 (continued)

Month	Indicative Monthly Water Requirement (ML/day)	Groundwater Abstraction during Mining (ML/day)	Process Water Demand (ML/day)
October	3.4	minor	<2.6
November	5.7	minor	<4.9
December	6.3	minor	<5.5
January 2011	6.3	minor	<5.5
February	9.2	minor	<8.4
March	7.4	minor	<6.6
April	7.6	minor	<6.8
May	6.0	minor	<5.4
June	3.9	minor	<3.3
July	3.7	minor	<3.1
August	3.3	minor	<2.7
September	3.3	minor	<2.7
October	3.4	minor	<2.8
November	5.7	minor	<5.1
December	6.3	minor	<6.0
January 2012	6.3	minor	<6.0
February	9.2	minor	<8.9
March	7.4	minor	<7.1
April	7.6	minor	<7.6
May	6.0	minor	<6.0
June	3.9	minor	<3.9
July	3.7	minor	<3.7
August	3.3	minor	<3.3
September	3.3	minor	<3.3
October	3.4	minor	<3.4

Note: Negligible groundwater abstraction during mining is considered to be <0.02ML/day
Minor groundwater abstraction during mining is considered to be <1ML/day.

Groundwater Well Licence applications for abstraction associated with mine dewatering should provide for an upper-bound abstraction of 300 ML/annum.

The results of the groundwater flow modelling indicate the mining of the Waroona Deposit will have local drawdown impacts on the groundwater resources of the superficial formations.

The drawdowns are also expected to reduce groundwater baseflow contributions to i) the springs on the western dunal fringe; and ii) streamflow within the Nanga Brook and Ferraro Brook.

Modelling has sought to quantify these impacts so that they can be appropriately managed based on:

- the rights of other users of the local groundwater and surface water resources; and
- ecological and environmental considerations.

Regulatory authorisation for groundwater abstraction from the superficial formations during mining should be sought through application for a Groundwater Well Licence (abstraction) from the DEWCP. An appropriate application is provided in Appendix G. This application would be supported by the technical content of this report and the monitoring and management protocols, that form an Operating Strategy, outlined below.

7.1 Operating Strategy

The Operating Strategy pertains to the Groundwater Well Licence (abstraction) for the localised dewatering of the superficial formations during mining. It is anticipated that the licence would only relate to sump-pumping from the bottom of the pit. Abstracted groundwater would be preferentially used for mining operations (dust suppression) and process water supply.

The mining operations would also divert runoff from disturbed areas for process water supply use. Runoff from undisturbed areas would be preferentially diverted to Ferraro Brook, Nanga Brook or downstream of the springs on the western dunal fringe to limit potential reductions in streamflow due to the mining operations. The diversion of runoff would need to be incorporated into the mine plan, to accommodate the mine plan requirements for water storage (e.g. potentially a clean water dam at Ferraro Brook).

Groundwater and surface water monitoring programmes have been developed to enable assessment and management of the drawdown impacts due to groundwater abstraction during mining. The key objectives of the monitoring programmes are shown in Table 22. The monitoring programmes involve quantitative and qualitative measurements of the water resources in:

- in-pit sumps and sump-pumps;
- existing pit-perimeter multipiezometer bores;
- a regional piezometer bore network; and
- local water courses, including Ferraro Brook and Nanga Brook, that are near the proposed mine areas.

Table 22

Objectives of Monitoring Programmes

Objective	Key Items	Outcomes
1. Definition of natural and seasonal baseline conditions - before the commencement of mining	• Monthly groundwater level monitoring in all existing and proposed multipiezometer bores. • Quarterly sampling of selected superficial formations, Leederville Formation and bedrock profile piezometers to define hydrochemistry parameters and seasonal changes. • Monthly recording of streamflow at designated points in the Ferraro Brook, Nanga Brook, Wealand Road Brook and downstream of the springs on the western dunal fringe. • Quarterly sampling of streamflow at locations marginally upstream and downstream of the mine area to define quality and seasonal changes. • Census of private bores and groundwater and streamflow use. To be completed in the lead-up to commencement of mining - say first quarter of 2007.	• Baseline data for quantitative and qualitative assessments of impacts.
2. Assessment of the impacts of groundwater abstraction during mining	• Weekly measurement of sump-pump operation and aggregate groundwater abstraction volumes. • Monthly measurement of groundwater levels in piezometers. • Monthly cumulative collation of groundwater abstracted during mining. • Monthly recording of streamflow in the Ferraro Brook, Nanga Brook and downstream of the springs on the western dunal fringe. • Quarterly sampling of streamflow in the Wealand Road Brook. • Monthly assessment of groundwater and runoff diverted for process water supply. • Quarterly sampling of selected piezometers to provide transient quality data for the superficial formations, Leederville Formation and bedrock profiles. • Annual assessment and reporting on the impacts of the mining and water resource management issues.	• To develop an understanding of the impacts of mining on the groundwater and surface water resources. • To provide data to appropriately define and manage any adverse impacts from mining.
3. Provision of data for refinement of the groundwater flow model	• Items (1) and (2). • Refinement of model parameters and predictive outcomes if appropriate to enhance management objectives.	• Increase confidence in the model and predictive outcomes.
4. Meeting reporting requirements of the regulators	• Annual reporting of groundwater abstraction volumes and measured impacts of the abstraction. • Review of management protocols to ensure they remain effective.	• Compliance with the terms, limitations and conditions of the Groundwater Well Licence (abstraction).

An important component of the monitoring programme will be a database that allows efficient entry and collation of data. It is recommended that a monitoring database is developed to provide:

- hydrographs for the multipiezometers and piezometers;
- cumulative graphs of groundwater abstraction;
- groundwater level data suitable for contouring;
- groundwater abstraction summaries;
- groundwater quality parameters;
- streamflow records; and
- streamflow quality.

7.1.1 In-Pit Sump-Pumping

The in-pit sump-pumps would be included in the monitoring programme. To accommodate the defined monitoring requirements, the individual sump-pumps or combined sump-pumping systems should be equipped with flow meter(s) to define instantaneous abstraction rates and cumulative abstraction volumes and a clock that defines hours of operation times.

7.1.2 Pit-Perimeter Multipiezometers

The multipiezometer network in perimeter areas of the Waroona Deposit is comprised of the W7, W9, W10, W12, W13, W15, W16, W17, W18, W19, W20, W21, W22, W23, W24, W25, and W26 sites. The W5 site occurs within the pit, and should also be monitored prior to being encroached on by mining activities.

These multipiezometers would provide data on the drawdown impacts within the superficial formations, shallow Leederville Formation and bedrock profile in the vicinity of the pits. Based on the results of the groundwater modelling, this network of bores would be adequate to monitor the expected groundwater drawdown.

The locations of the multipiezometers are shown on Figure 11.

7.1.3 Private Bores

Further to the water resources census (Appendix F), nearby private bores should be monitored, particularly in the vicinity of the Nanga Brook, to assess impacts due to mining at these locations.

7.1.4 Monitoring Stations on Local Streams

A network of monitoring stations on the local streams is planned to provide data on streamflow occurrence and streamflow quality. The monitoring stations occur at:

- Nanga Brook, with three sites, one upstream, one at the existing Hill St Weir gauge station and one downstream of the mine.
- Ferraro Brook, with two sites, one at the existing Ferraro gauge station and one downstream of the mine.
- Wealand Road Brook, with one site downstream of the mine.
- Downstream of the dunal fringe springs.
- The confluence of the dunal fringe springs stream and Nanga Brook.
- The existing Mullins gauge station.

The existing gauging stations and proposed additional monitoring sites are outlined in Table 23 and on Figure 49. The sites should be adjusted to facilitate easy access for inspection and sampling. Collection of samples would be limited to the times that the streams are in flow.

Table 23

Designated Gauging and Monitoring Stations on Local Streams

Gauging and Monitoring Stations	AMG Co-ordinates	
	mN	mE
Nanga Brook		
- NB1 (upstream)	400932	6366668
- NB2 (downstream)	399150	6366805
- Hiill Street Weir gauging station	Existing	existing
Ferraro Brook		
- FB1 (downstream)	399334	6367980
- Ferraro gauging station	Existing	existing
Wealand Road Brook		
- WRB1 (downstream)	400158	6368964
Dunal Fringe Springs		
- W1 (downstream)	399318	6367353
- NBW1 (downstream)	398861	6367393
- Mullins gauging station	Existing	existing

Each monitoring station should be established at least two years in advance of mining to provide reasonable assessments of baseline conditions and the subsequent impacts of mining.

The gauging of Nanga Brook should be undertaken at least three years before mining, ideally commencing now.

7.1.5 Water Resources Monitoring Programme

A monitoring programme appropriate for the assessments of the impacts of mining on the shallow groundwater and surface water resources is outlined in Table 24.

Surface water and groundwater monitoring should be established at least two years in advance of mining to provide reasonable assessments of baseline conditions and the subsequent impacts of mining.

Table 24
Surface Water and Shallow Groundwater Resources
Monitoring Programme

Monitoring	Parameters	Monitoring Frequency
BASELINE SAMPLING		
Pit-Perimeter Multipiezometers		
• All sites	Groundwater Levels	Monthly
• W15, W16, W17, W18, W19, W20, W22, W24, W25, W26	Groundwater Quality pH, TDS, Cl, Na, SO_4, K, Ca, Mg, Fe, SiO_2, Al, Mn, Total Alkalinity, HCO_3	Quarterly (January, April, July and October)
Regional Piezometers		
• All sites	Groundwater Levels	Monthly
Streamflow Stations		
• Gauged Sites	Streamflow Rates and Volumes	Monthly
• All Sites	Observed Streamflow	Monthly
• All Sites	Streamflow Quality: pH, TDS, TSS, Turbidity, Cl, Na, SO_4, K, Ca, Mg, Fe, SiO_2, Al, Mn, HCO_3, Total Alkalinity; Ammonia, NO_3, NO_2, Total P, total Kjeldahl Nitrogen, Filterable Reactive Phosphorus	Quarterly at times the stream is flowing at the monitoring station (January, April, July and October)
DURING MINING AND POST-MINING[1]		
Sump-pumps	Abstraction volumes of groundwater and runoff	Weekly
	Operating hours	Weekly
	Collation of cumulative discharge	Monthly
Pit-perimeter Multipiezometers		
• All Sites	Groundwater levels	Monthly
• W15, W16, W17, W18, W19, W20, W22, W24, W25, W26	Groundwater quality (as above)	Quarterly (January, April, July and October)
Regional Piezometers		
• All Sites	Groundwater levels	Monthly

Table 24 (continued)

Monitoring	Parameters	Monitoring Frequency
Streamflow Stations		
• Gauged Sites	Streamflow Rates and Volumes	Monthly
• All Sites	Observed streamflow	Monthly
• All Sites	Streamflow quality (as above)	Quarterly at times of flow (January, April, July and October)

Note: 1 The duration of post-mining monitoring is not defined. It would be linked to, and dependent on, rehabilitation programme schedules and rates of water table recovery. The minimum duration would be two years.

7.1.6 Assessments of Impacts

An Aquifer Review assessment of the effects of mine dewatering abstraction on the local water resources would be undertaken every year. The review would conform to guidelines issued by the DEWCP. The Aquifer Review outlining the results of these assessments would be submitted to the Commission for compliance with the Groundwater Well Licence (abstraction).

Key aspects of the Aquifer Review should include:

- definition of the project area and local hydrogeology;
- plans of the mine areas, with definition of backfilled mine blocks, current mined void and future mine blocks;
- all groundwater level data for the pit-perimeter multipiezometers and regional piezometers;
- summary records of the local climate, particularly rainfall;
- abstraction records associated with the mine dewatering, with differentiation of groundwater and rainfall runoff volumes discharged from the mine areas;
- information on other users of the groundwater and surface water resources;
- all monitoring data associated with local streamflow and surface water resources;
- assessments of the impacts of abstraction on the local groundwater and surface water resources;
- comparisons between observed and predicted impacts and interpretation of the reasons of any significant variations;
- revision of the predicted impacts of abstraction; and
- revision of the Operating Strategy as required to maintain appropriate monitoring and management protocols.

The following conclusions have been defined based on the findings outlined in this report.

- Development of the Waroona Deposit is forecast to commence in mid-2007 and continue until late-2012.

  The pit will extend below the water table, necessitating groundwater abstraction during mining.

- Site investigations involving reconnaissance drilling, installation of groundwater exploration bores, aquifer testing and groundwater sampling have been completed to provide a broad understanding of:

  - local geology and stratigraphy;
  - hydrogeology including aquifer systems, hydraulic parameters, water table elevations and groundwater quality; and
  - interaction between the shallow groundwater resources and streamflow in Nanga Brook, Ferraro Brook, Wealand Road Brook and the western dunal fringe springs.

- Data from the site investigations have been collated in the development of a groundwater flow model of the Waroona Deposit and surrounds. The model has been calibrated to observed water table elevations and subsequently applied in predictive simulations to define the impacts of groundwater abstraction during mining on the local environment and others users of the local water resources. The modelling has investigated:

  - rates of groundwater abstraction during mining;
  - drawdown of the water table due to groundwater abstraction during mining;
  - potential reductions of baseflow to local streams, particularly Nanga Brook, Ferraro Brook and the western dunal fringe springs;
  - recovery of the water table subsequent to the cessation of mining; and
  - post-mining water table configuration.

- Outputs from the predictive groundwater flow model indicate:

  - Drawdown of the water table during the mining period with cones of depression that extend:
    - west, beneath the dunal fringe springs and close to adjoining nearby residences;
    - south and west, close to Nanga Brook and nearby residences; and
    - north, beneath Ferraro Brook.

- The impacts due to groundwater abstraction during mining include:
  - diminished local groundwater baseflow to the Nanga Brook, Ferraro Brook and dunal fringe springs;
  - potential for impact to nearby residences utilising shallow groundwater for stock and irrigation purposes.
- In the post-mining period, progressive recovery of the water table would occur for up to about 10 years.
- In order to define actual drawdown impacts, the existing network of piezometer bores should be monitored.
- Streamflow of the Nanga Brook, Ferraro Brook and downstream of the western dunal fringe springs may need to be artificially replenished to sustain the existing environment.
- Shallow groundwater users to the west and south of the mined area, where drawdown of the water table is likely to occur as a consequence of mining, may need their water supplies to be supplemented by alternative sources.
- Drawdown of the water table beyond the mine boundaries also has the potential to adversely impact on vegetation that uptakes shallow groundwater.

- The impacts of groundwater abstraction during the mining of the Waroona Deposit will need to be monitored and appropriately managed in terms of water conservation and environmental/ecological effects. An operating strategy has been developed that defines monitoring and management protocols based on the predictive results of the groundwater flow modelling. The defined monitoring programmes involve quantitative and qualitative measurements of the water resources in:
  - in-pit sump and sump-pumps;
  - existing pit-perimeter multipiezometer bores;
  - a proposed regional piezometer bore network; and
  - local water courses that transect the mine area including Nanga Brook, Ferraro Brook, Wealand Road Brook and the dunal fringe springs.

  The proposed regional piezometer bore network is existing. Nearby private bores should also be monitored, particularly in the vicinity of Nanga Brook.

  Locations of gauging and monitoring stations on Nanga Brook, Ferraro Brook, Wealand Road Brook and the dunal fringe springs have been defined.

  Schedules for monitoring and analytical parameters for all sites have also been defined and specified.

The Operating Strategy also defines reporting requirements to the regulatory authorities in the form of an annual Aquifer Review. Key aspects of the Aquifer Review include:

- abstraction records from the mine dewatering;
- all groundwater level data;
- monitoring records from the surface water resources;
- assessments of the impacts of the mine dewatering abstractions;
- comparisons between observed and predicted impacts; and
- revision of the Operating Strategy (if required).

No environmentally protected wetlands are located within 5km of the Waroona Deposit. The nearest protected wetland is located approximately 10km northwest of the deposit, beyond the South Western Highway (DOLA, Swan Coastal Plain Lakes, Miscellaneous Plan No. 1815, Sheet 17 of 27).

A suite of recommendations is outlined below to provide the basis for appropriate monitoring, management and conservation of the local water resources. These recommendations include:

- The establishment of a network of monitoring stations on the Nanga Brook, Ferraro Brook, Wealand Road Brook and the downstream of the western dunal fringe springs.
- Strict adherence to the outlined Operating Strategy with its prescribed monitoring, management and reporting protocols.
- Conservation and preservation of the Nanga Brook, Ferraro Brook, Wealand Road Brook and downstream of the western dunal fringe springs environments and streamflow. The measures adopted should prevent degradation, due to mining activity and local ground disturbances, of:
  - stream embankments and vegetation;
  - streamflow rates; and
  - streamflow quality, particularly TSS, turbidity and nutrient loadings.

  The mine development plans will need to incorporate specific designs and procedures to achieve these measures, including:
  - artificial recharge where drawdown of the water table will deplete baseflow contribution to surface waters (particularly downstream of the western dunal fringe springs, Nanga Brook and Ferraro Brook);
  - drainage and runoff control from disturbed areas;
  - retention of runoff from disturbed catchment areas;
  - minimisation of land disturbances where practical;
  - preservation of drainage from areas upstream of the mine into the existing water courses; and
  - provision of buffer zones with limited or no access by mining equipment, along the alignments of the local water courses.

  It should be noted that the diversion of runoff would need to accommodate the mine plan requirements for water storage (e.g. potentially a clean water dam at Ferraro Brook).
- Provisions should be made to compensate residents that use the Nanga Brook surface water, in the event that mining causes an adverse impact on the streamflow quantity and quality.
- Provisions should be made to artificially recharge the dunal fringe spring to preserve the local ecology.
- Provisions should be made to supplement the local shallow groundwater users, in the event that mining causes an adverse impact on the existing water supplies and supply infrastructure.

- Provisions should be continued until after mining, until such a time that the water table recovers to near-baseline elevations.
- Vegetation in areas where the water table is comparatively shallow and expected to be lowered due to the proposed mining activity should be monitored and provisions made to rehabilitate in the event of stress due to water loss.
- Baseline hydrology study on the Nanga Brook should be completed to:
  - characterise the upstream catchment reaches adjacent to the proposed mine area and downstream domains;
  - investigate the influence of local small dams;
  - quantify water use by local residents; and
  - provide quantitative assessments of water balance, particularly baseflow contributions from local reaches.

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Hill, A.L., Semeniuk, C.A., Semenuik, V. Del Marco, A. (1996). Wetlands of the Swan Coastal Plain, Volume 2b. Wetland Mapping, Classification and Evaluation, Wetland Atlas.

Water & Rivers Commission (1998) - Proposed Harvey Basin Surface Water Allocation Plan. Water Resource Allocation and Planning Series Report 14.

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Chk'd By	IGB	12 Mar 02
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WAROONA DEPOSIT- IMPACTS OF MINING
ON SHALLOW GROUNDWATER RESOURCES

LOCATION PLAN

Figure 1

URS

URS AUSTRALIA PTY LTD Perth Office +61 8 9221 1630

Tue 01 Jun 04

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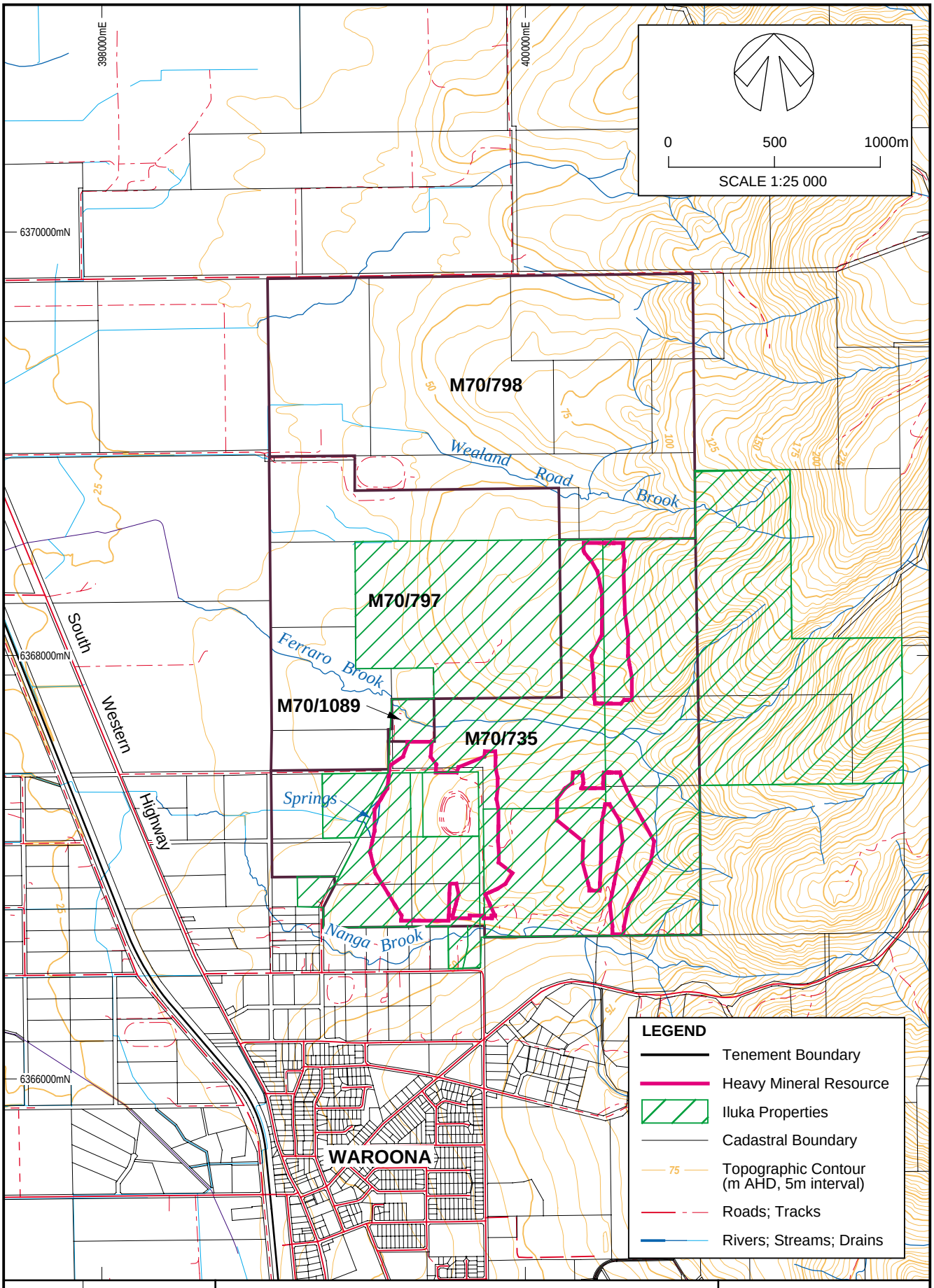

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SITE PLAN

Figure 2

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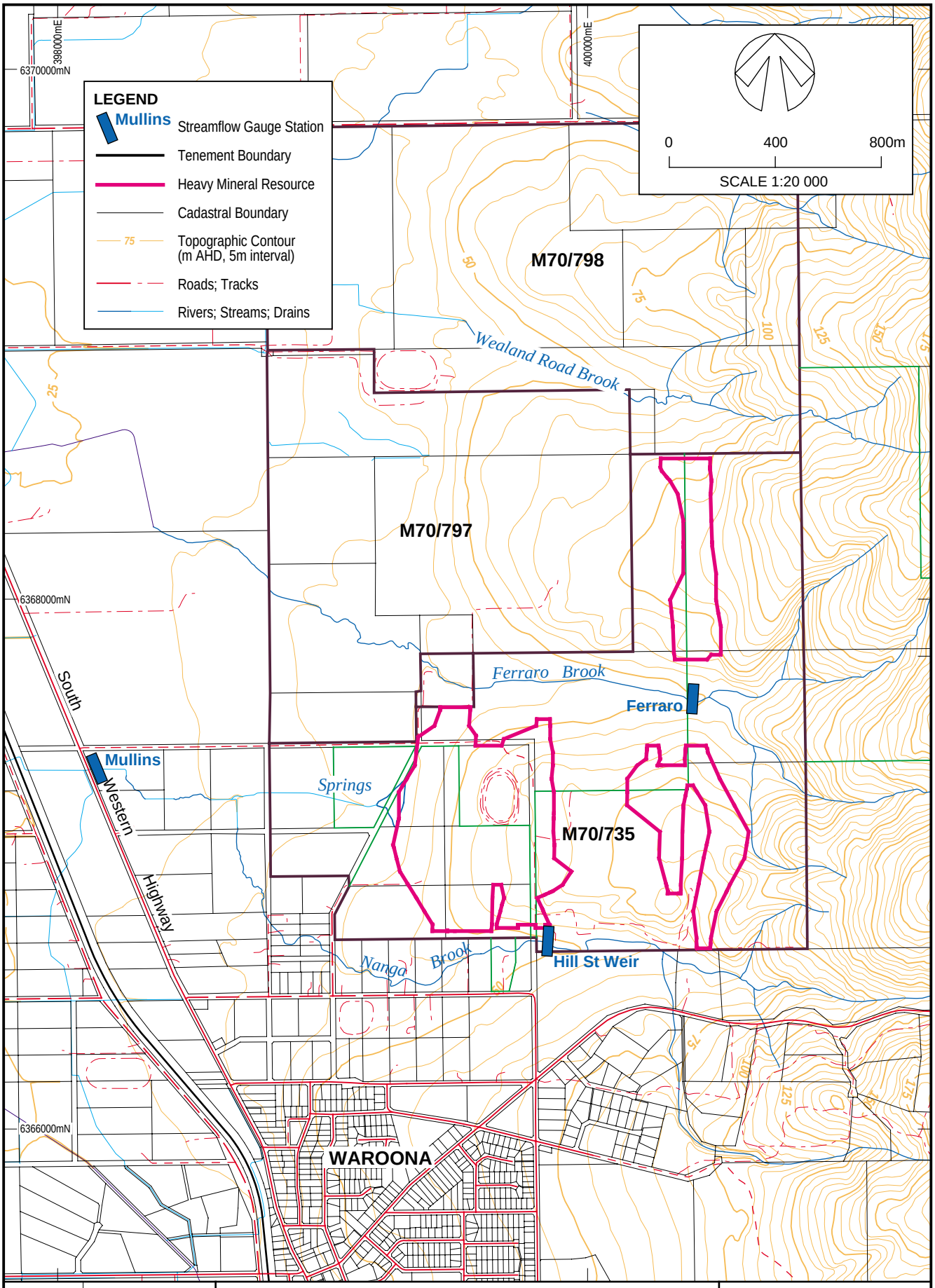

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STREAMFLOW GAUGE STATIONS

Figure 3

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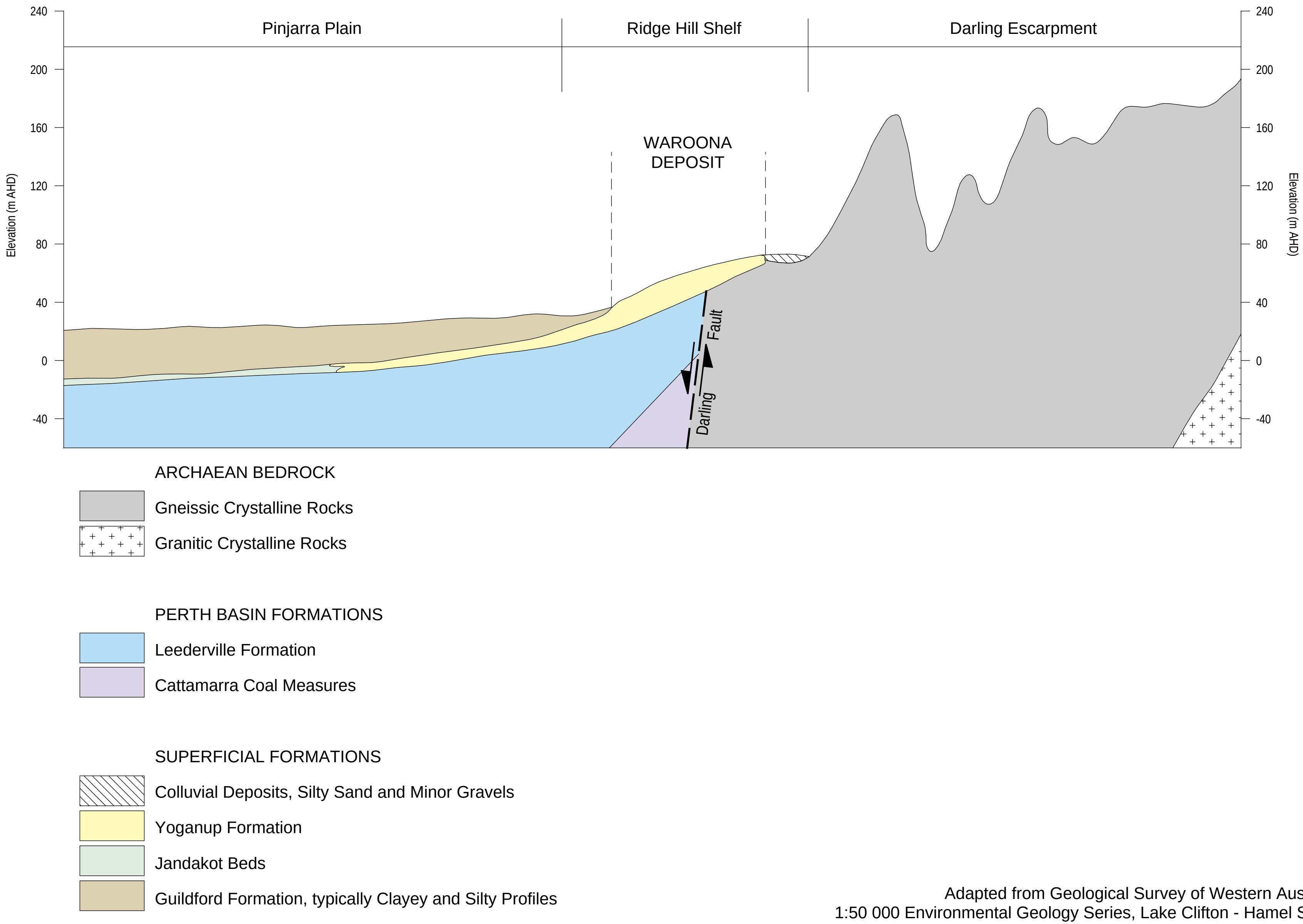

Adapted from Geological Survey of Western Australia
1:50 000 Environmental Geology Series, Lake Clifton - Hamel Sheet

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WAROONA PROJECT - IMPACTS OF
MINING ON SHALLOW GROUNDWATER RESOURCES

TYPICAL SHALLOW GEOLOGICAL PROFILE REGIONAL CONTEXT

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Figure 4

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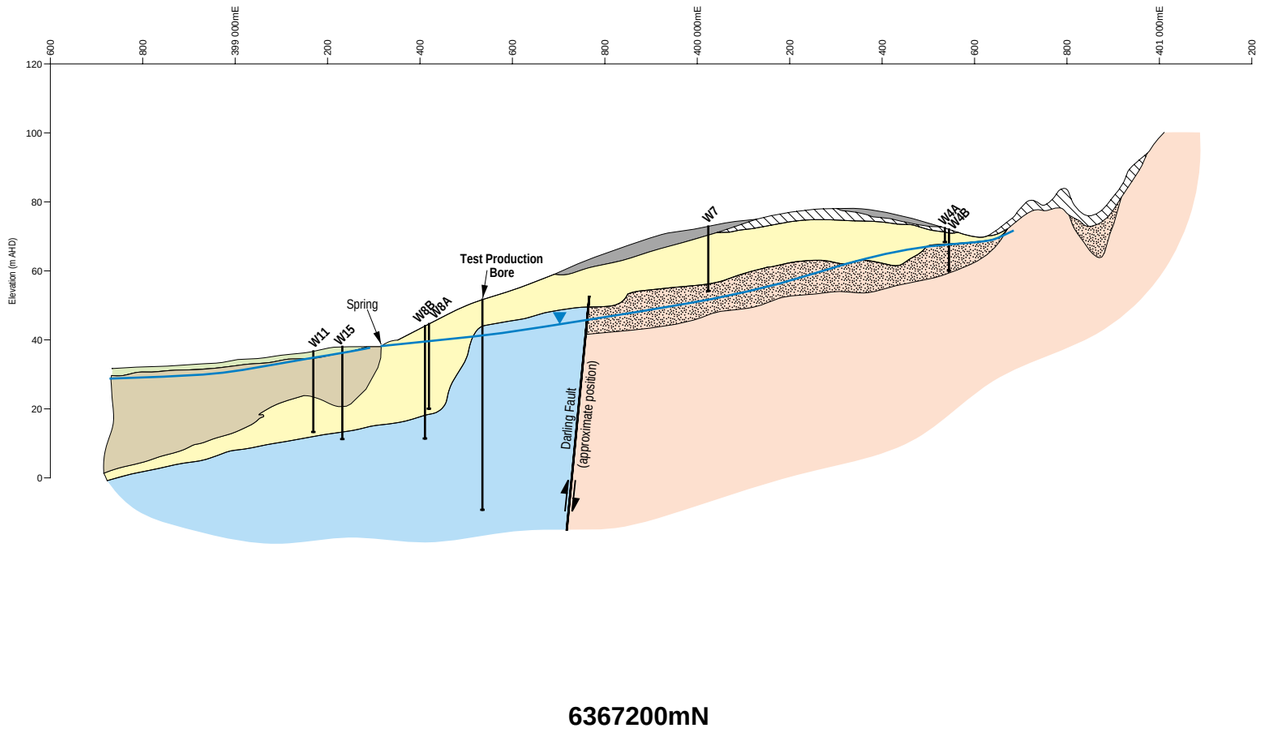

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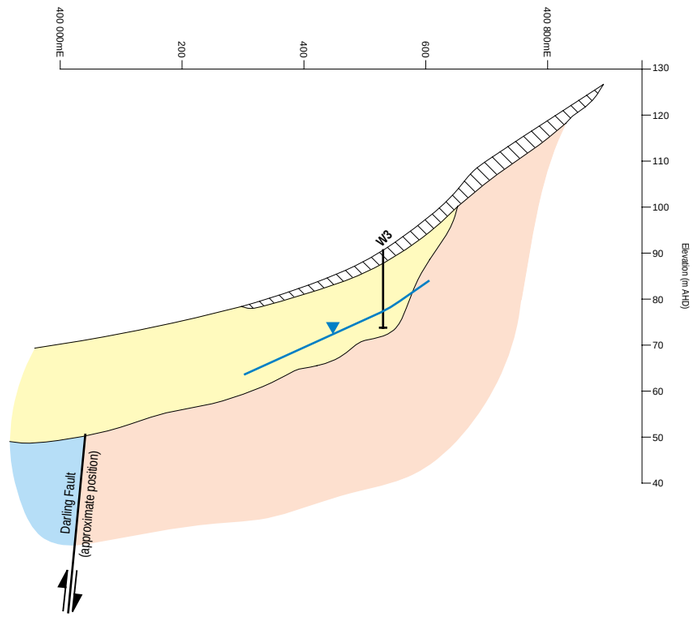

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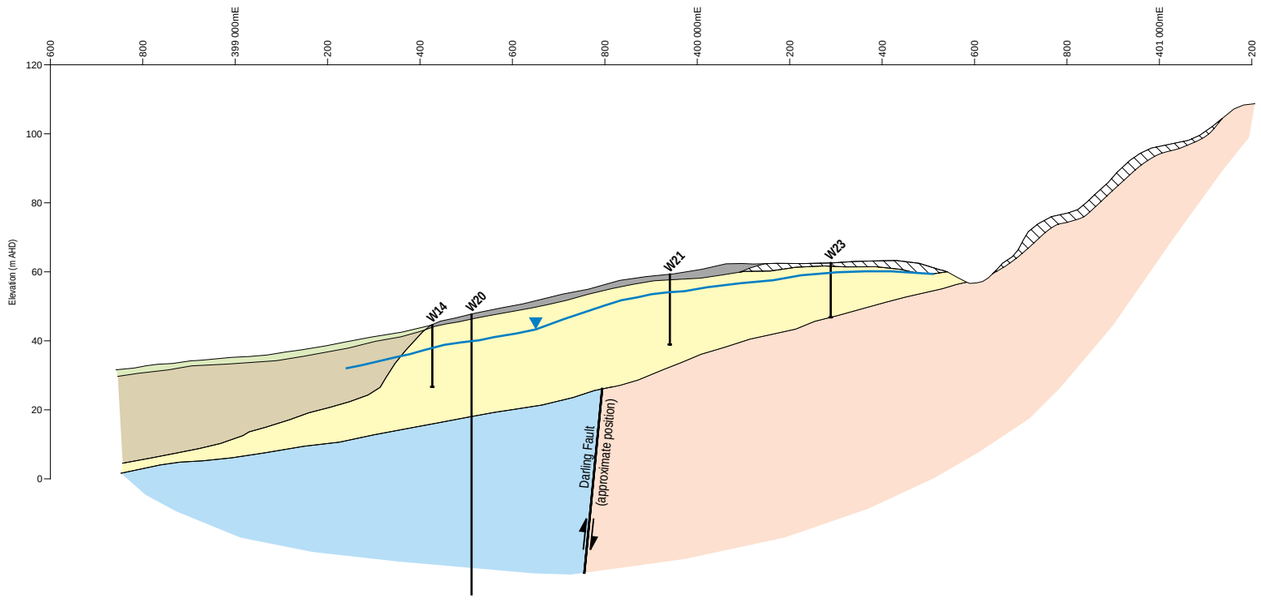

6367600mN

- Surficial Sands
- Ironstone Gravel Colluvial Deposits
- Silty Colluvium Deposits
- Guildford Formation - Clay and Silt
- Yoganup Formation
- Leederville Formation
- Archaean Bedrock (stippled zones are weathered bedrock)
- W7 Existing Monitoring Bore
- Water Table Profile

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WAROONA DEPOSIT - IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SHALLOW GEOLOGICAL PROFILES BASED ON LOCAL GEOLOGY

Figure 5

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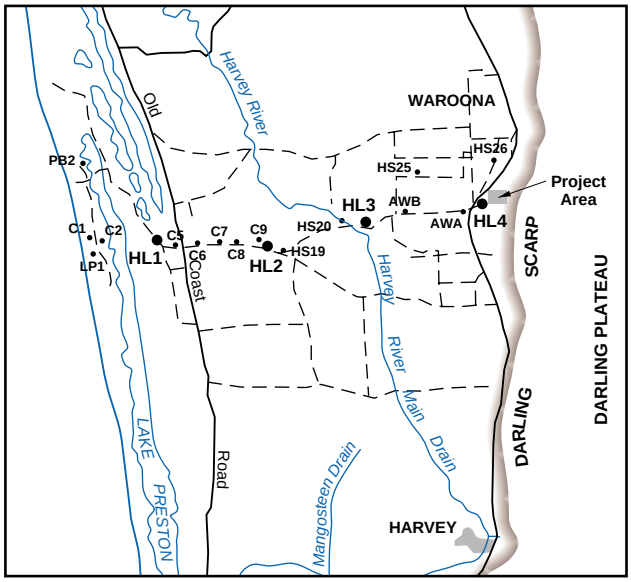
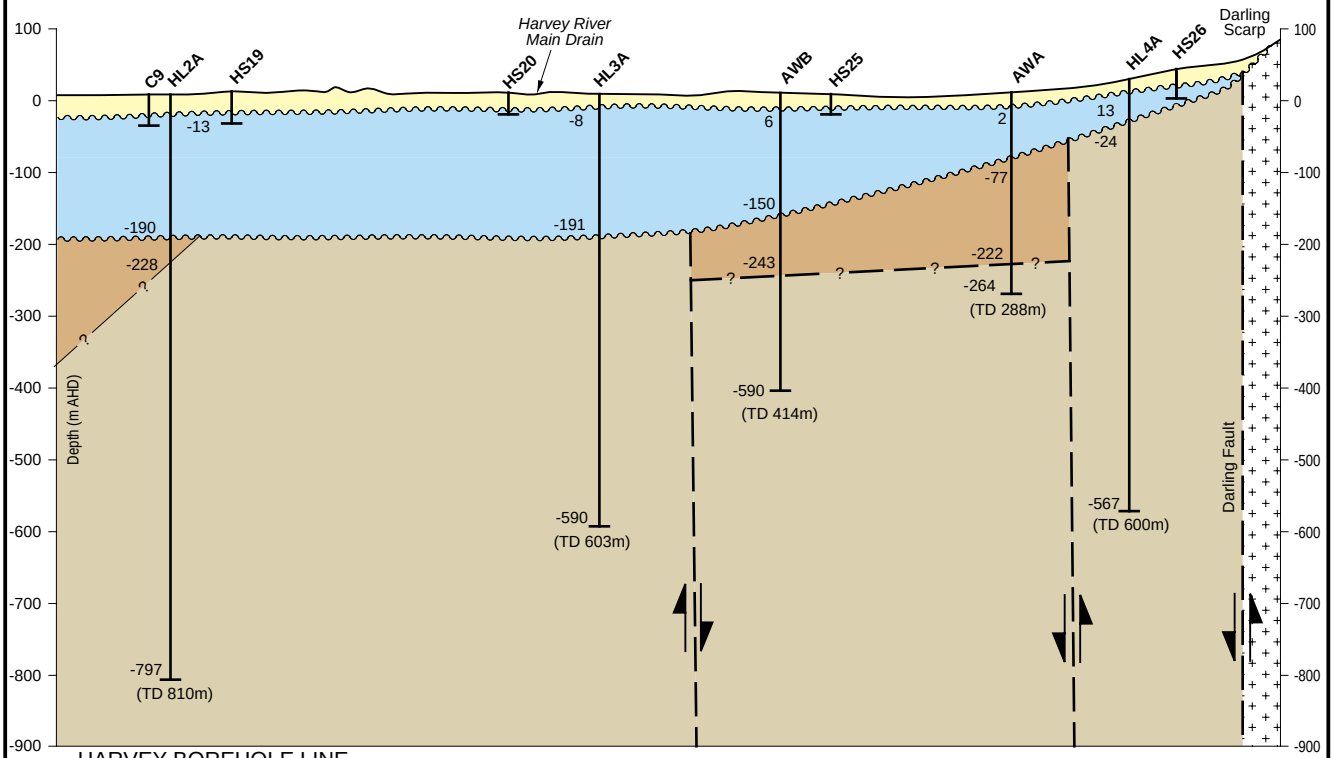


LEGEND

- Superficial Formations
- Leederville Formation
- Cattamarra Coal Measures
- Eneabba Formation
- Existing Bore
- -567 Depth (m AHD)
- Fault
- Unconformity
- ?— Geological Boundary Uncertain



HARVEY BOREHOLE LINE

0 2000 4000m

Horizontal Scale
Vertical Exageration x10

Reference: Hydrogeology of the Harvey Borehole Line, Perth Basin (Deeney, 1989)

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LOCAL STRATIGRAPHY

Figure 6

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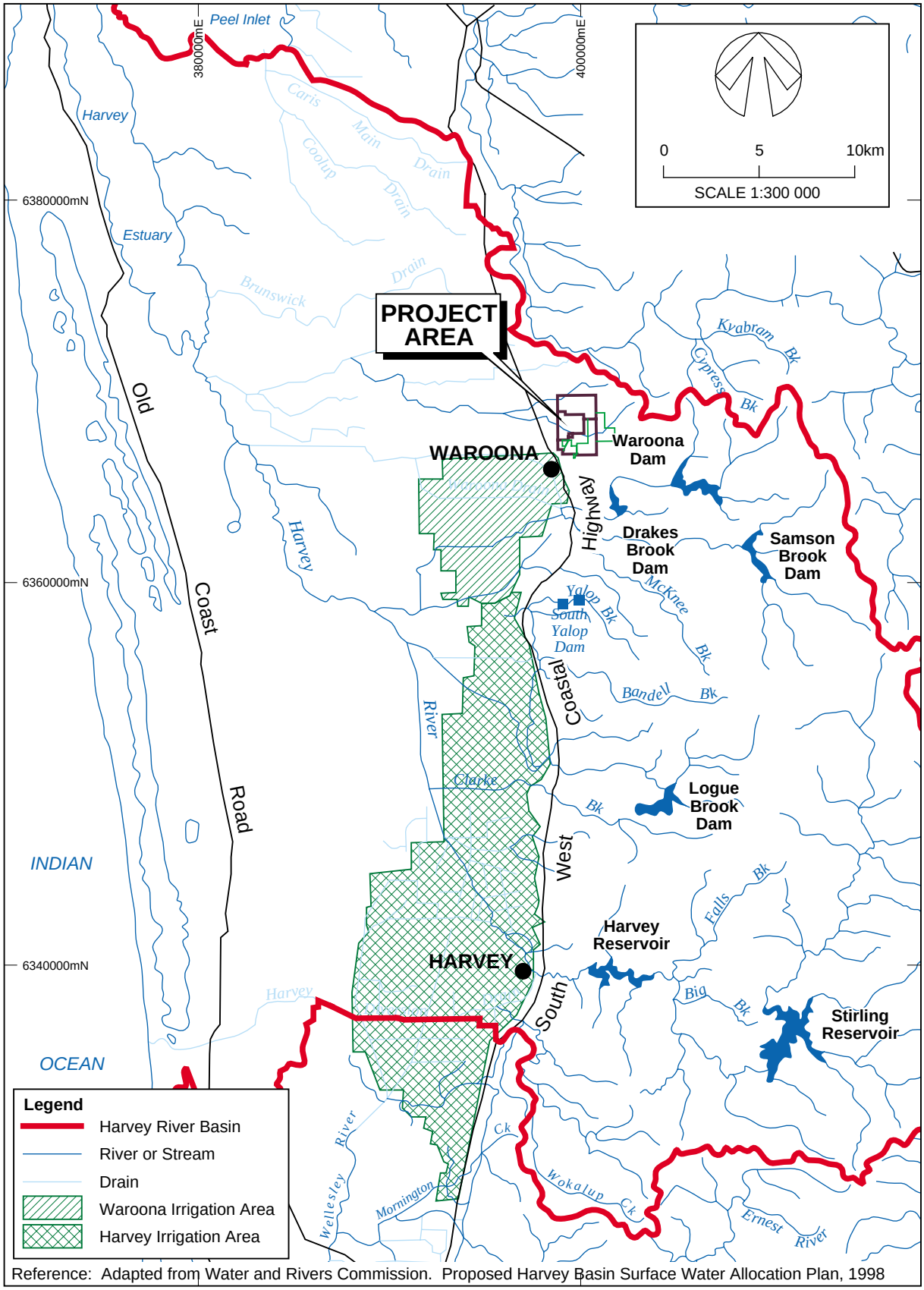

Reference: Adapted from Water and Rivers Commission. Proposed Harvey Basin Surface Water Allocation Plan, 1998

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HARVEY RIVER BASIN
MAJOR SURFACE WATER FEATURES

Figure 7

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MURRAY GROUNDWATER AREA

Figure 8

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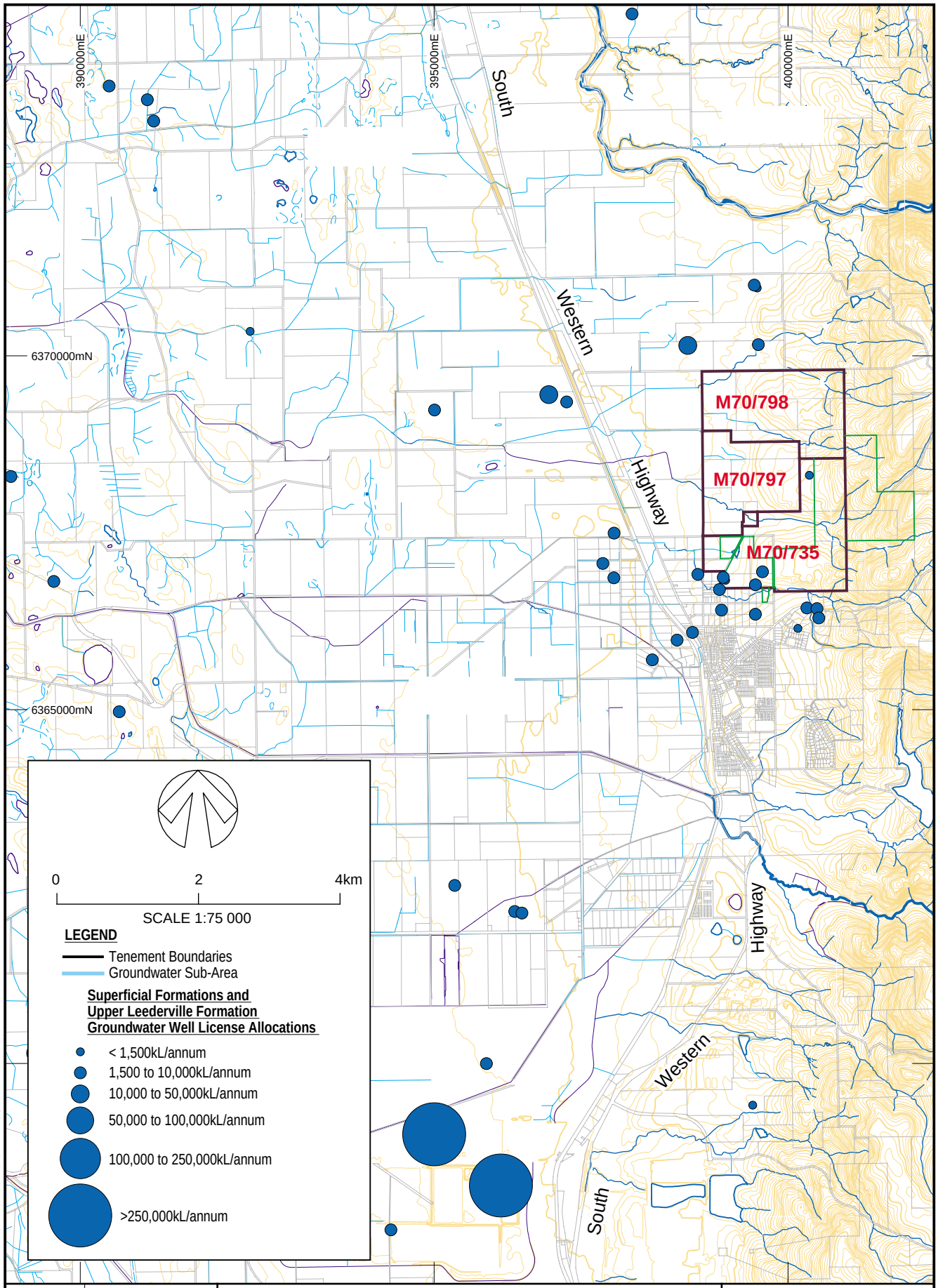

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WAROONA DEPOSIT - IMPACTS OF
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LICENSED GROUNDWATER USERS SUPERFICIAL FORMATIONS AND UPPER LEEDERVILLE FORMATION (NOVEMBER 2001)

Figure 9

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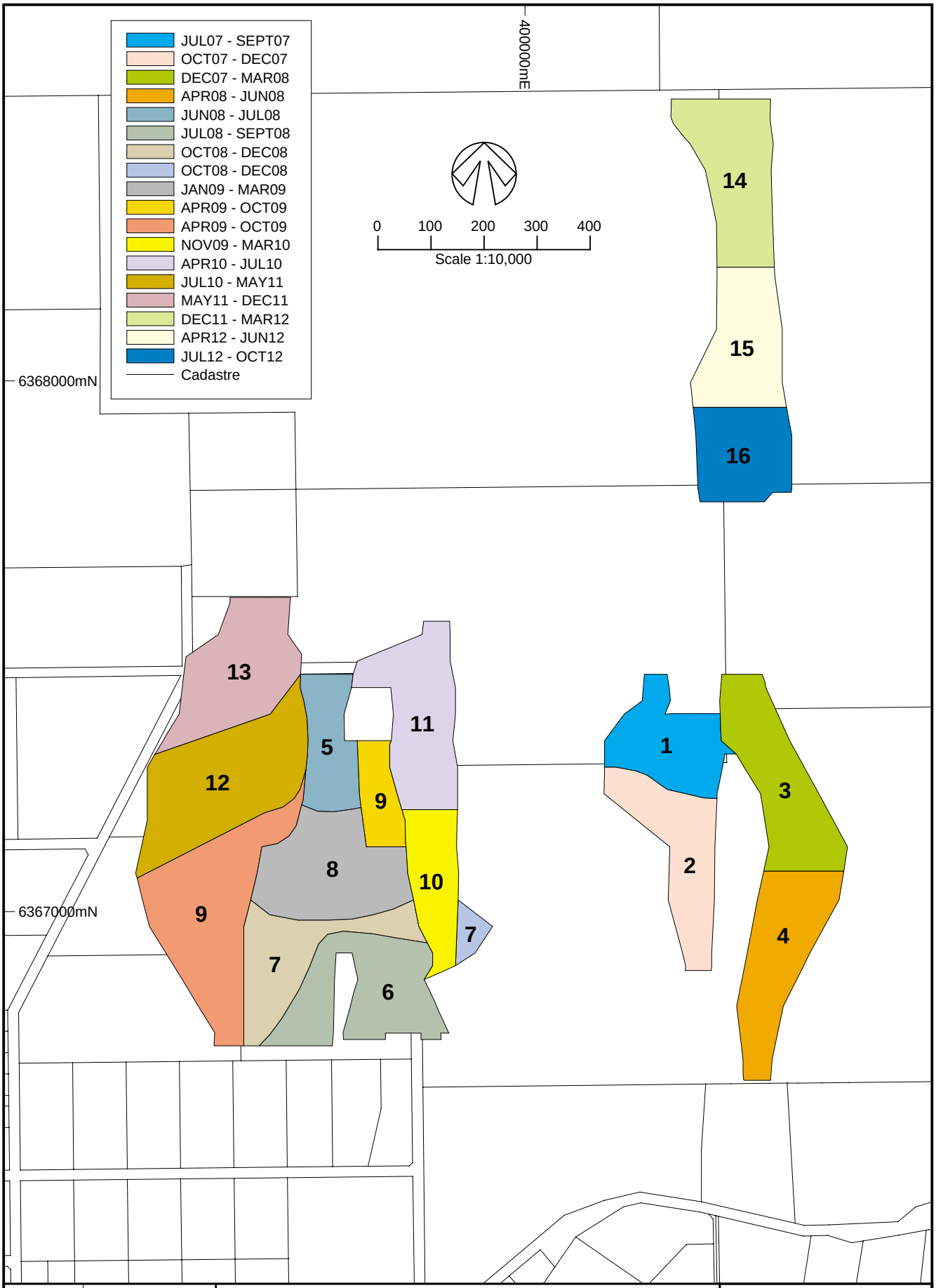
44047021r001f9.dgn



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WAROONA DEPOSIT - IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

MINING SCHEDULE

Figure 10

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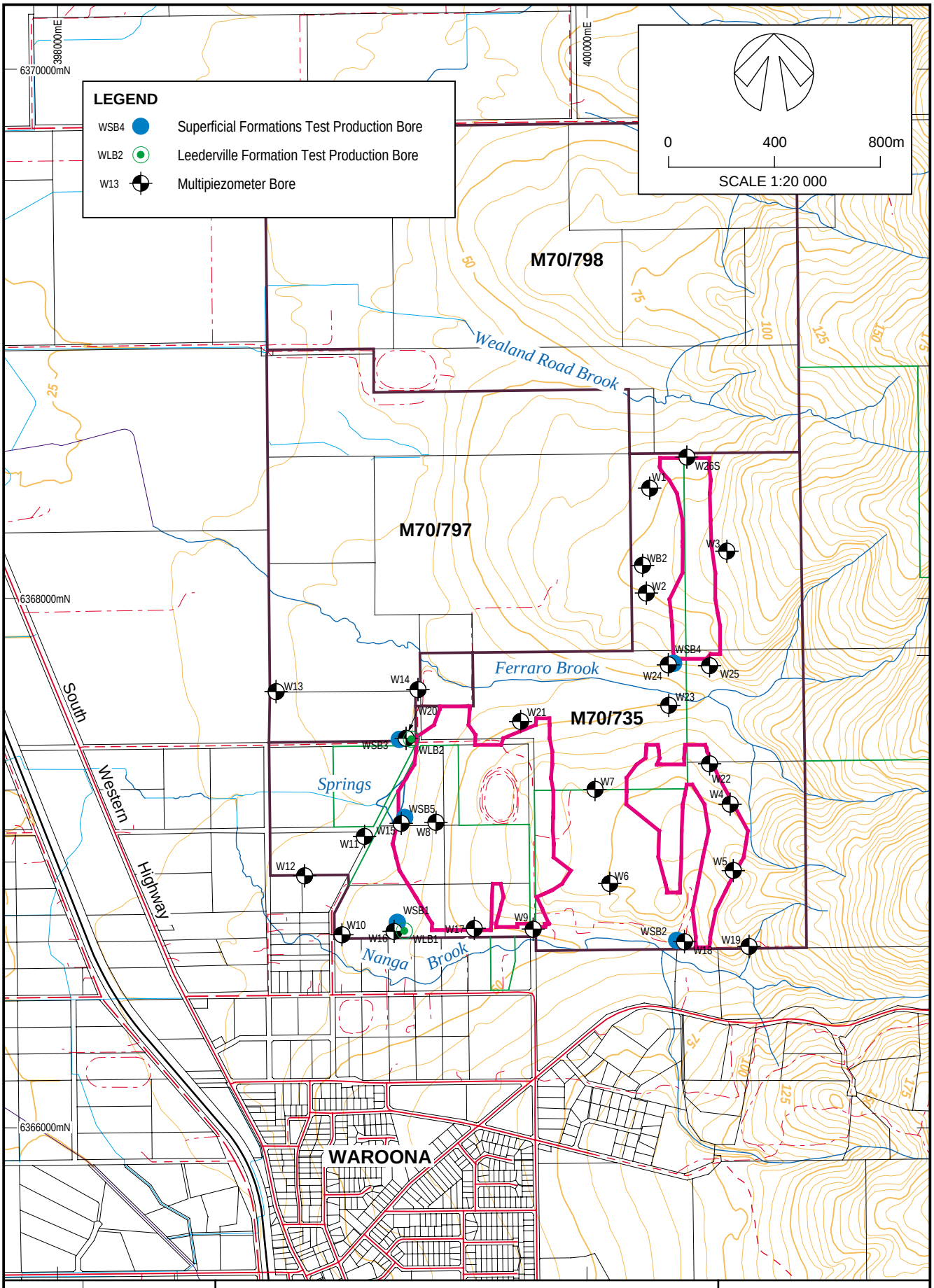

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LOCATIONS OF GROUNDWATER BORES

Figure 11

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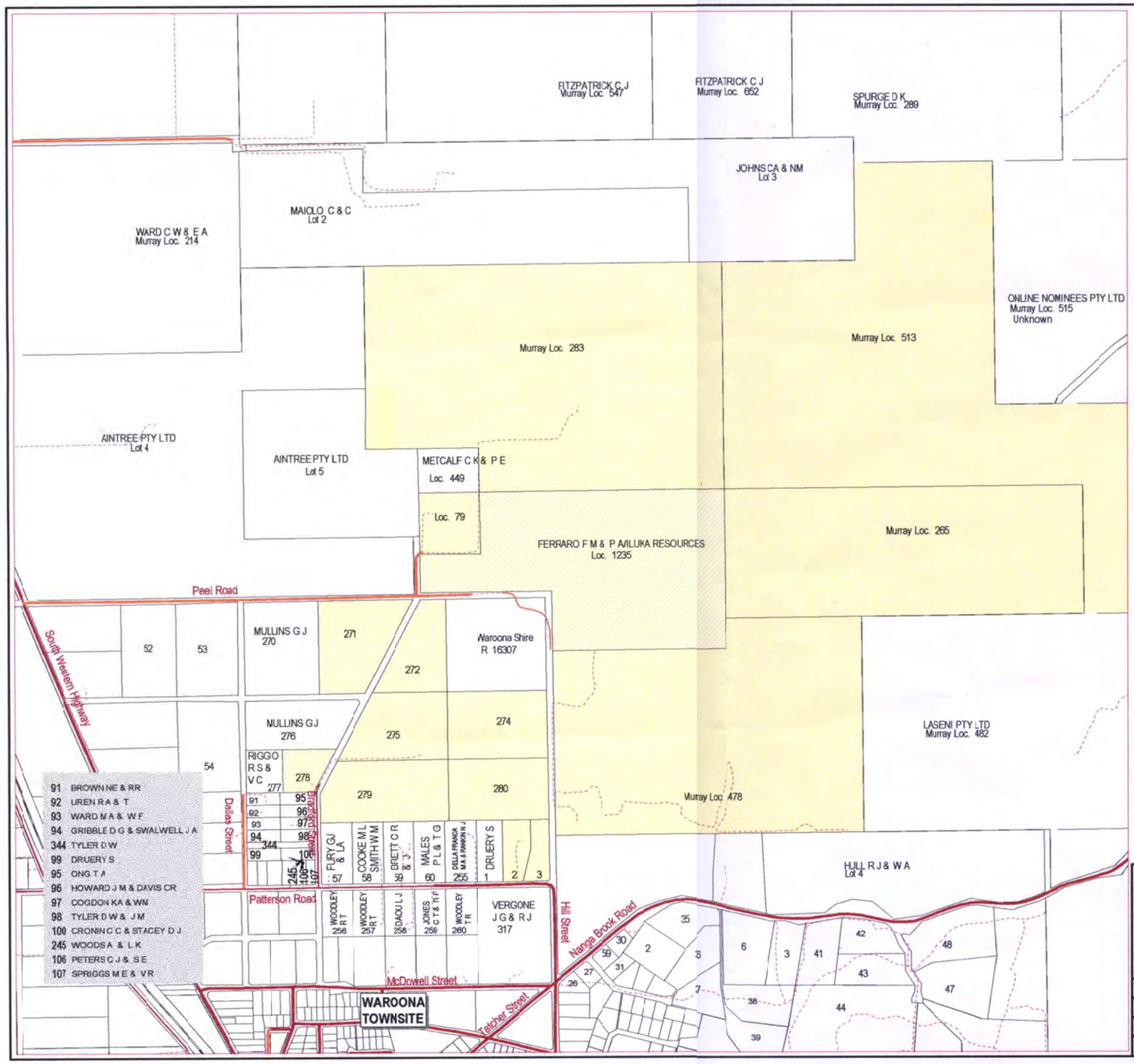

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LOCATION OF NEARBY RESIDENCES

Figure 12

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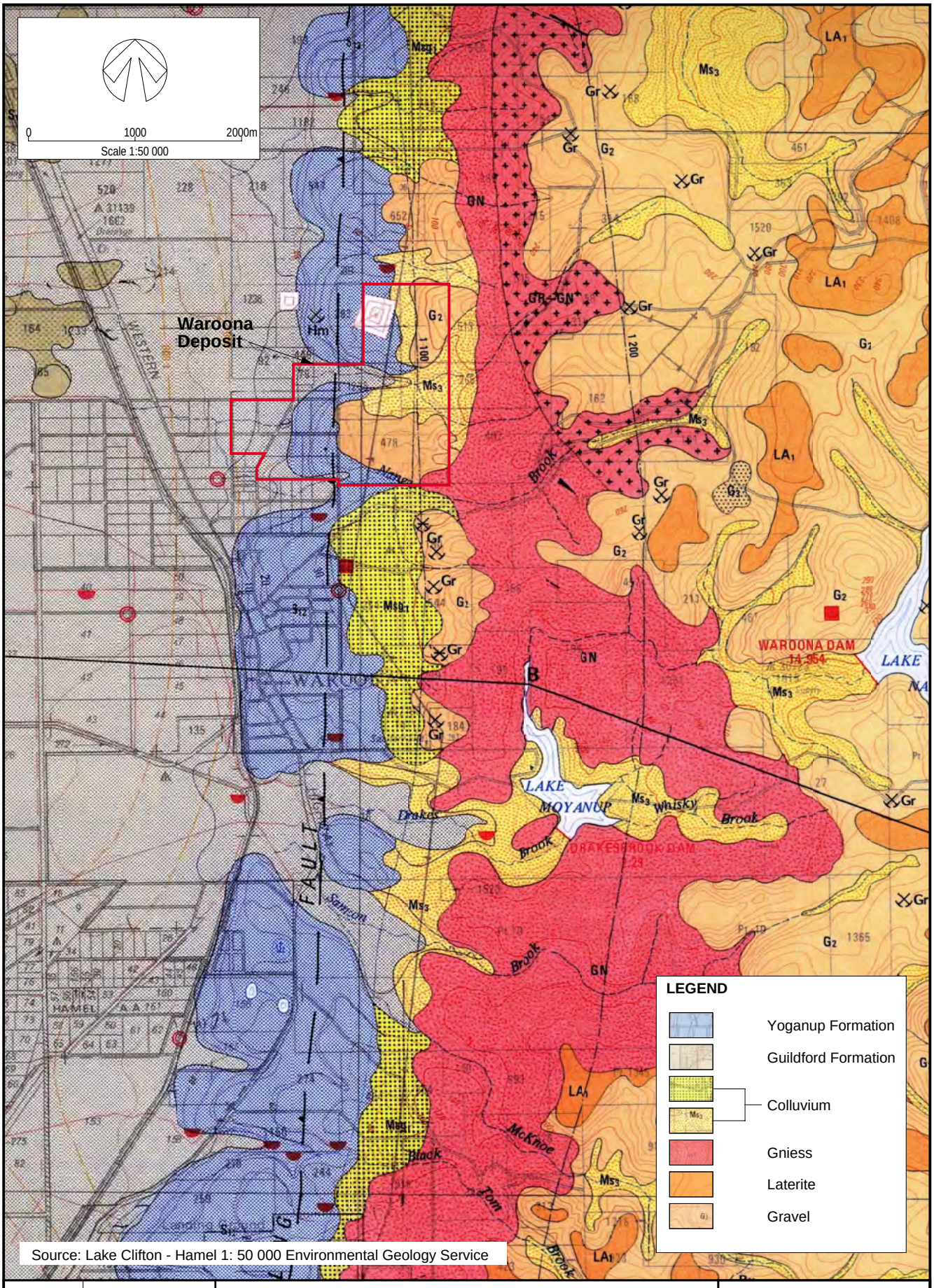

Source: Lake Clifton - Hamel 1: 50 000 Environmental Geology Service

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SURFACE GEOLOGY MAPPING

Figure 13

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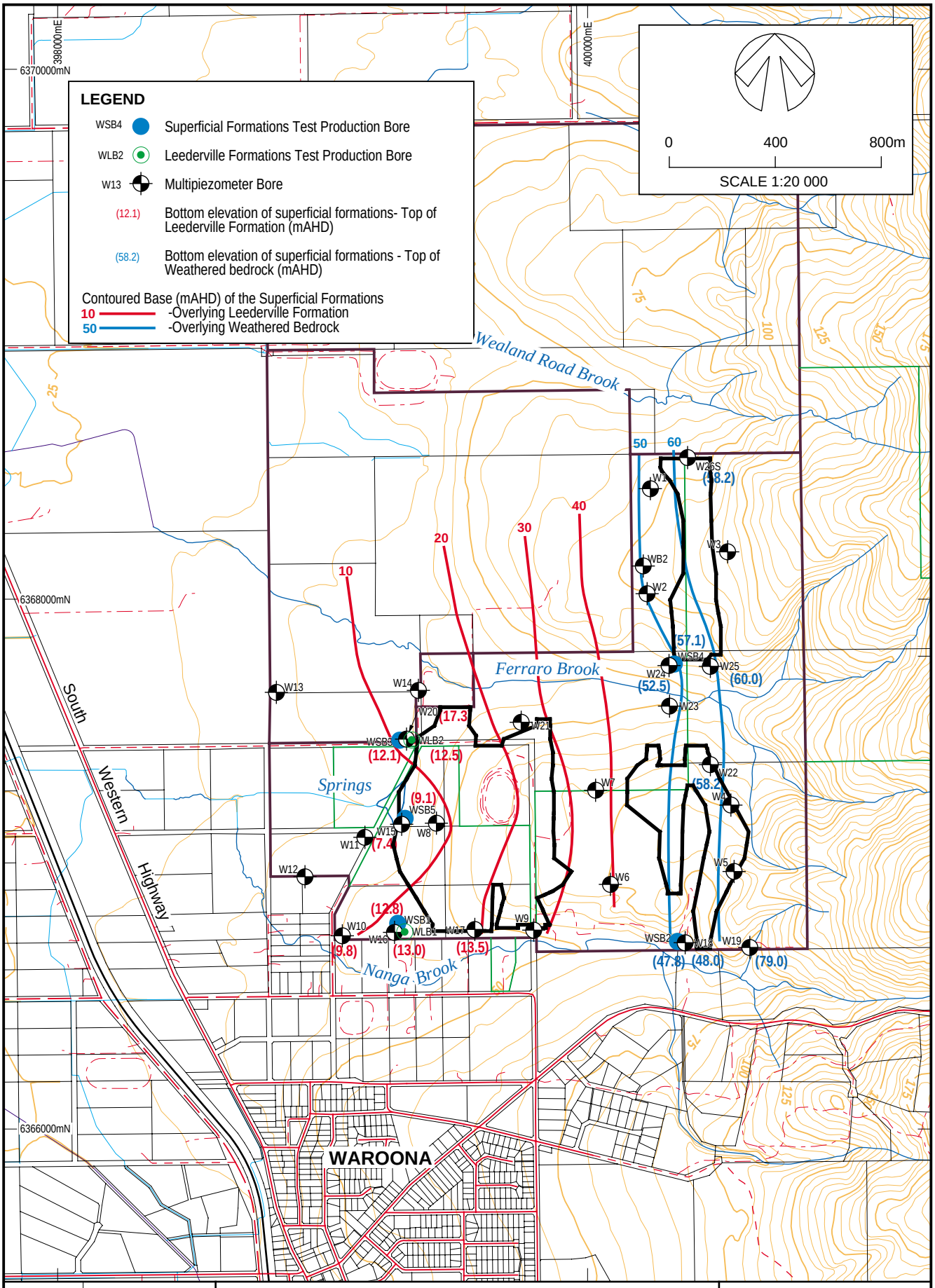

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BOTTOM ELEVATIONS OF THE SUPERFICIAL FORMATIONS

Figure 14

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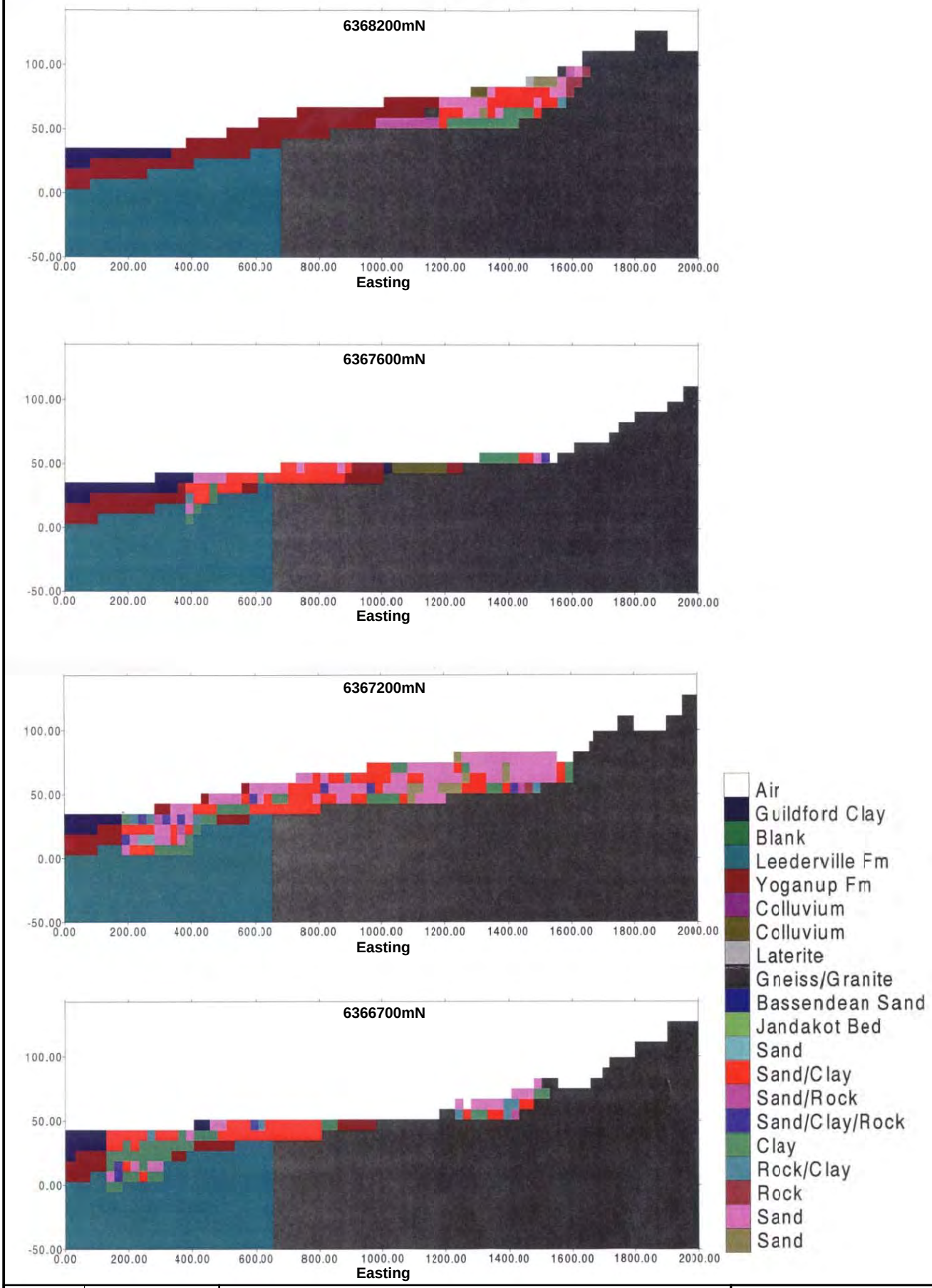
44047021r001f14.dgn



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TYPICAL GEOLOGICAL PROFILES

Figure 15a

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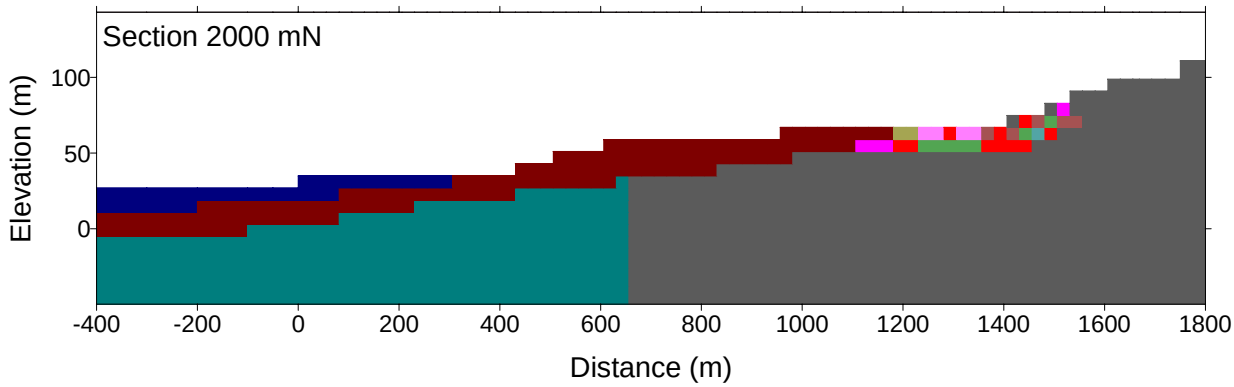

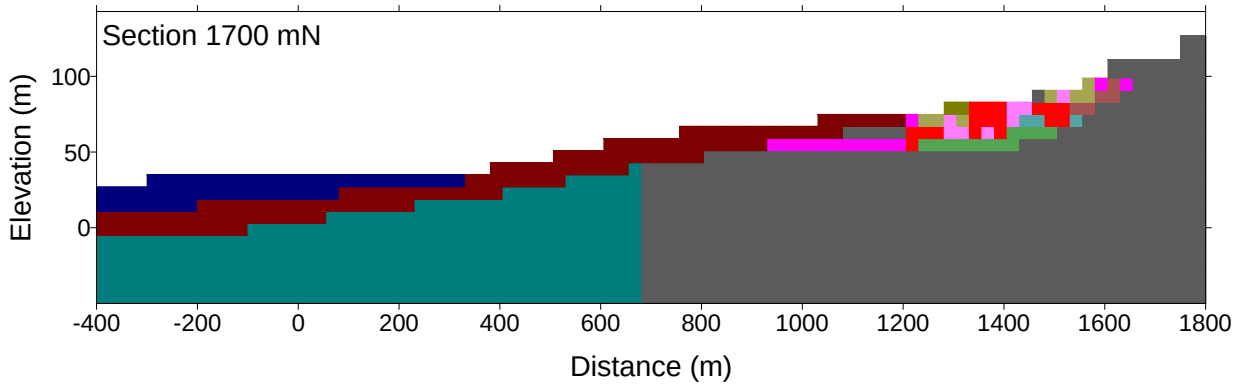

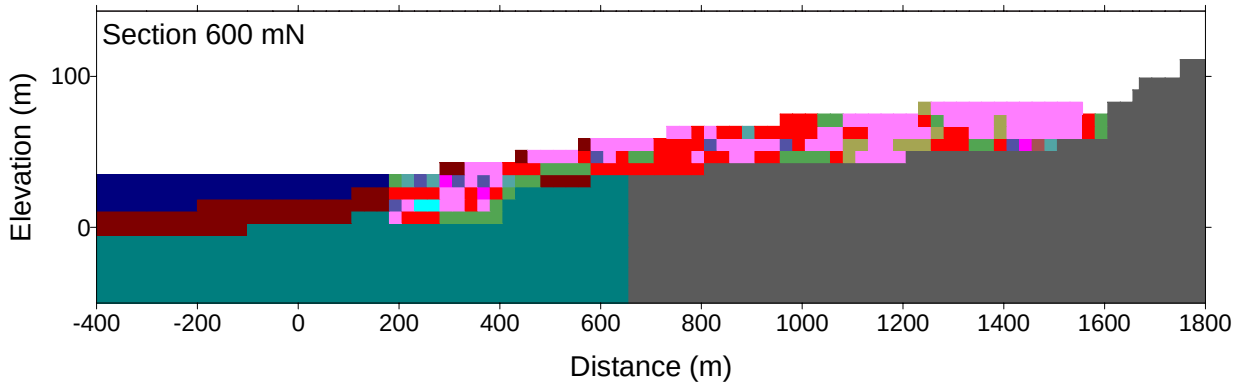

Regional Geology

- Air
- Guildford Fm - Sandy SILT
- Tailings
- Leederville Fm
- Yoganup Fm - SAND
- Colluvium - Sandy SILT
- Colluvium - Sand SILT
- Laterite - Gravel
- Granite - Gneiss
- Guildford Fm - SAND
- Jandakot Beds

Local Lithology

- Sand
- Sand/Clay
- Sand/Rock
- Sand/Clay/Rock
- Clay
- Rock/Clay
- Rock
- Sand
- Sand

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TYPICAL GEOLOGICAL PROFILES

Figure 15b

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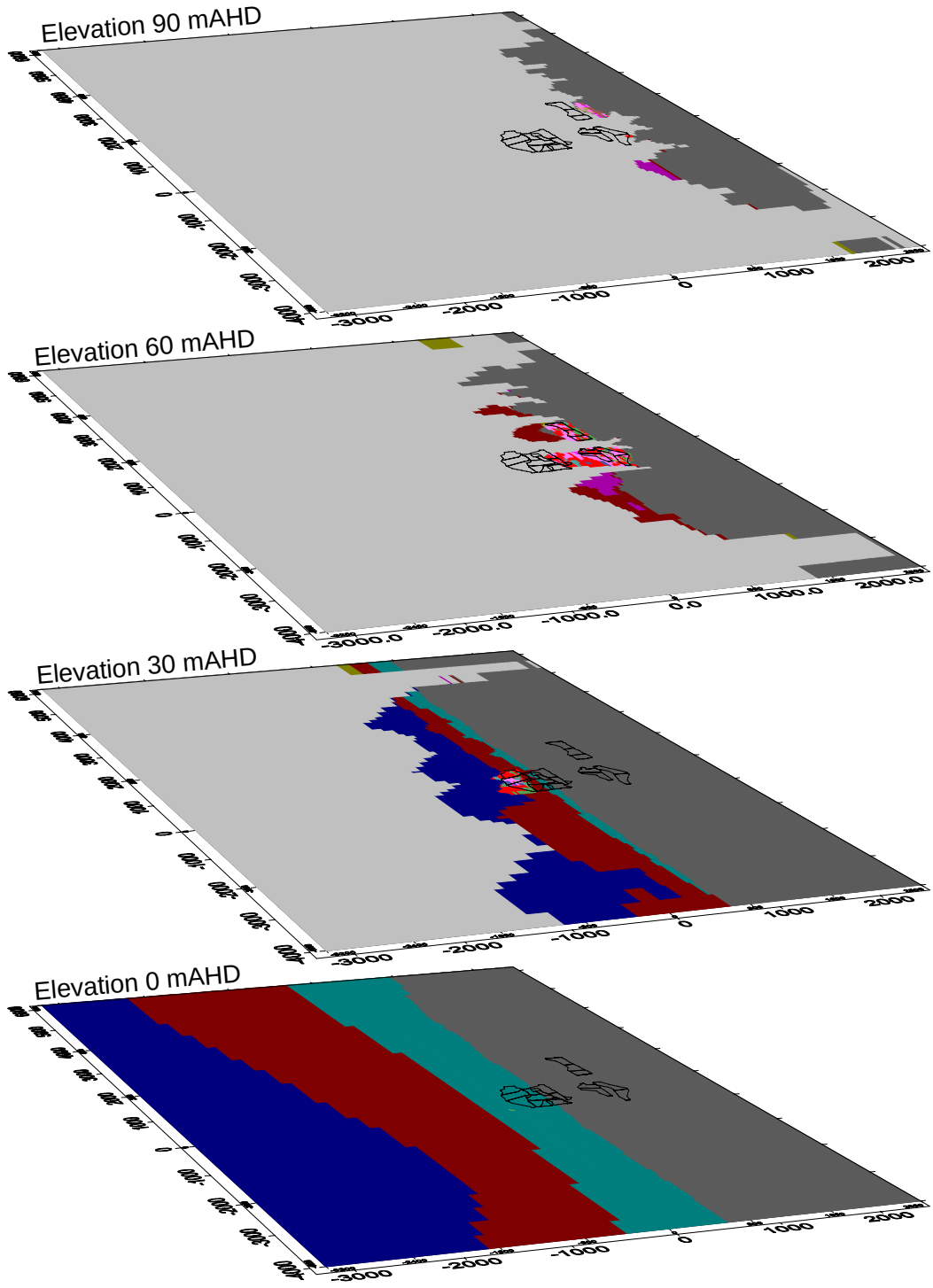
figure15b.srf



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MODEL MATERIAL TYPE DISTRIBUTION (PLAN VIEWS)

Figure 15c

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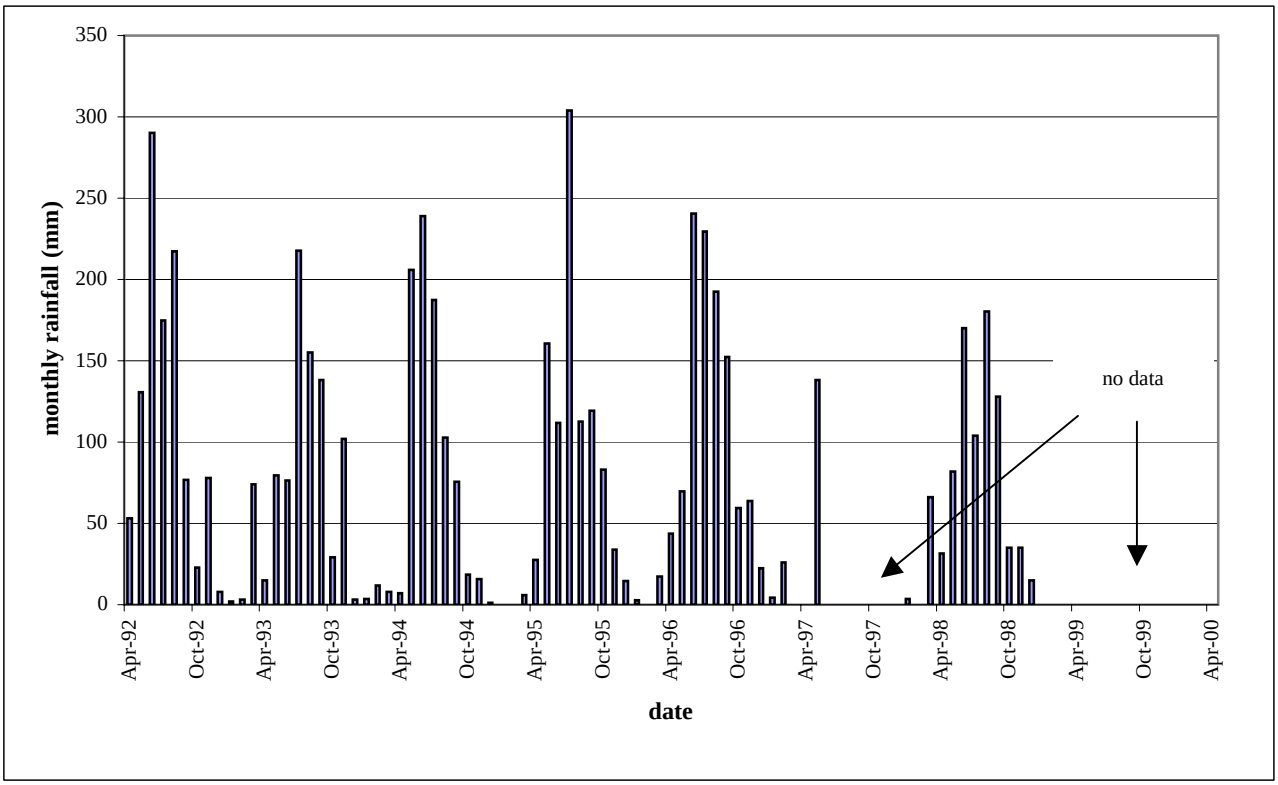
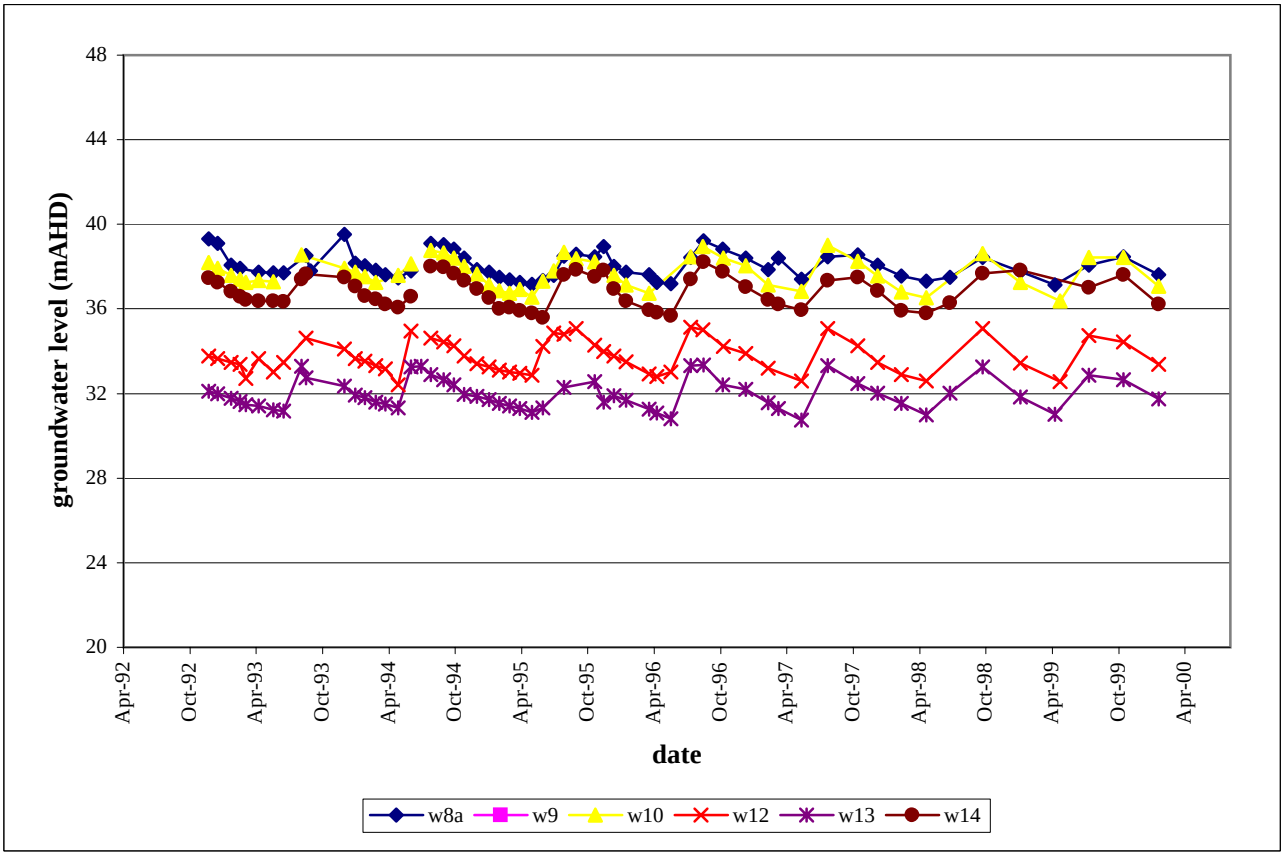
figure15c.srf





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Revision No.		0

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WAROONA DEPOSIT - IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

GROUNDWATER HYDROGRAPHS

SHALLOW GROUNDWATER - WESTERN AREA

Figure 16

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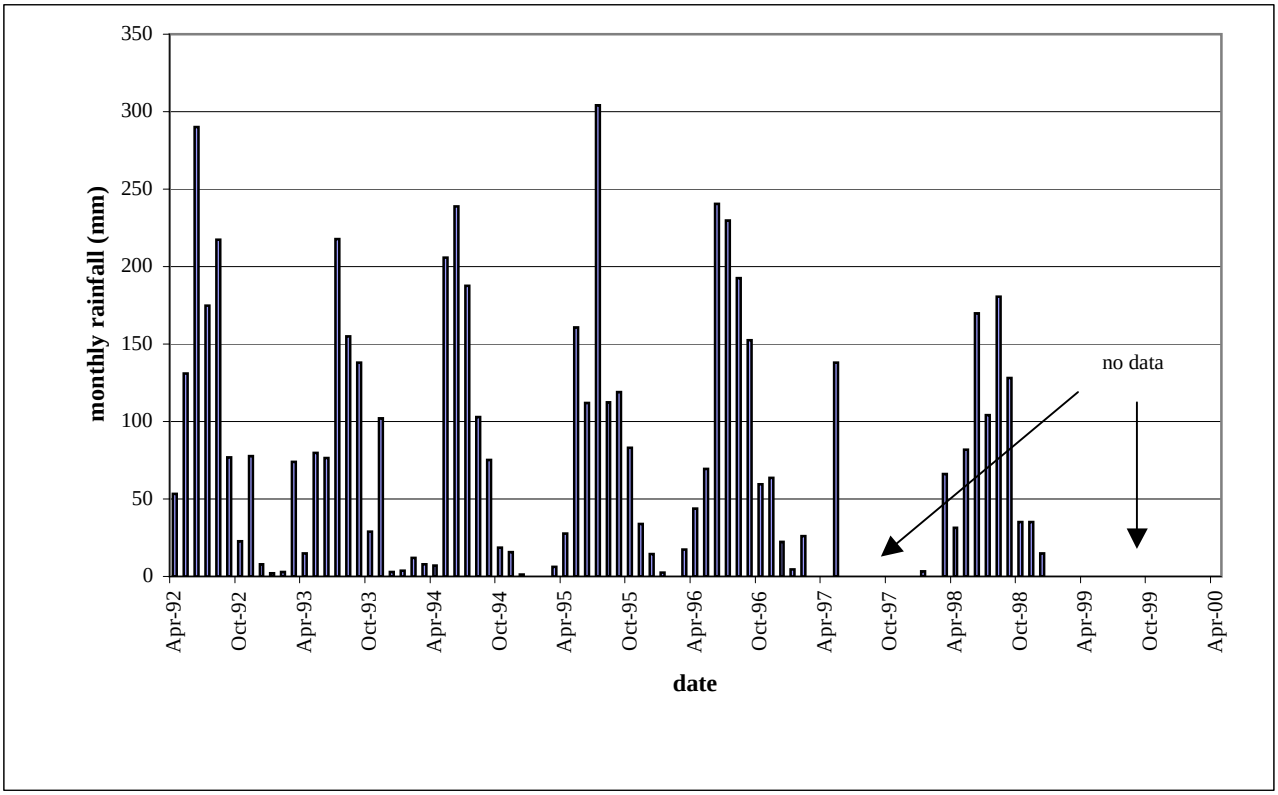

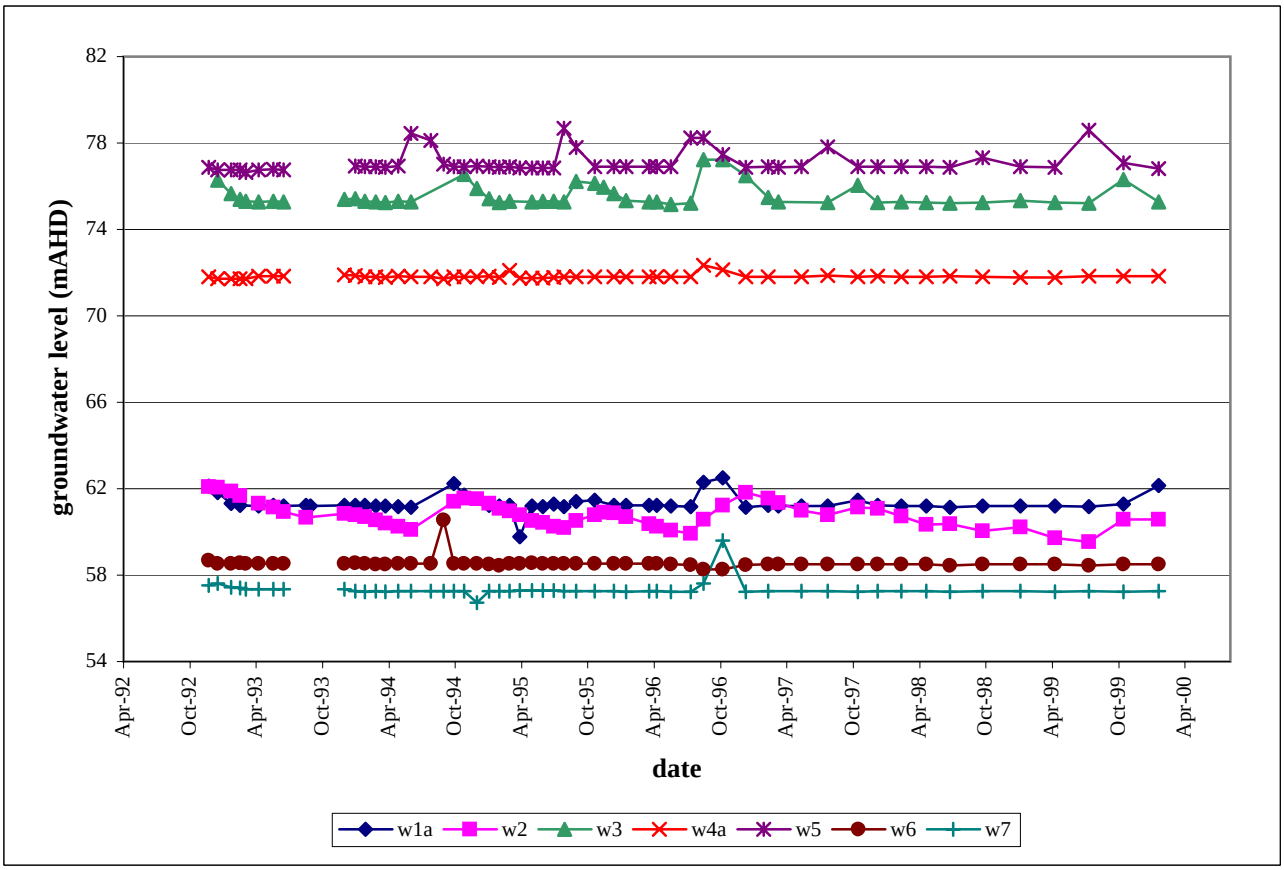

Job No.	44047-021-071	
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Chk'd By	I.G.B.	18/3/02
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GROUNDWATER HYDROGRAPHS

SHALLOW GROUNDWATER - EASTERN AREAS

Figure 17

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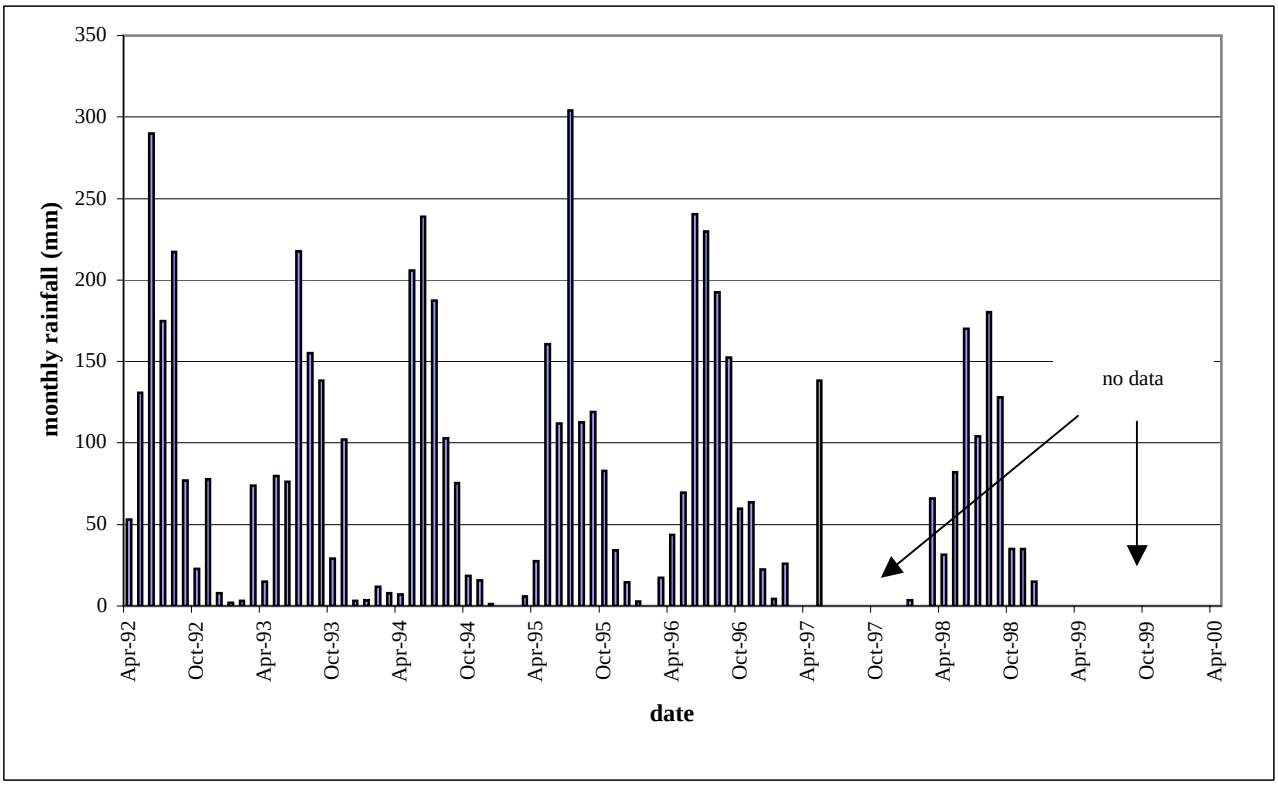

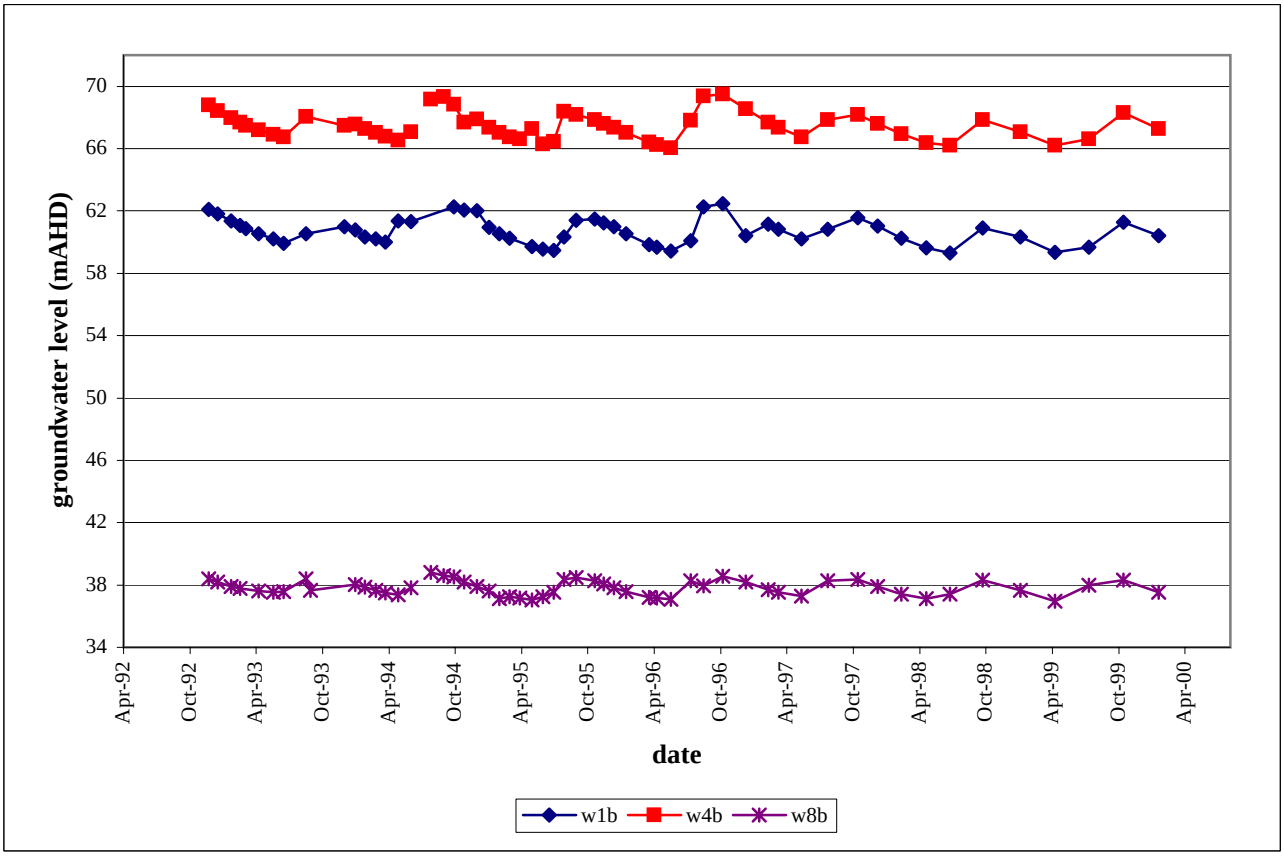

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GROUNDWATER HYDROGRAPHS

UPPER LEEDERVILLE FORMATION/BASEMENT

Figure 18

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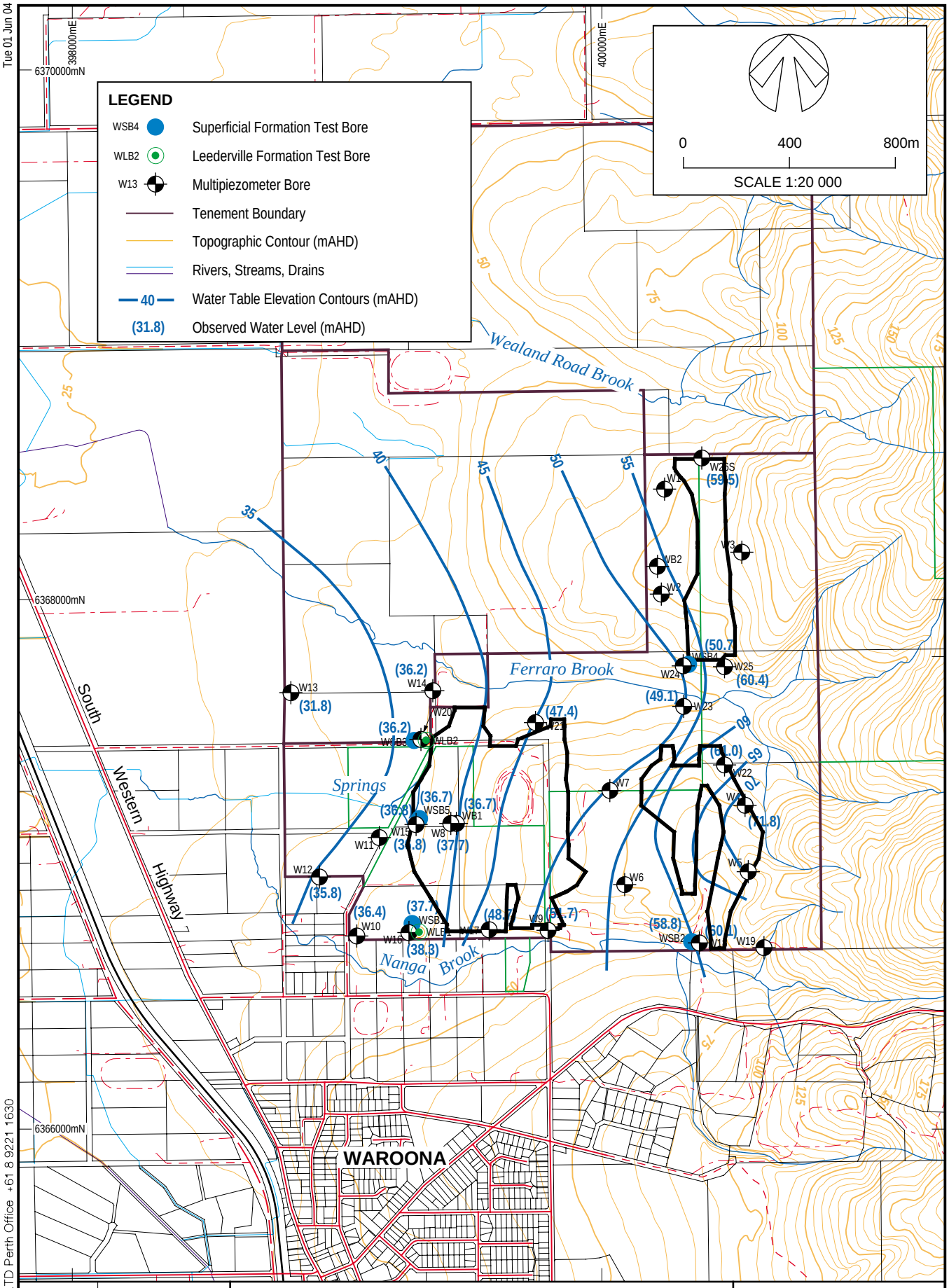

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WATER TABLE ELEVATIONS MAY 2001

Figure 19

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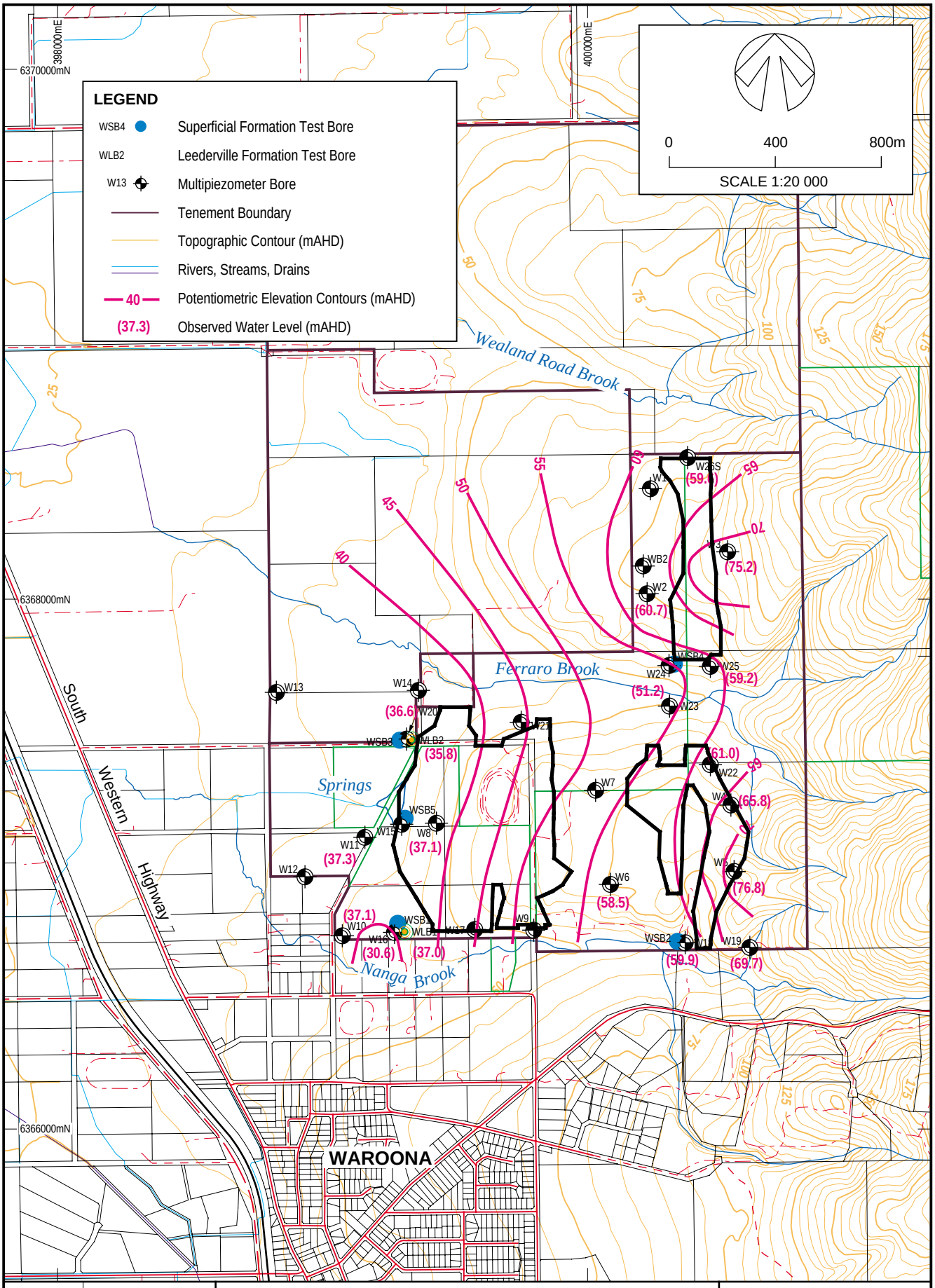

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MINING ON SHALLOW GROUNDWATER RESOURCES

POTENTIOMETRIC HEADS - LEEDERVILLE FORMATION AND ARCHEAN BEDROCK - MAY 2001

Figure 20

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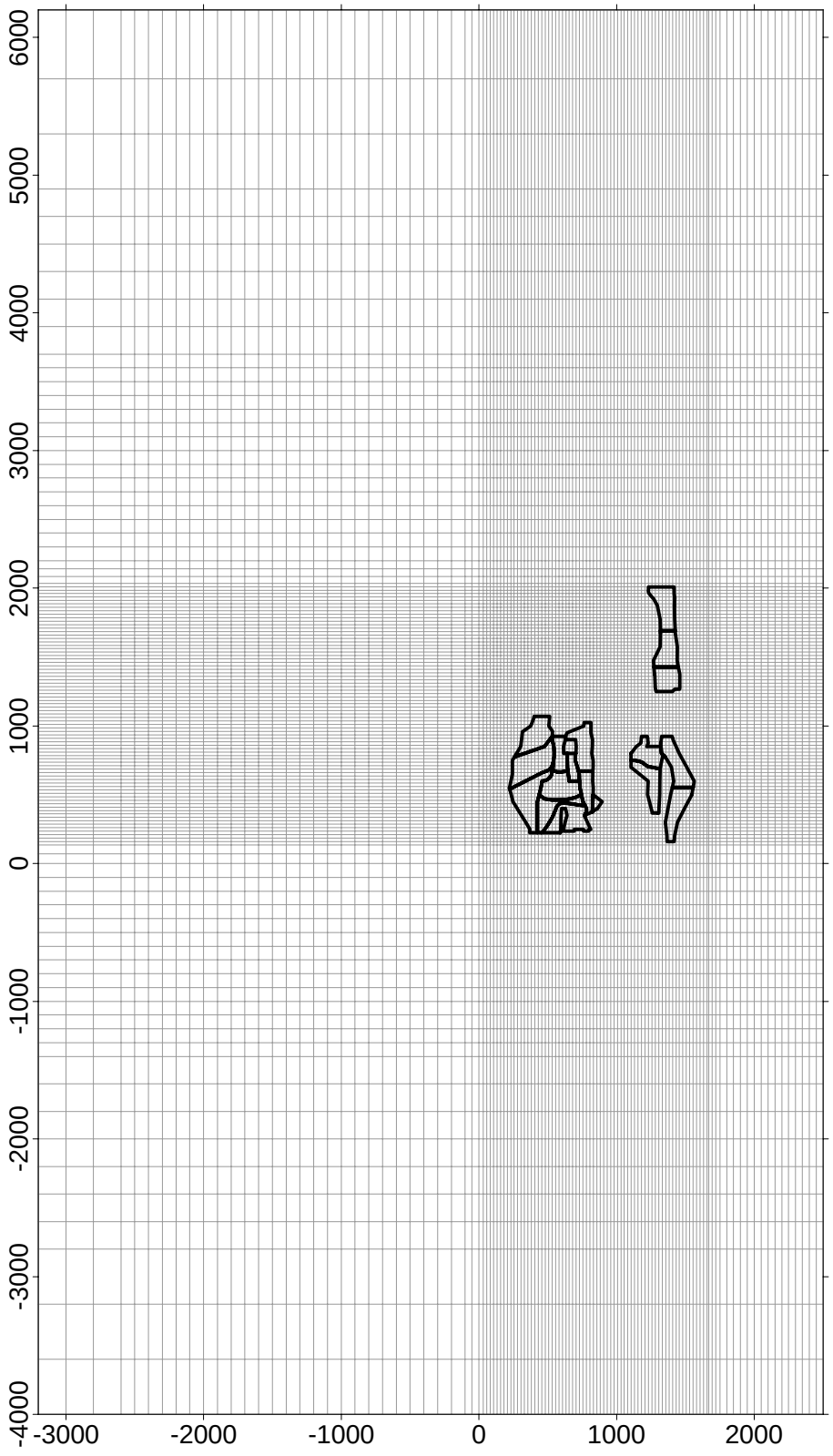

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WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

MODEL DOMAIN

Figure 21

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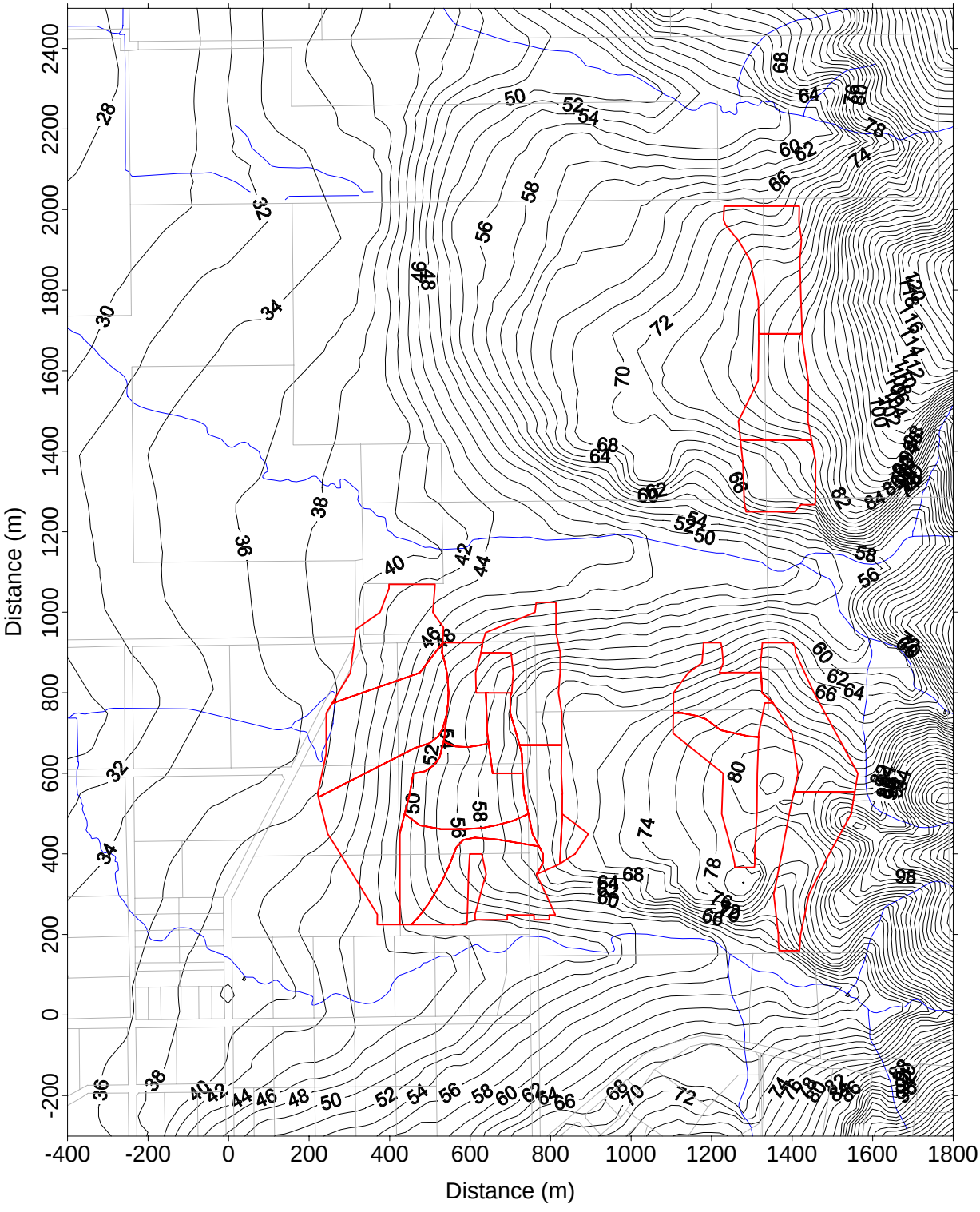
figure21.srf



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MODEL SURFACE TOPOGRAPHY (mAHD)

Figure 22

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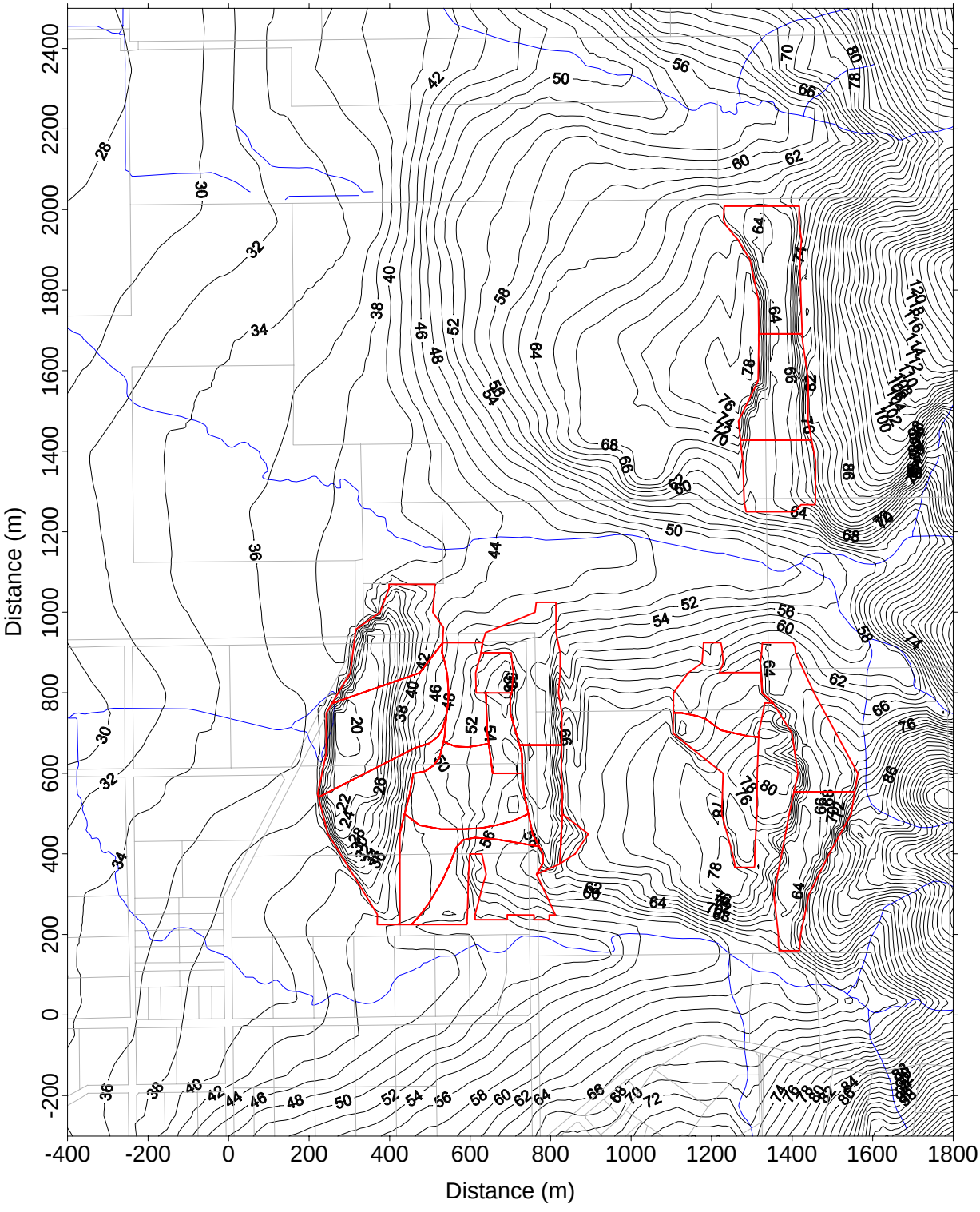
figure22.srf



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MINE PIT-FLOOR ELEVATION (mAHD)

Figure 23a

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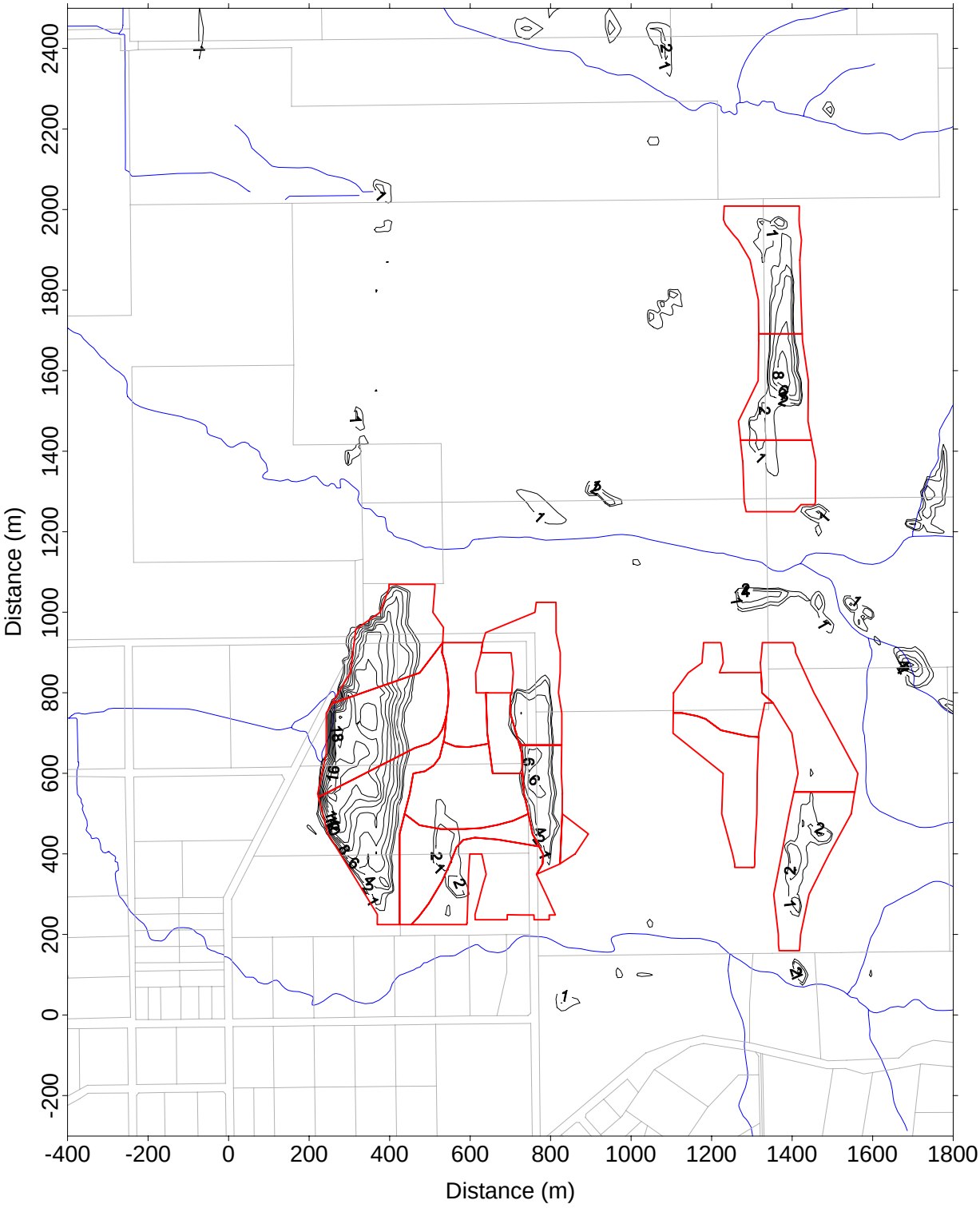
figure23a.srf



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SIMULATED SATURATED THICKNESS OF MINE BLOCKS (m)

Figure 23b

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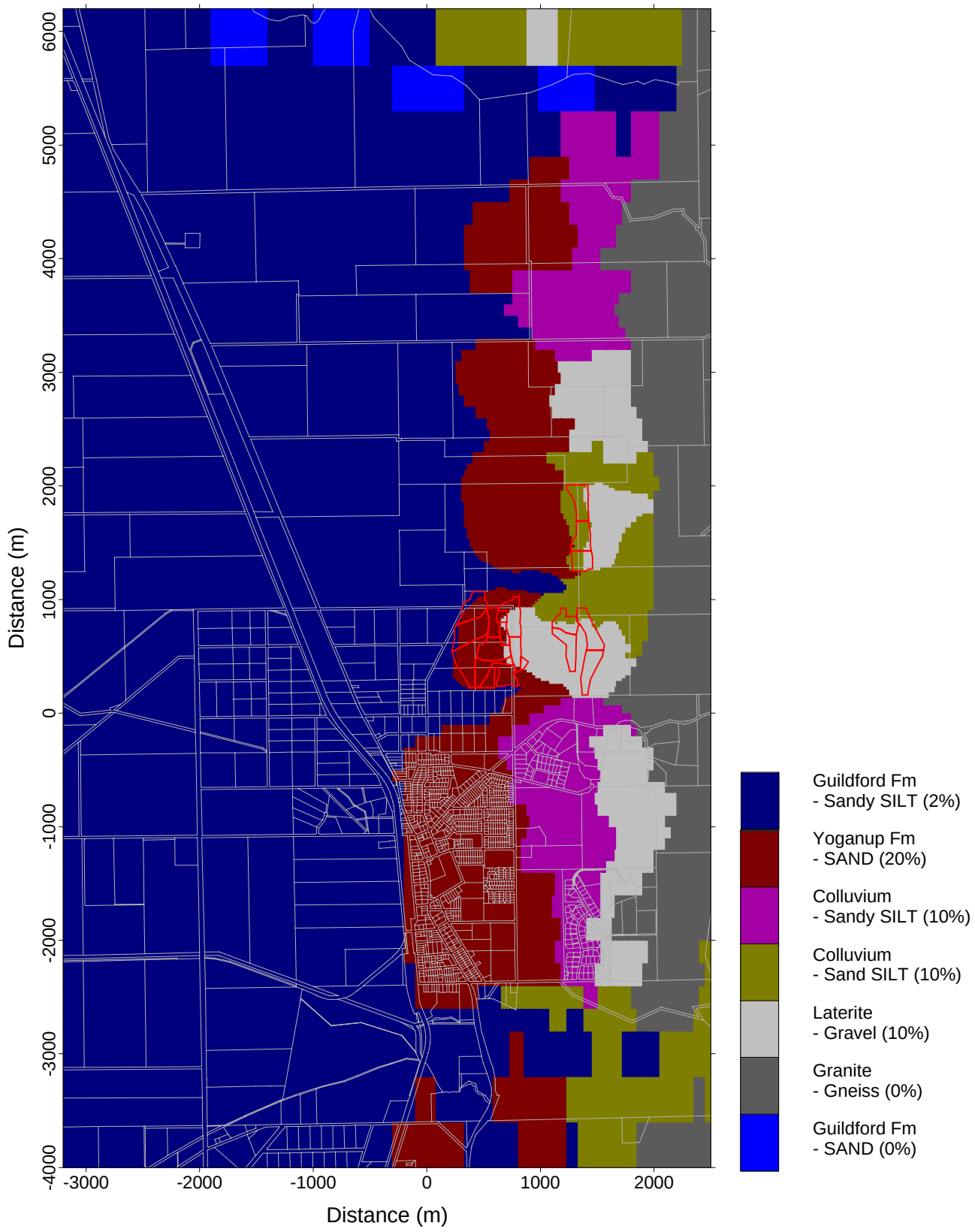
figure23b.srf



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RECHARGE ZONES

Figure 24

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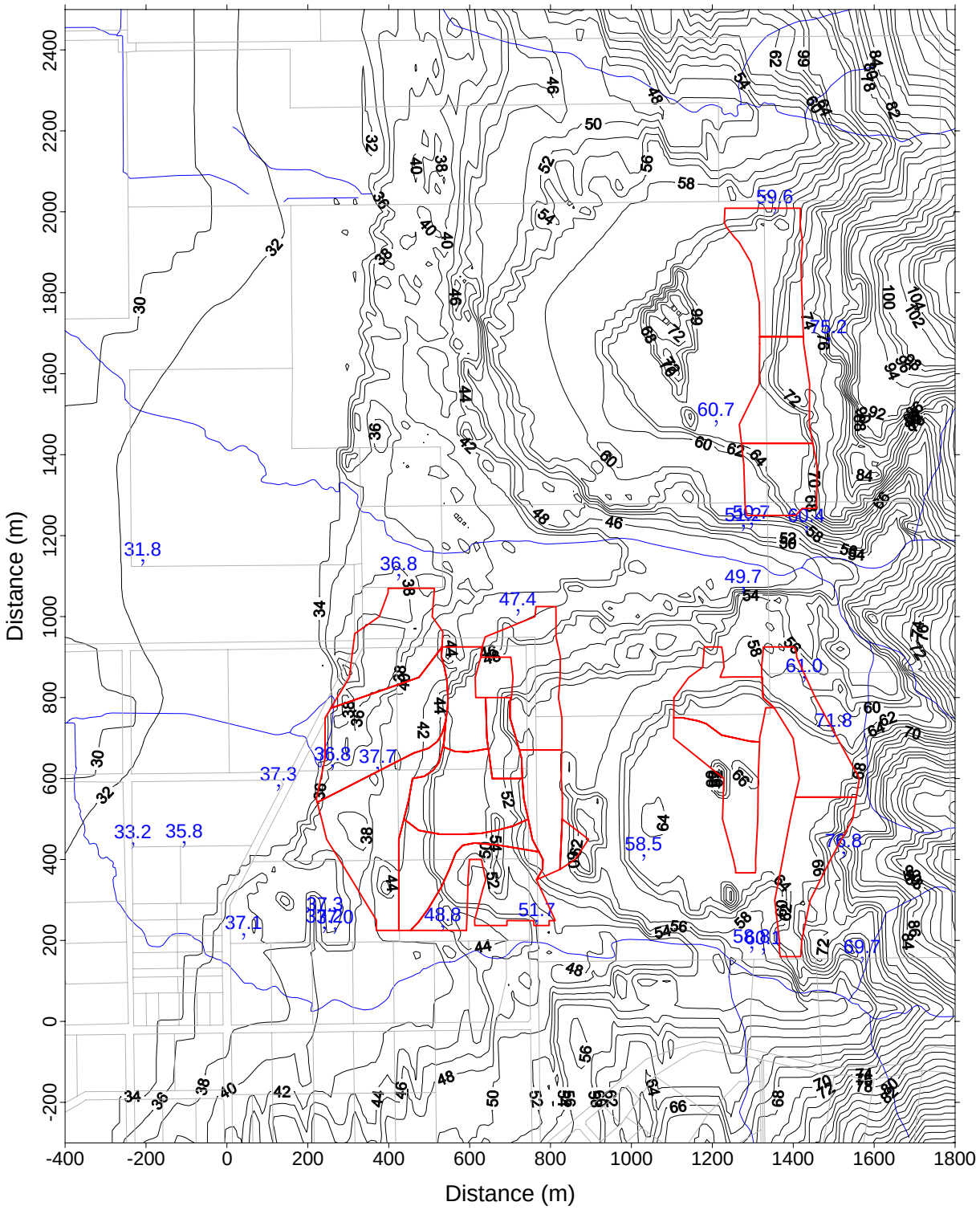
figure24.srf



36.8 Observed water table elevations (mAHD, May 2001)

Simulated water table elevations (mAHD)

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MODEL CALIBRATION : SIMULATED PRE-MINING WATER TABLE CONTOURS (mAHD)

Figure 25a

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figure25a.srf

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	Dewatering Period				Transient Time (days)																
Mine Block	Start Date	Stop Date	Start Days	Stop Days	0	92	168	275	351	381	458	550	640	854	1005	1111	1415	1629	1736	1837	1950
1	1-Jul-07	30-Sep-07	1	92																	
2	1-Oct-07	15-Dec-07	92	168																	
3	16-Dec-07	31-Mar-08	168	275																	
4	1-Apr-08	15-Jun-08	275	351																	
5	16-Jun-08	15-Jul-08	351	381																	
6	16-Jul-08	30-Sep-08	381	458																	
7	1-Oct-08	31-Dec-08	458	550																	
8	1-Jan-09	31-Mar-09	550	640																	
9	1-Apr-09	31-Oct-09	640	854																	
10	1-Nov-09	31-Mar-10	854	1005																	
11	1-Apr-10	15-Jul-10	1005	1111																	
12	16-Jul-10	15-May-11	1111	1415																	
13	16-May-11	15-Dec-11	1415	1629																	
14	16-Dec-11	31-Mar-12	1629	1736																	
15	1-Apr-12	10-Jul-12	1736	1837																	
16	11-Jul-12	31-Oct-12	1837	1950																	

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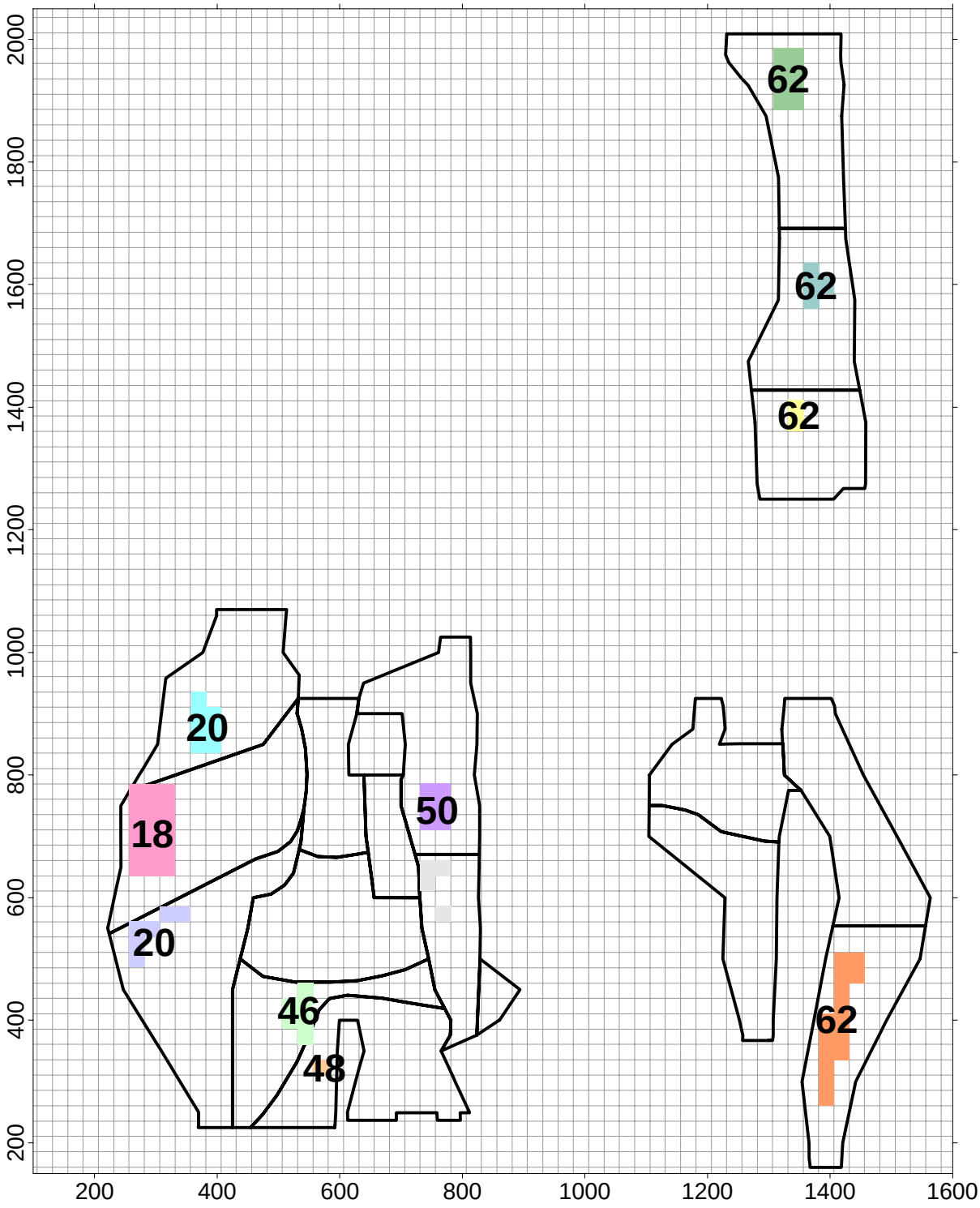
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DEWATERING SCHEDULE

Figure 26

URS

figure26.srf



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WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

CONSTANT HEAD LEVELS

Figure 27

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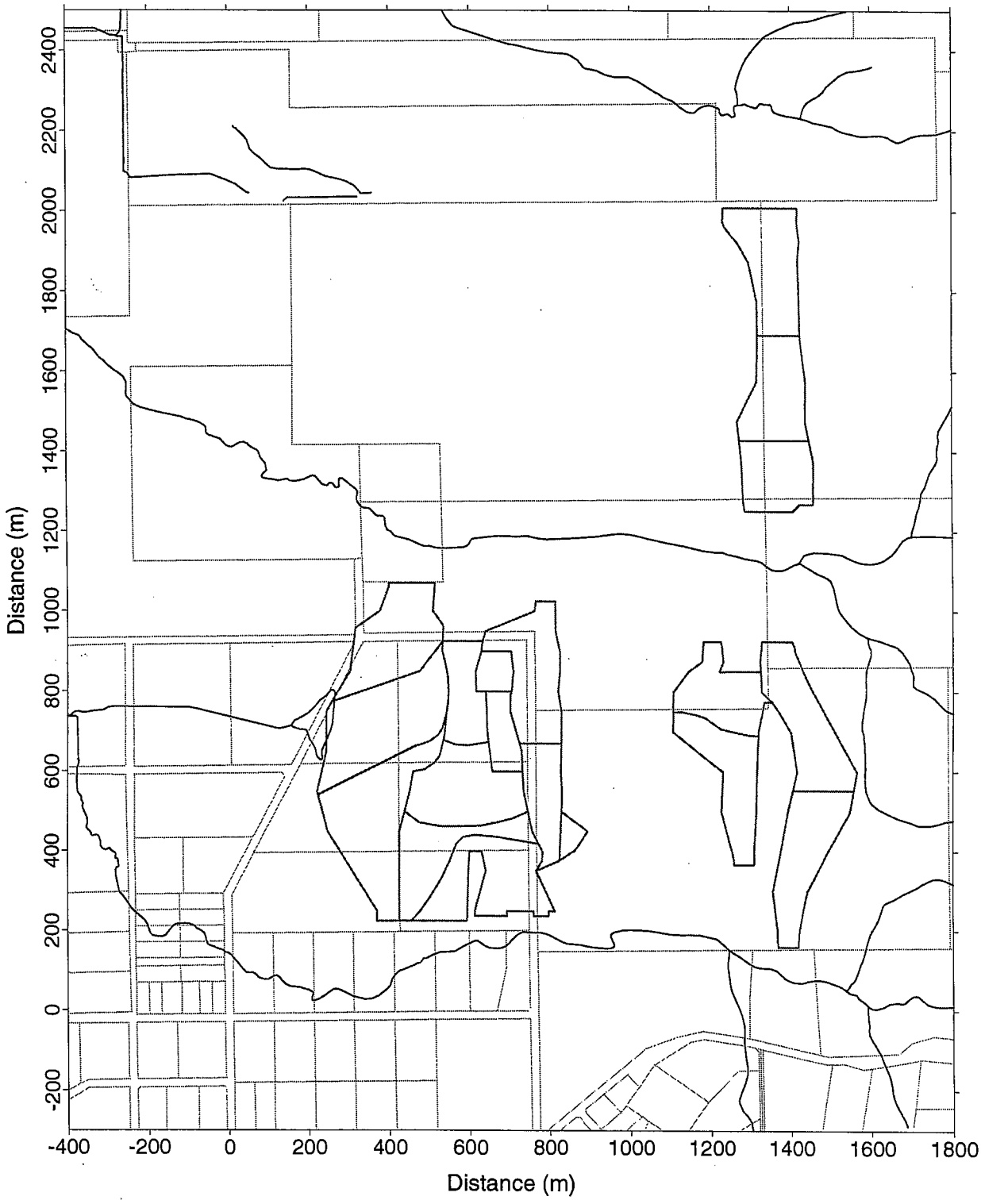
figure27.srf



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Chk'd By	IGB	24 Jun '02
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SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 1

Figure 28

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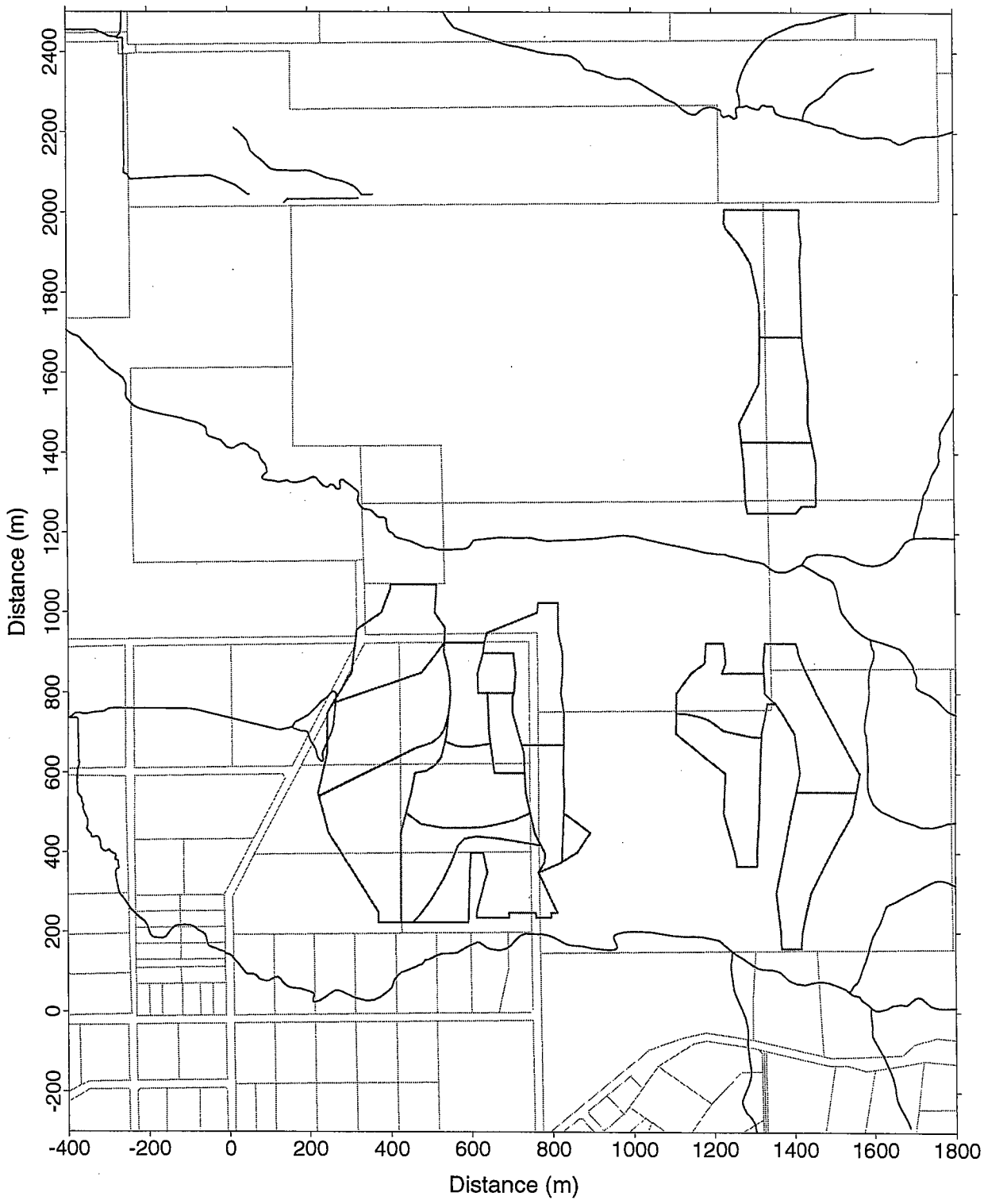
figure28.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
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SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 2

Figure 29

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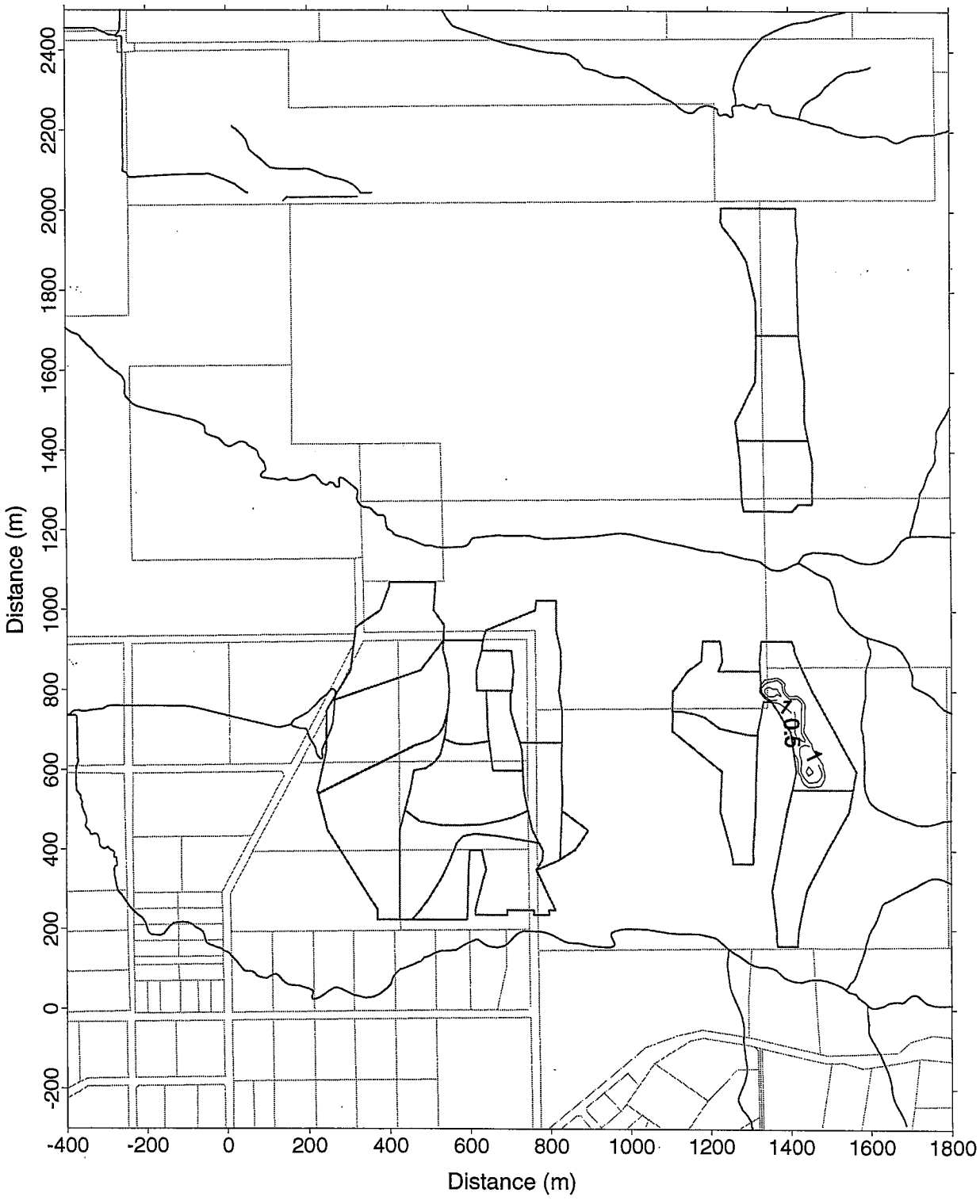
figure29.srf



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SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 3

Figure 30

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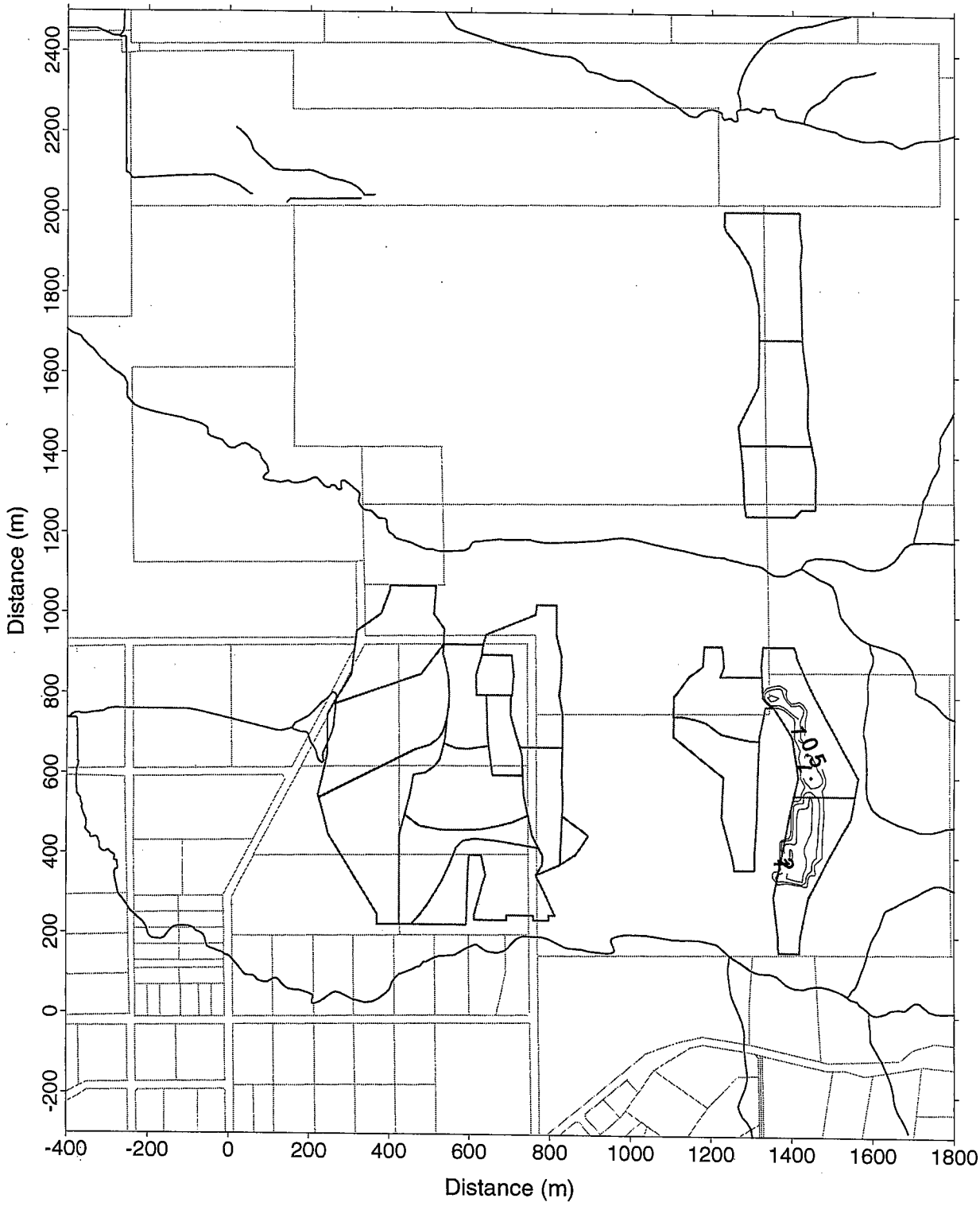
figure30.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
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SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 4

Figure 31

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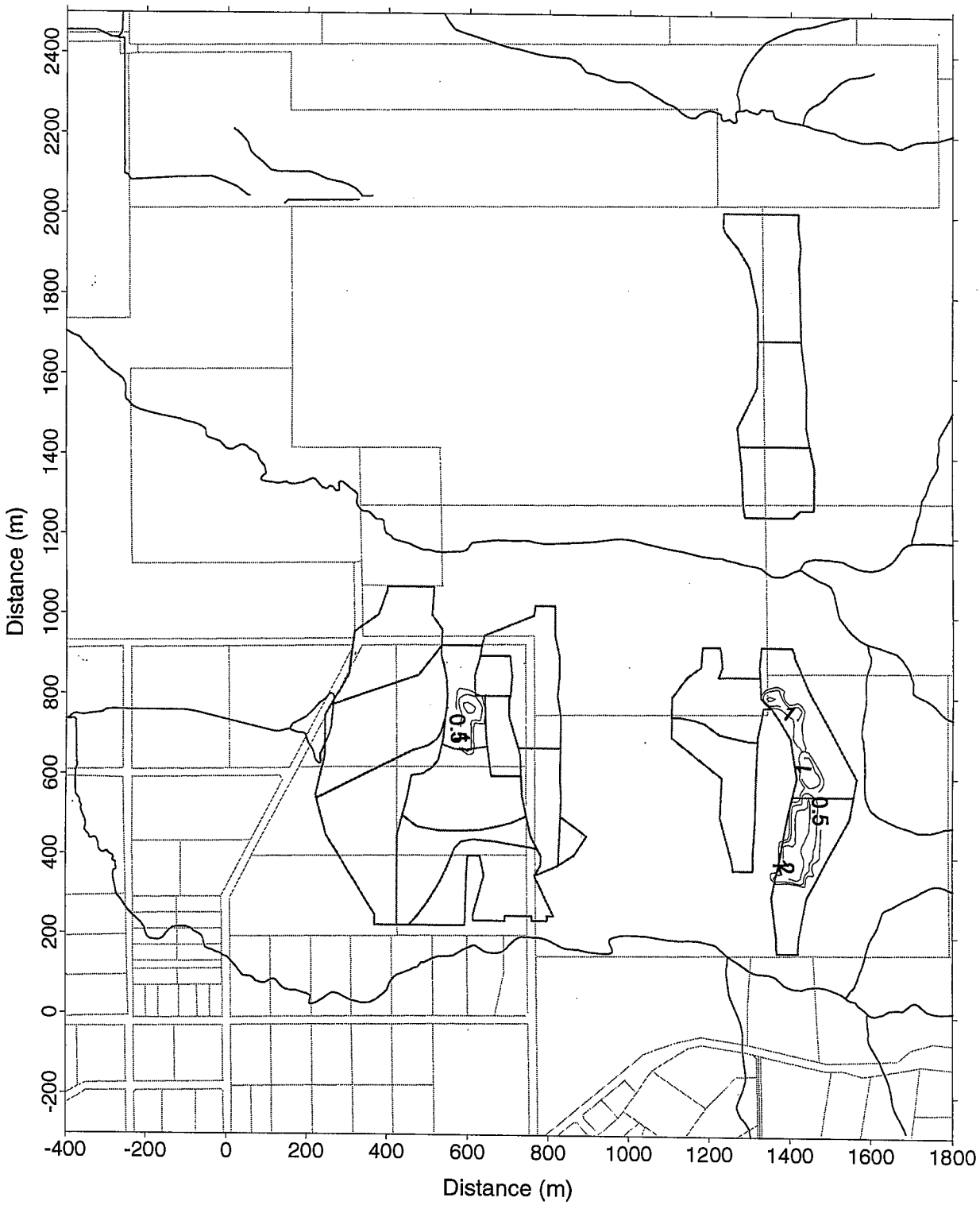
figure31.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 5

Figure 32

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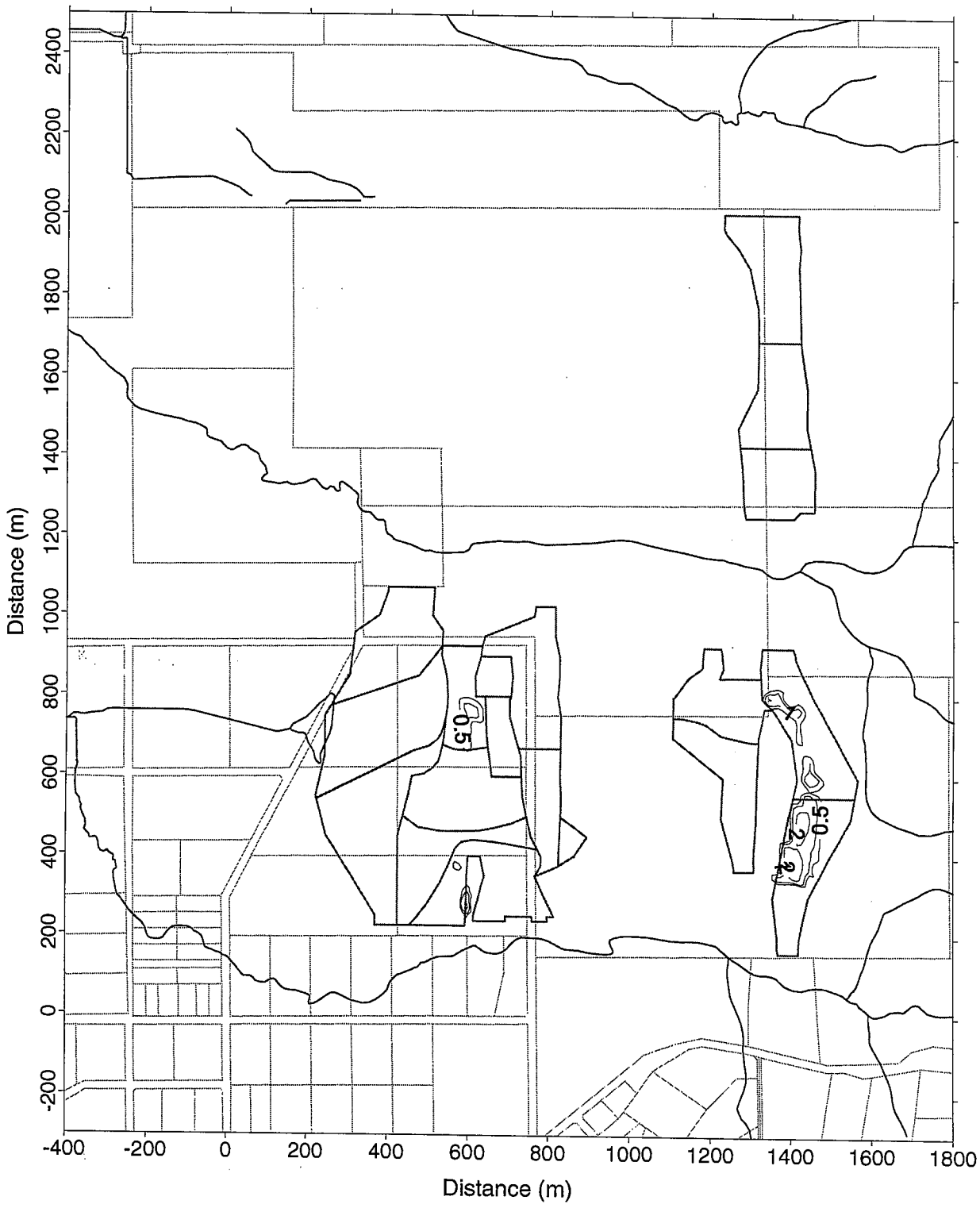
figure32.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 6

Figure 33

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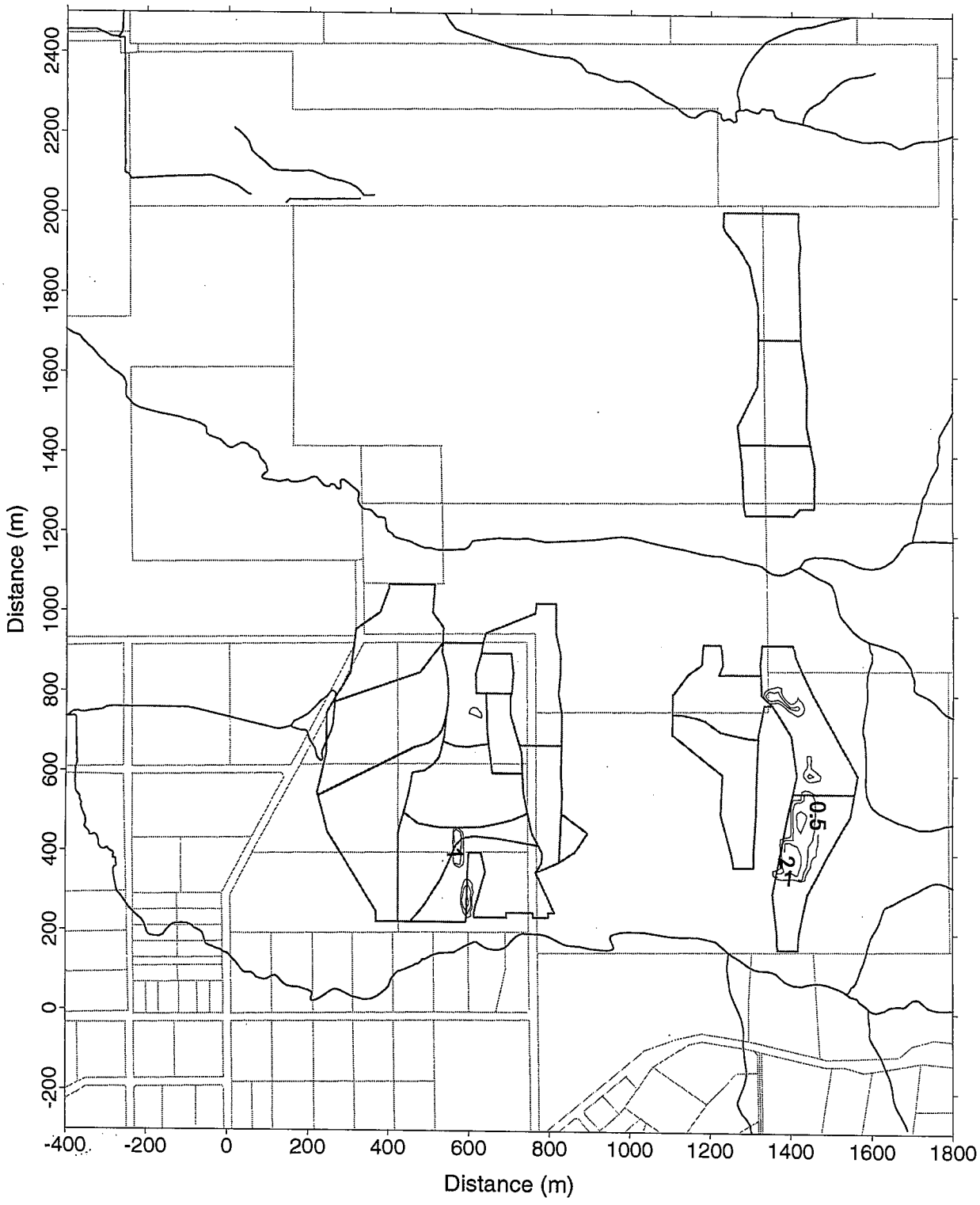
figure33.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

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WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 7

Figure 34

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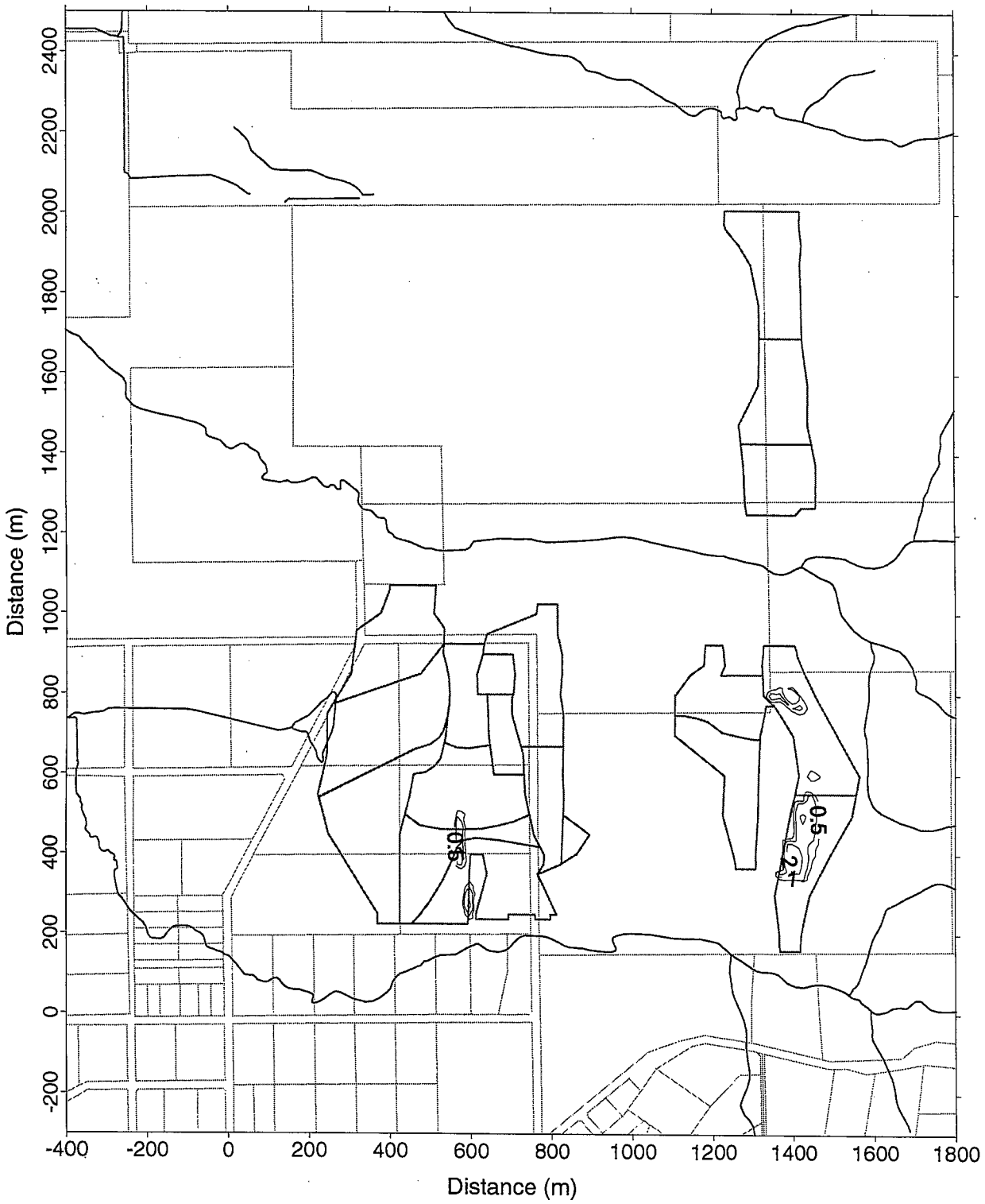
figure34.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 8

Figure 35

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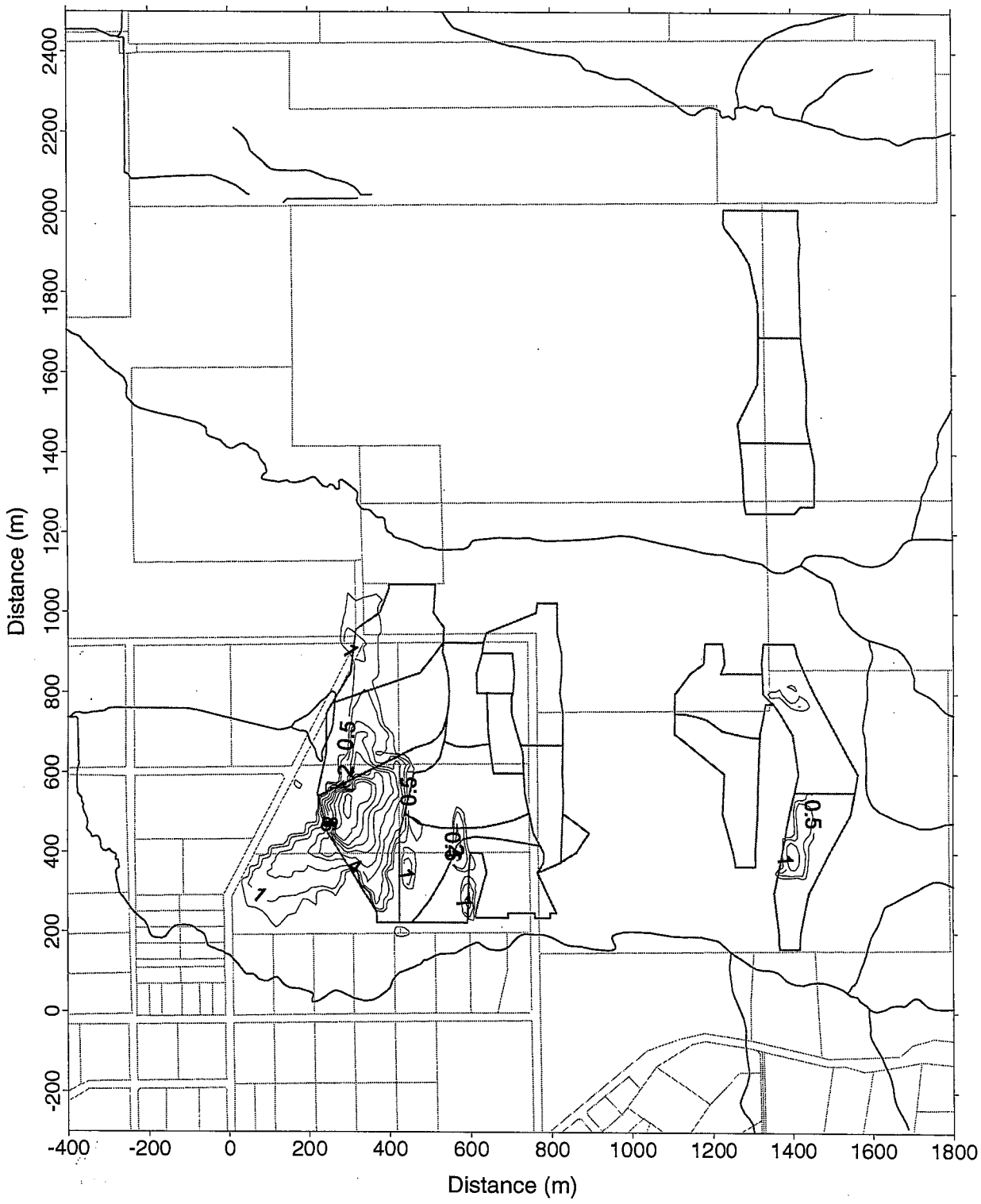
figure35.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 9

Figure 36

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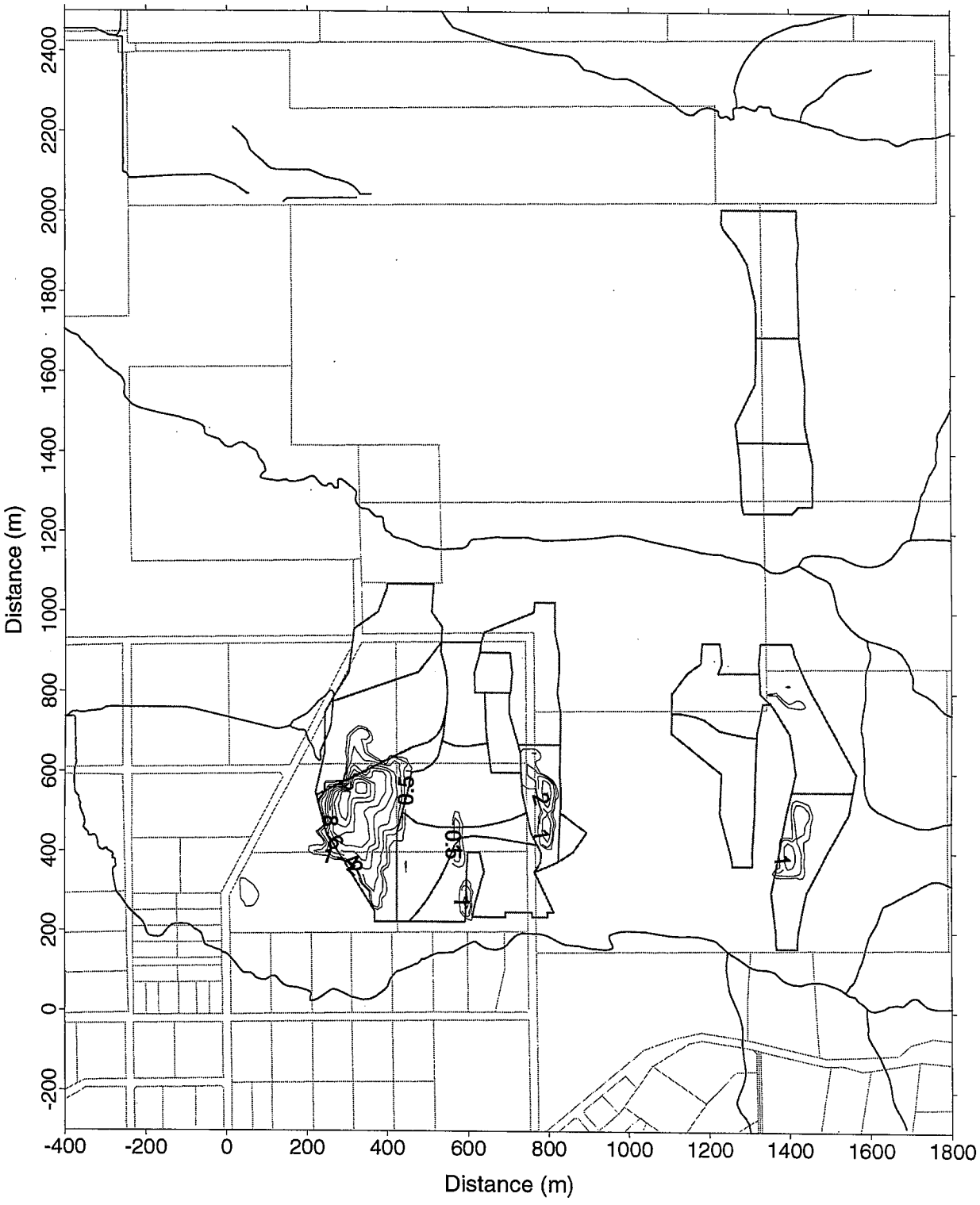
figure36.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 10

Figure 37

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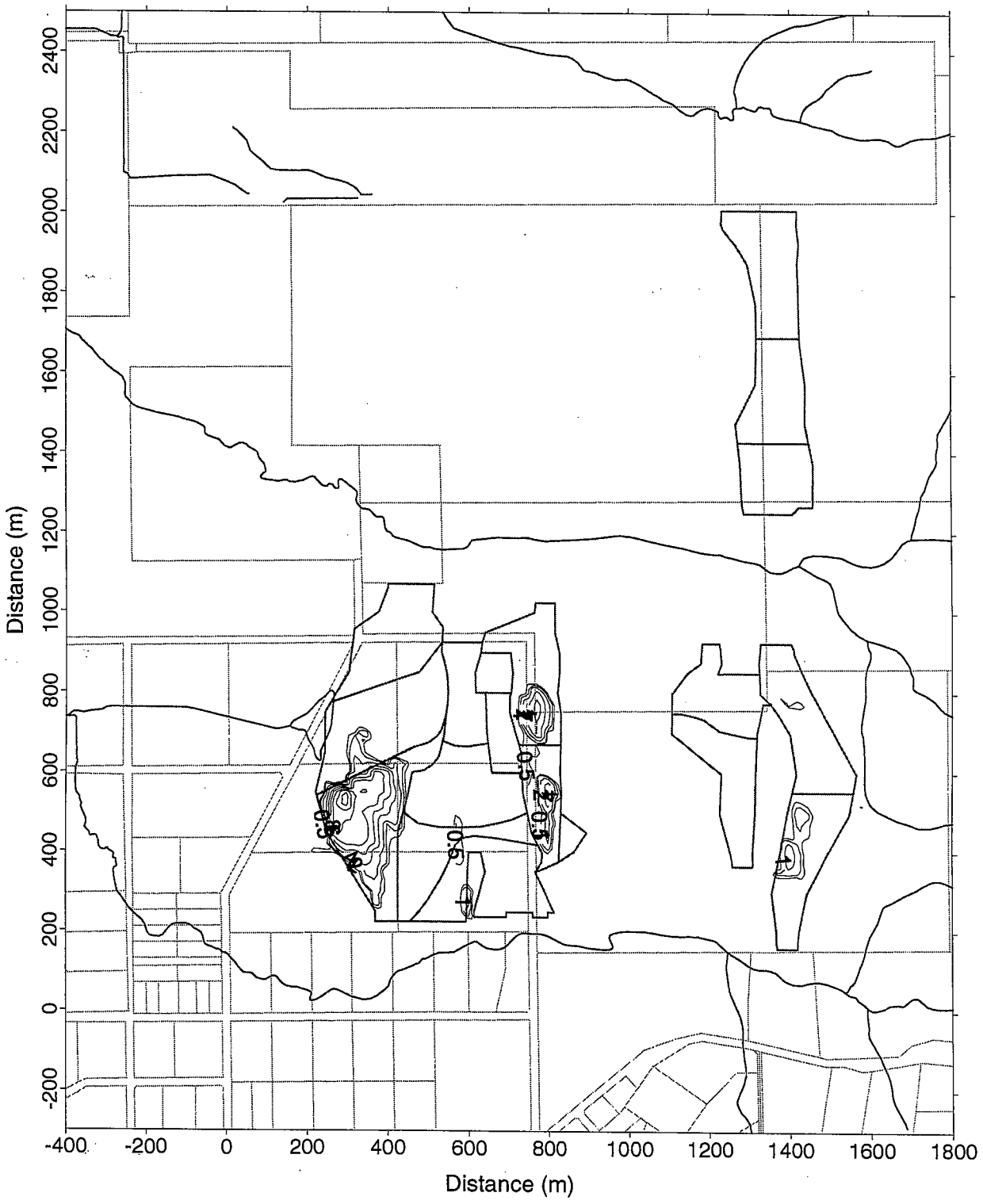
figure37.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 11

Figure 38

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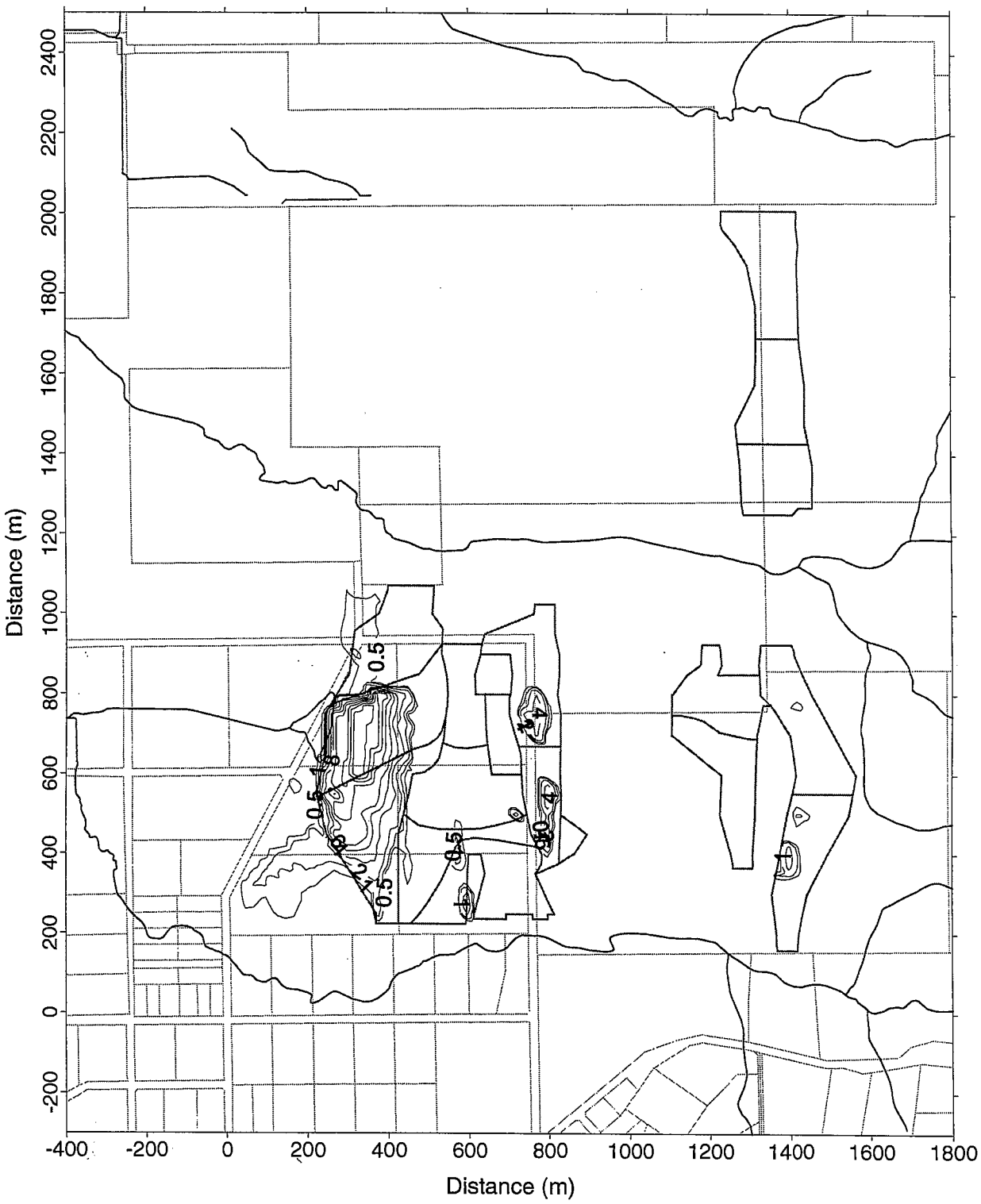
figure38.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 12

Figure 39

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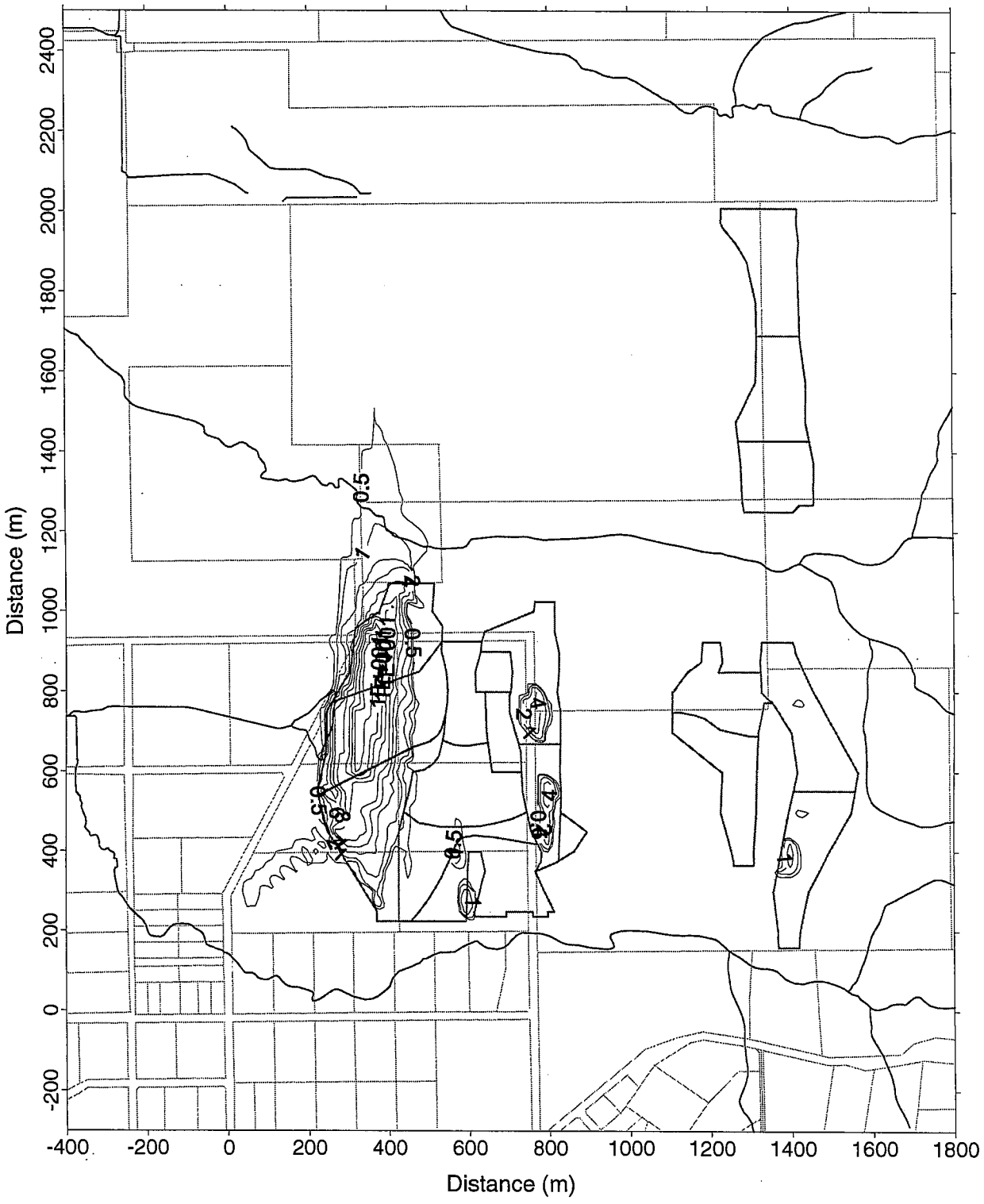
figure39.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 13

Figure 40

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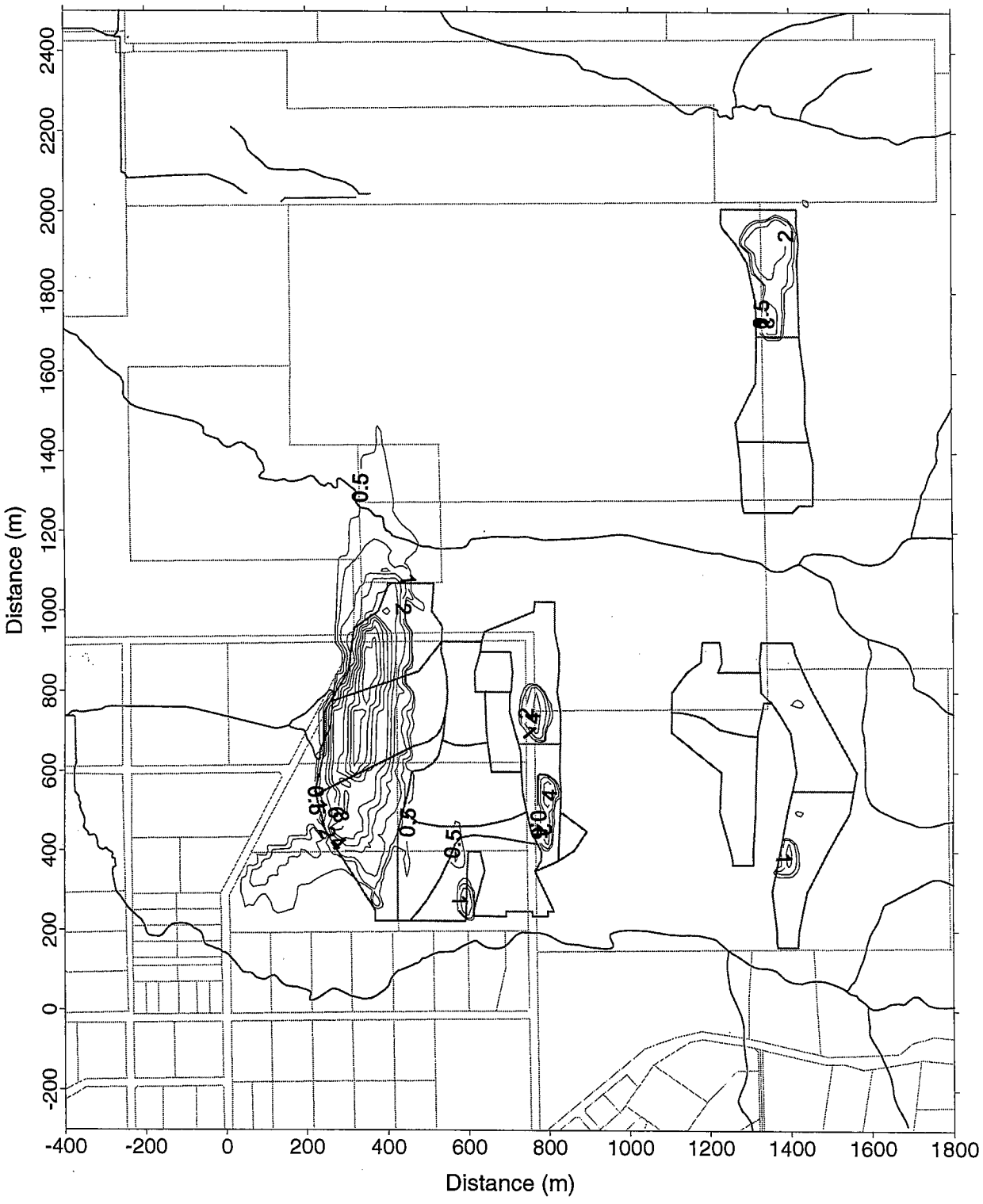
figure40.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Iluka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 14

Figure 41

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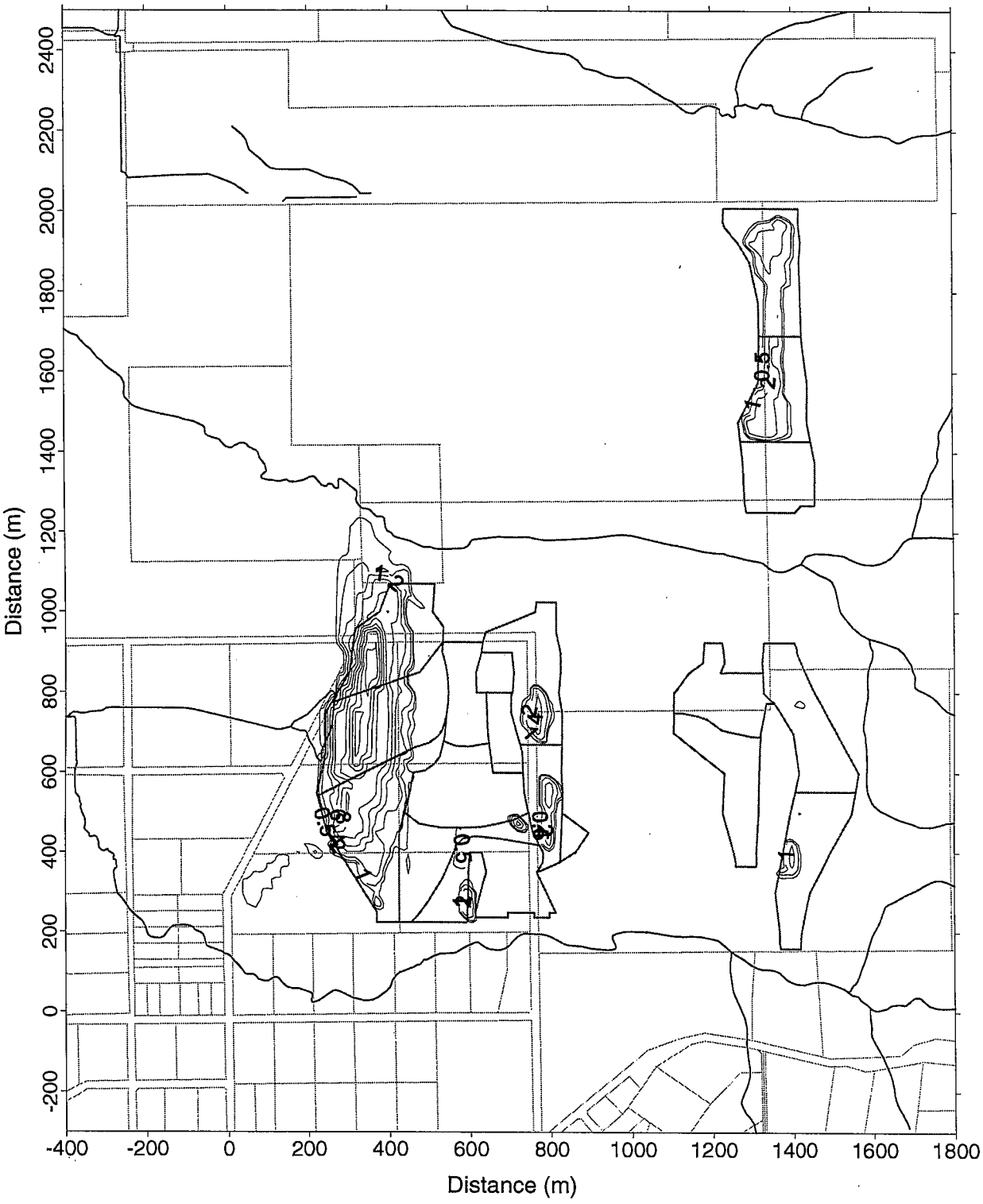
figure41.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 15

Figure 42

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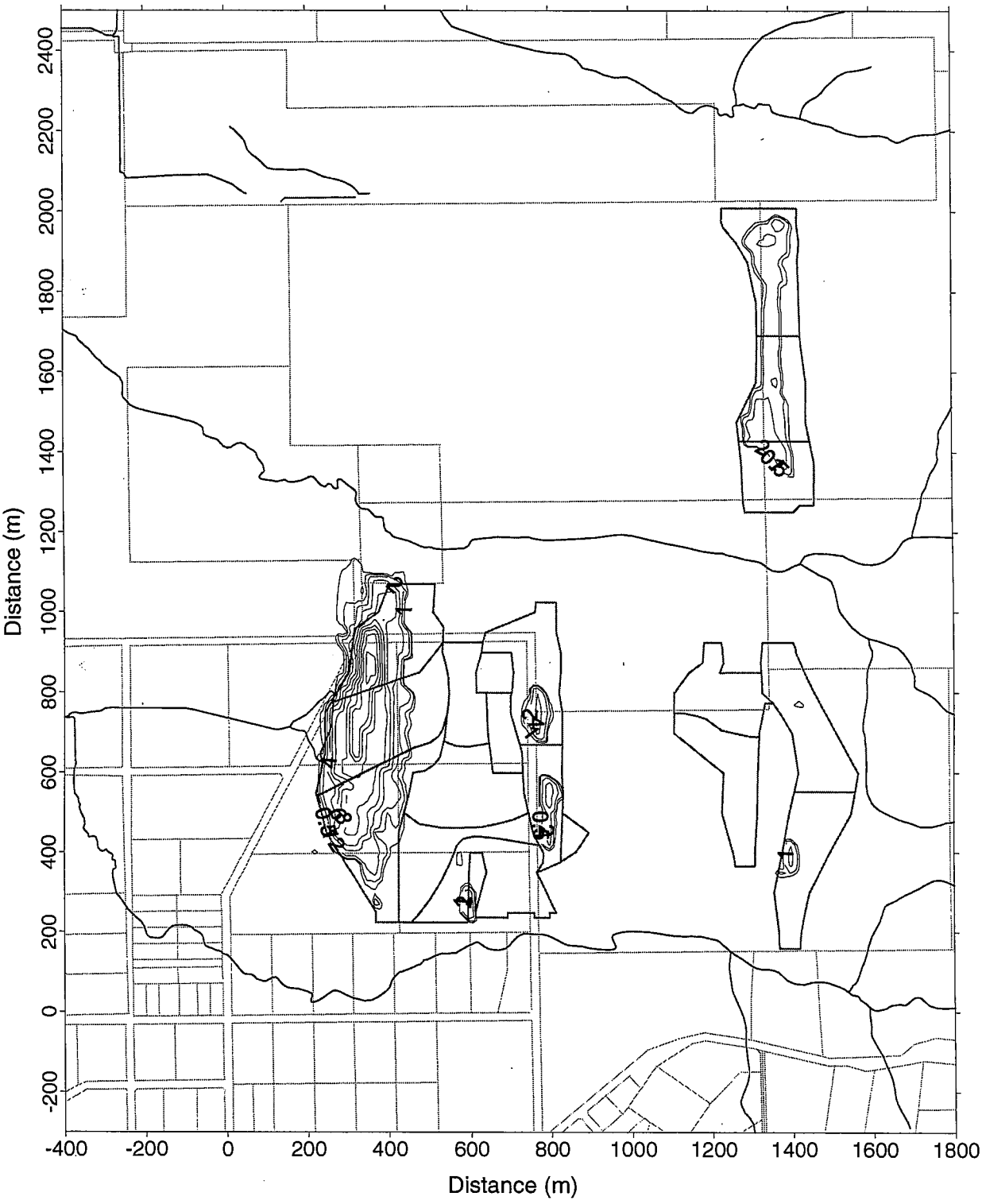
figure42.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
END OF MINING BLOCK 16

Figure 43

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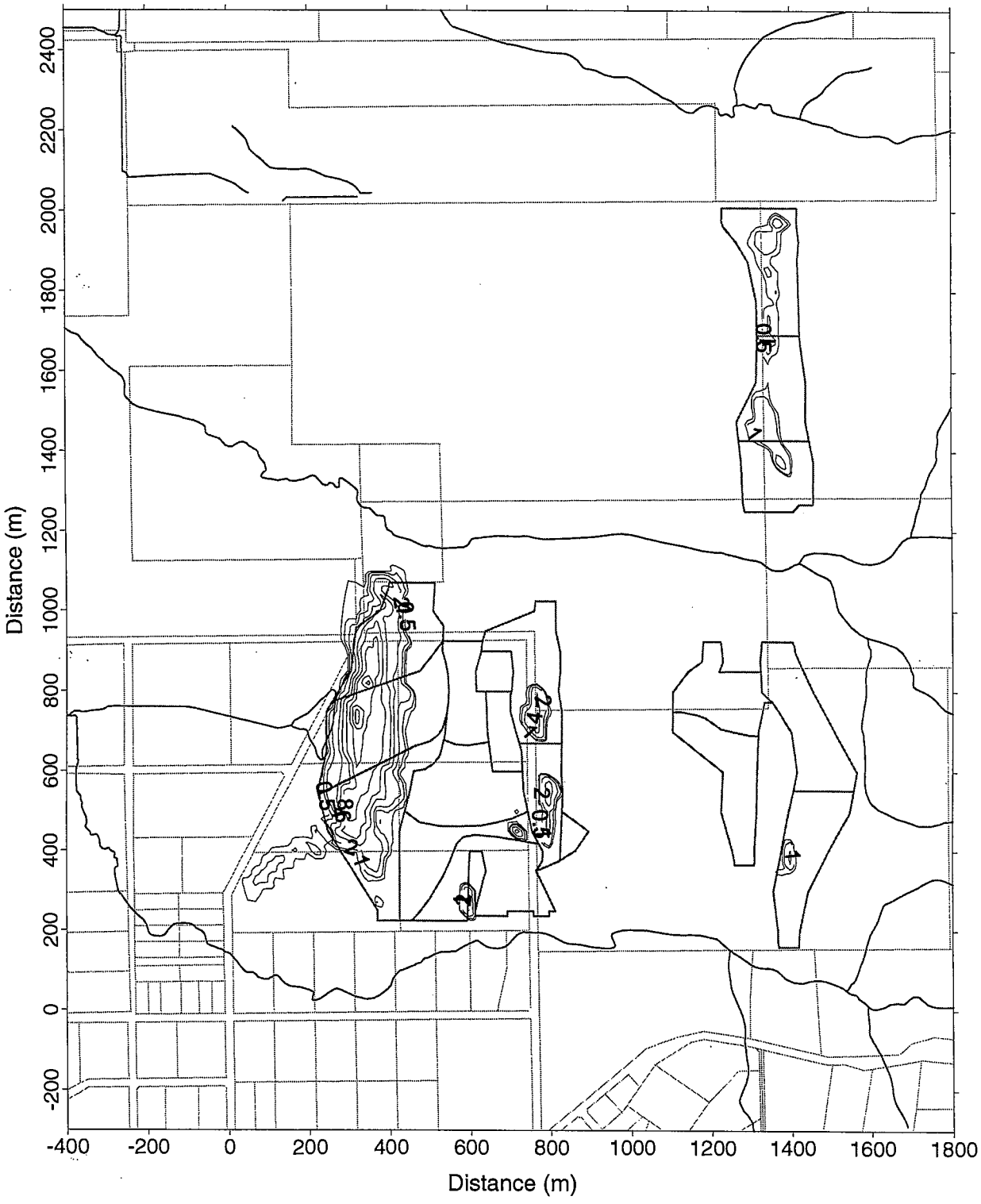
figure43.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
1 YEAR AFTER END OF MINING

Figure 44

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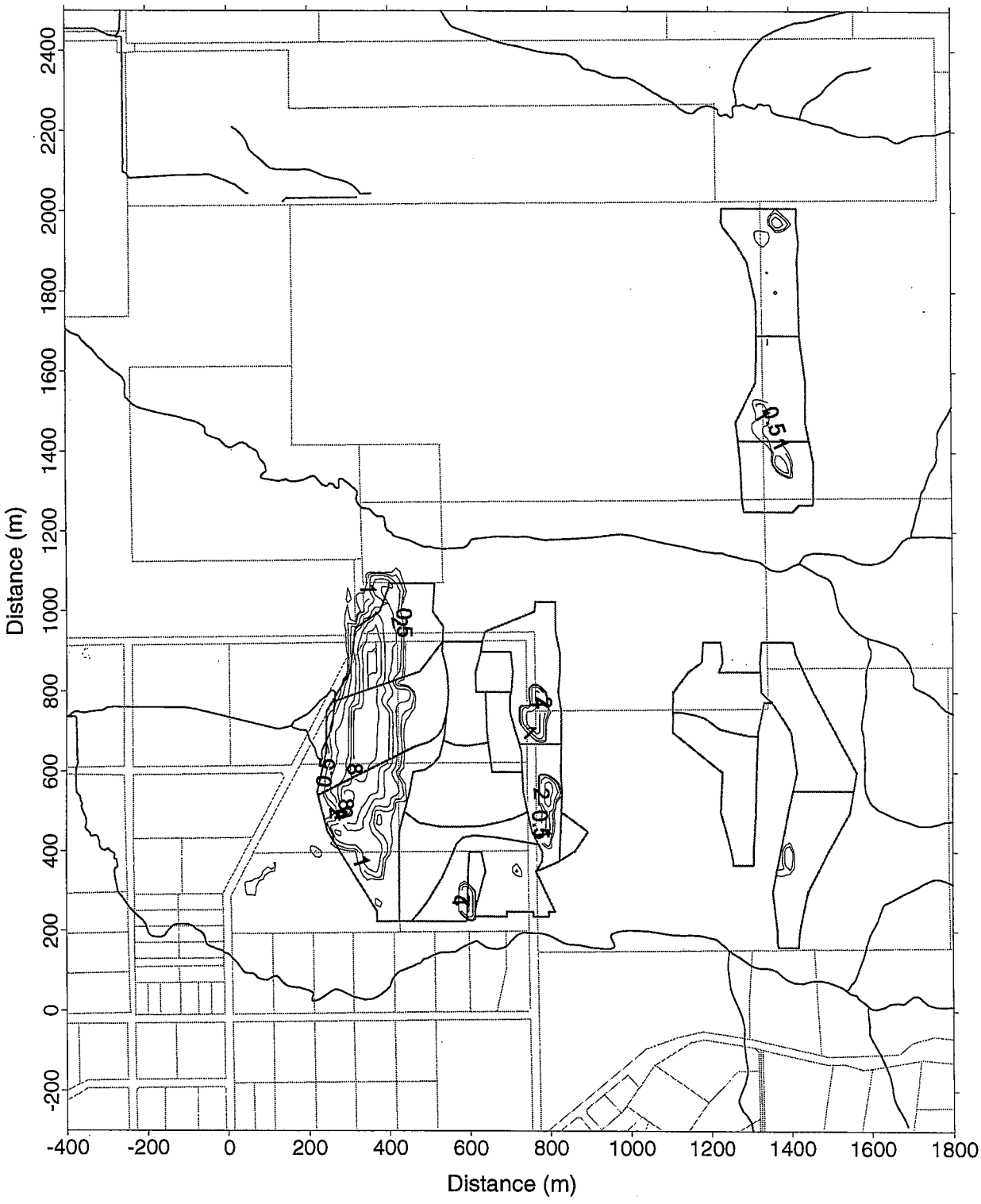
figure44.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
2 YEARS AFTER END OF MINING

Figure 45

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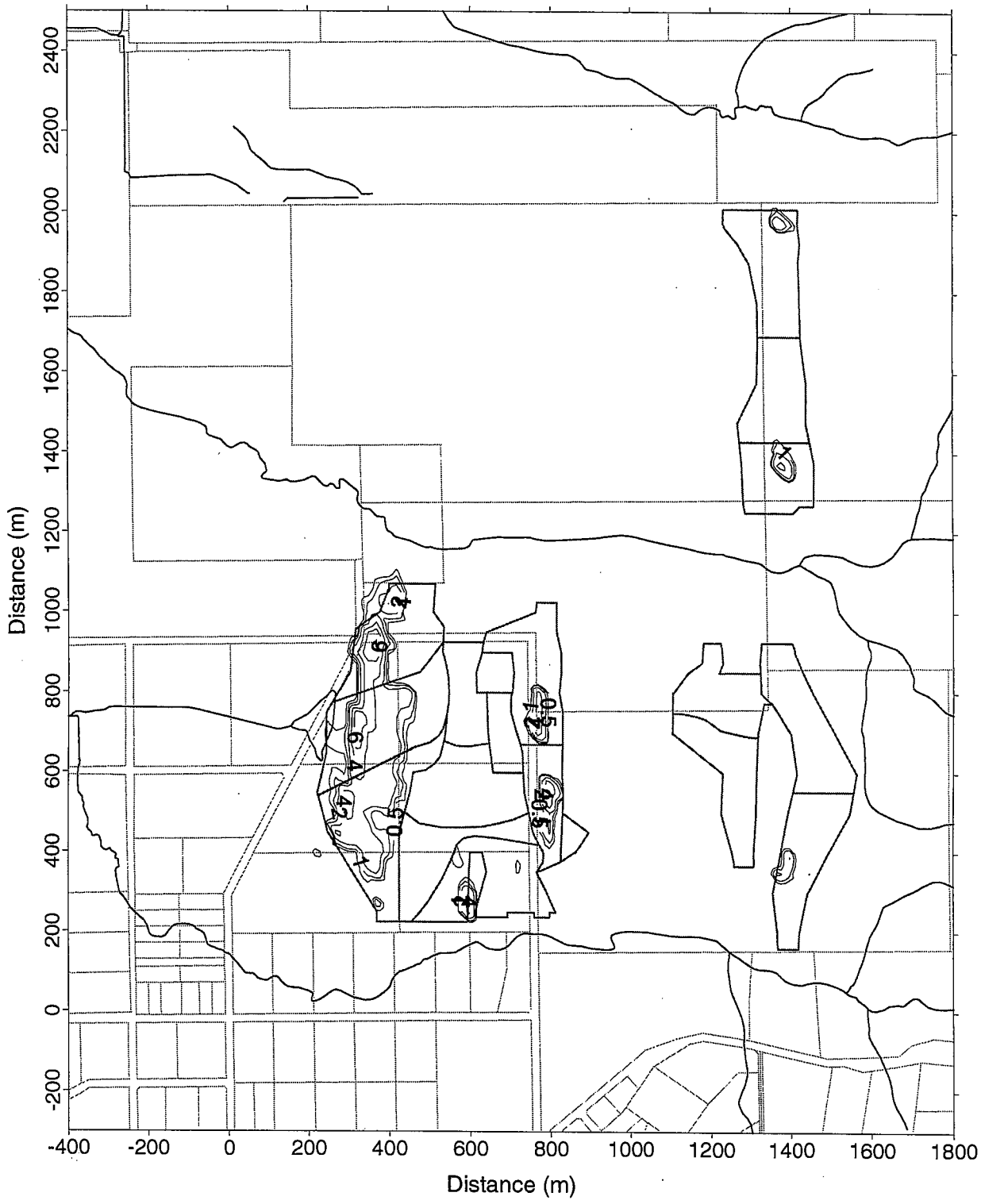
figure45.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
5 YEARS AFTER END OF MINING

Figure 46

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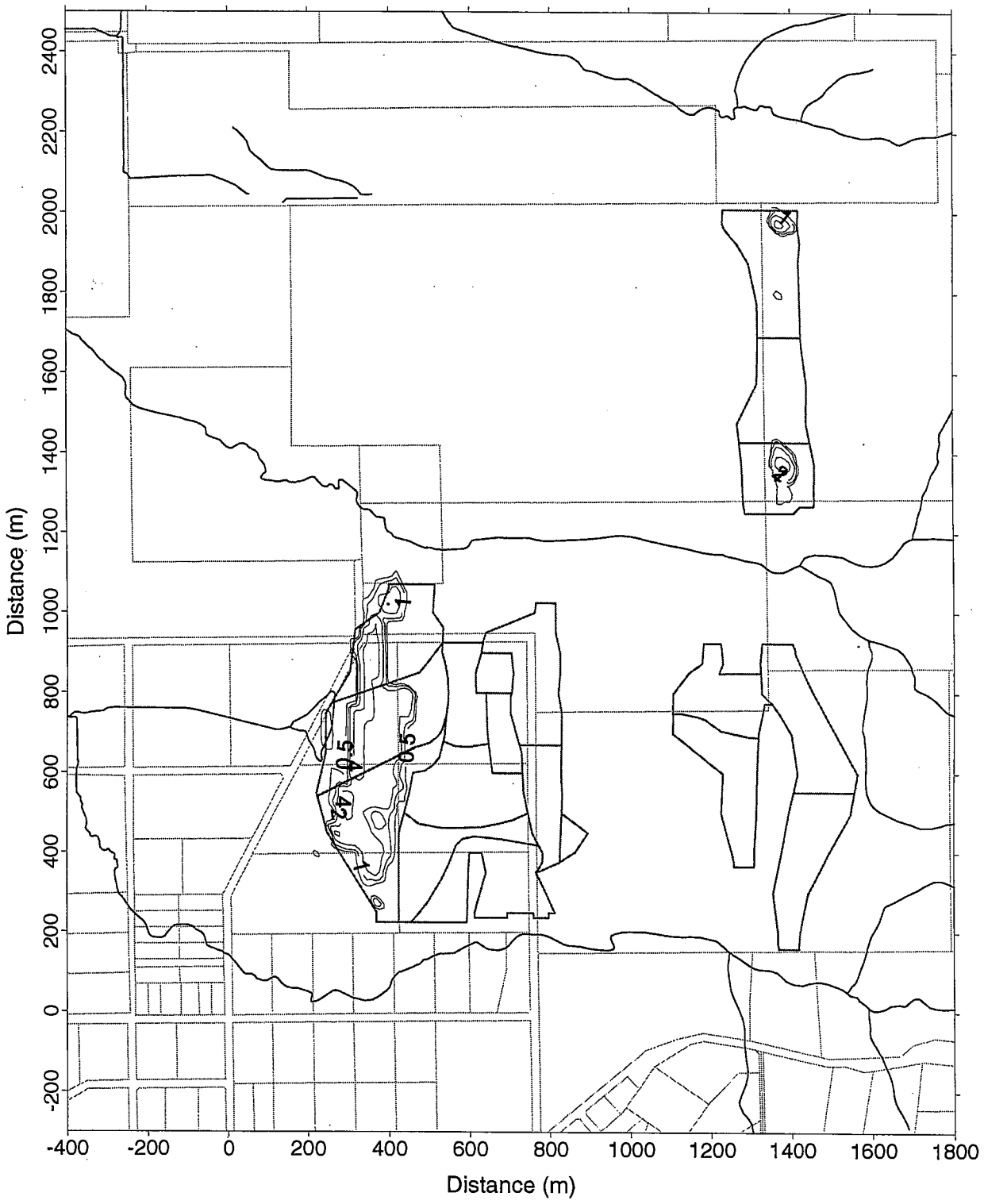
figure46.srf



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Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
10 YEARS AFTER END OF MINING

Figure 47

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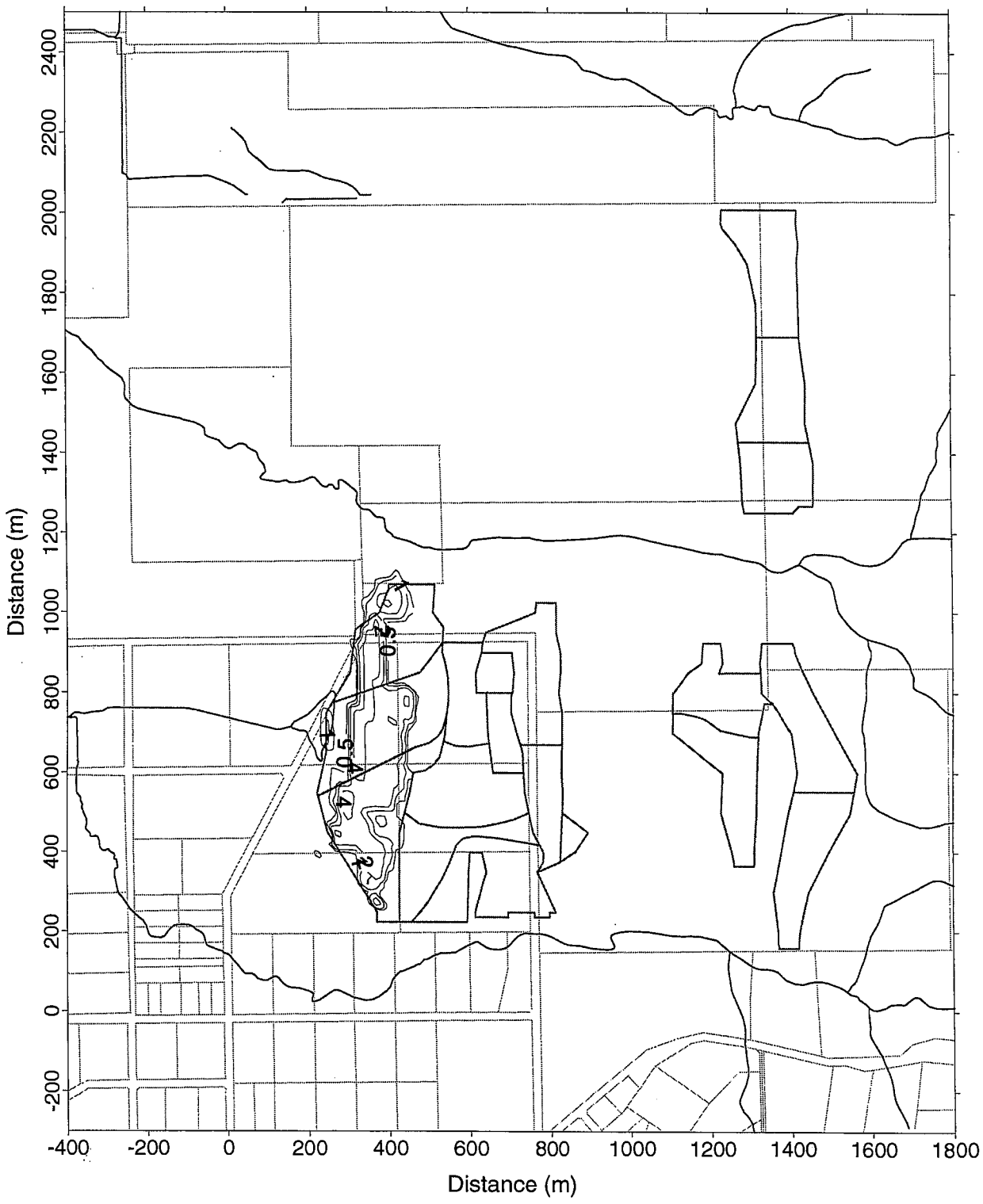
figure47.srf



Job No.	44047-021-562	
Prep. By	ECPL	24 Jun '02
Chk'd By	IGB	24 Jun '02
Revision No.		0

Illuka Resource Limited
WAROONA DEPOSIT : IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

SIMULATED DRAWDOWN (m)
20 YEARS AFTER END OF MINING

Figure 48

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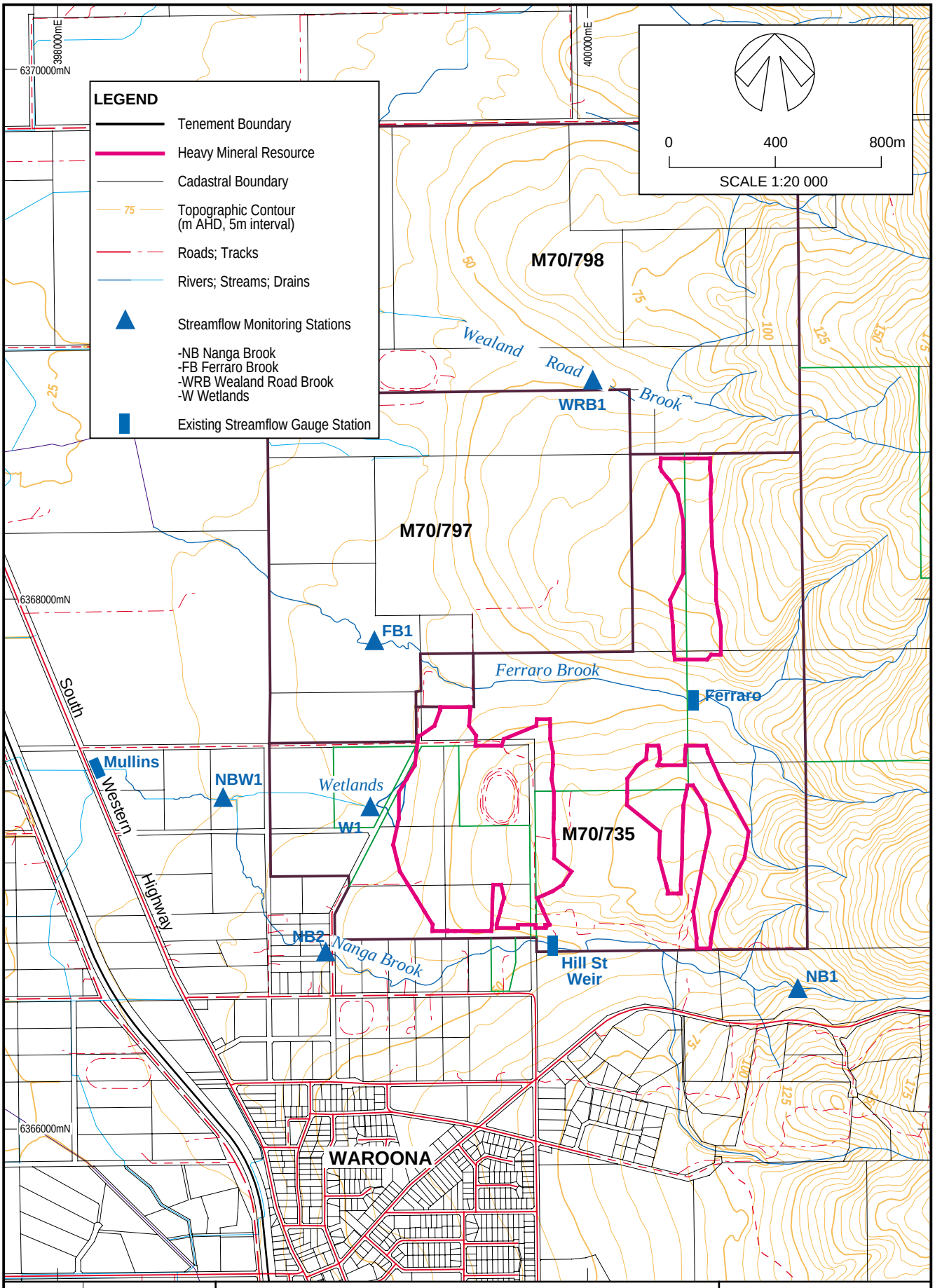
figure48.srf



Job No.	44047-021-562	
Prep. By	JM	12 Mar 02
Chk'd By	IGB	12 Mar 02
Revision No.		0

Iluka Resources Limited
WAROONA DEPOSIT - IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES

PROPOSED STREAMFLOW MONITORING SITES

Figure 49

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Tue 01 Jun 04

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Appendix A
Groundwater Well Licence No. 99260 (exploration)

WATER AND RIVERS
COMMISSION

YOUR REF
OUR REF SW7255
ENQUIRIES Henry Sieradzki
DISTRICT TEL 9721 0666

N. Fantera

Iluka Resources Limited
PO Box 96
Capel WA 6271

Re: Groundwater Well Licence No. 99260
Rights in Water and Irrigation Act 1914

ML70/798 Hall Rd, M70/797 Wealand Rd and M70/735 Peel Rd, Waroona

The Water and Rivers Commission has approved your application for groundwater exploration and test pumping on the above properties. As per your application, exploration and test pumping is limited to the Superficial and Leederville formations.

Groundwater Well Licence No. 99260 has been issued and is enclosed. The licence is valid until 31 July 2000 or until you cease being the legal occupant of that property, whichever is the earlier. A timetable for your exploration program was not indicated on your application. Should an extension to the licence period be required please advise this office.

Your attention is drawn to the special terms and conditions contained within the licence, these must be complied with. Condition numbers A001, A015, C009 and C033 relate to bore construction, your drilling contractor should be made aware of these.

Any enquires relating to this licence should be directed to the Bunbury office of the Water and Rivers Commission on (08) 9721 0666.

Yours sincerely

Henry Sieradzki
Water Resource Officer
South West Region
31 July 2000

SOUTH WEST REGION
UNIT 2 LESCHENAULT QUAYS AUSTRAL PARADE BUNBURY WA 6230 PO BOX 261 BUNBURY WA 6231
TELEPHONE (08) 9721 0666 FACSIMILE (08) 9271 0600
E-MAIL ADDRESS correspondence@wrc.wa.gov.au
NATIONAL RELAY SERVICE (AUSTRALIAN COMMUNICATION EXCHANGE) 132 544
MANAGING AND PROTECTING WESTERN AUSTRALIA'S MOST VITAL RESOURCE
ABN 60 061 300 220

WATER AND RIVERS COMMISSION

GROUNDWATER WELL LICENCE No. 00099260

Issued under section 26D of the Rights in Water and Irrigation Act 1914.

Name and address of licensee	Iluka Resources Ltd PO Box 96 Capel 6271
Description of land on which wells are located	M70/798 Hall Rd, M70/797 Wealand Rd, M70/735 Peel Rd Waroona
Location of wells	As per your application received July 3rd, 2000
Things that may be done pursuant to this licence	Sink exploratory well
Purpose for which licence is issued	Sink exploratory bores and carry out test pumping
Licence Expiry	July 31st, 2001 The term of the licence may be extended by the Commission.

The licence is subject to the following terms, limitations and conditions

- That the casing or casings are equipped with centralisers not less than one per casing length and are inserted in a hole providing an annulus of not less than 30mm and that the annulus is pressure cement grouted from the top of the screen to the surface. (A001)
- That on completion of the exploratory drilling programme the licensee shall submit a hydrogeological assessment of the groundwater resource, prepared by a groundwater professional. (A013)

This licence is issued subject to and in accordance with the regulations relating to wells in Groundwater Areas proclaimed under the Act.

Given under my hand this 2nd day of August, 2000.

AUTHORISED OFFICER

Debbie Blake, A/Area Leader (North) Allocation & Protection

WATER AND RIVERS COMMISSION

GROUNDWATER WELL LICENCE No. 00099260

Issued under section 26D of the Rights in Water and Irrigation Act 1914.

Terms, limitations and conditions continued

- That should the bore be abandoned it shall be cemented off to the satisfaction of the Water and Rivers Commission within 30 days of being abandoned. (A015)
- The well must be constructed by a driller having a current class 2 water well drillers certificate issued by the Western Australian branch of the Australian Drilling Industry Association or other certification approved by the Water and Rivers Commission as equivalent. (C033)
- That bore construction is limited to the screening of one discrete aquifer interval per bore. (C009)
- That the licensee submit the particulars of completed borehole form to the Water and Rivers Commission's regional office in Bunbury by the end of pump testing . (S016)
- That 48 hours prior notice is given to the Water and Rivers Commission of the commencement date for drilling. (O001)
- A production licence may not necessarily be issued at the conclusion of the exploratory programme authorised by gwl 99260. (O154)

End of Licence Conditions

This licence is issued subject to and in accordance with the regulations relating to wells in Groundwater Areas proclaimed under the Act.

Given under my hand this 2nd day of August, 2000.

AUTHORISED OFFICER

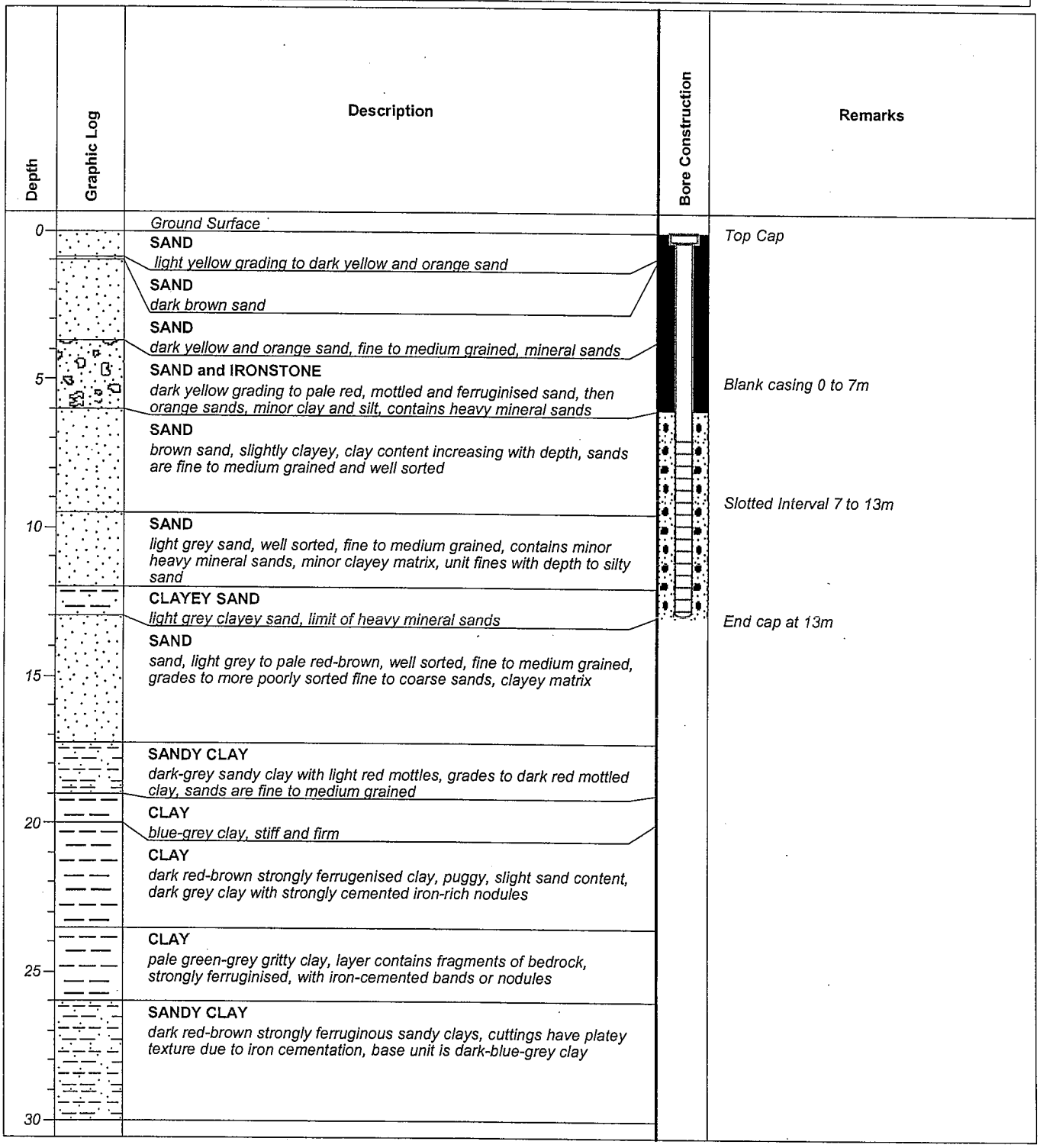
Debbie Blake, A/Area Leader (North) Allocation & Protection

Appendix B
Groundwater Exploration Bores - Completion Diagrams

PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 13m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Existing Monitoring Bore
DRILLING METHOD Existing Monitoring Bore

COORDINATES NTH 6367270 mN
COORDINATES EAST 400027 mE
R.L. COLLAR 70.58 mAHD
STATIC WATER LEV DRY
TOTAL DEPTH 13m
DATE MEASURED 31/5/01
BORE STATUS Multipiezometer Bore

BOREHOLE W7



JOB No 44047-021-071
DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

LOGGED BY IGB
DRAWN BY TJS
CHECKED BY IGB

URS
Dames & Moore
Woodward Clyde

PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 3.9m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Existing monitoring bore
DRILLING METHOD Existing monitoring bore

COORDINATES NTH 6366765 mN
COORDINATES EAST 399804 mE
R.L. COLLAR 54.19m AHD
STATIC WATER LEV 2.17
TOTAL DEPTH 30m
DATE MEASURED 31/5/01
BORE STATUS Multipiezometer

BOREHOLE W9

Depth	Graphic Log	Description	Bore Construction	Remarks
0		*Ground Surface*		
		SANDS and CLAY *grey sands and clay, clays are yellow-brown*		*Top Cap* *0-1m Blank Casing*
		SANDS and CLAY *yellow sands, very fine with clay matrix*		*1 to 3.9m Slotted Interval*
		IRONSTONE and CLAY *red-brown clay and cemented ironstone, predominatly ironstone*		
		CLAY *light grey-blue, stiff and firm, minor qtz. sand, fine grained, contains heavy mineral sands*		*3.9m End Cap*
5		**CLAYEY SAND** *very poorly sorted, light blue-grey, sands are fine to coarse grained, feldspathic, minor pebble fraction*		
		CLAY *blue-grey, stiff and firm, minor sand - typically fine grained*		
10		**SANDS and CLAYEY SANDS** *yellow grading to dark red-brown ferruginous sands and clayey sands, granitic with feldspars and ferro-mag minerals*		
		SAND *light yellow-green sands, poorly sorted up to coarse grained*		
		CLAY *dark blue-grey, firm*		
		CLAYEY SANDS *dark red, poorly sorted*		
15		**SANDY CLAY** *blue-grey, sand poorly sorted*		

JOB No 44047-021-071
DRILLING COMPANY Existing Monitoring Bore
DRILLER

LOGGED BY IGB
DRAWN BY WSM
CHECKED BY IGB

URS
Dames & Moore
Woodward Clyde

PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 3.9m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Existing monitoring bore
DRILLING METHOD Existing monitoring bore

COORDINATES NTH 6366765 mN
COORDINATES EAST 399804 mE
R.L. COLLAR 54.19m AHD
STATIC WATER LEV 2.17
TOTAL DEPTH 30m
DATE MEASURED 31/5/01
BORE STATUS Multipiezometer

BOREHOLE W9

Depth	Graphic Log	Description	Bore Construction	Remarks
		SANDY CLAY *blue-grey, sand poorly sorted*		
		SANDY CLAY *dark red mottled sandy clay*		
		SANDY CLAY *dark brown-green-grey, sandy clay*		
		CLAYEY SAND *dark red, ferruginous, fine to coarse grained, poorly sorted*		
		SANDY CLAY *dark brown-green-grey sandy clays, hard and indurated beds present within core cutting*		
20		**CLAY** *blue-grey clays*		
		SANDS and CLAYS *dark green-grey-brown sands, clays, poorly sorted with numerous pebbles of bedrock variably weathered of granitic and gneissic origin*		
25		**CLAY** *dark blue-grey*		
		SANDS and CLAY *grey-green, well sorted, sands are fine to medium grained*		
		CLAY *dark brown to dark-grey clay, numerous hard bedded platey cores, darkly ferrugenised with relic texture*		
		CLAY *dark brown clay and weathered ferruginous sandy clay*		
30				

JOB No 44047-021-071
DRILLING COMPANY Existing Monitoring Bore
DRILLER

LOGGED BY IGB
DRAWN BY WSM
CHECKED BY IGB

URS
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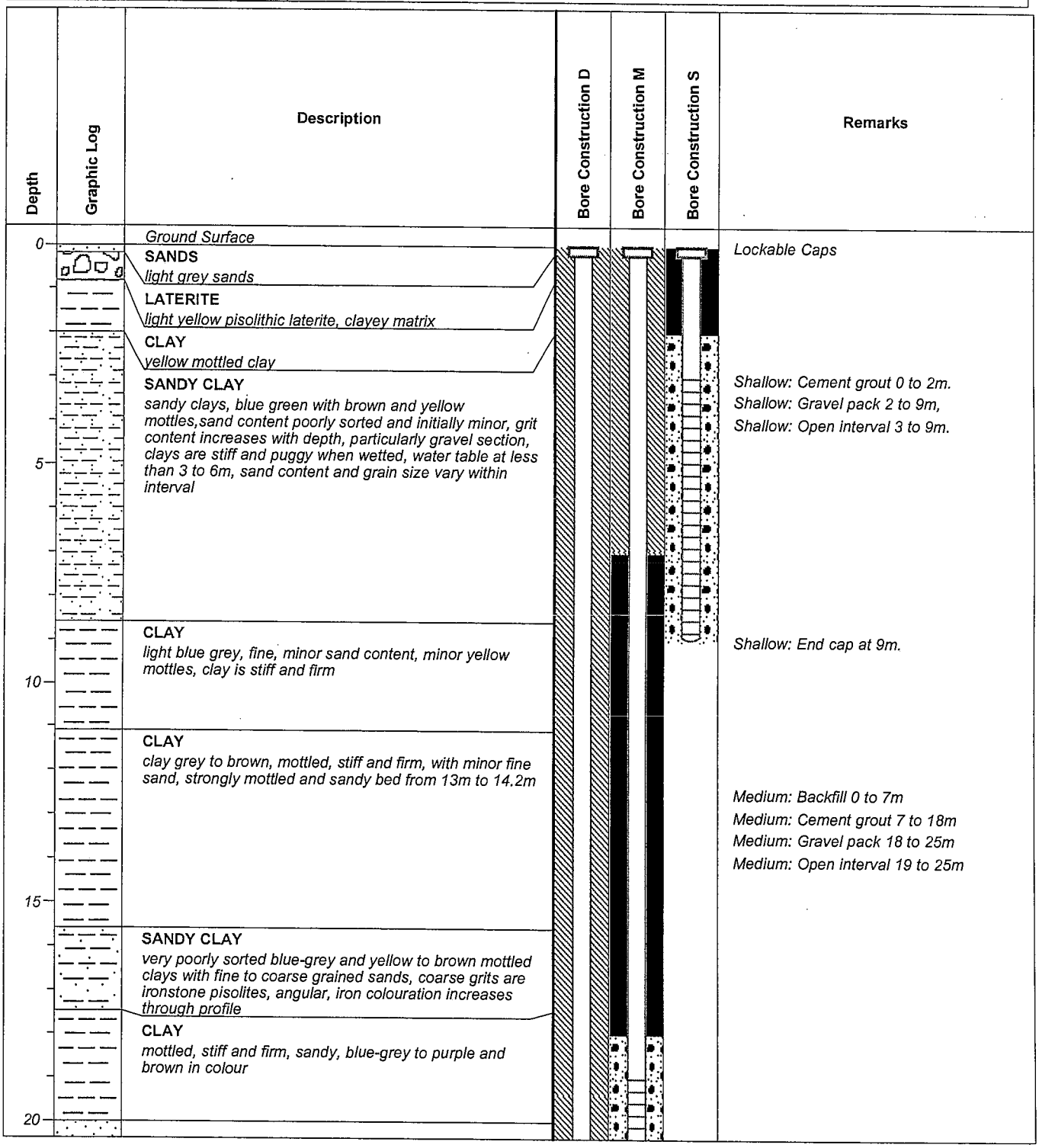
Woodward Clyde

PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 9m, 25m, 40m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Rig
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366875 mN
COORDINATES EAST 399216 mE
R.L. COLLAR 40.6 mAHD
STATIC WATER LEV 3.5m, 3.26m, 2.88m
TOTAL DEPTH 9m, 25m, 40m
DATE MEASURED 31/5/01
BORE STATUS Multipiezometer Bore

BOREHOLE W10



JOB No 44047-021-071
DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

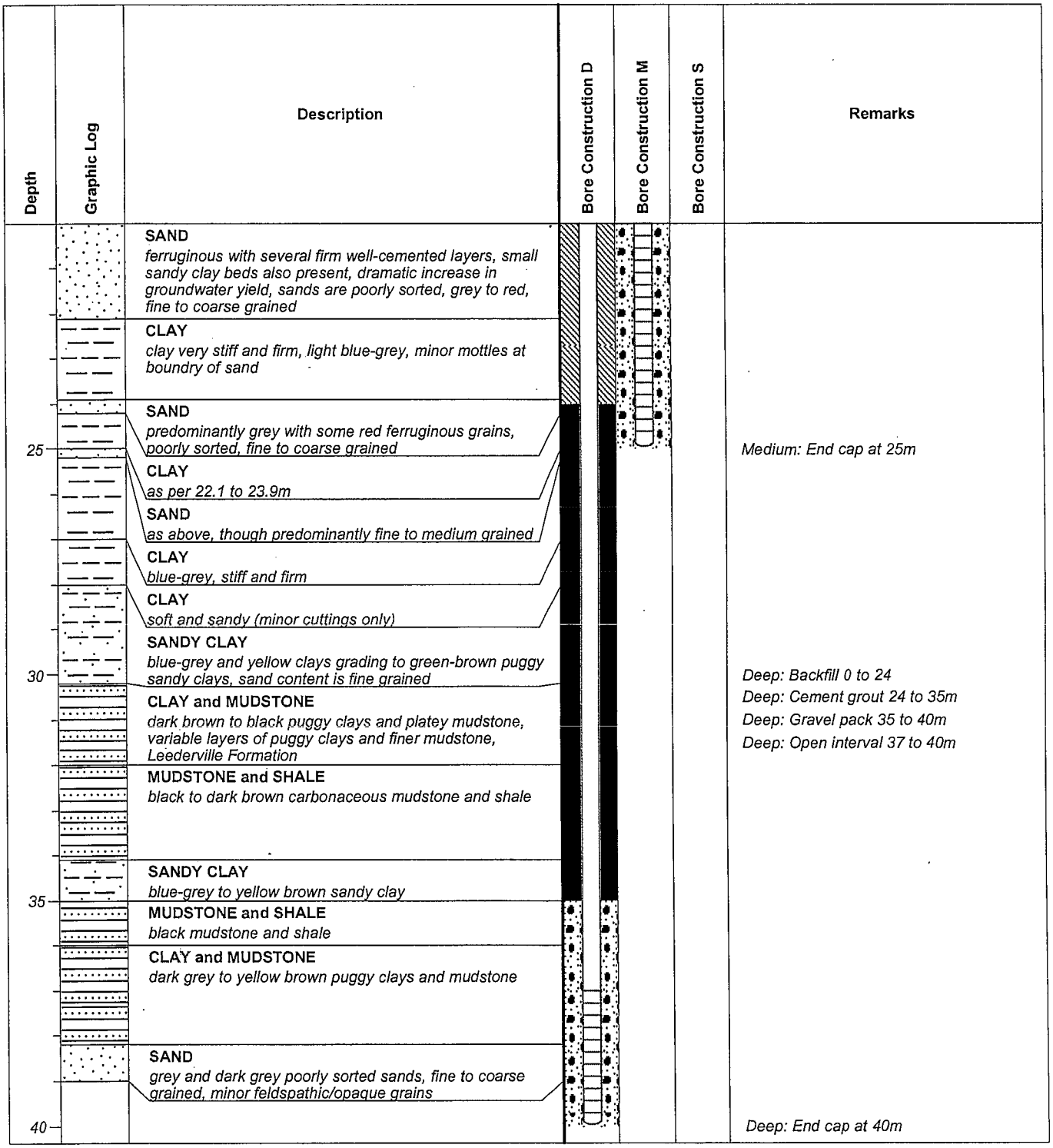
LOGGED BY IGB
DRAWN BY WSM
CHECKED BY IGB

URS
Dames & Moore
Woodward Clyde

PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 9m, 25m, 40m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Rig
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366875 mN
COORDINATES EAST 399216 mE
R.L. COLLAR 40.6 mAHD
STATIC WATER LEV 3.5m, 3.26m, 2.88m
TOTAL DEPTH 9m, 25m, 40m
DATE MEASURED 31/5/01
BORE STATUS Multipiezometer Bore

BOREHOLE W10



JOB No 44047-021-071
DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

LOGGED BY IGB
DRAWN BY WSM
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URS
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Woodward Clyde

PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 25, 40m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367100 mN
COORDINATES EAST 399074 mE
R.L. COLLAR 37.5m AHD
STATIC WATER LEV 1.63, 1.04m
DATE MEASURED 31/5/01
TOTAL DEPTH 25, 40m
BORE STATUS Multipiezometer Bore

BOREHOLE W12

Depth	Graphic Log	Description	Bore Construction W12D	Bore Construction W12S	Remarks
0		*Ground Surface*			*Lockable Caps*
		SAND *Light grey and brown clayey with thin topsoil*			
		SAND *Light brown clayey with hard laterised sandstone fragments*			
		CLAY *Light brown and grey gritty with hard laterised sandstone fragments*			*** NB bores have been labelled incorrectly* *Shallow (25m) is Labelled W12D* *Deep (40m) is Labelled W12S*
5		CLAY *Light brown and grey gritty clay.*			*W12D - Cement grout 0 to 11m*
		CLAY *Light grey to buff gritty with hard laterised sandstone fragments*			*W12S - Backfill 0 to 17m*
		CLAY *Light grey stiff gritty clay*			*W12D - Blank Casing 0 to 13m*
10					*W12S - Blank Casing 0 to 30m*
15					*W12D - Open interval 13 to 25m*
					W12D - Gravel Pack 11 to 25m
					W12S - Cement grout 17 to 28m
20					

JOB No 44047-021-071
DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

LOGGED BY 1992 log - old bore position
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BOREHOLE W12

PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 25, 40m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367100 mN
COORDINATES EAST 399074 mE
R.L. COLLAR 37.5m AHD
STATIC WATER LEV 1.63, 1.04m
DATE MEASURED 31/5/01
TOTAL DEPTH 25, 40m
BORE STATUS Multipiezometer Bore

Depth	Graphic Log	Description	Bore Construction W12D	Bore Construction W12S	Remarks
25					*W12D - End Cap at 25m*
30					*W12S - Gravel Pack 28 to 40m*
35					*W12S - Open interval 30 to 40m*
40					*W12S - End Cap at 40m*

JOB No 44047-021-071
DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

LOGGED BY 1992 log - old bore position
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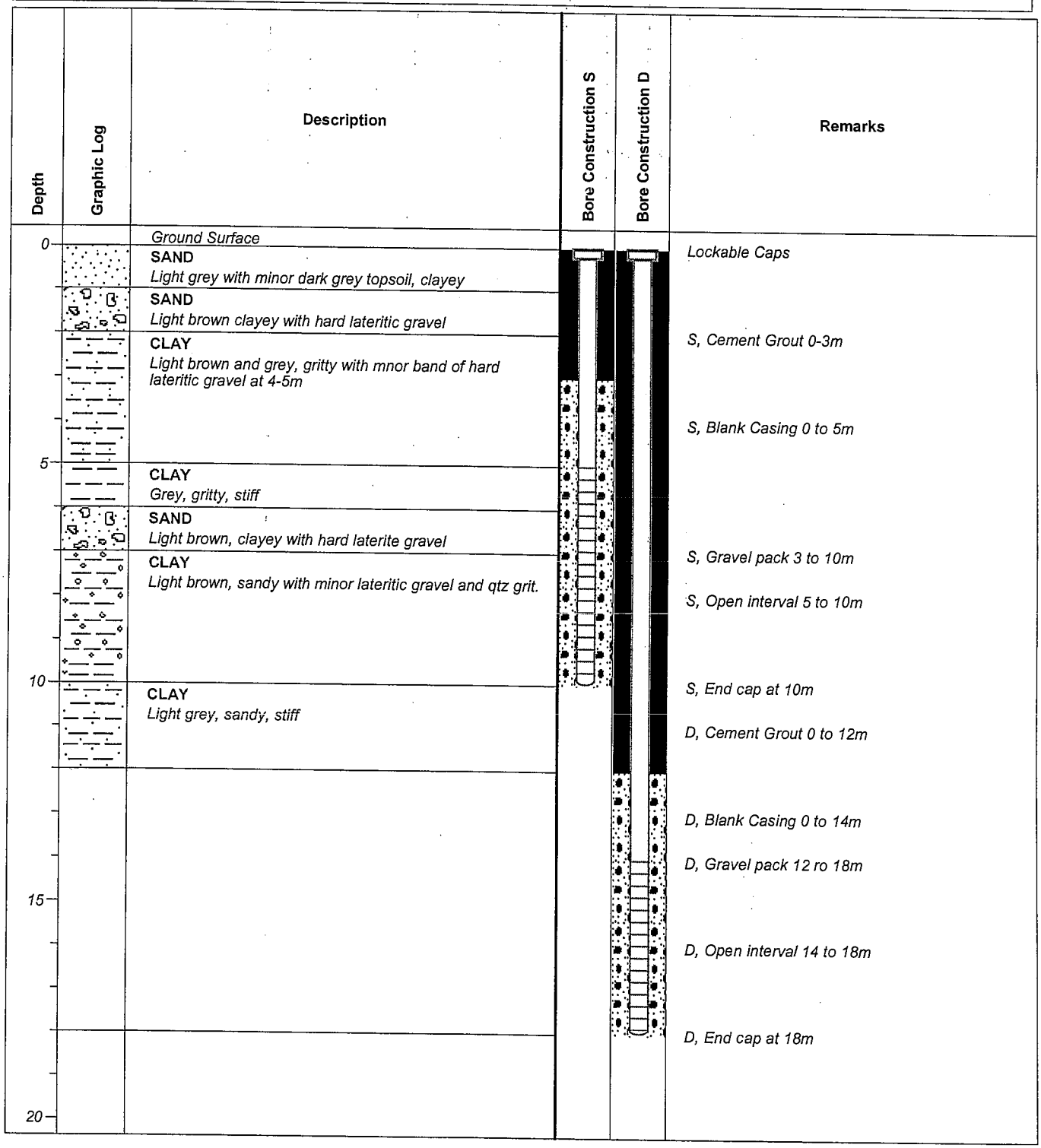
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 10m, 18m
MIN SCREEN DIAM 80 mm
MIN CASED DIAM 80 mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367796 mN
COORDINATES EAST 398966 mE
R.L. COLLAR 34.1 m AHD
STATIC WATER LEV 1.98m, 2.77m
DATE MEASURED 8/2/01
TOTAL DEPTH 10m,18m
BORE STATUS Multipiezometer Bores

BOREHOLE W13



JOB No 44047-021-071
DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

LOGGED BY 1992 log of existing hole
DRAWN BY SM
CHECKED BY TJS

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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 10m, 18m
MIN SCREEN DIAM 80 mm
MIN CASED DIAM 80 mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367796 mN
COORDINATES EAST 398966 mE
R.L. COLLAR 34.1 m AHD
STATIC WATER LEV 1.98m, 2.77m
DATE MEASURED 8/2/01
TOTAL DEPTH 10m,18m
BORE STATUS Multipiezometer Bores

BOREHOLE W13

Depth	Graphic Log	Description	Bore Construction S	Bore Construction D	Remarks
0		*Ground Surface*			
		SAND *Light grey with minor dark grey topsoil, clayey*			*Lockable Caps*
		SAND *Light brown clayey with hard lateritic gravel*			*S, Cement Grout 0-3m*
		CLAY *Light brown and grey, gritty with minor band of hard lateritic gravel at 4-5m*			*S, Blank Casing 0 to 5m*
5		**CLAY** *Grey, gritty, stiff*			
		SAND *Light brown, clayey with hard laterite gravel*			*S, Gravel pack 3 to 10m*
		CLAY *Light brown, sandy with minor lateritic gravel and qtz grit.*			*S, Open interval 5 to 10m*
10		**CLAY** *Light grey, sandy, stiff*			*S, End cap at 10m* *D, Cement Grout 0 to 12m*
					D, Blank Casing 0 to 14m *D, Gravel pack 12 ro 18m*
15					*D, Open interval 14 to 18m*
					D, End cap at 18m
20					

JOB No 44047-021-071
DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

LOGGED BY 1992 log of existing hole
DRAWN BY SM
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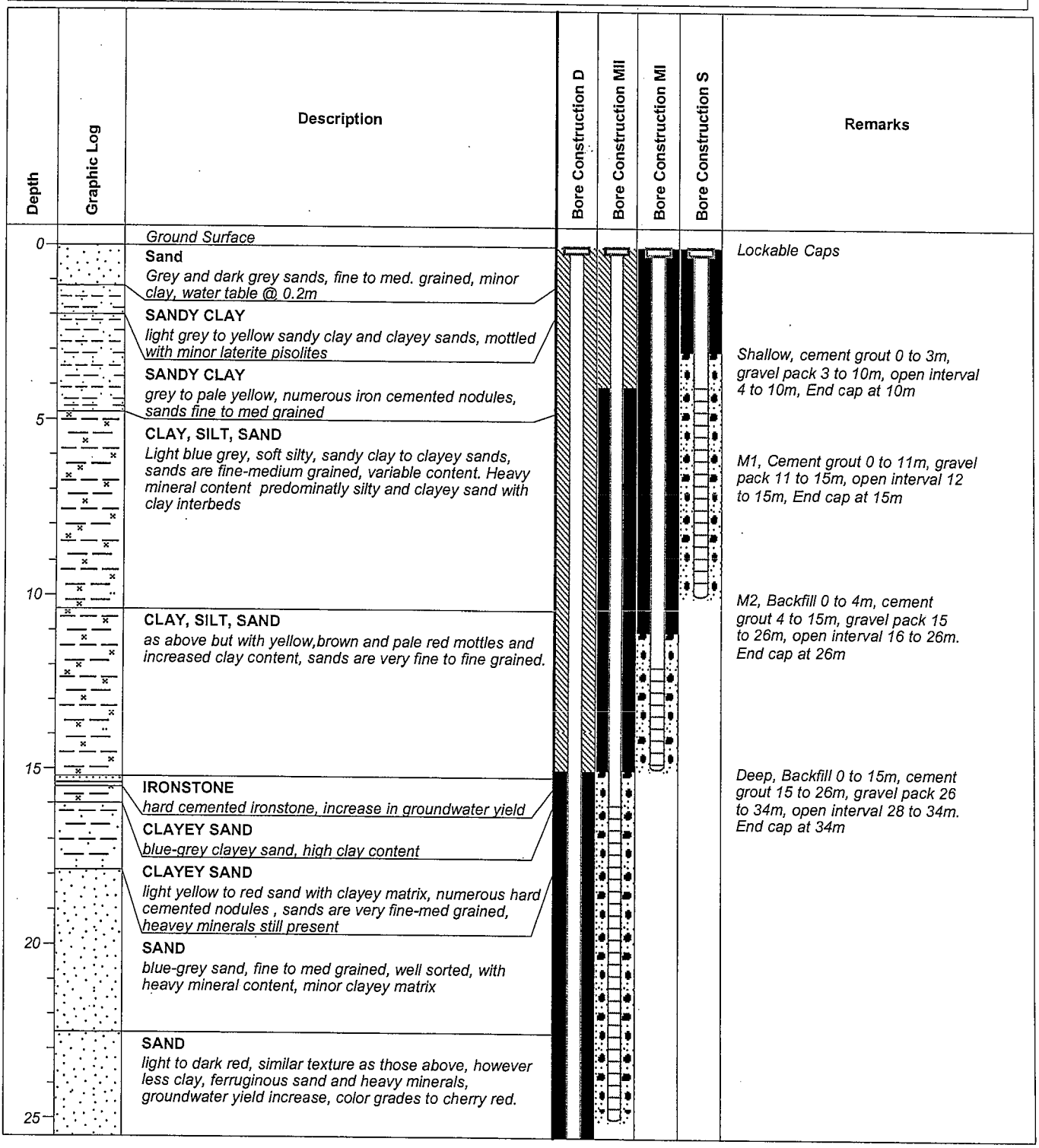
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 10, 15, 26, 34m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Rig
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367296 mN
COORDINATES EAST 399438 mE
R.L. COLLAR 38.4m AHD
TOTAL DEPTH 10, 15, 26, 34m
STATIC WATER LEV 1.04m, 1.00m, 0.96m, 1.08m
DATE MEASURED 31/5/01
BORE STATUS Multipiezometer Bore

BOREHOLE W15



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DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 10, 15, 26, 34m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Rig
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367296 mN
COORDINATES EAST 399438 mE
R.L. COLLAR 38.4m AHD
TOTAL DEPTH 10, 15, 26, 34m
STATIC WATER LEV 1.04m, 1.00m, 0.96m, 1.08m
DATE MEASURED 31/5/01
BORE STATUS Multipiezometer Bore

BOREHOLE W15

Depth	Graphic Log	Description	Bore Construction D	Bore Construction MII	Bore Construction MI	Bore Construction S	Remarks
		CLAY *blue-grey clay with red, yellow and brown mottles, grading to stiff mottled clay with dark grey and dark brown mottles*					
		SAND *Light green-grey sand, very poorly sorted, fine to coarse grained, minor clay, feldspathic*					
30		**MUDSTONE CLAY** *dark blue-grey micaceous mudstone/clay, firm bedded and platey cuttings*					
		SANDY CLAY *green-brown, puggy, hard mottles evident, grits are poorly sorted up to coarse grained*					
35		**MUDSTONE/SHALE** *black to dark brown mudstone/shale, carbonaceous, variably puggy and bedded, Leederville Formation*					
40							
45							
50							

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DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

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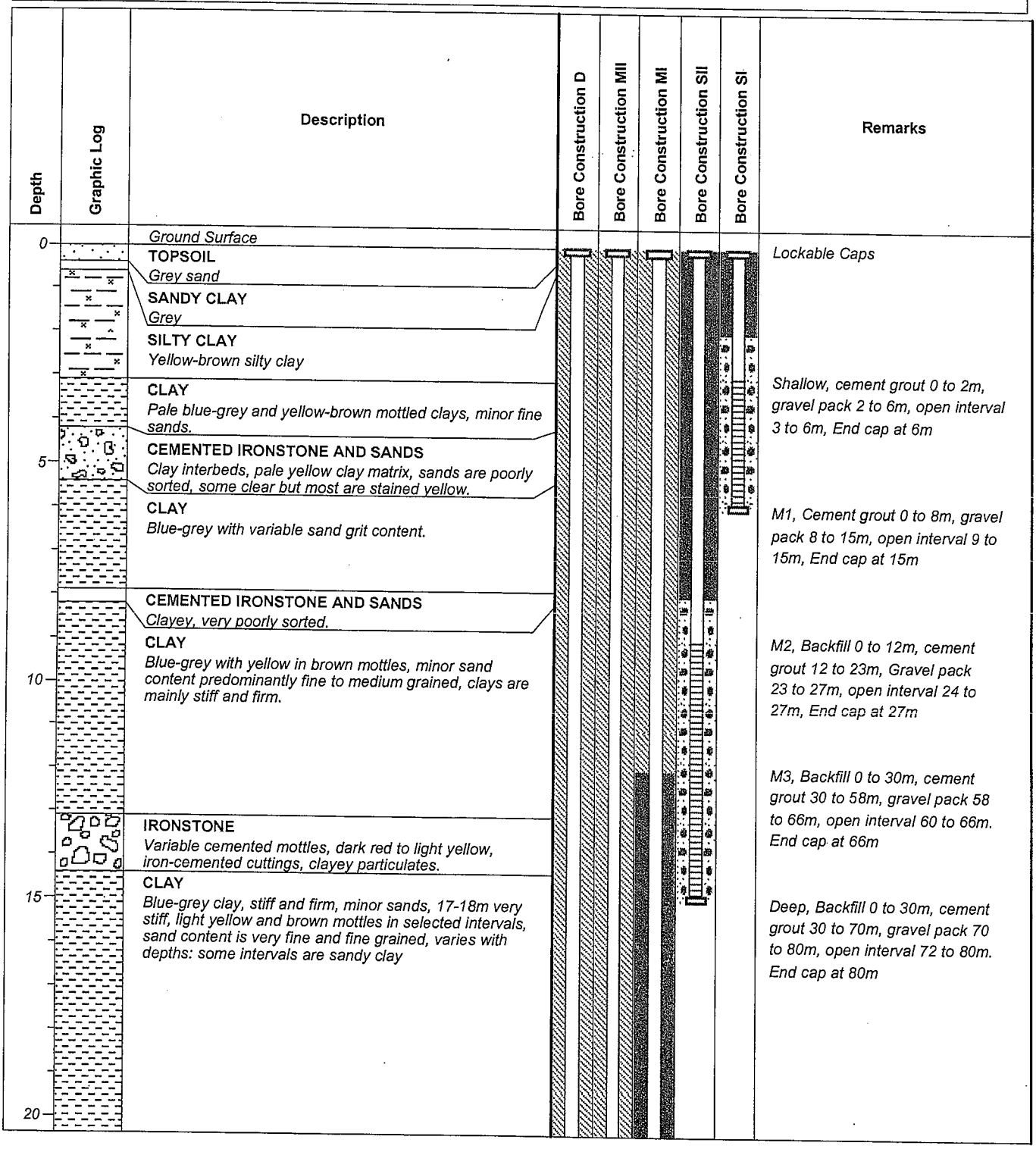
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 6,15,27,66 amd 80m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366890 mN
COORDINATES STH 399422 mE
R.L. COLLAR 43.5m AHD
STATIC WATER LEV 4.73, 4.97, 5.71, 12.42, 12.27m
DATE MEASURED 31/5/01
TOTAL DEPTH 6, 15, 27, 66 and 80m
BORE STATUS Multipiezometer Bore

BOREHOLE W16



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DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 6,15,27,66 amd 80m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366890 mN
COORDINATES STH 399422 mE
R.L. COLLAR 43.5m AHD
STATIC WATER LEV 4.73, 4.97, 5.71, 12.42, 12.27m
DATE MEASURED 31/5/01
TOTAL DEPTH 6, 15, 27, 66 and 80m
BORE STATUS Multipiezometer Bore

BOREHOLE W16

Depth	Graphic Log	Description	Bore Construction D	Bore Construction MII	Bore Construction MI	Bore Construction SII	Bore Construction SI	Remarks
		CLAY *Blue-grey clay, stiff and firm, minor sands, 17-18m very stiff, light yellow and brown mottles in selected intervals, sand content is very fine and fine grained, varies with depths: some intervals are sandy clay*						
		CLAY AND CLAYEY SANDS *Light red to yellow-brown - sands are very fine grained.*						
25		**SAND** *Light grey to red-brown fine to medium grained, numerous ferruginous grains and heavy mineral sands, dramatic increase in groundwater yields.*						
		CLAY *Light blue-grey, stiff and firm, minor red and brown mottles, minor sand.*						
30		**CLAYEY SAND** *Light yellow to yellow-green, very poorly sorted, fine to coarse grained and minor >2mm fraction, basal sands are more clay free.*						
		MUDSTONE *Dark grey and brown, minor green-brown lenses, variably puggy to firm.*						
35								
		SAND *Light grey medium to coarse grained, minor pebble fraction, minor opaque grains.*						
40								

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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 6,15,27,66 amd 80m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366890 mN
COORDINATES STH 399422 mE
R.L. COLLAR 43.5m AHD
STATIC WATER LEV 4.73, 4.97, 5.71, 12.42, 12.27m
DATE MEASURED 31/5/01
TOTAL DEPTH 6, 15, 27, 66 and 80m
BORE STATUS Multipiezometer Bore

BOREHOLE W16

Depth	Graphic Log	Description	Bore Construction D	Bore Construction MII	Bore Construction MI	Bore Construction SII	Bore Construction SI	Remarks
		MUDSTONE AND SHALE *Dark grey and brown, numerous firm and hard core samples.*						
		SANDY MUDSTONE *Dark grey, sandy mudstone, perhaps contains thin sand interbeds, sand medium grained, predominantly clear quartz, some orange stained, minor opaque grains.*						
45								
50								
55								
60								

JOB No 44047-021-071
DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 6,15,27,66 amd 80m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366890 mN
COORDINATES STH 399422 mE
R.L. COLLAR 43.5m AHD
STATIC WATER LEV 4.73, 4.97, 5.71, 12.42, 12.27m
DATE MEASURED 31/5/01
TOTAL DEPTH 6, 15, 27, 66 and 80m
BORE STATUS Multipiezometer Bore

BOREHOLE W16

Depth	Graphic Log	Description	Bore Construction D	Bore Construction MII	Bore Construction MI	Bore Construction SII	Bore Construction SI	Remarks
		CLAYEY SAND *Sands/gravels, very coarse grained quartz and minor opaque fraction, sands well sorted <3mm, clay matrix grey (mudstones). Becomes more gritty with depth (increasing sand content), clays become grey-brown with less mudstone content.*						
		CLAYEY SAND *Sands medium to coarse grained, moderate to well sorted, clays grey brown, clay content increasing with depth*						
65								
70		**SANDY CLAY** *Significant increase in clay content, sands medium to coarse grained as above, clays sticky khaki-brown.*						
		SANDY CLAY/CLAYEY SAND *Varies between clayey sand and sandy clay. Sands med-coarse grained as above, clays sticky khaki-brown as above.*						
75								
80								

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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 8m, 17m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366900 mN
COORDINATES EAST 399715 mE
R.L. COLLAR 50.8m AHD
STATIC WATER LEV 1.41m, 1.47m
DATE MEASURED 31/5/01
TOTAL DEPTH 8m, 17m
BORE STATUS Multipiezometer Bore

BOREHOLE W17

Depth	Graphic Log	Description	Bore Construction S	Bore Construction D	Remarks
0		*Ground Surface*			
		Clayey Soil *grey clayey soil*			*Lockable Caps*
		IRONSTONE *ironstone and pisolitic gravels in yellow brown clay matrix, mottled zone*			
		CLAY *yellow-brown mottled clay*			
		CLAY *light grey-blue, minor fine sand grits, moderately stiff and firm, light yellow and red mottles*			*S, cement 0 to 1m, gravel pack 1 to 8m, open interval 2 to 8m*
5		**SILTY SAND** *grey to blue grey silty sand, very fine to fine grained, soft minor clay interbeds, heavy mineral sand evident, water table less 6m*			
		CLAY *dark grey clay with white flecks, stiff and firm, sandy, gritty texture, heavy mineral sands*			*S, End cap at 8m*
		CLAY *dark grey to red-brown clays, coarse grits @ 8.1- 8.5m*			
10					*D, Backfill 0 to 1m, cement, 1 to 12 gravel pack 12 to 16m, open interval 14 to 17m*
		SANDY CLAY *poorly sorted, light green to grey clays with yellow and brown mottles*			
		CLAY *dark grey clay, firm and stiff*			
		SANDY CLAY *sandy clay, dark grey, poorly sorted, numerous opaque grains, typically fine to medium and coarse grained*			
15					

JOB No 44047-021-071
DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

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BOREHOLE W17

PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 8m, 17m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366900 mN
COORDINATES EAST 399715 mE
R.L. COLLAR 50.8m AHD
STATIC WATER LEV 1.41m, 1.47m
DATE MEASURED 31/5/01
TOTAL DEPTH 8m, 17m
BORE STATUS Multipiezometer Bore

Depth	Graphic Log	Description	Bore Construction S	Bore Construction D	Remarks
		SANDY CLAY *grey-green sandy clay, very poorly sorted, increased sand content from beds above, +2mm fraction present, base of Guildford Formation*			
		CLAY *dark grey, minor brown mottles, stiff, firm and dry, numerous hard, bedded platey small cores firm and indurated, mottling increases with depth - blue, dark grey and brown-red, cuttings typically hard and pastey*			*D, End cap at 17m*
20					
25					
30		*30m, End of Reconnaissance Hole*			

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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 10m, 15m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366851 mN
COORDINATES EAST 400508 mE
R.L. COLLAR 62.68 mAHD
STATIC WATER LEV 2.15m, 1.97m
DATE MEASURED 31/5/01
TOTAL DEPTH 10m, 15m
BORE STATUS Multipiezometer Bore

BOREHOLE W18

Depth	Graphic Log	Description	Bore Construction S	Bore Construction D	Remarks
0		*Ground Surface*			
		SAND *Red brown and yellow sand. Fine to medium grained and well sorted.*			*Lockable covers*
					S, Cement grout 0 to 2m.
		SILTY SANDS *Yellow silty sands and ironstone nodules. Sands are fine to medium grained. Heavy mineral content and ferruginised sands. Minor mottled clay beds.*			*S, 0 to 4m, blank casing*
5		**CLAY** *Light blue grey sandy clay / clayey sands grades to sandy clay. Very poorly sorted, with sands and ironstone pebbles up to +2mm*			*D, 0 to 11m, cement grout*
					D, 0 to 12m, blank casing
		CLAY *Blue and white clay grading to mottled yellow and red. Minor fine sands. Blue and white clay with yellow and red mottles or staining. Hard indurated nodules from 10-11m*			*S, Slotted interval 4 to 10m*
10					*S, End cap at 10m*
		SAND *Granite and feldspathic with pebbles of broken quartz. Yellow grey clayey matrix. Grades to weathered granite.*			*D, Slotted interval 12 to 15m*
		GRANITE *Weathered granite. Ferruginised and variably weathered granitic sands. Getting harder with depth.*			
15					*D, End cap at 15m*

JOB No 44047-021-071
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DRILLER Ted

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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd
TOTAL CASED DEPTH 2.0m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366833 mN
COORDINATES EAST 400753 mE
R.L. COLLAR 72.65 mAHD
STATIC WATER LEV 2.27m
TOTAL DEPTH 2.1m
DATE MEASURED 31/5/01
BORE STATUS Multipiezometer Bore

BOREHOLE W19

Depth	Graphic Log	Description	Bore Construction	Remarks
0		*Ground Surface*		
		SANDY CLAY *dark brown sandy clay, minor lateritic pisolites*		*Lockable cap* *0 to 0.5m cement grout, 0.5 to 2m*
		SANDY CLAY *yellow sandy clay*		*gravel pack 0.5 to 2m*
		GRANITIC SAND *coarse granitic sand, minor iron staining*		*1 to 2m open interval*
		End of hole 2.1m		*End cap at 2m*
5				

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DRILLER Ted

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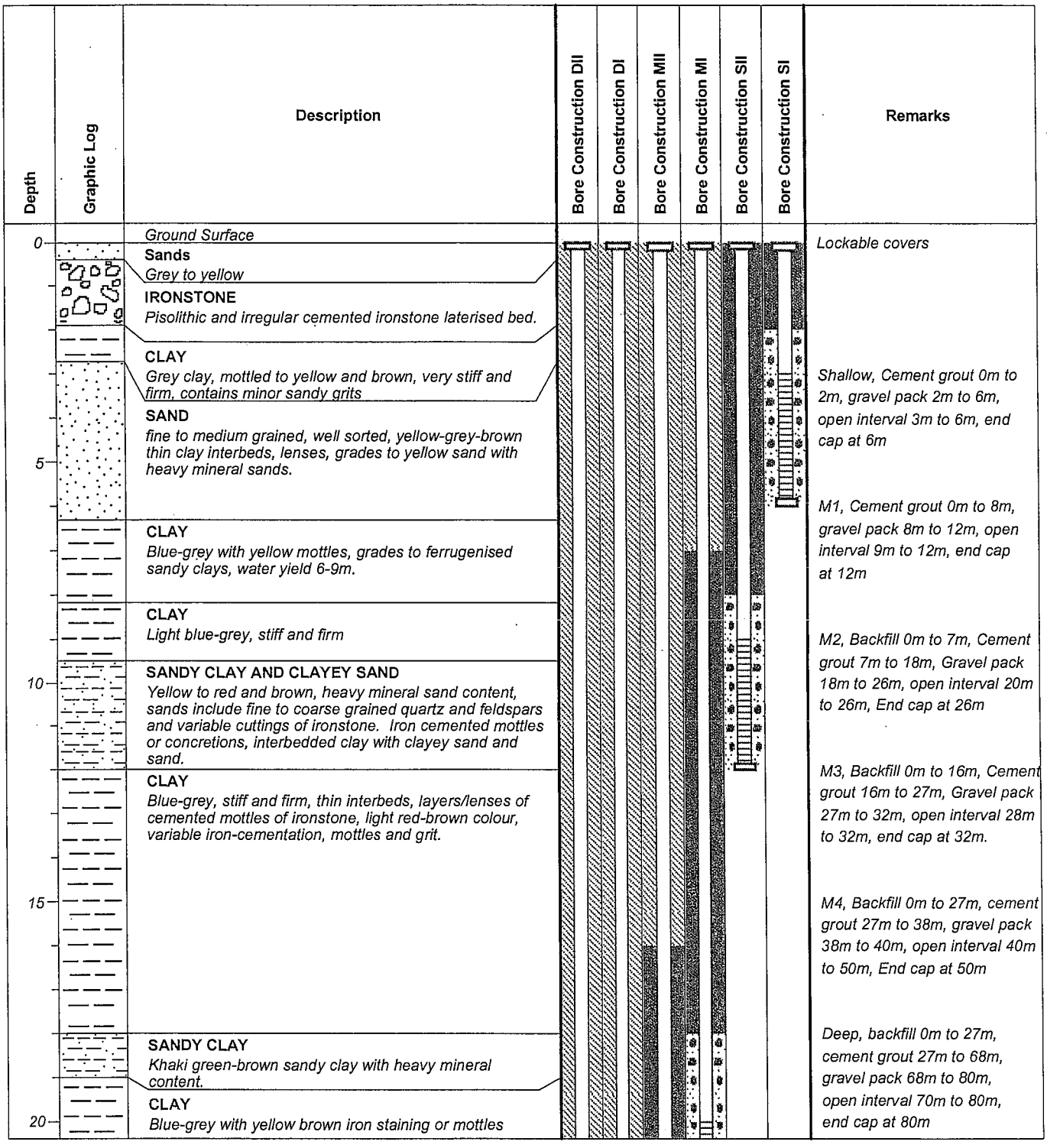
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 6m,12m,26m,32m,50m,80m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367768 mN
COORDINATES EAST 399595 mE
R.L. COLLAR 41m AHD
STATIC WATER LEV 4.04m,4.14m,4.18m,4.15m,3.65m,3.63m
TOTAL DEPTH 80m
DATE MEASURED 30/5/01
BORE STATUS Multipiezometer Bore

BOREHOLE W20



JOB No 44047-021-071
DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

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DRAWN BY TJS
CHECKED BY NRH

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Woodward Clyde

PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 6m,12m,26m,32m,50m,80m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367768 mN
COORDINATES EAST 399595 mE
R.L. COLLAR 41m AHD
STATIC WATER LEV 4.04m,4.14m,4.18m,4.15m,3.65m,3.63m
TOTAL DEPTH 80m
DATE MEASURED 30/5/01
BORE STATUS Multipiezometer Bore

BOREHOLE W20

Depth	Graphic Log	Description	Bore Construction DII	Bore Construction DI	Bore Construction MII	Bore Construction MI	Bore Construction SII	Bore Construction SI	Remarks
		CLAY *Blue-grey with yellow brown iron staining or mottles*							
		SAND *Fine to medium grained red to black strongly ferrugenised, clay free*							
		CLAY *Blue-grey*							
		SAND *Ferrugenised sand, fine to medium grained*							
25		**CLAY** *Blue grey clay interbedded with green-brown clayey sands.*							
		SANDY CLAY *Blue-grey to dark brown sandy clay, strongly ferrugenised beds/mottles.*							
		SAND *Light grey, quartz and feldspathic, poorly sorted, lightly ferrugenised, medium to coarse grained, clay free*							
		SAND *Coarse angular bedrock and red-grey sands.*							
30		**Mudstone/Shale** *Black mudstone/shale, carbonaceous, very fine shale core*							
		BEDROCK *Dark brown chips of bedrock together with quartz and grey sands*							
		SANDS *Red and grey ferrugenised sands, quartzoze and feldspathic, poorly sorted - fine to coarse grained, grades to chips of dark grey rock and granitic bedrock*							
35									
40									

JOB No 44047-021-071
DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

LOGGED BY IGB/TJS
DRAWN BY TJS
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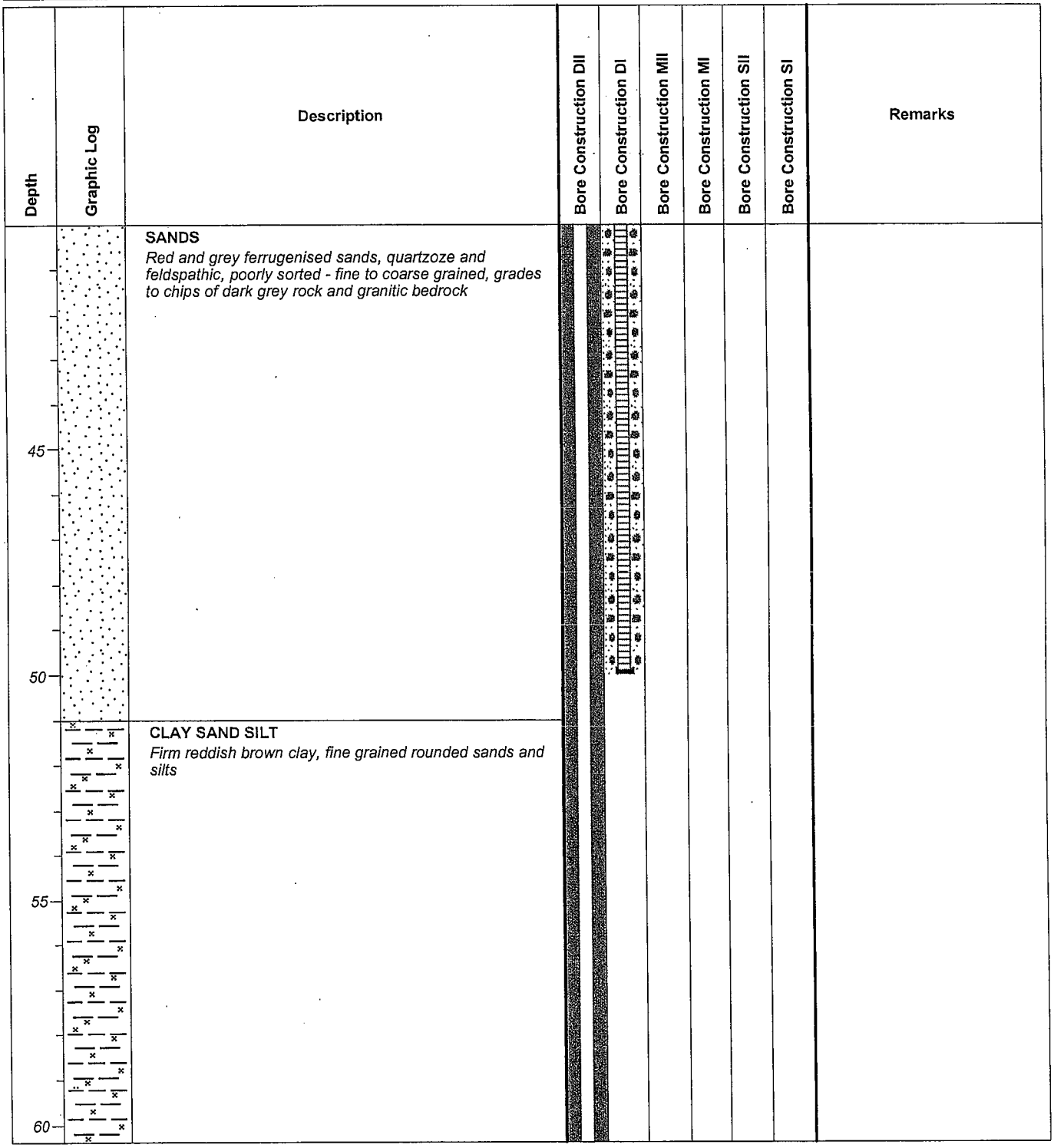
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 6m,12m,26m,32m,50m,80m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367768 mN
COORDINATES EAST 399595 mE
R.L. COLLAR 41m AHD
STATIC WATER LEV 4.04m,4.14m,4.18m,4.15m,3.65m,3.63m
TOTAL DEPTH 80m
DATE MEASURED 30/5/01
BORE STATUS Multipiezometer Bore

BOREHOLE W20



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DRILLING COMPANY Iluka Resources Ltd.
DRILLER Ted

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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 6m,12m,26m,32m,50m,80m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367768 mN
COORDINATES EAST 399595 mE
R.L. COLLAR 41m AHD
STATIC WATER LEV 4.04m,4.14m,4.18m,4.15m,3.65m,3.63m
TOTAL DEPTH 80m
DATE MEASURED 30/5/01
BORE STATUS Multipiezometer Bore

BOREHOLE W20

Depth	Graphic Log	Description	Bore Construction DII	Bore Construction DI	Bore Construction MII	Bore Construction MI	Bore Construction SII	Bore Construction SI	Remarks
65		CLAY SAND SILT *Firm reddish brown clay, fine grained rounded sands and silts*							
70									
75									
80									

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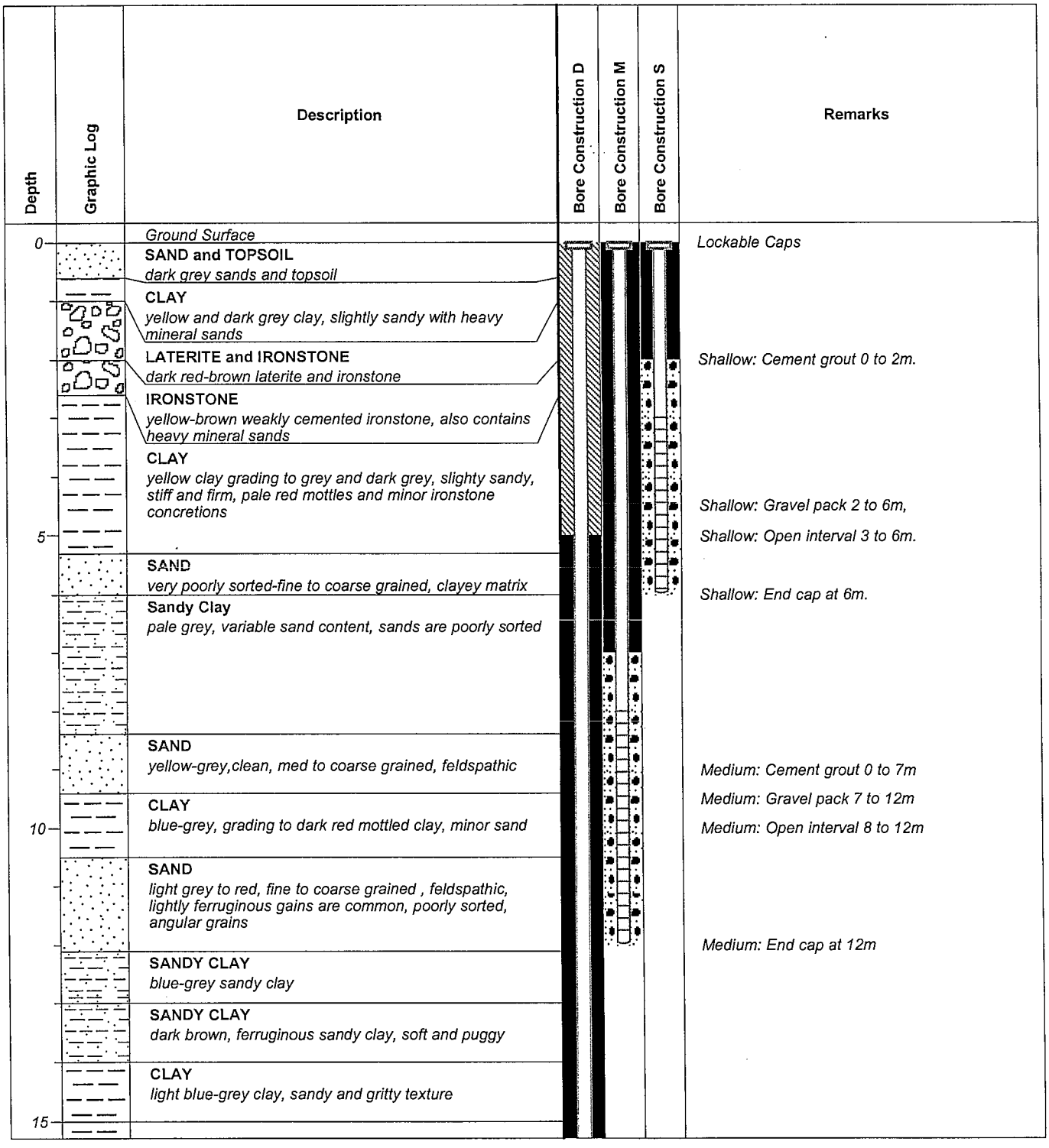
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 6m, 12m, 24m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367683 mN
COORDINATES EAST 399890 mE
R.L. COLLAR 49.2 mAHD
TOTAL DEPTH 6m, 12m, 24m
STATIC WATER LEV 1.26m, 1.78m, 3.52m
DATE MEASURED 31/5/01
BORE STATUS Multipiezometer Bore

BOREHOLE W21



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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 6m, 12m, 24m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367683 mN
COORDINATES EAST 399890 mE
R.L. COLLAR 49.2 mAHD
TOTAL DEPTH 6m, 12m, 24m
STATIC WATER LEV 1.26m, 1.78m, 3.52m
DATE MEASURED 31/5/01
BORE STATUS Multipiezometer Bore

BOREHOLE W21

Depth	Graphic Log	Description	Bore Construction D	Bore Construction M	Bore Construction S	Remarks
20		**MOTTLED CLAY** *dark grey and brown and blue-grey mottled clay,firm and puggy, variable sand/grit content, clayey sand @ 22.0-22.5, grey*				*Deep: Backfill 0 to 5m* *Deep: Cement grout 5 to 16m* *Deep: Gravel pack 16 to 24m* *Deep: Open interval 8 to 12m*
25						*Deep: End cap at 24m*
30						

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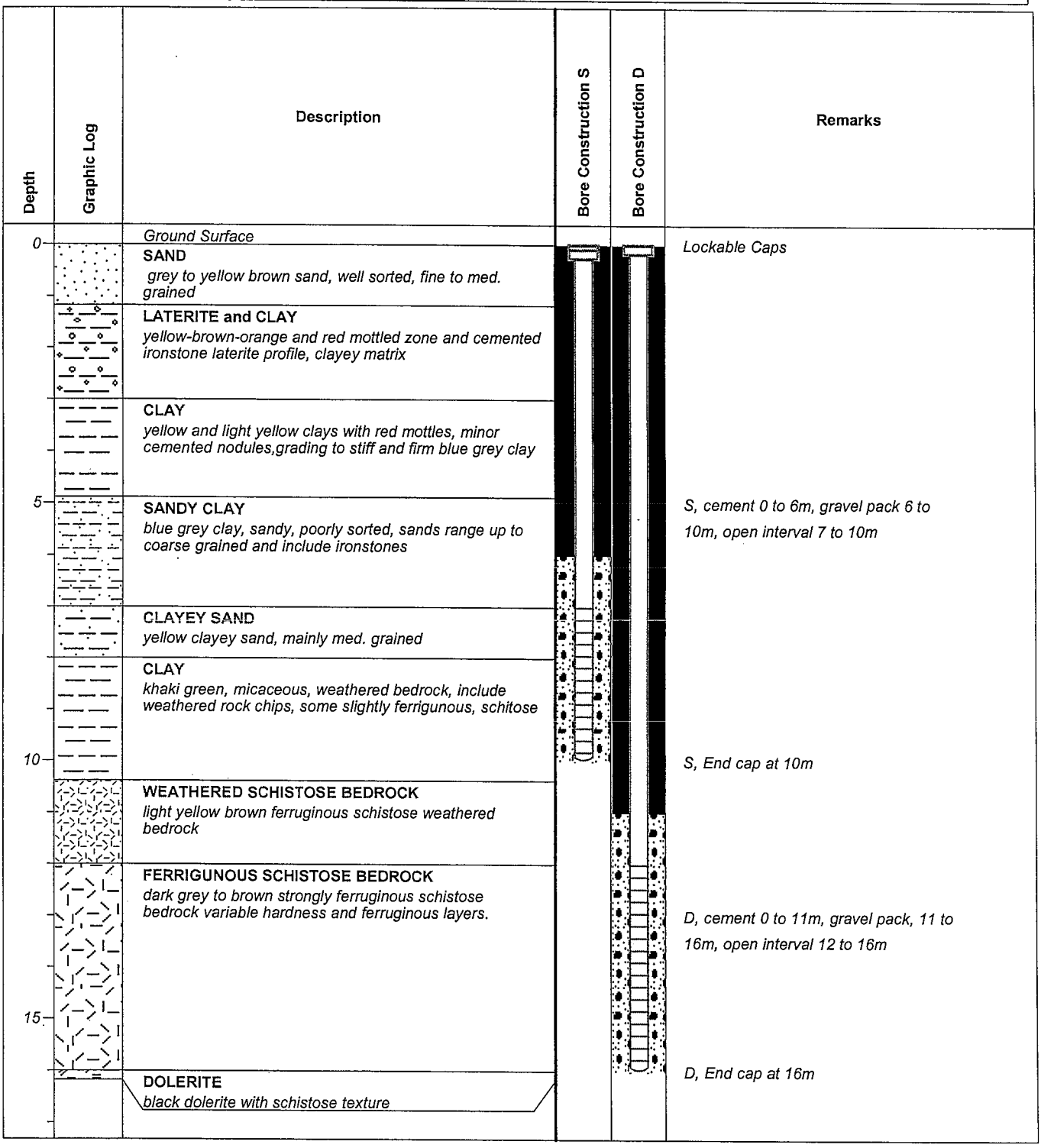
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 10m, 16m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367523 mN
COORDINATES EAST 400603 mE
R.L. COLLAR 68.9m AHD
STATIC WATER LEV 7.27m, 7.29m
DATE MEASURED 31/5/01
TOTAL DEPTH 10, 16m
BORE STATUS Multipiezometer Bore

BOREHOLE W22



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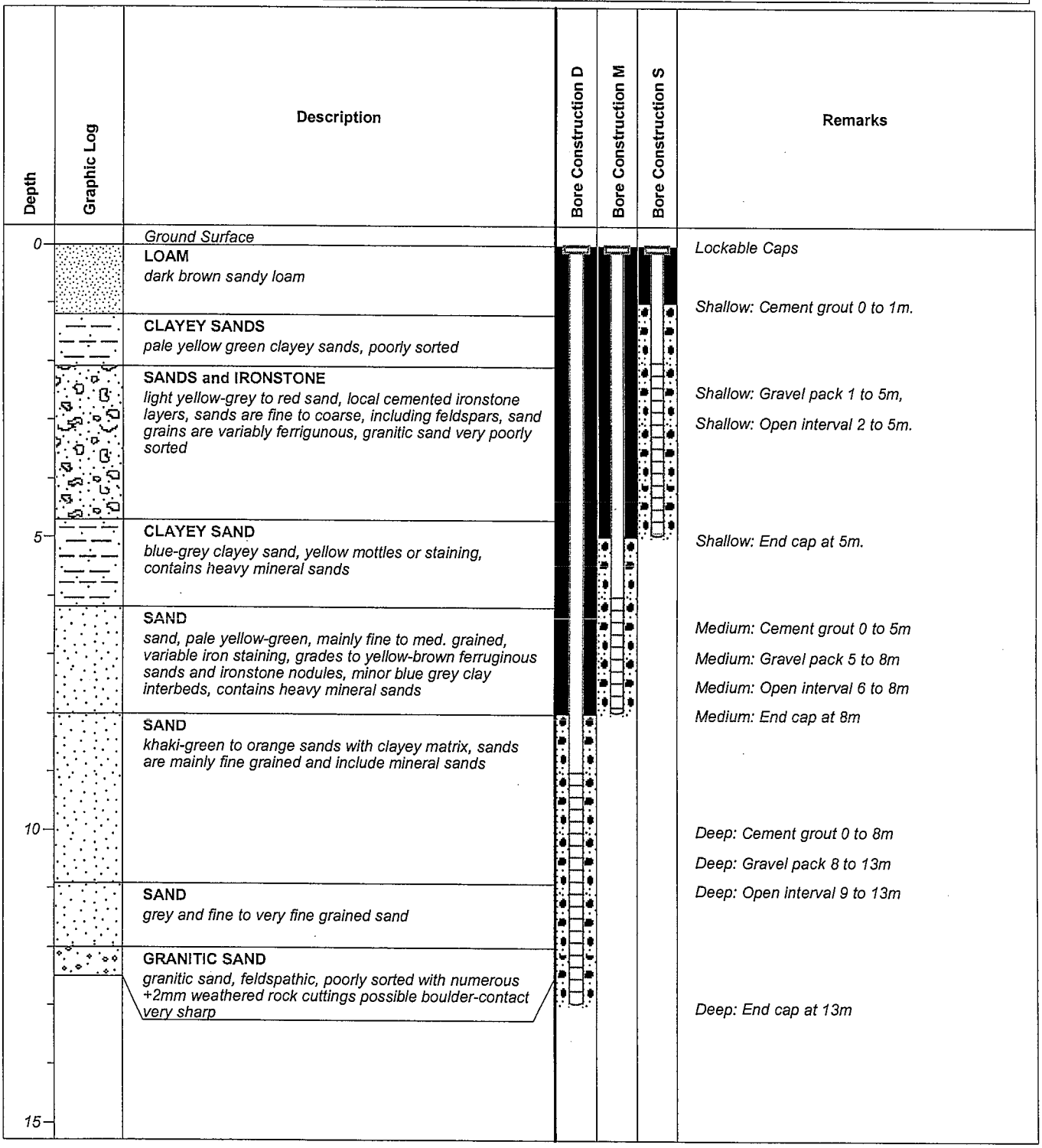
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 5m, 8m, 13m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367743 mN
COORDINATES EAST 400449 mE
R.L. COLLAR 50.96m AHD
TOTAL DEPTH 5m, 8m, 13m
STATIC WATER LEV 1.19m, 0.56m, 0.61m
DATE MEASURED 31/5/01
BORE STATUS Multipiezometer Bore

BOREHOLE W23



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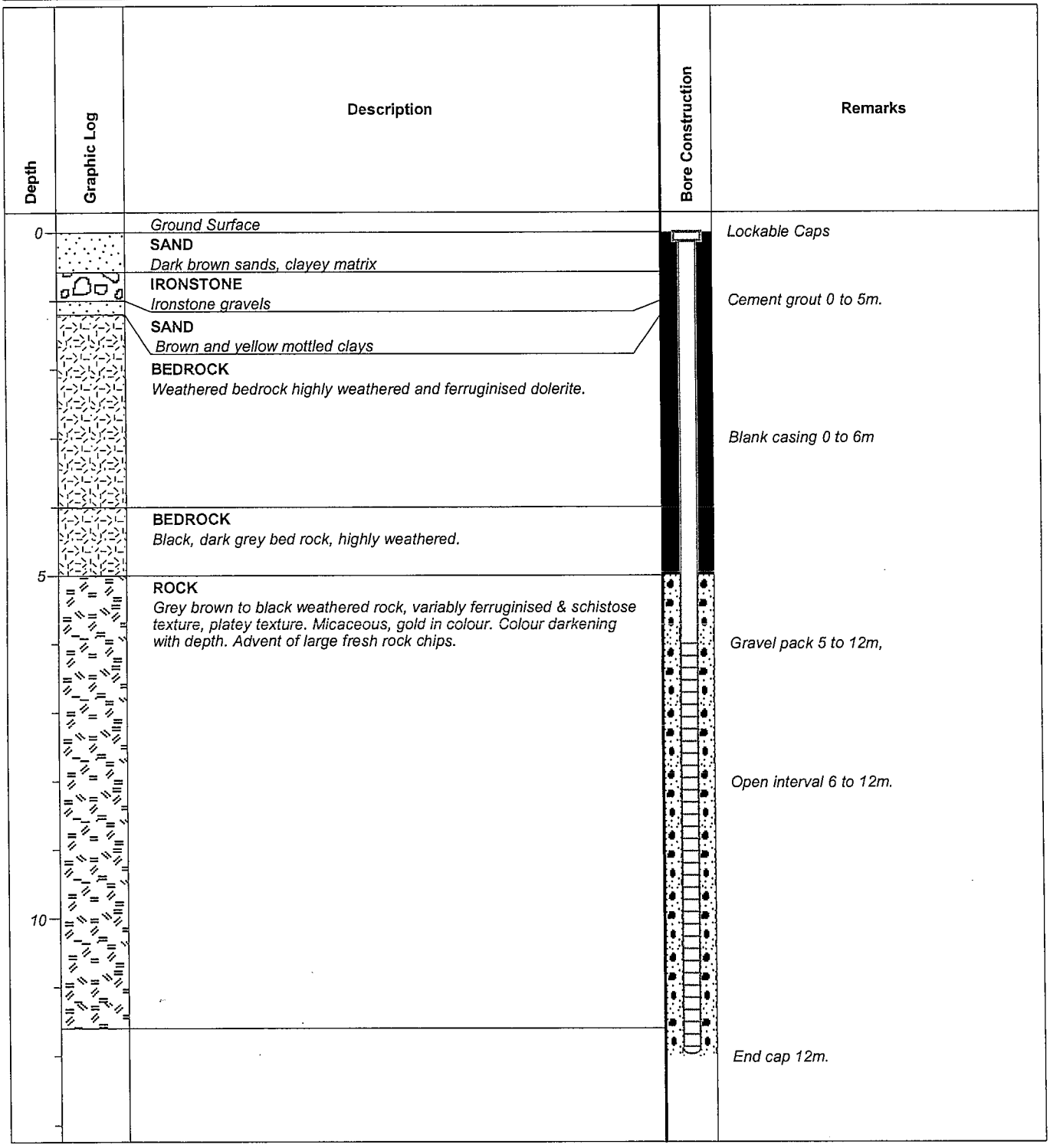
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 12m
MIN SCREEN DIAM 80mm
MIN CASED DIAM 80mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367897 mN
COORDINATES EAST 400448 mE
R.L. COLLAR 58.37m AHD
STATIC WATER LEV 6.40m
TOTAL DEPTH 12m
DATE MEASURED 31/5/01
BORE STATUS Multipiezometer Bore

BOREHOLE W24



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DRILLER

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BOREHOLE W25

PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resourrces Ltd.
TOTAL CASED DEPTH 1.5m, 9m
MIN SCREEN DIAM 80 mm
MIN CASED DIAM 80 mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367894 mN
COORDINATES EAST 400604 mE
R.L. COLLAR 65.5m AHD
STATIC WATER LEV 1.63m, 2.66m
DATE MEASURED 31/5/01
TOTAL DEPTH 1.5m, 9m
BORE STATUS Multipiezometer Bore

Depth	Graphic Log	Description	Bore Construction S	Bore Construction D	Remarks
0		*Ground Surface*			*Lockable Caps*
		SAND *Brown sand fine graded.*			*S, Cement Grout at Surface* *S, Blank Casing 0 to 0.5m* *S, Gravel pack 0 to 1.5m*
		IRONSTONE *Ironstone nodules*			*S, Open interval 0.5 to 1.5m*
		CLAY *Blue grey clay. Firm and stiff, mottled yellow and brown.*			*S, End Cap at 1.5m*
		WEATHERED ROCK. *Dark green brown weathered rock. Micaceous with schistose texture. Variably iron-stained, Schist is dark grey in colour. Colour darkening with depth. Strongly ferruginised zone 8.0-8.9m with groundwater flows.*			*D, Cement grout 0 to 5m*
5					*D, Blank casing 0 to 6m*
					D, Gravel pack 5 to 9m
					D, Open interval 6 to 9m
					D, End Cap at 9m
10					

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DRILLER Ted

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BOREHOLE W26

PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 9m, 12m
MIN SCREEN DIAM 80 mm
MIN CASED DIAM 80 mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6368682 mN
COORDINATES EAST 400517.8 mE
R.L. COLLAR 69m AHD
STATIC WATER LEV 9.24m, 8.7m
DATE MEASURED 31/5/01
TOTAL DEPTH 9m,12m
BORE STATUS Multipiezometer Bores

Depth	Graphic Log	Description	Bore Construction S	Bore Construction D	Remarks
		Ground Surface			
0		**SAND** *Light yellow brown sand. Well sorted, Medium gravel grades to yellow sand with heavy mineral content.*			*Lockable Caps*
		CLAY *Blue grey with yellow and red mottles or staining minor fine sand. Grades to mottled clay with cemented ironstone granules*			*S, Cement Grout 0-5m*
5		**CLAY** *White clay with yellow and red mottles or staining. Minor sand Kaolin. Quite stiff and puggy*			*S, Blank Casing 0 to 6m* *D, Cement Grout 0 to 9m* *S, Gravel pack 5 to 9m* *S, Open interval 6 to 9m* *S, End cap at 9m* *D, Blank Casing 0 to 10m*
10		**GRANITE SAND** *Granite sands with some clay bands, coarse quartz and feldspar aggregate to +2cm. Mildly ironstained*			*D, Gravel pack 9 ro 12m* *D, Open interval 10 to 12m* *D, End cap at 12m*

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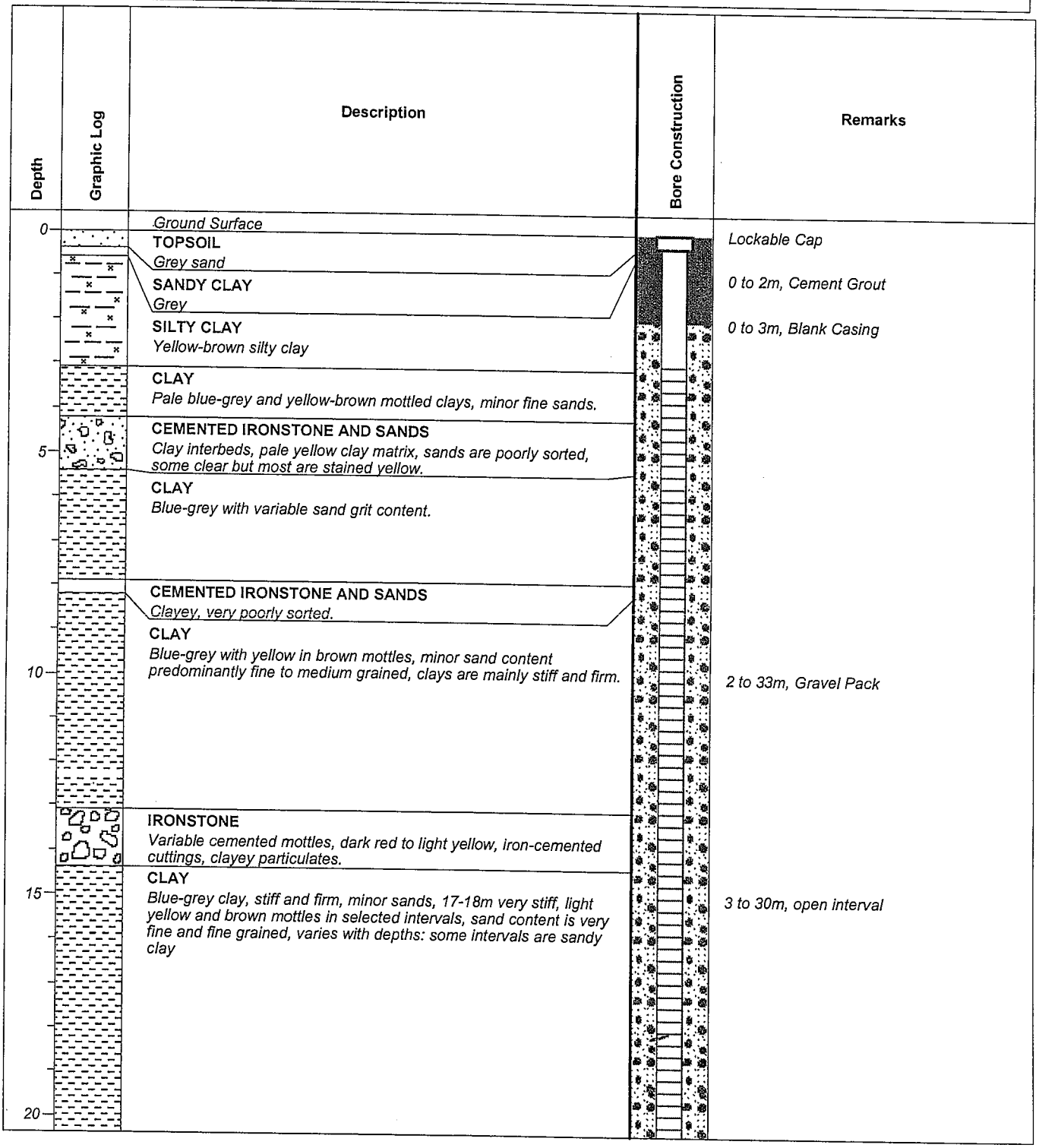
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 30m
MIN SCREEN DIAM 195mm
MIN CASED DIAM 195mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366924 mN
COORDINATES EAST 399424 mE
R.L. COLLAR 43 mAHD
STATIC WATER LEV 5.55 m
TOTAL DEPTH 33m
DATE MEASURED 31/5/01
BORE STATUS Production Bore

BOREHOLE WSB1



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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 30m
MIN SCREEN DIAM 195mm
MIN CASED DIAM 195mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366924 mN
COORDINATES EAST 399424 mE
R.L. COLLAR 43 mAHD
STATIC WATER LEV 5.55 m
TOTAL DEPTH 33m
DATE MEASURED 31/5/01
BORE STATUS Production Bore

BOREHOLE WSB1

Depth	Graphic Log	Description	Bore Construction	Remarks
		CLAY AND CLAYEY SANDS *Light red to yellow-brown - sands are very fine grained.*		
25		**SAND** *Light grey to red-brown fine to medium grained, numerous ferruginous grains and heavy mineral sands, dramatic increase in groundwater yields.*		
		CLAY *Light blue-grey, stiff and firm, minor red and brown mottles, minor sand.*		
		CLAYEY SAND *Light yellow to yellow-green, very poorly sorted, fine to coarse grained and minor >2mm fraction, basal sands are more clay free.*		
30		**MUDSTONE** *Dark grey and brown, minor green-brown lenses, variably puggy to firm.*		*30m, End cap*
35				
40				

JOB No 44047-021-071
DRILLING COMPANY Wintergreene Drilling
DRILLER Kevin Wintergreene

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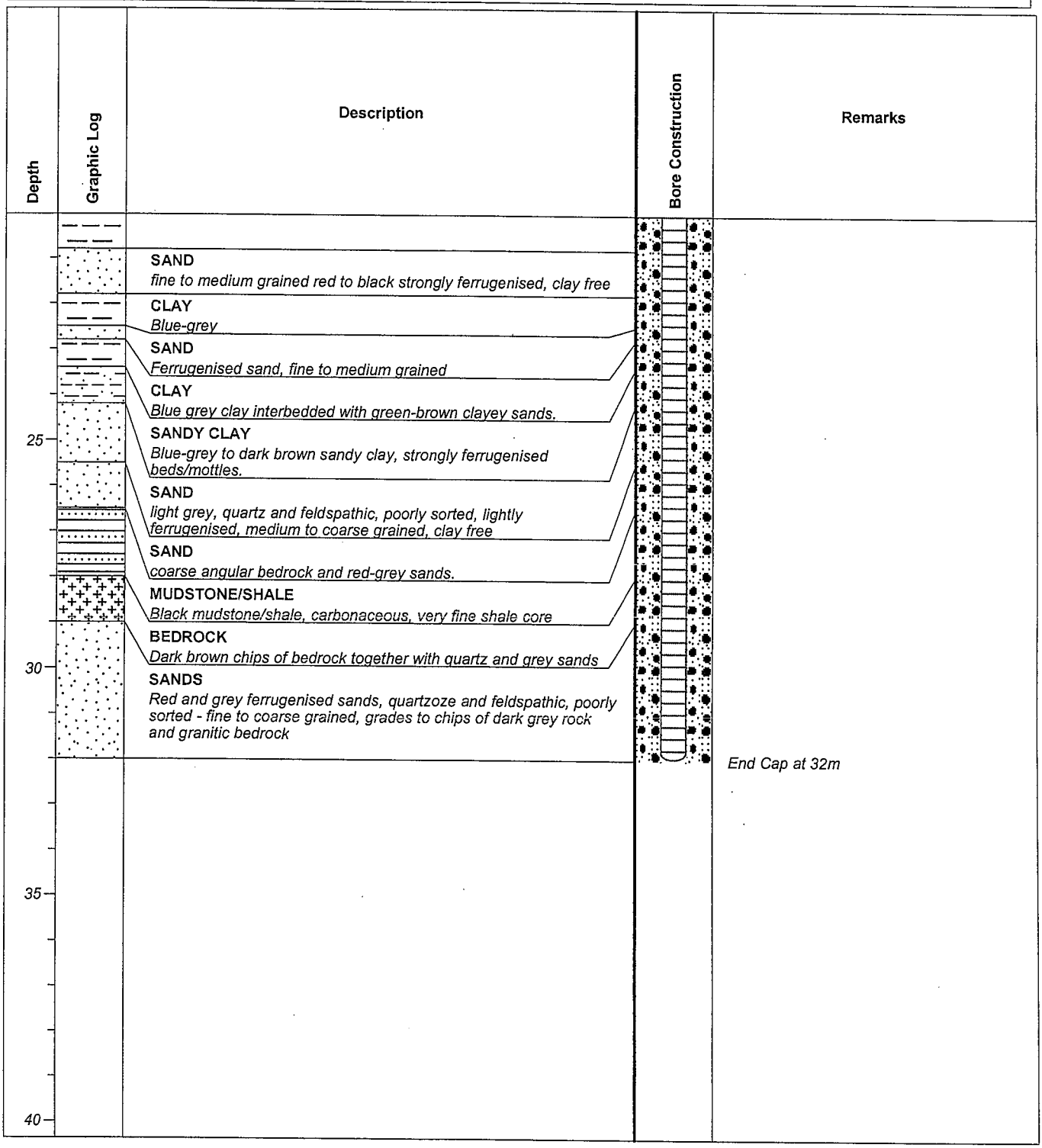
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 32m
MIN SCREEN DIAM 195mm
MIN CASED DIAM 195mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367763 mN
COORDINATES EAST 399572 mE

BOREHOLE WSB3

R.L. COLLAR 40.28m AHD
STATIC WATER LEV 3.77m
TOTAL DEPTH 32 m
DATE MEASURED 31/5/01
BORE STATUS Production Bore



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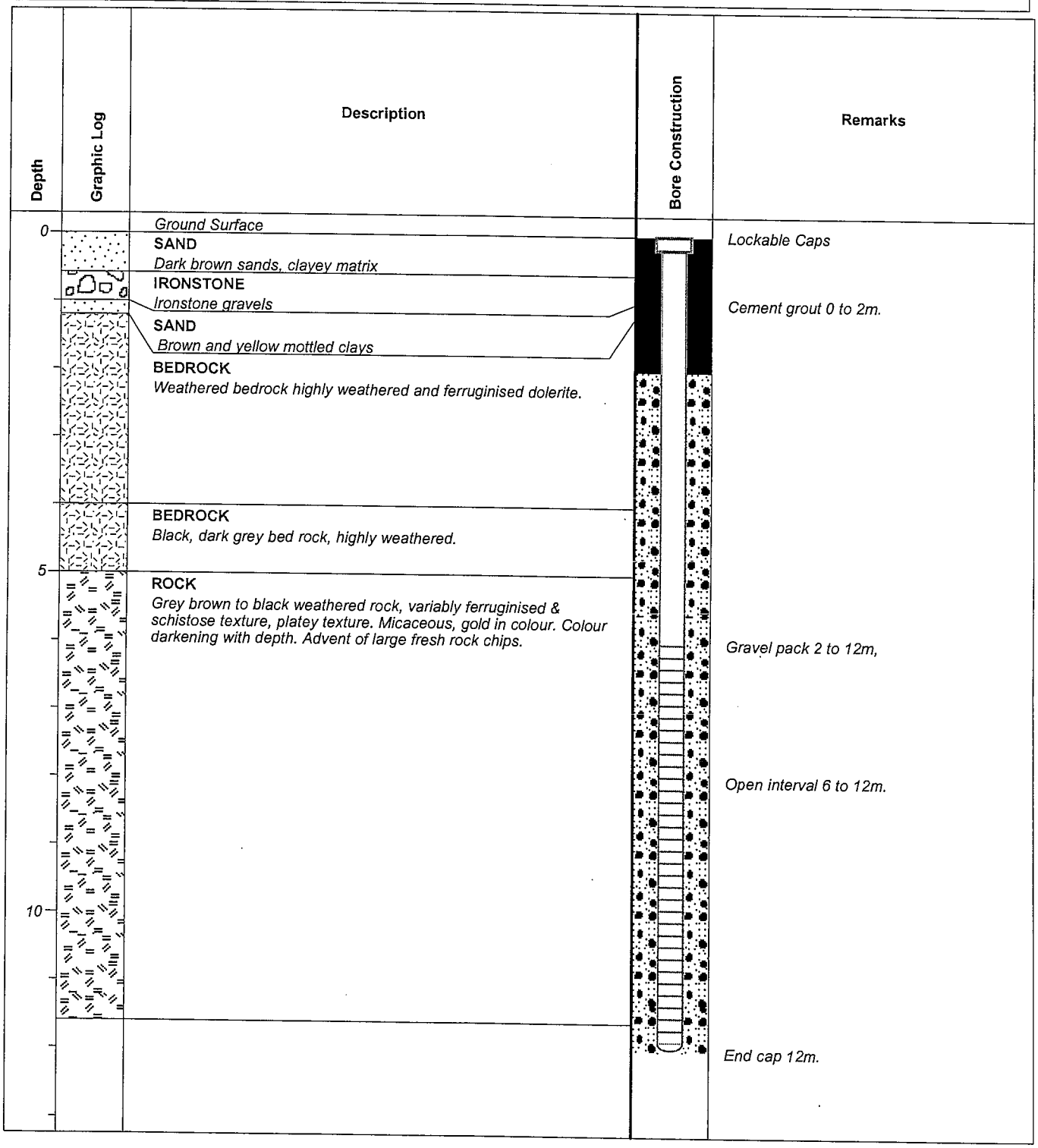
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 12m
MIN SCREEN DIAM 125mm
MIN CASED DIAM 125mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367903 mN
COORDINATES EAST 400468 mE
R.L. COLLAR 60 mAHD
STATIC WATER LEV 8.54m
TOTAL DEPTH 12 m
DATE MEASURED 31/5/01
BORE STATUS Production Bore

BOREHOLE WSB4



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DRILLER Kevin Wintergreene

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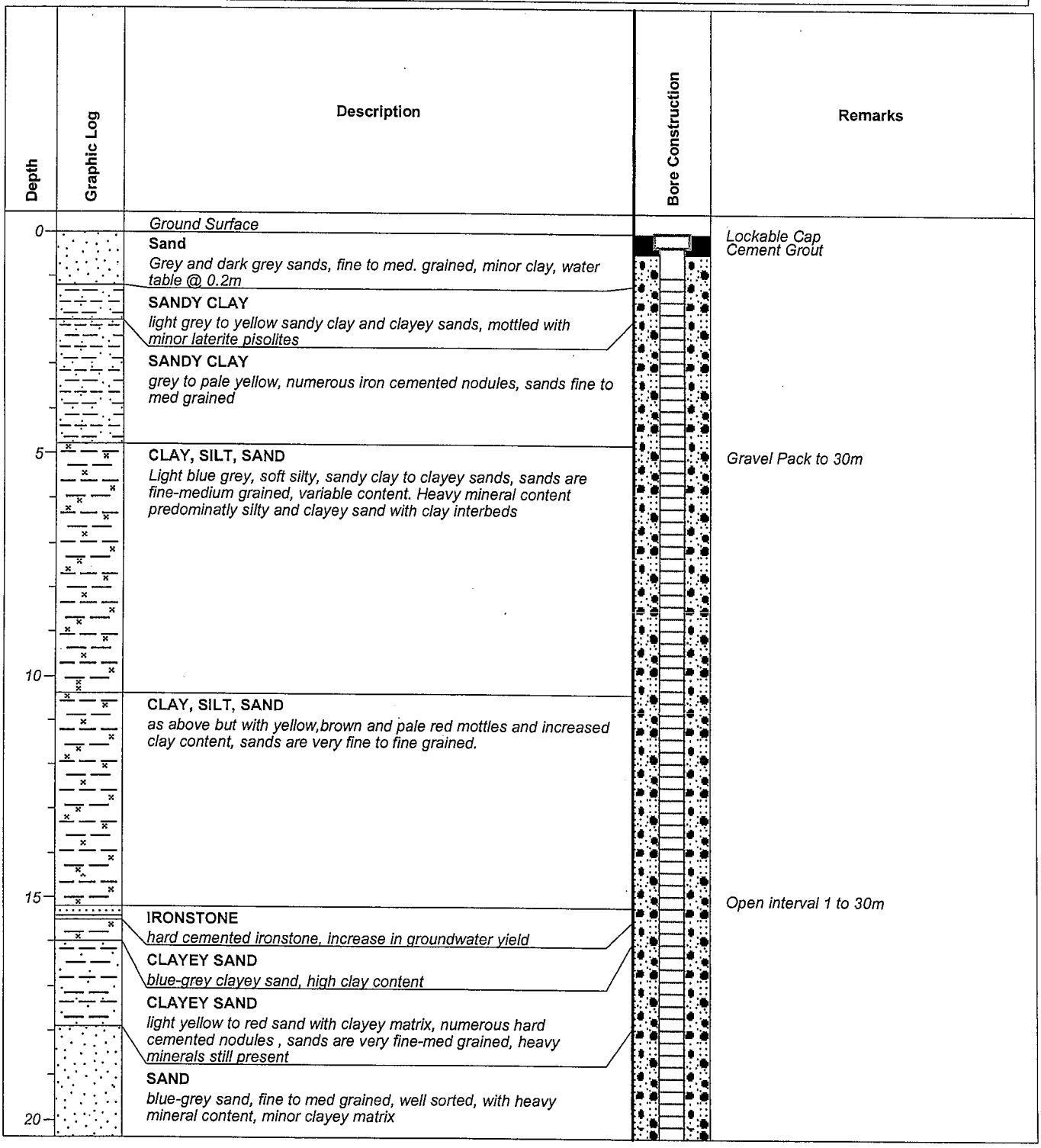
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 30m
MIN SCREEN DIAM 195mm
MIN CASED DIAM 195mm
DRILLING RIG Western 1200 Kelly Rig
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367320 mN
COORDINATES EAST 399452 mE
R.L. COLLAR 38.3m AHD
STATIC WATER LEV 1.34m
TOTAL DEPTH 30m
DATE MEASURED 31/5/01
BORE STATUS Production Bore

BOREHOLE WSB5



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DRILLER Kevin Wintergreene

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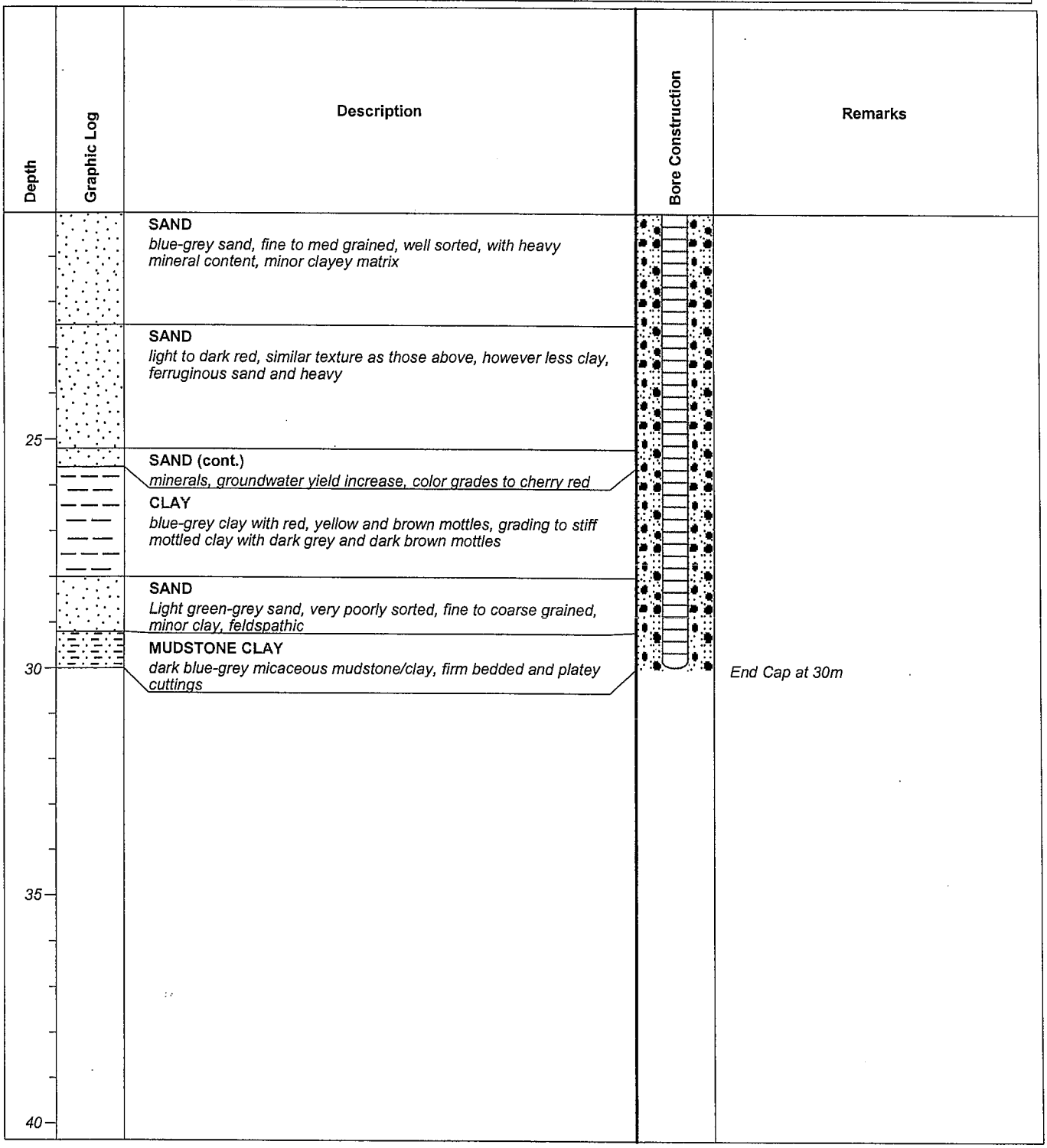
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 30m
MIN SCREEN DIAM 195mm
MIN CASED DIAM 195mm
DRILLING RIG Western 1200 Kelly Rig
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367320 mN
COORDINATES EAST 399452 mE
R.L. COLLAR 38.3m AHD
STATIC WATER LEV 1.34m
TOTAL DEPTH 30m
DATE MEASURED 31/5/01
BORE STATUS Production Bore

BOREHOLE WSB5



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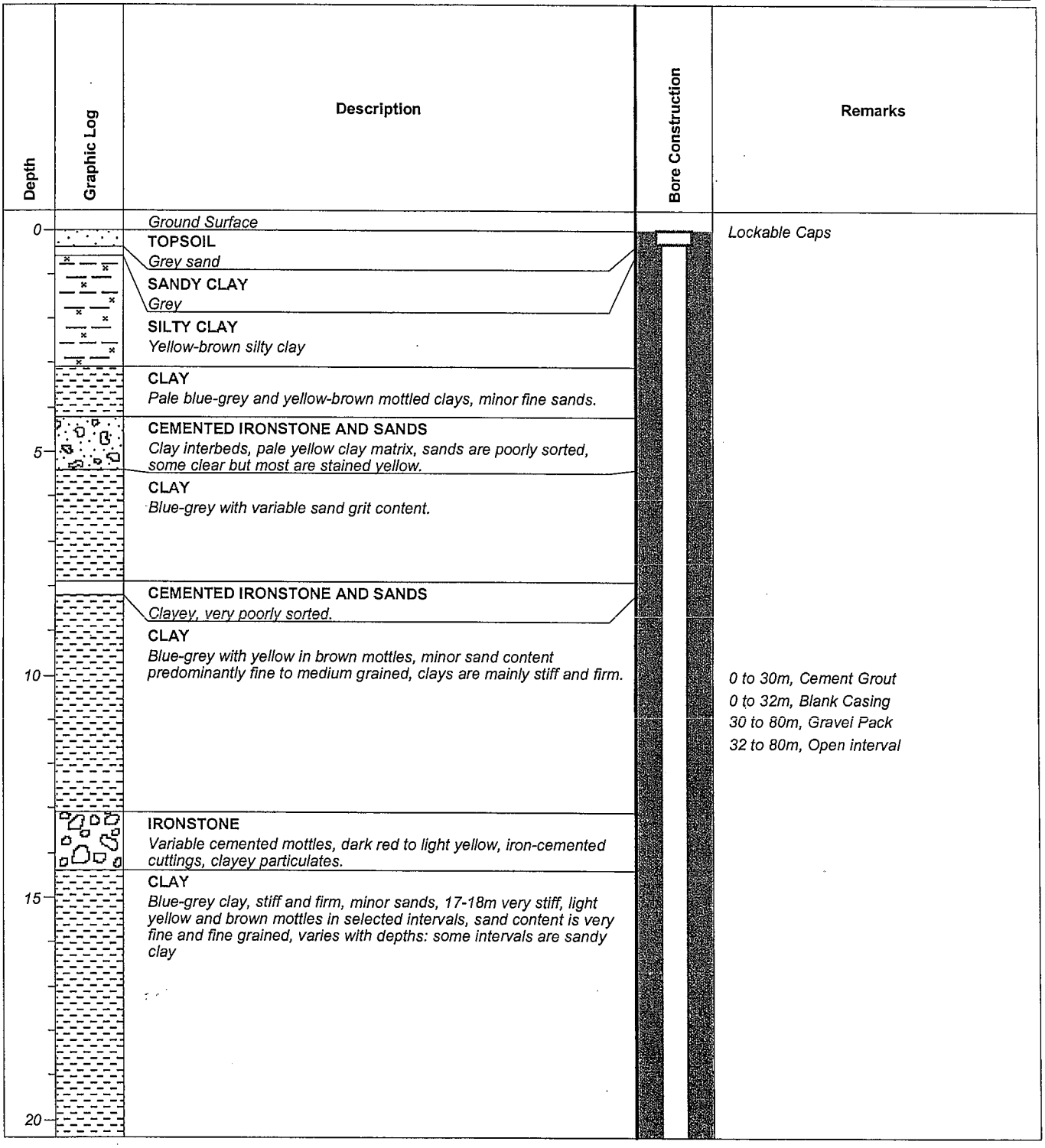
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 80m
MIN SCREEN DIAM 195mm
MIN CASED DIAM 195mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366892 mN
COORDINATES EAST 399450 mE
R.L. COLLAR 43.7m AHD
STATIC WATER LEV 6.33m
TOTAL DEPTH 80m
DATE MEASURED 31/5/01
BORE STATUS Production Bore

BOREHOLE WLB1



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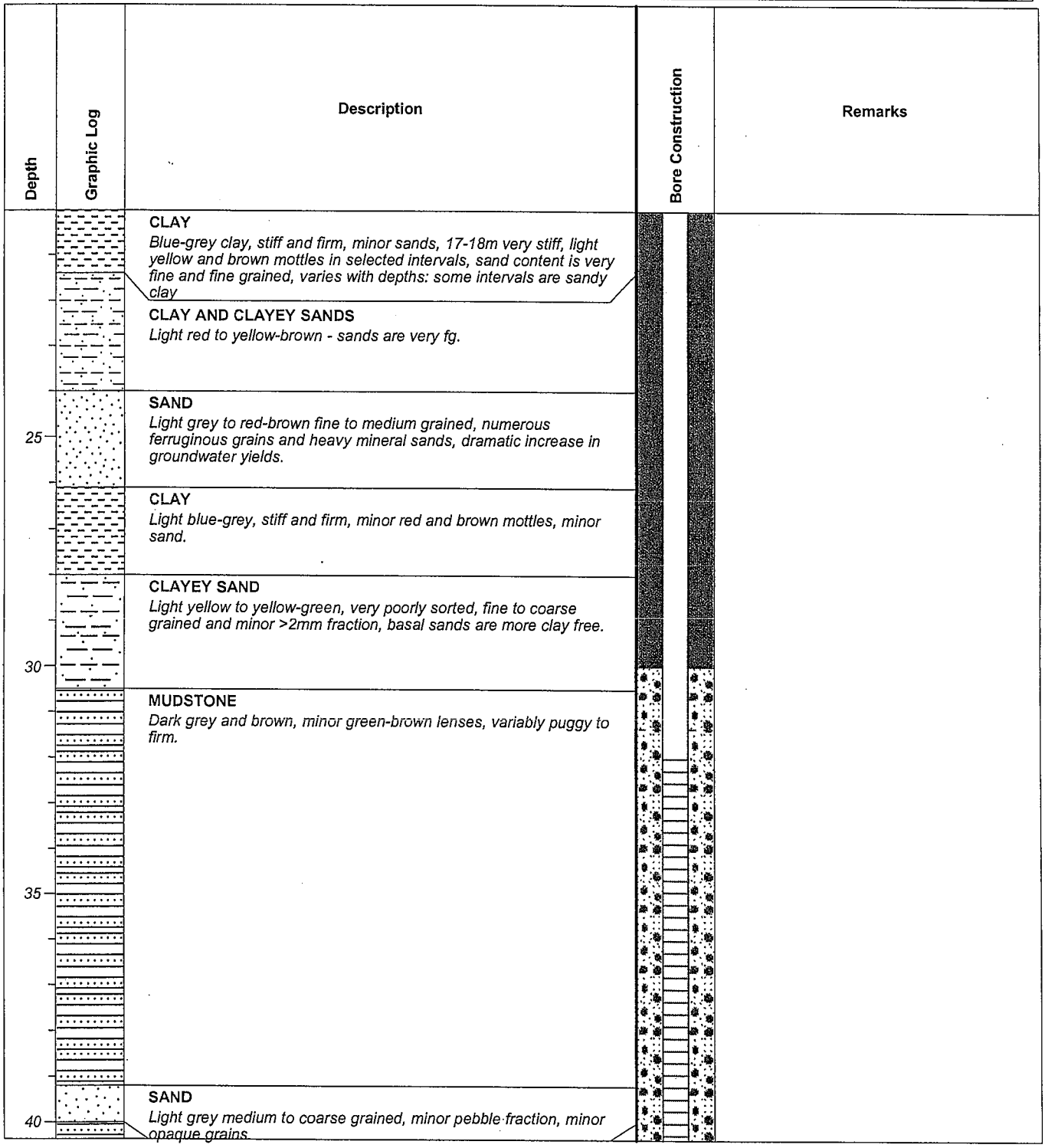
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 80m
MIN SCREEN DIAM 195mm
MIN CASED DIAM 195mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366892 mN
COORDINATES EAST 399450 mE

BOREHOLE WLB1

R.L. COLLAR 43.7m AHD
STATIC WATER LEV 6.33m
TOTAL DEPTH 80m
DATE MEASURED 31/5/01
BORE STATUS Production Bore



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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 80m
MIN SCREEN DIAM 195mm
MIN CASED DIAM 195mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366892 mN
COORDINATES EAST 399450 mE

BOREHOLE WLB1

R.L. COLLAR 43.7m AHD
STATIC WATER LEV 6.33m
TOTAL DEPTH 80m
DATE MEASURED 31/5/01
BORE STATUS Production Bore

Depth	Graphic Log	Description	Bore Construction	Remarks
		MUDSTONE AND SHALE *Dark grey and brown, numerous firm and hard core samples.*		
45		**SANDY MUDSTONE** *Dark grey, sandy mudstone, perhaps contains thin sand interbeds, sand medium grained, predominantly clear quartz, some orange stained, minor opaque grains.*		
50				
55				
60				

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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 80m
MIN SCREEN DIAM 195mm
MIN CASED DIAM 195mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6366892 mN
COORDINATES EAST 399450 mE
R.L. COLLAR 43.7m AHD
STATIC WATER LEV 6.33m
TOTAL DEPTH 80m
DATE MEASURED 31/5/01
BORE STATUS Production Bore

BOREHOLE WLB1

Depth	Graphic Log	Description	Bore Construction	Remarks
		CLAYEY SAND *Sands/gravels, very coarse grained quartz and minor opaque fraction, sands well sorted <3mm, clay matrix grey (mudstones). Becomes more gritty with depth (increasing sand content), clays become grey-brown with less mudstone content.*		
65		**CLAYEY SAND** *Sands medium to coarse grained, moderate to well sorted, clays grey brown, clay content increasing with depth*		
70		**SANDY CLAY** *Significant increase in clay content, sands medium to coarse grained as above, clays sticky khaki-brown.*		
75		**SANDY CLAY/CLAYEY SAND** *Varies between clayey sand and sandy clay. Sands med-coarse grained as above, clays sticky khaki-brown as above.*		
80				

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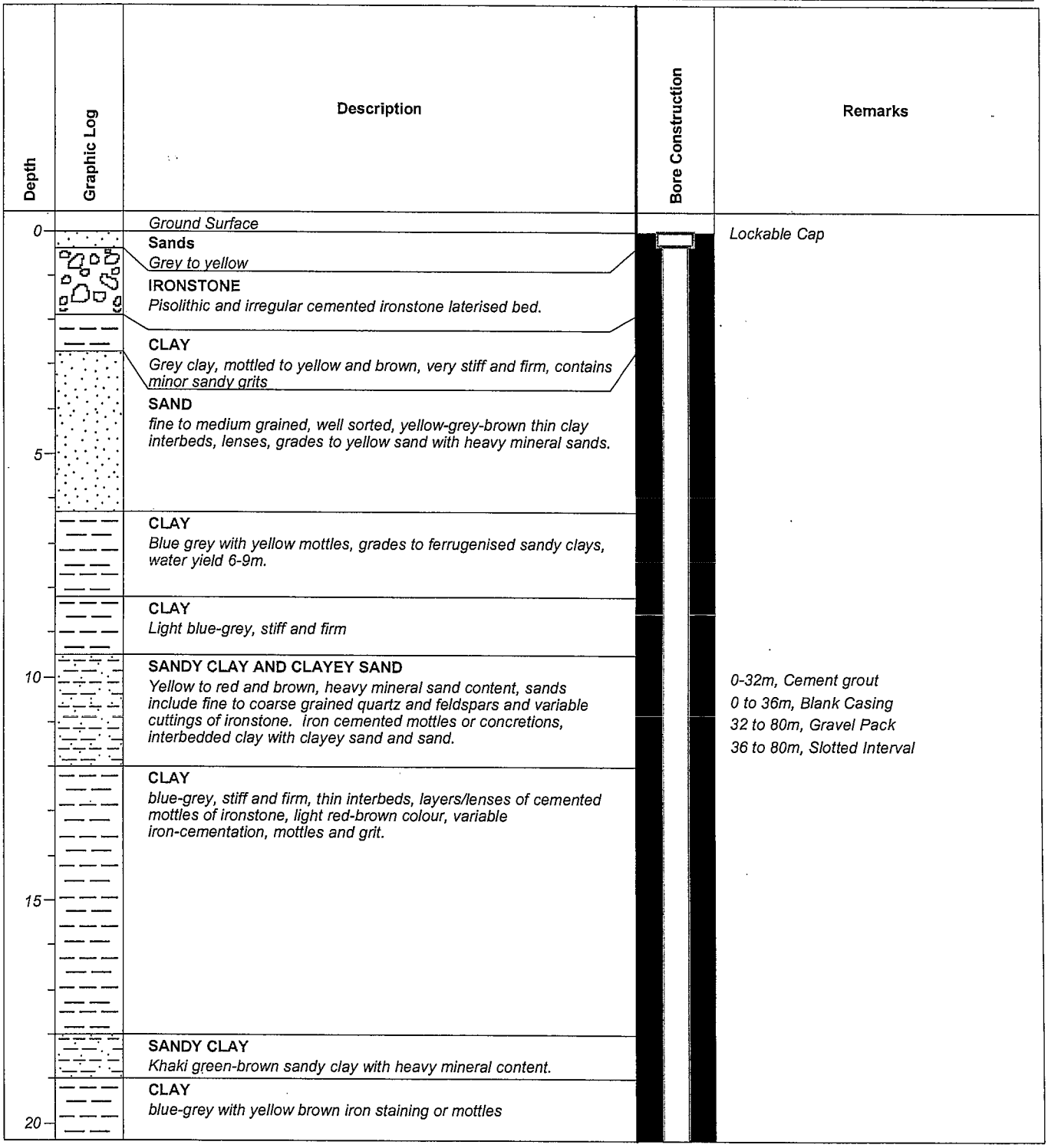
PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 80m
MIN SCREEN DIAM 195mm
MIN CASED DIAM 195mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367764 mN
COORDINATES EAST 399617 mE
R.L. COLLAR 40.8m AHD
STATIC WATER LEV 4.73m
TOTAL DEPTH 80m
DATE MEASURED 31/5/01
BORE STATUS Production Bore

BOREHOLE WLB2



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DRILLING COMPANY Wintergreene Drilling
DRILLER Kevin Wintergreene

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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 80m
MIN SCREEN DIAM 195mm
MIN CASED DIAM 195mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367764 mN
COORDINATES EAST 399617 mE

BOREHOLE WLB2

R.L. COLLAR 40.8m AHD
STATIC WATER LEV 4.73m
TOTAL DEPTH 80m
DATE MEASURED 31/5/01
BORE STATUS Production Bore

Depth	Graphic Log	Description	Bore Construction	Remarks
		CLAY *blue-grey with yellow brown iron staining or mottles*		
		SAND *fine to medium grained red to black strongly ferrugenised, clay free*		
		CLAY *Blue-grey*		
		SAND *Ferrugenised sand, fine to medium grained*		
		CLAY *Blue grey clay interbedded with green-brown clayey sands.*		
25		**SANDY CLAY** *Blue-grey to dark brown sandy clay, strongly ferrugenised beds/mottles.*		
		SAND *light grey, quartz and feldspathic, poorly sorted, lightly ferrugenised, medium to coarse grained, clay free*		
		SAND *coarse angular bedrock and red-grey sands.*		
		Mudstone/Shale *Black mudstone/shale, carbonaceous, very fine shale core*		
		BEDROCK *Dark brown chips of bedrock together with quartz and grey sands*		
30		**SANDS** *Red and grey ferrugenised sands, quartzoze and feldspathic, poorly sorted - fine to coarse grained, grades to chips of dark grey rock and granitic bedrock*		
35				
40				

JOB No 44047-021-071
DRILLING COMPANY Wintergreene Drilling
DRILLER Kevin Wintergreene

LOGGED BY IGB/TJS
DRAWN BY TJS
CHECKED BY JMM

URS
Dames & Moore
Woodward Clyde

PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
CLIENT Iluka Resources Ltd.
TOTAL CASED DEPTH 80m
MIN SCREEN DIAM 195mm
MIN CASED DIAM 195mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367764 mN
COORDINATES EAST 399617 mE
R.L. COLLAR 40.8m AHD
STATIC WATER LEV 4.73m
TOTAL DEPTH 80m
DATE MEASURED 31/5/01
BORE STATUS Production Bore

BOREHOLE WLB2

Depth	Graphic Log	Description	Bore Construction	Remarks
45		**SANDS** *Red and grey ferrugenised sands, quartzoze and feldspathic, poorly sorted - fine to coarse grained, grades to chips of dark grey rock and granitic bedrock*		
50				
		CLAY SAND SILT *Firm reddish brown clay, fine grained rounded sands and silts*		
55				
60				

JOB No 44047-021-071
DRILLING COMPANY Wintergreene Drilling
DRILLER Kevin Wintergreene

LOGGED BY IGB/TJS
DRAWN BY TJS
CHECKED BY JMM

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Dames & Moore
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PROJECT Waroona Deposit
Impacts of Mining on Shallow Groundwater Resources
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TOTAL CASED DEPTH 80m
MIN SCREEN DIAM 195mm
MIN CASED DIAM 195mm
DRILLING RIG Western 1200 Kelly Drive
DRILLING METHOD Mud Rotary

COORDINATES NTH 6367764 mN
COORDINATES EAST 399617 mE

BOREHOLE WLB2

R.L. COLLAR 40.8m AHD
STATIC WATER LEV 4.73m
TOTAL DEPTH 80m
DATE MEASURED 31/5/01
BORE STATUS Production Bore

Depth	Graphic Log	Description	Bore Construction	Remarks
65		CLAY SAND SILT *Firm reddish brown clay, fine grained rounded sands and silts*		
70				
75				
80				*End Cap at 80m*

JOB No 44047-021-071
DRILLING COMPANY Wintergreene Drilling
DRILLER Kevin Wintergreene

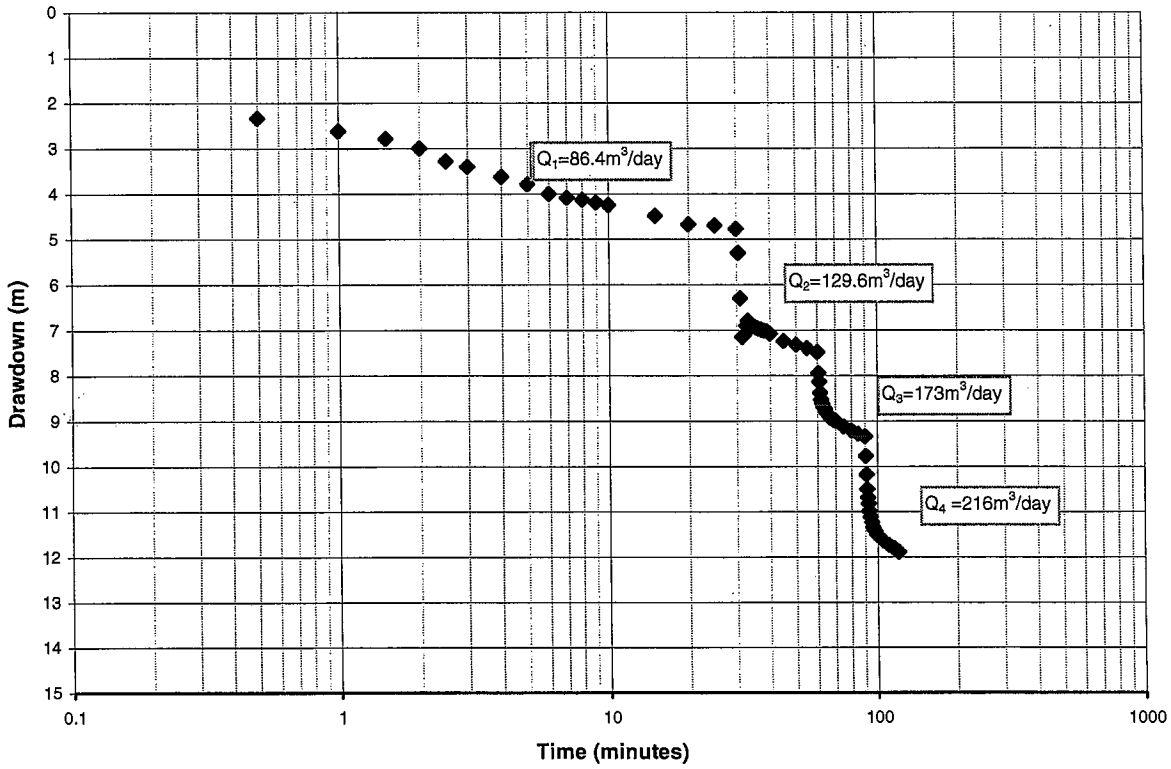
LOGGED BY IGB/TJS
DRAWN BY TJS
CHECKED BY JMM

URS
Dames & Moore
Woodward Clyde

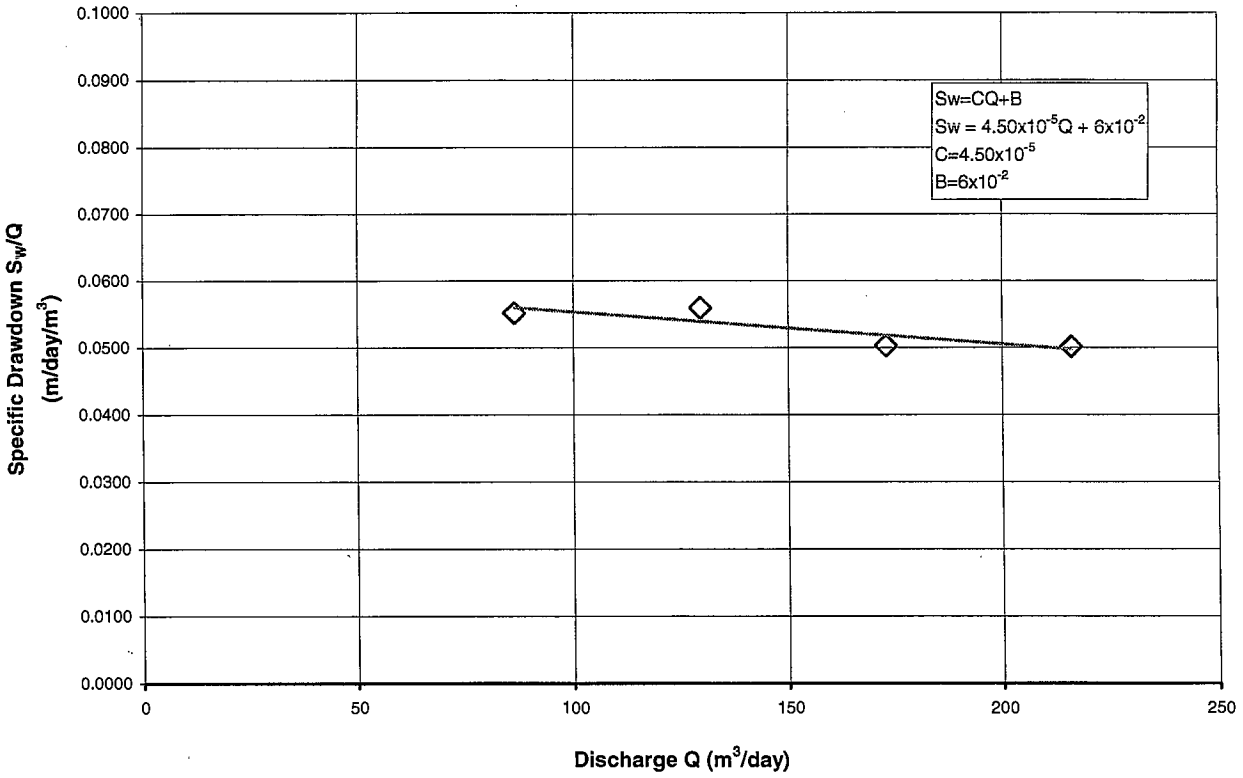
Appendix C
Test Production Bore Aquifer Test Plots

C1	WSB1	Step Drawdown Test
C2	WSB1	Constant-Discharge Test
C3	WSB1	Constant-Discharge Test – Observation Bore W16M1
C4	WSB2	Step Drawdown Test Ore
C5	WSB2	Constant-Discharge Test
C6	WSB3	Step Drawdown Test Two
C7	WSB3	Constant-Discharge Test
C8	WSB3	Constant-Discharge Test – Observation Bores
C9	WSB4	Constant-Discharge Test
C10	WSB5	Constant-Discharge Test
C11	WSB5	Constant-Discharge Test – Observation Bores
C12	WLB1	Step Drawdown Test
C13	WLB1	Constant-Discharge Test
C14	WLB1	Constant-Discharge Test – Observation Bores
C15	WLB2	Constant-Discharge test

STEP-DISCHARGE TEST
RAW DATA

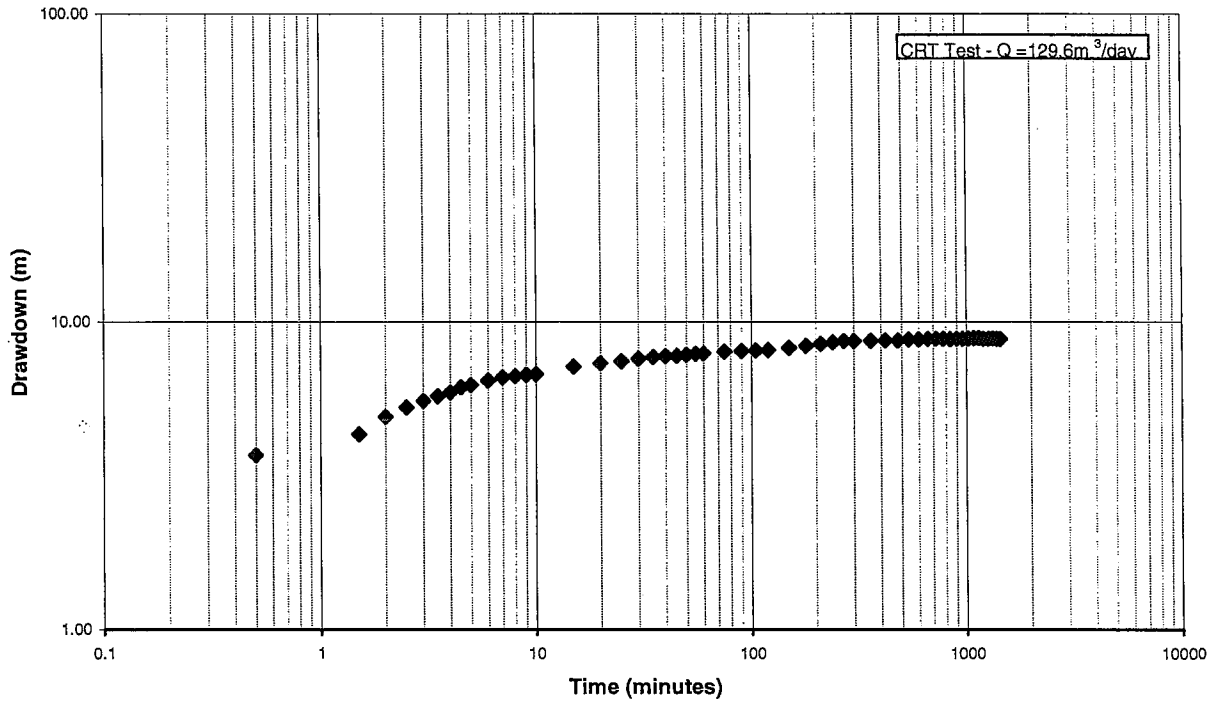


BIERSCHENK-WILSON ANALYSIS

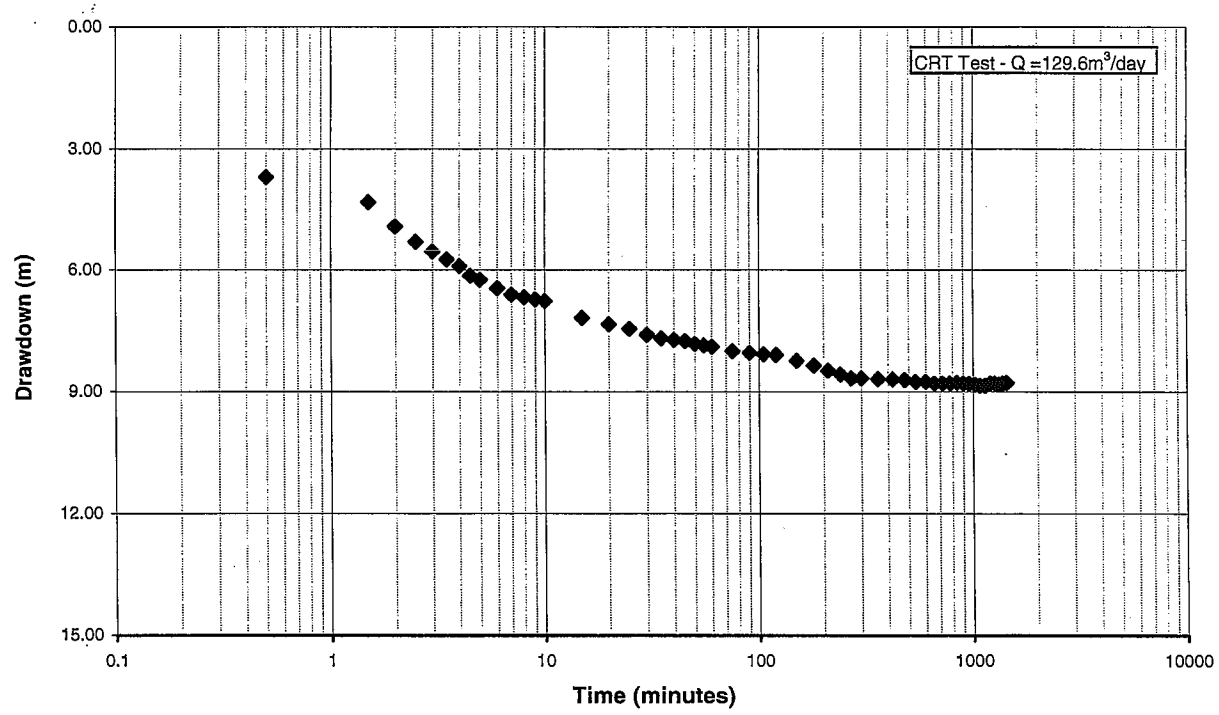


Job No.	44047-021-071		Iluka Resources Limited	**FIGURE C1**
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.		0	**WSB1 Step Drawdown Test**	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

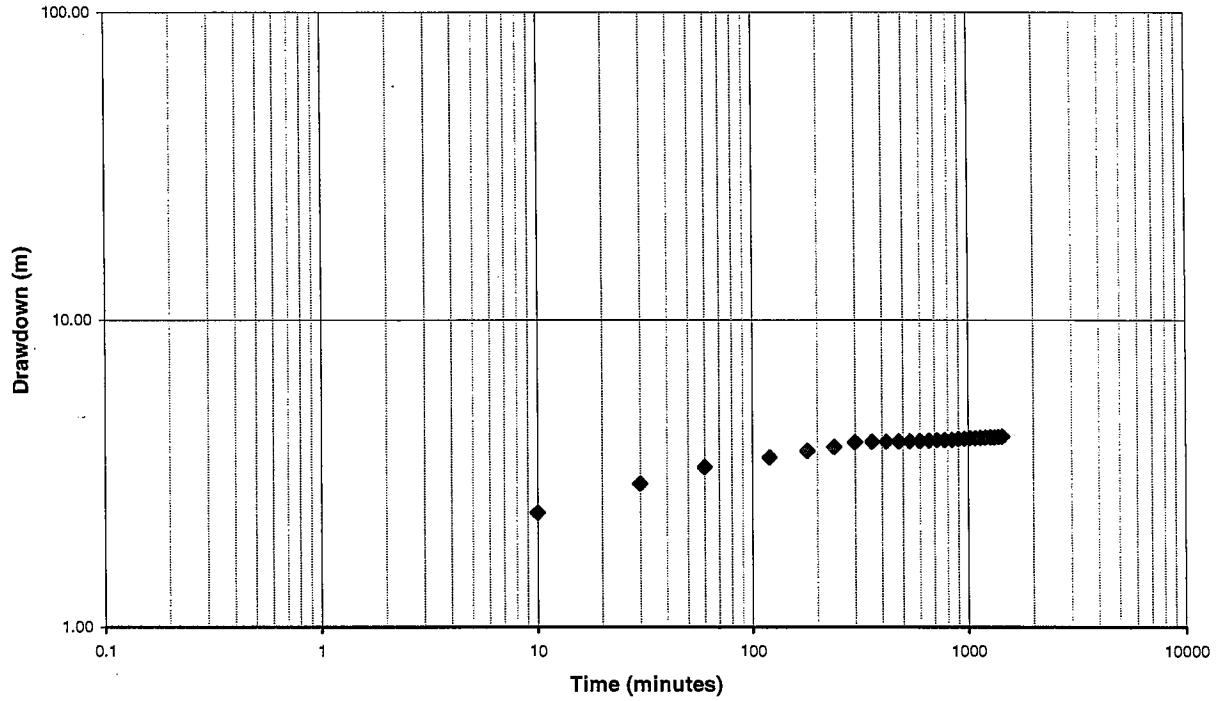


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

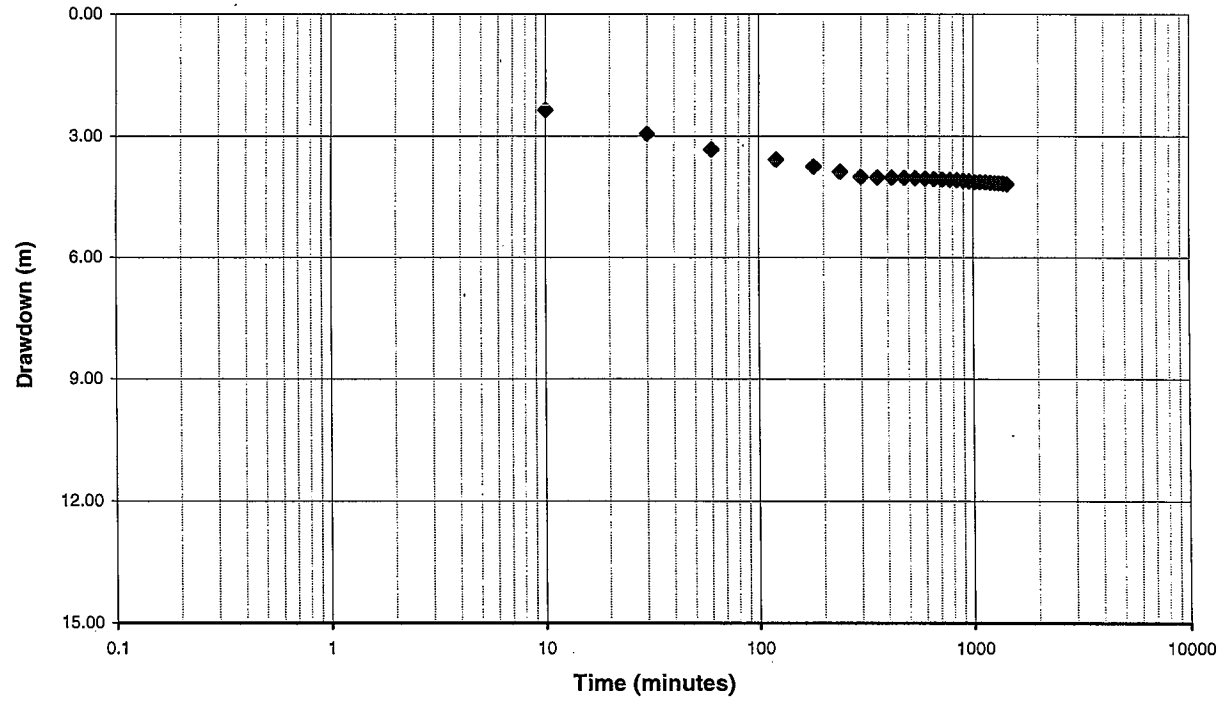


Job No.	44047-021-071		Iluka Resources Limited	**FIGURE C2**
Prep. By	SCH	22-May-01	WAROONA DEPOSIT	
Chk'd By	IGB	23-May-01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.		0	**WSB1 CONSTANT DISCHARGE TEST**	

OBSERVATION BORE- W16M1
CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

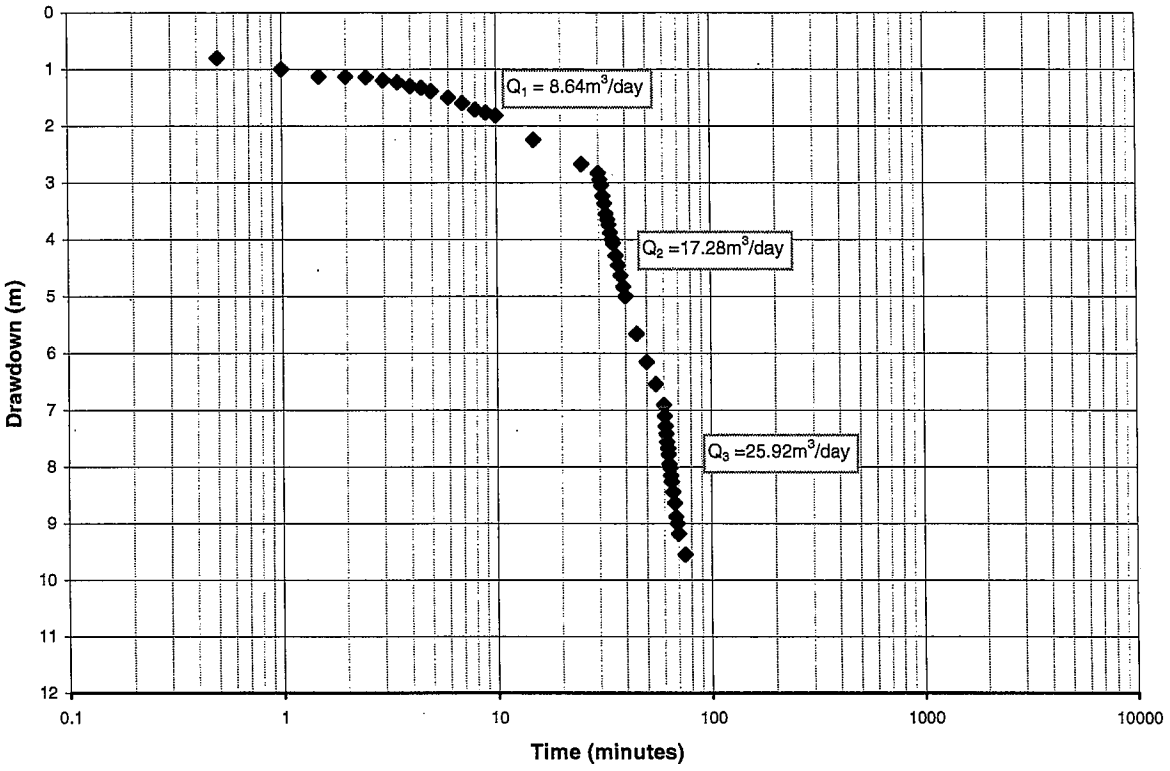


OBSERVATION BORE - W16M1
CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

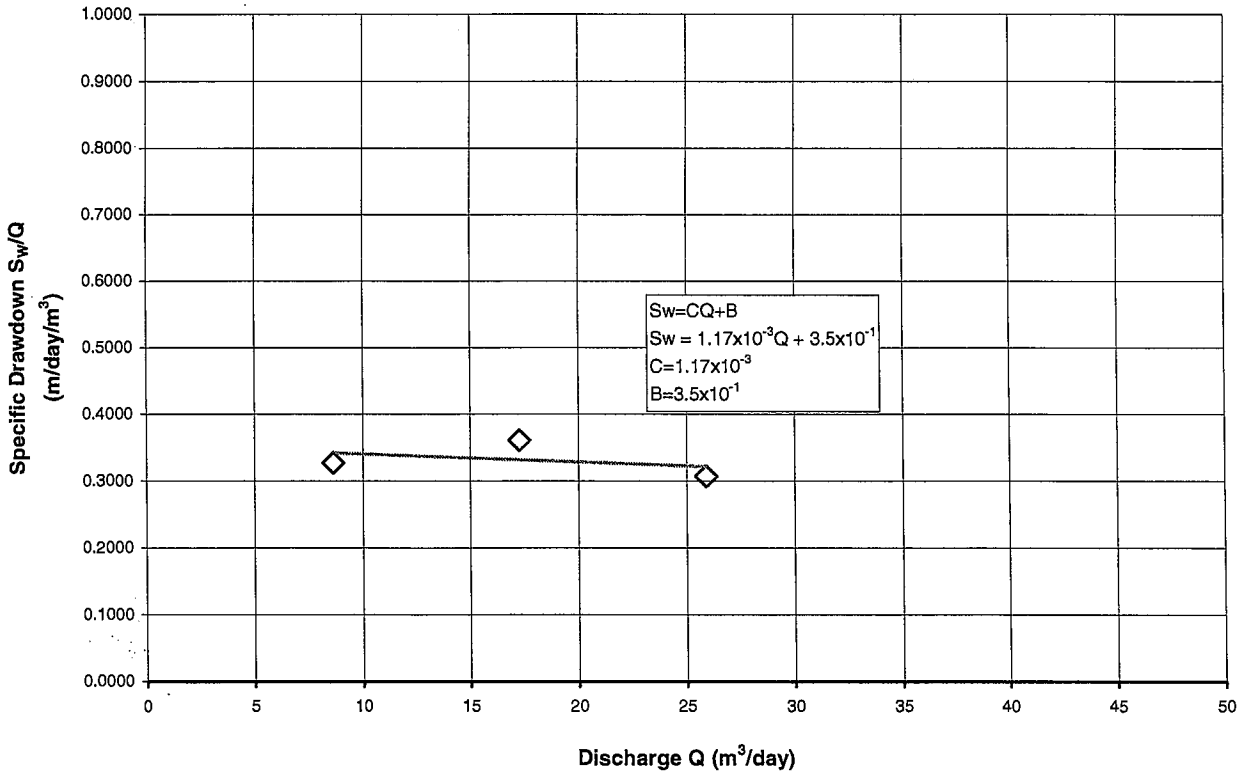


Job No.	44047-021-071		Iluka Resources Limited	FIGURE C3
Prep. By	SCH	23-Feb-01	WAROONA DEPOSIT	
Chk'd By	IGB	24-Feb-01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.		0	**WSB1 CONSTANT DISCHARGE TEST**	

STEP-DISCHARGE TEST
RAW DATA

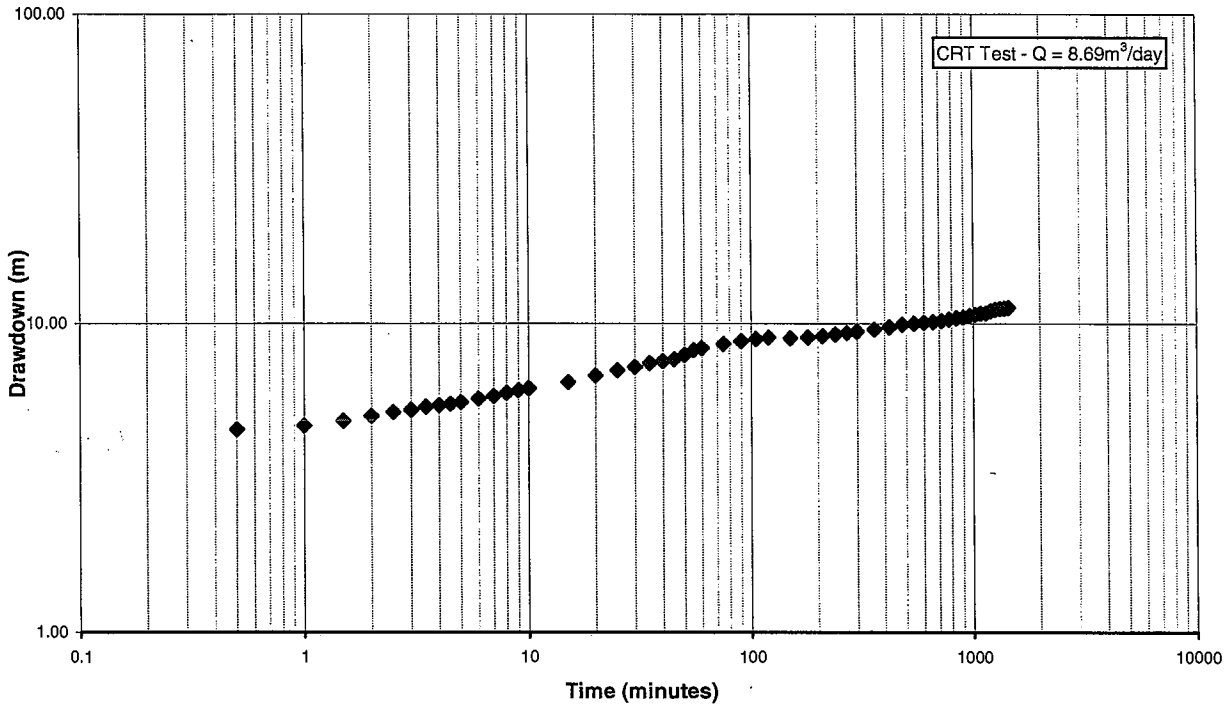


BIERSCHENK-WILSON ANALYSIS

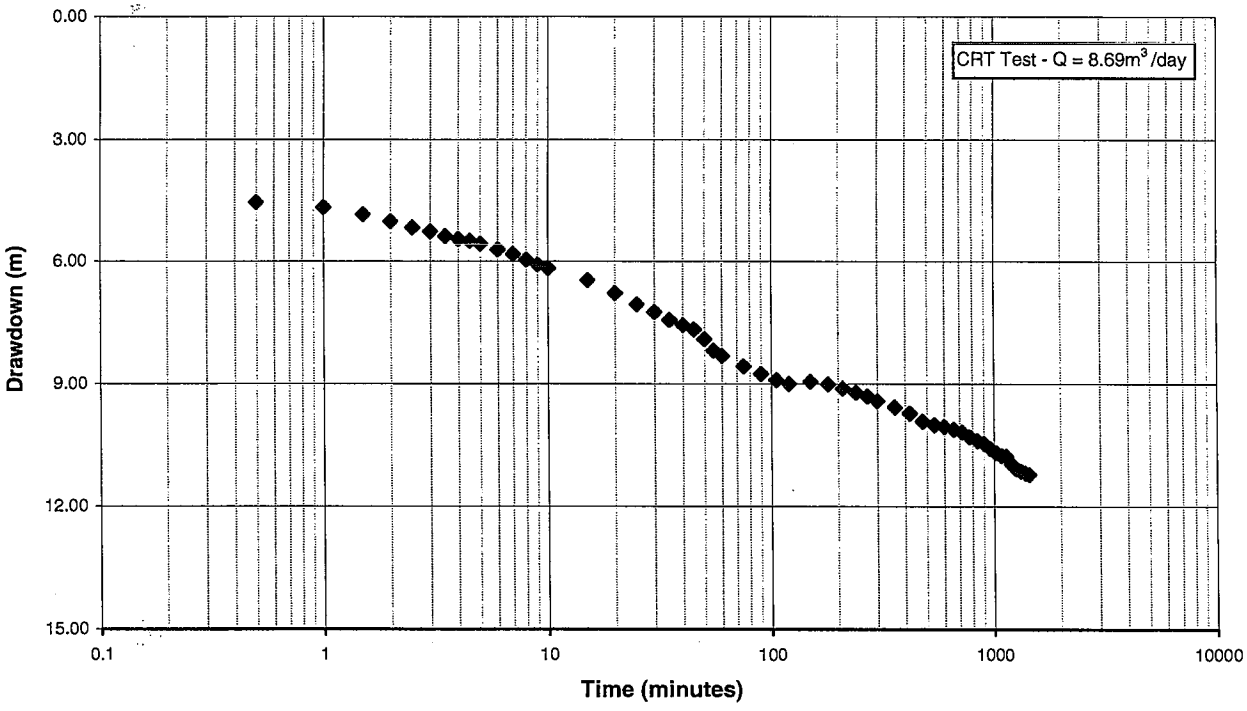


Job No.	44047-021-071		Iluka Resources Limited	**FIGURE C4**
Prep. By	NRH	18 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	19 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.		0	**WSB2 Step Drawdown Test**	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

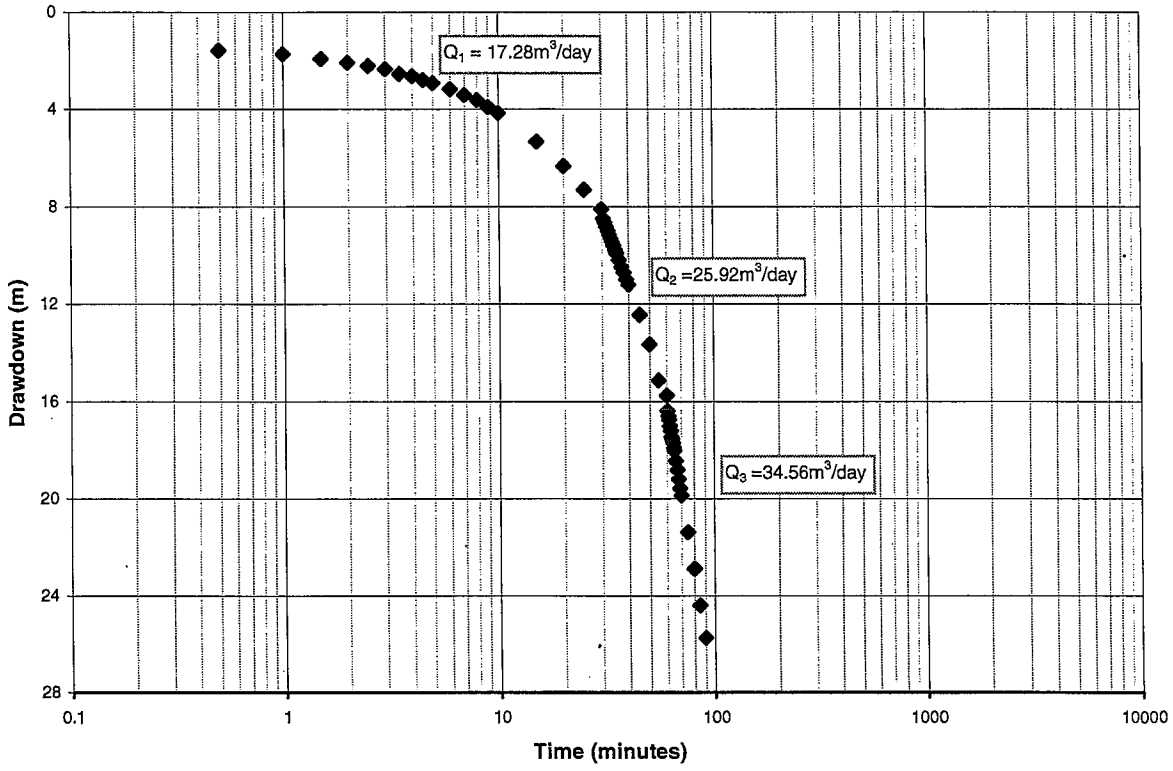


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

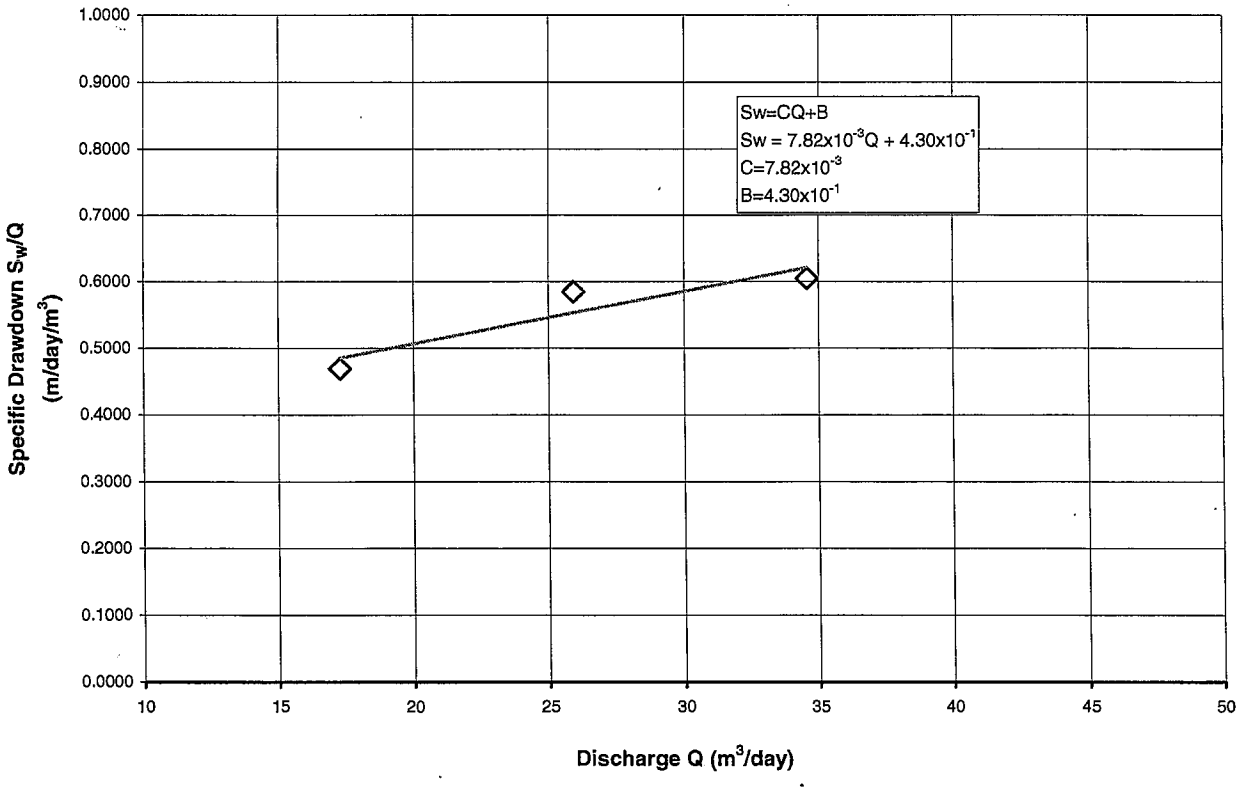


Job No.	44047-021-071		Iluka Resources Limited	FIGURE C5
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.		0	**WSB2 CONSTANT DISCHARGE TEST**	

STEP-DISCHARGE TEST
RAW DATA



BIERSCHENK-WILSON ANALYSIS

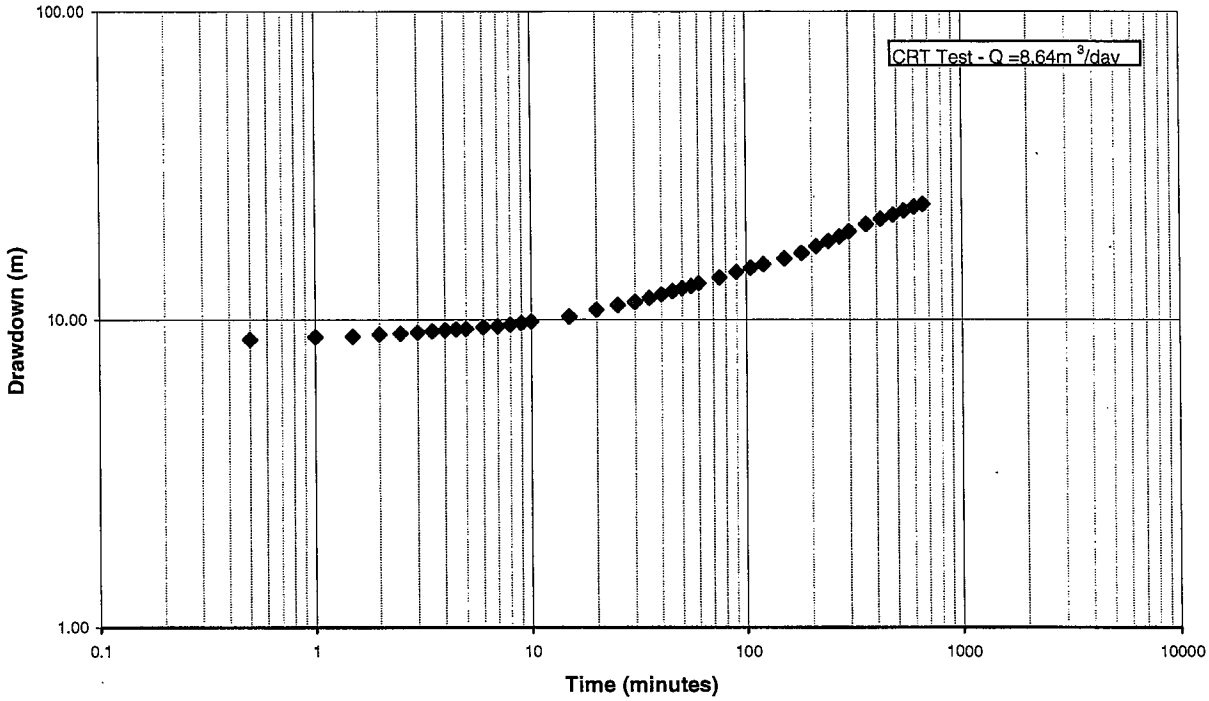


Job No.	44047-021-071		Iluka Resources Limited
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.		0	**WSB3 Step Drawdown Test**

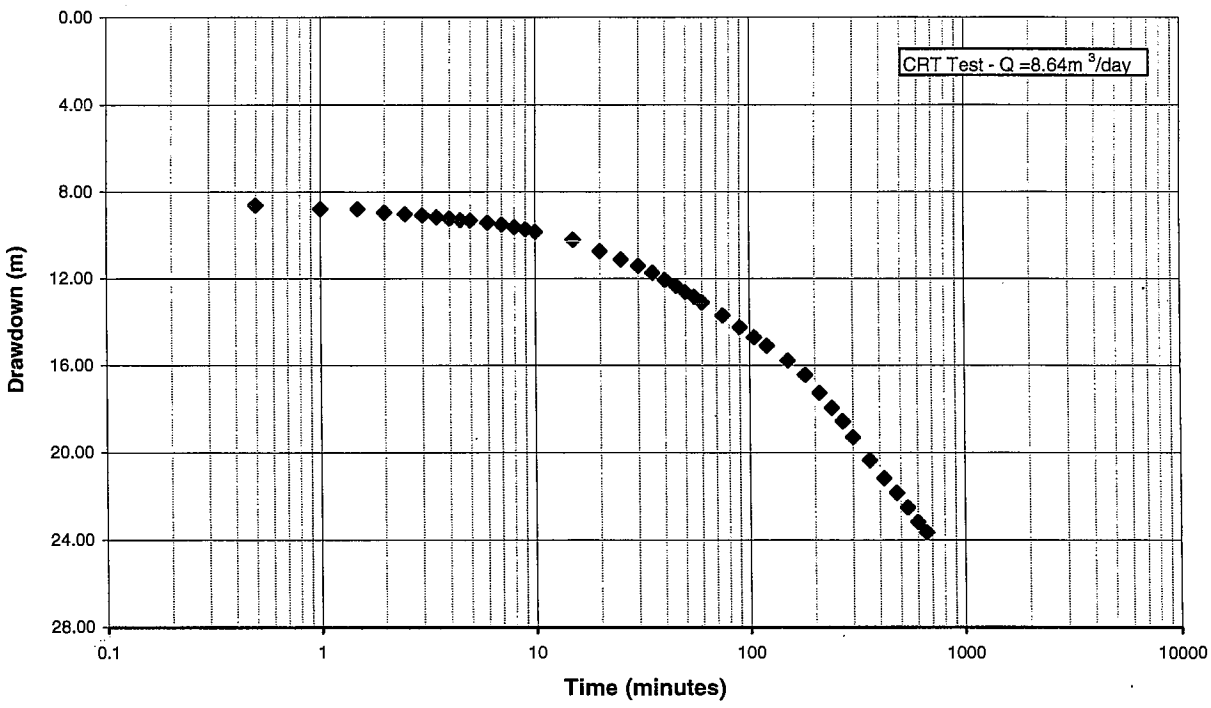
FIGURE C6

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



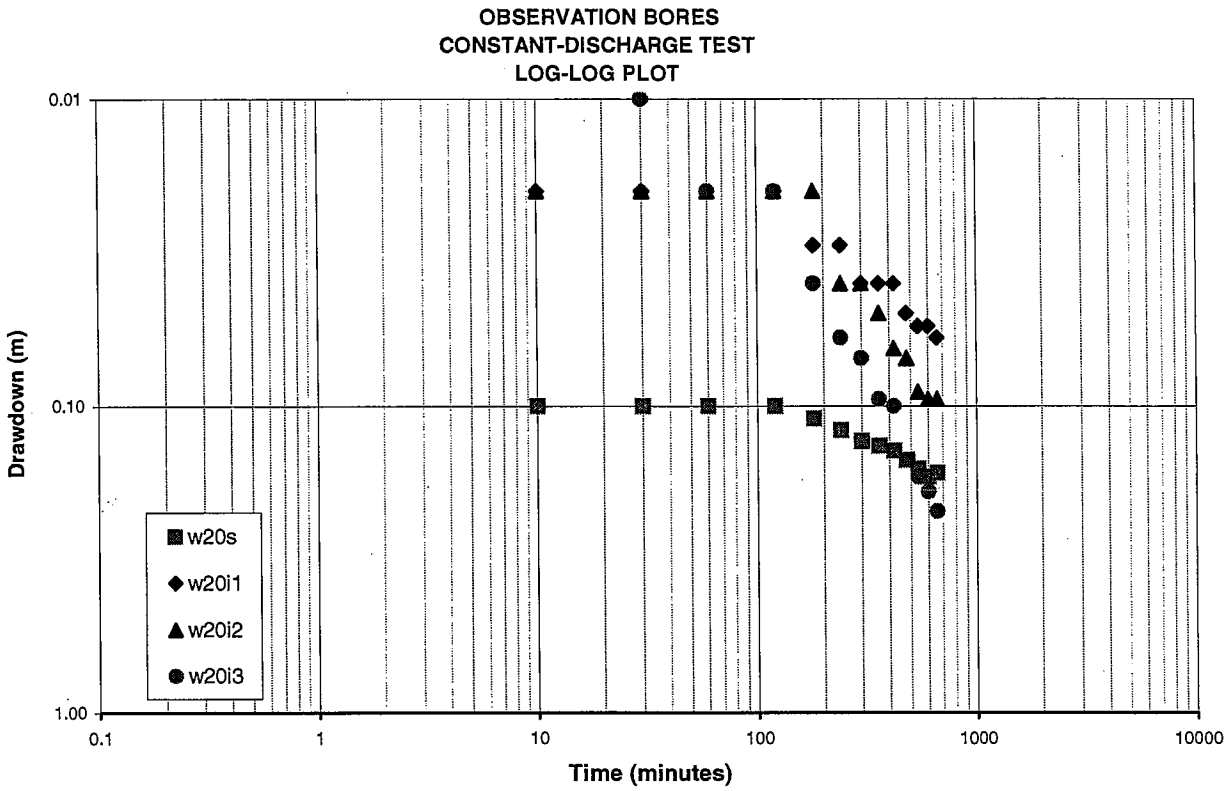
CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

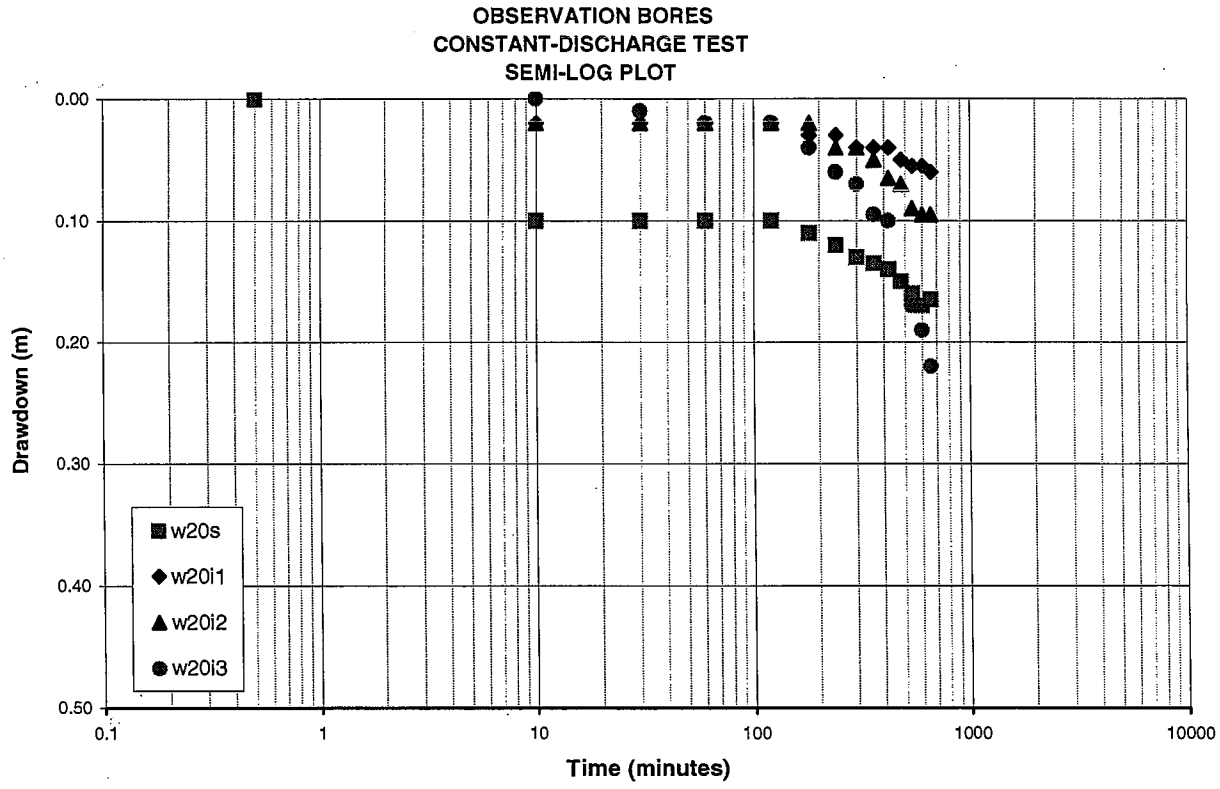


Job No.	44047-021-071		Iluka Resources Limited
Prep. By	SCH	18-May-01	WAROONA DEPOSIT
Chk'd By	IGB	19-May-01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.		0	**WSB3 CONSTANT DISCHARGE TEST**

FIGURE C7

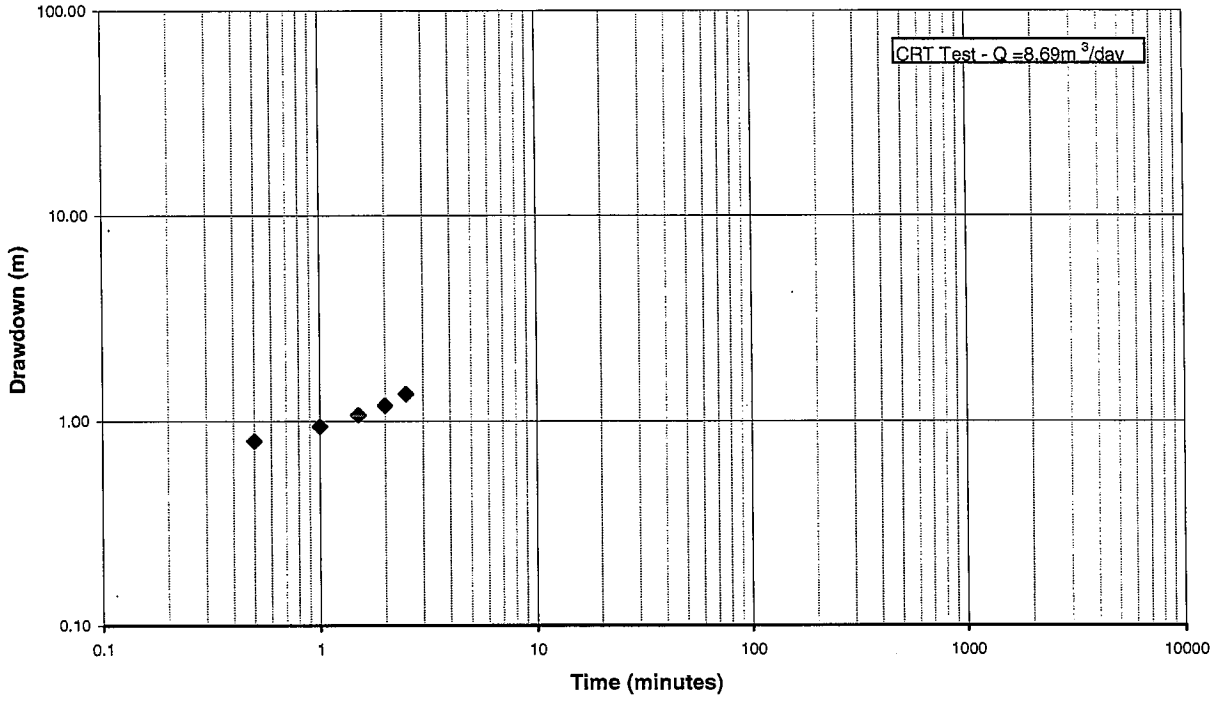
URS



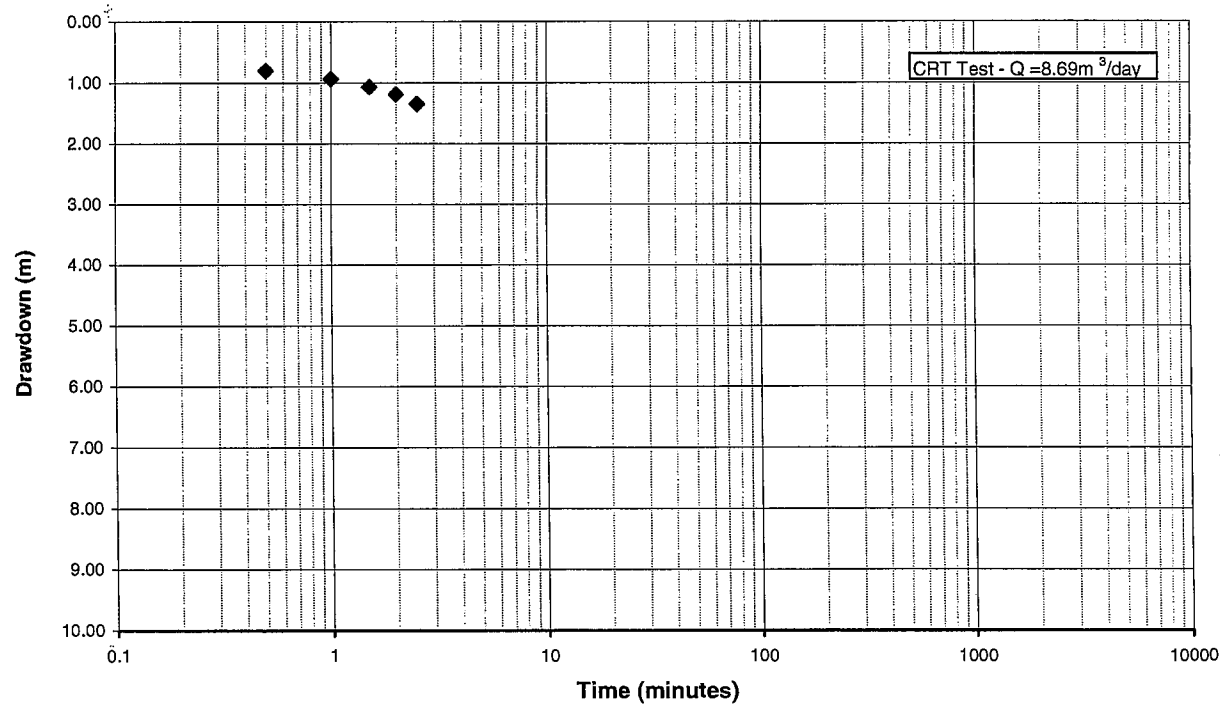


Job No.	44047-021-071		Iluka Resources Limited	FIGURE C8
Prep. By	SCH	22-May-01	WAROONA DEPOSIT	
Chk'd By	IGB	23-May-01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.		0	**WSB3 CONSTANT DISCHARGE TEST**	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

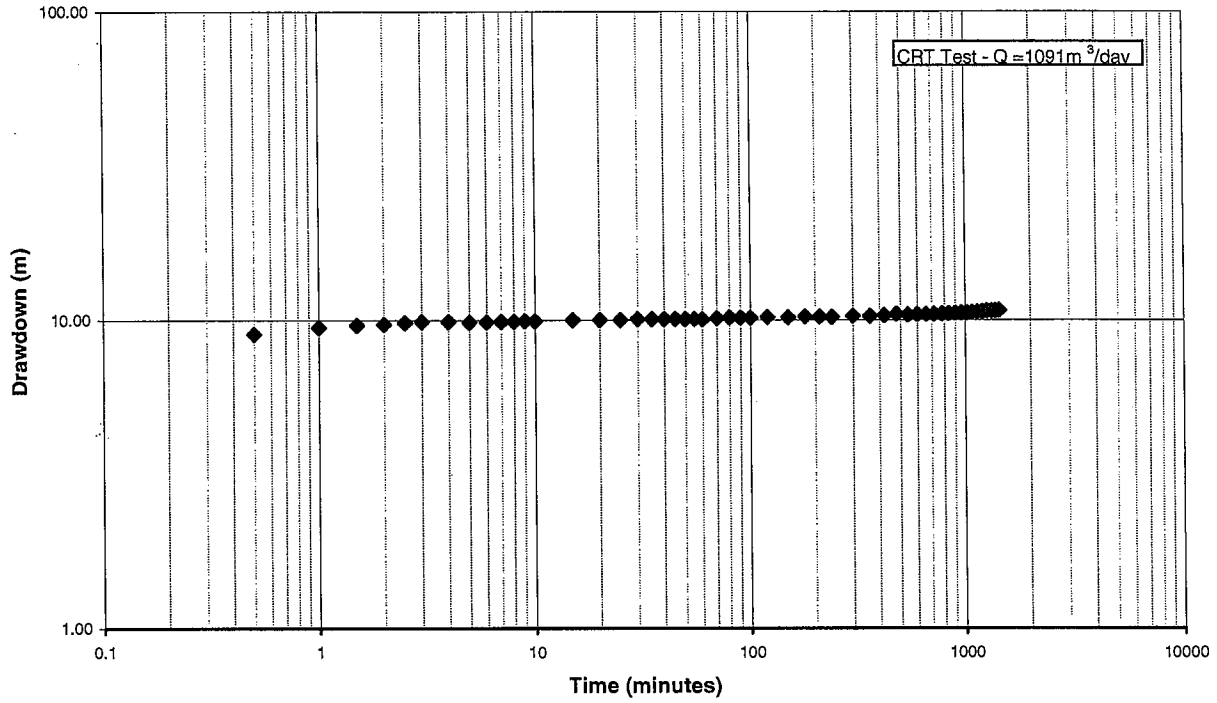


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

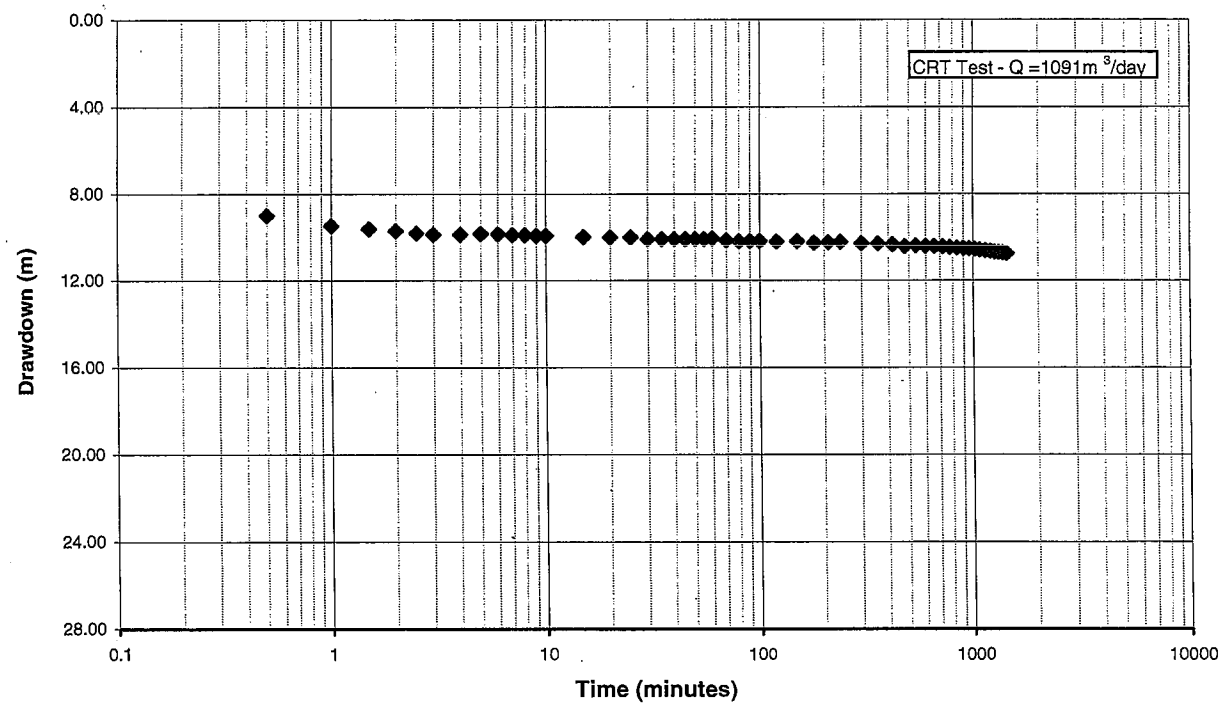


Job No.	44047-021-071		Iluka Resources Limited	**FIGURE C9**
Prep. By	NRH	18-May-01	WAROONA DEPOSIT	
Chk'd By	IGB	19-May-01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.		0	**WSB4 CONSTANT DISCHARGE TEST**	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

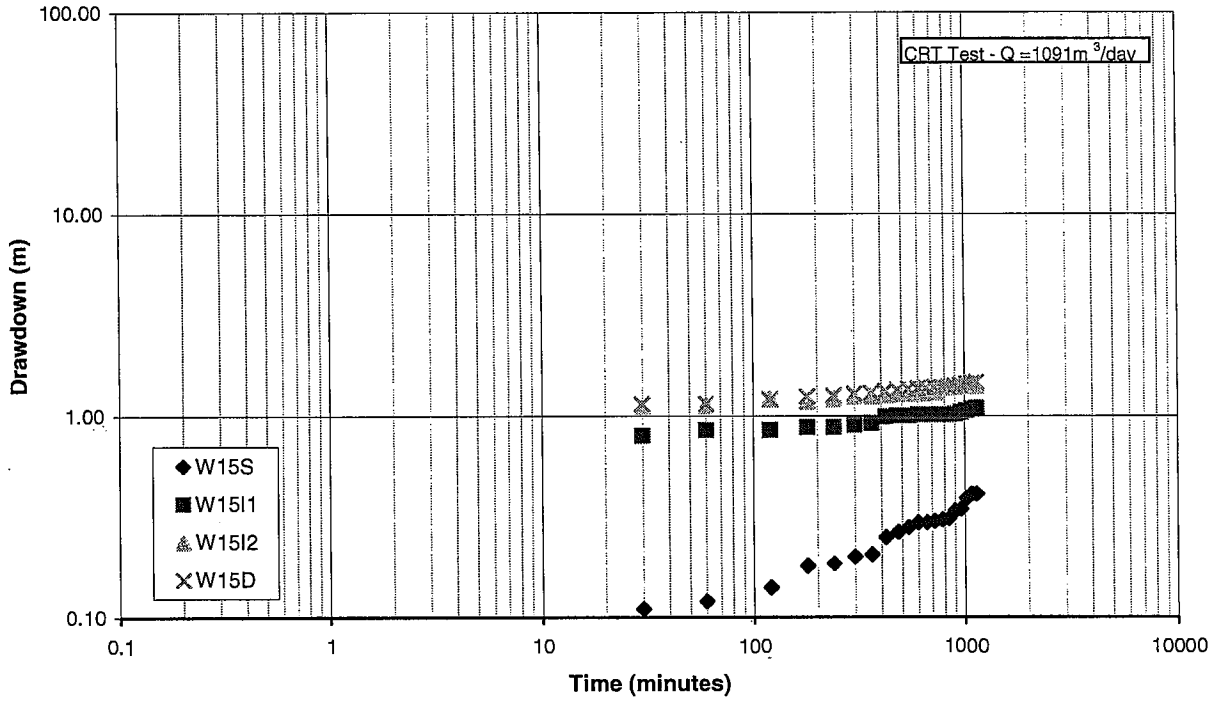


Job No.	44047-021-071		Iluka Resources Limited
Prep. By	NRH	18-May-01	WAROONA DEPOSIT
Chk'd By	IGB	19-May-01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.		0	**WSB5 CONSTANT DISCHARGE TEST**

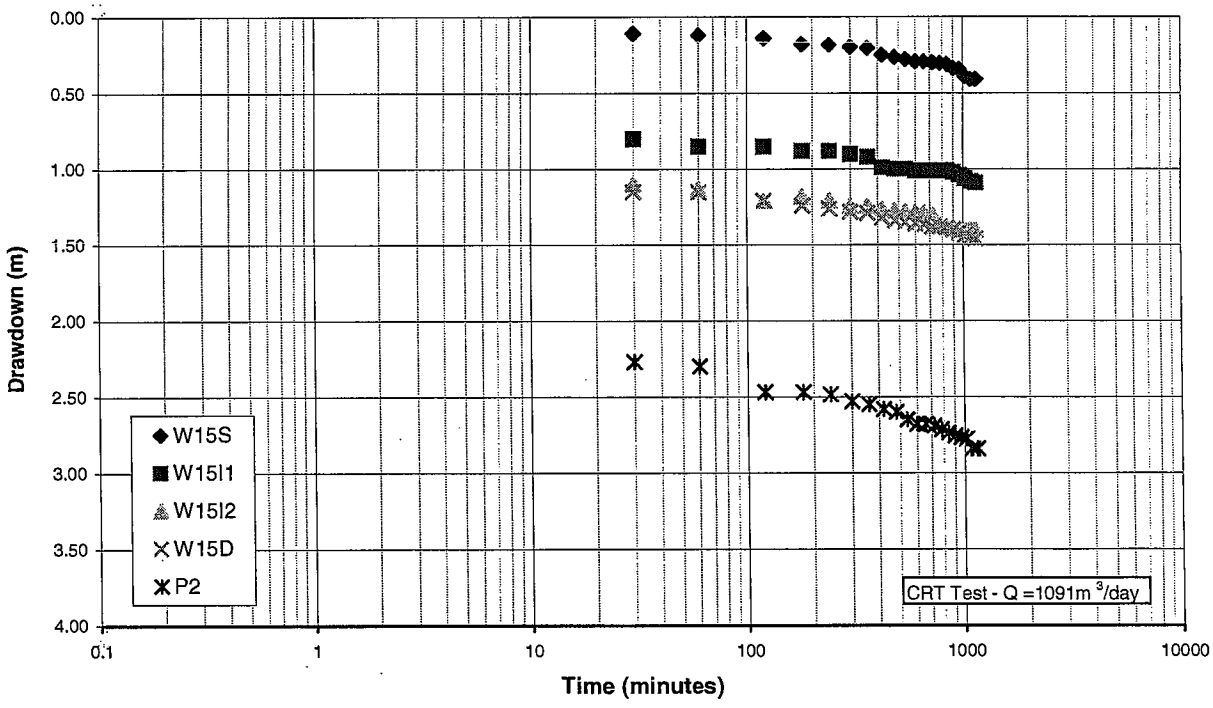
FIGURE C10

URS

OBSERVATION BORES
CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



OBSERVATION BORES
CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

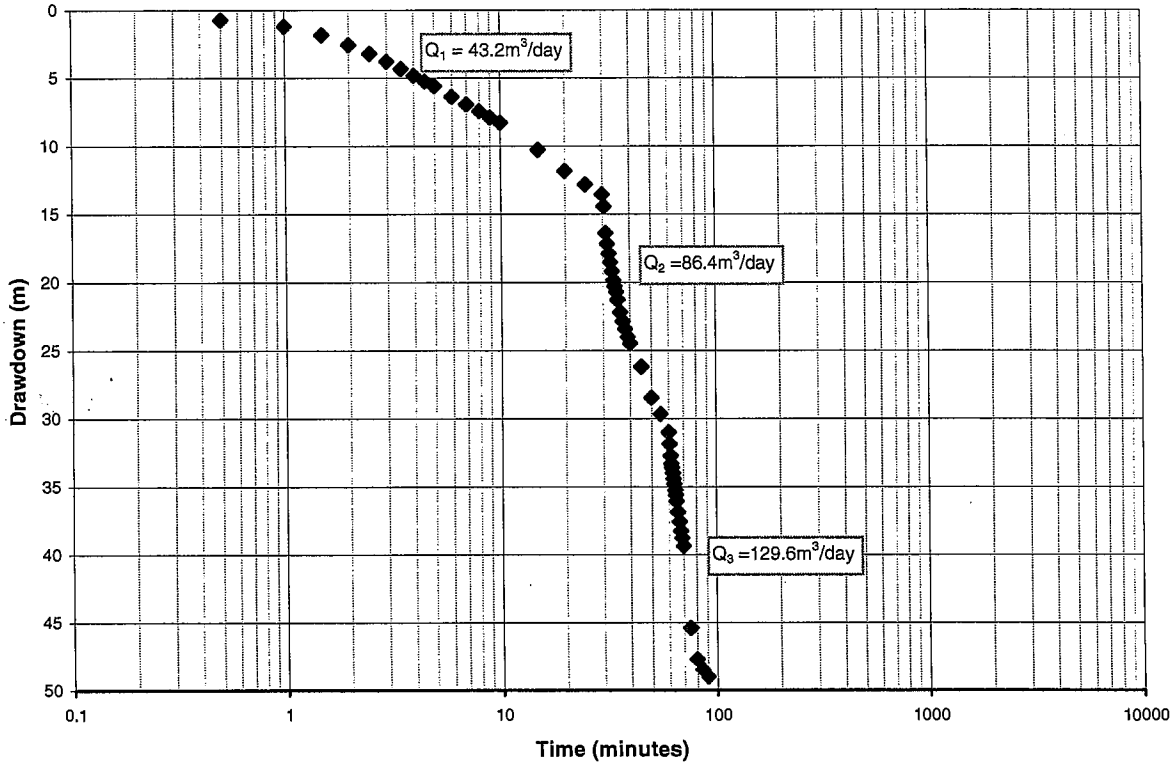


Job No.	44047-021-071		Iluka Resources Limited
Prep. By	NRH	18-May-01	WAROONA DEPOSIT
Chk'd By	IGB	19-May-01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.		0	**WSB5 CONSTANT DISCHARGE TEST**

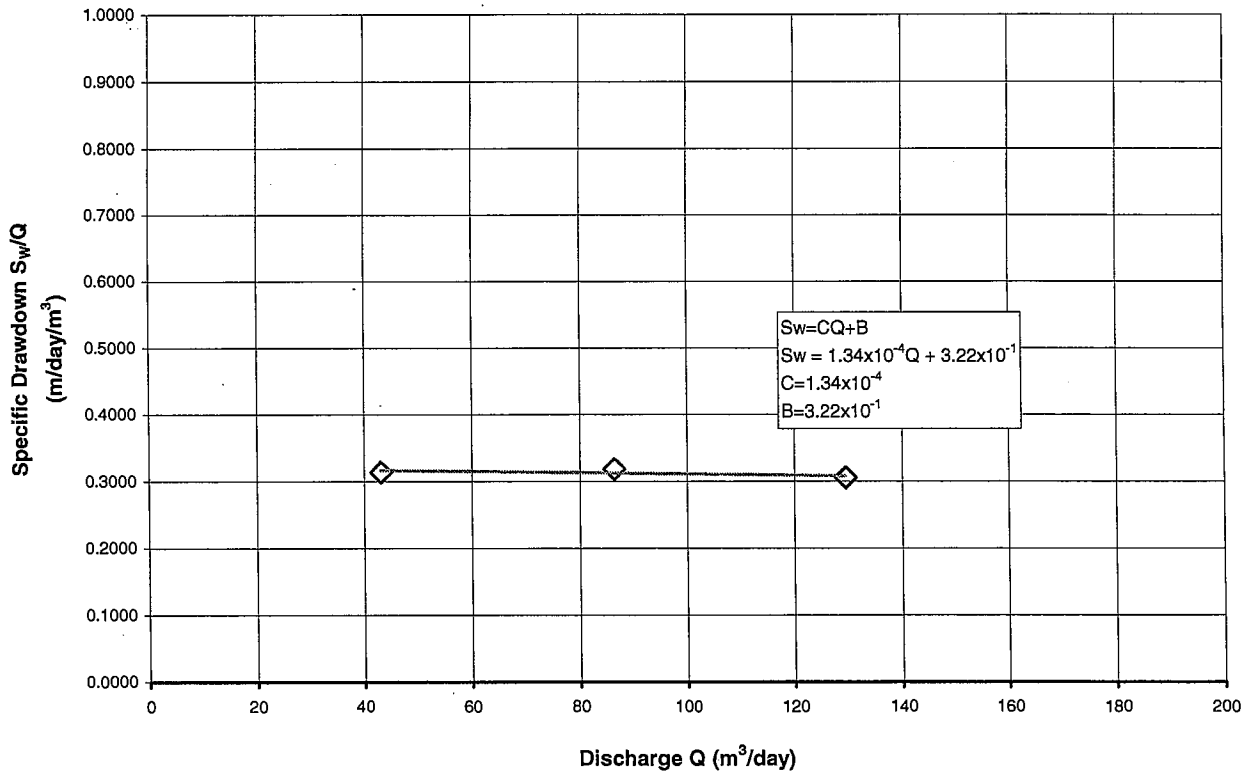
FIGURE C11

URS

STEP-DISCHARGE TEST
RAW DATA

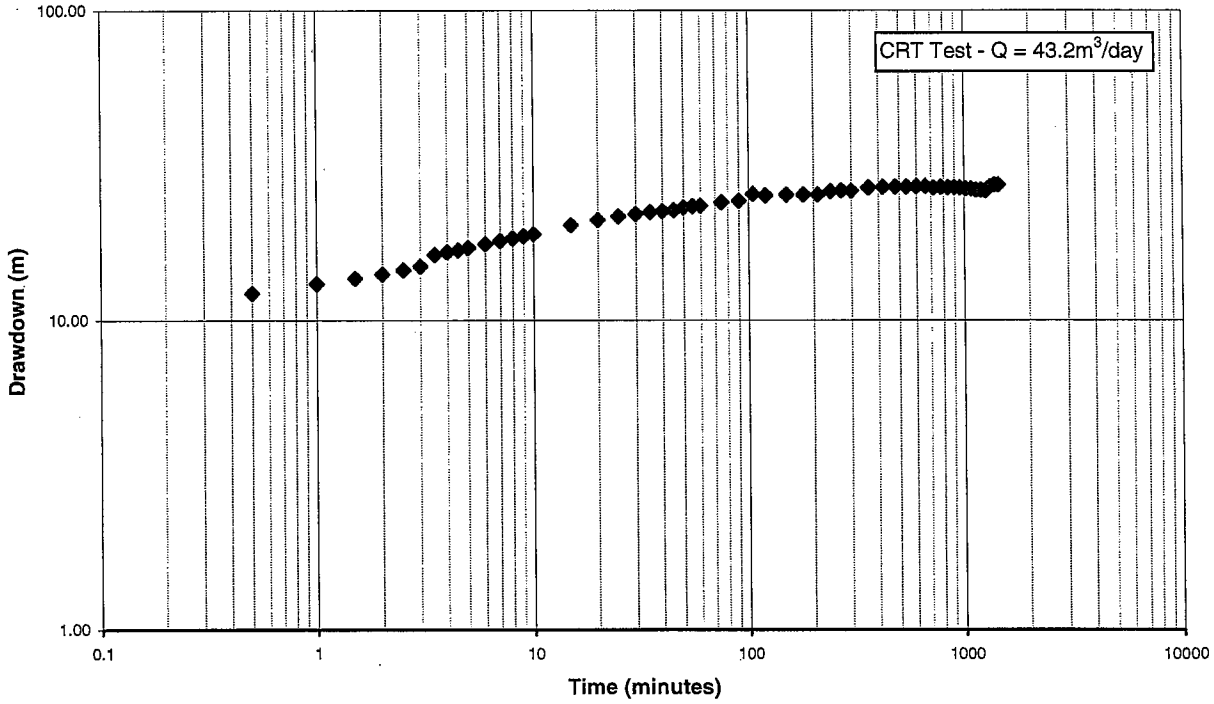


BIERSCHENK-WILSON ANALYSIS

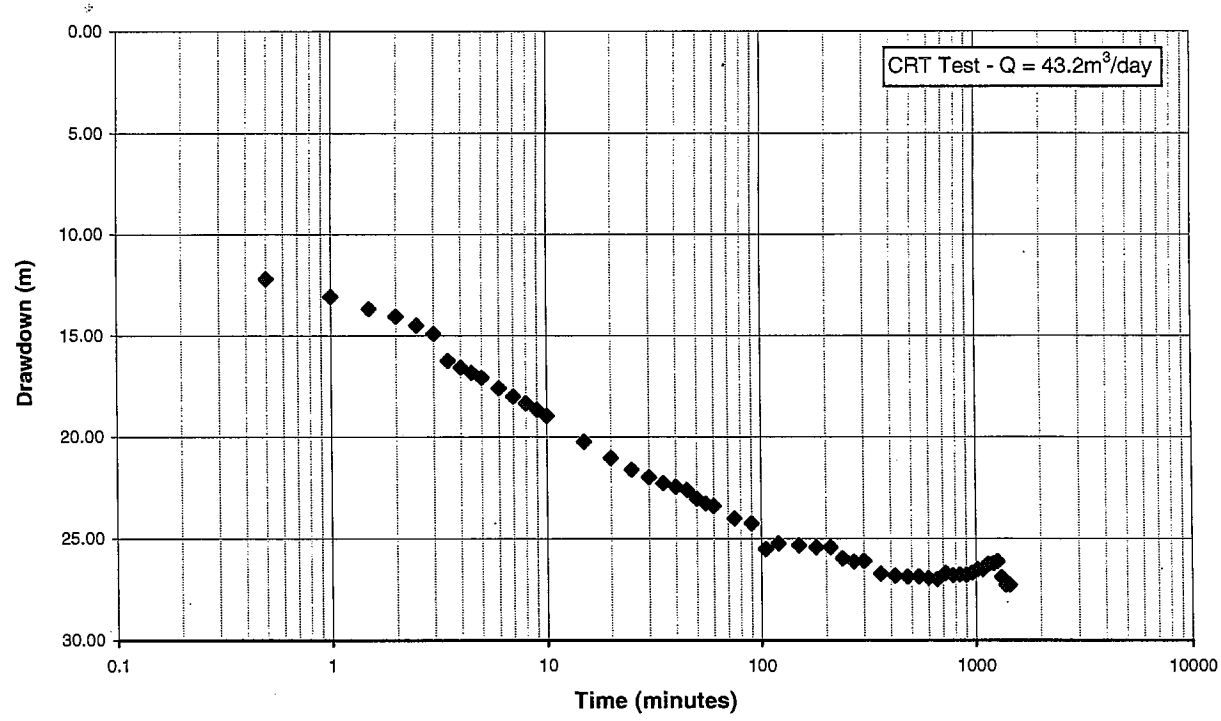


Job No.	44047-021-071		Iluka Resources Limited	FIGURE C12
Prep. By	TJS	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.		0	**WLB1 Step Drawdown Test**	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



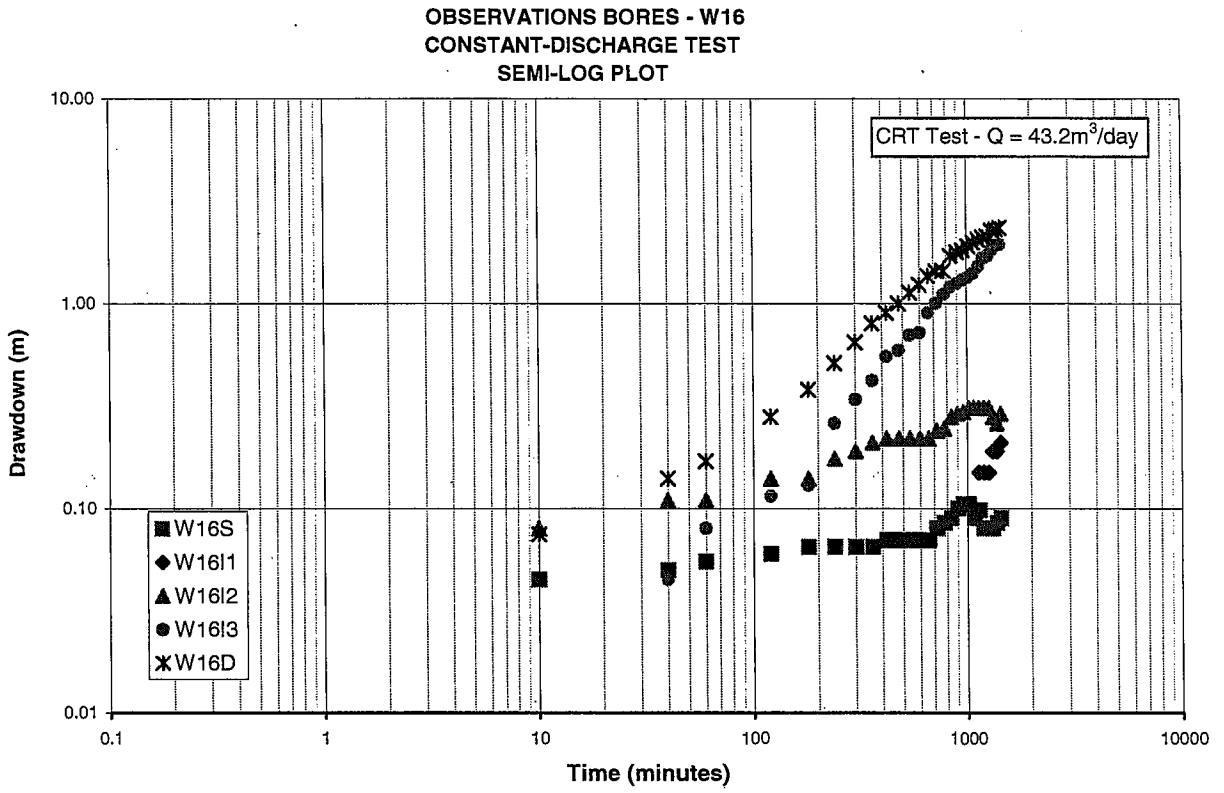
CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

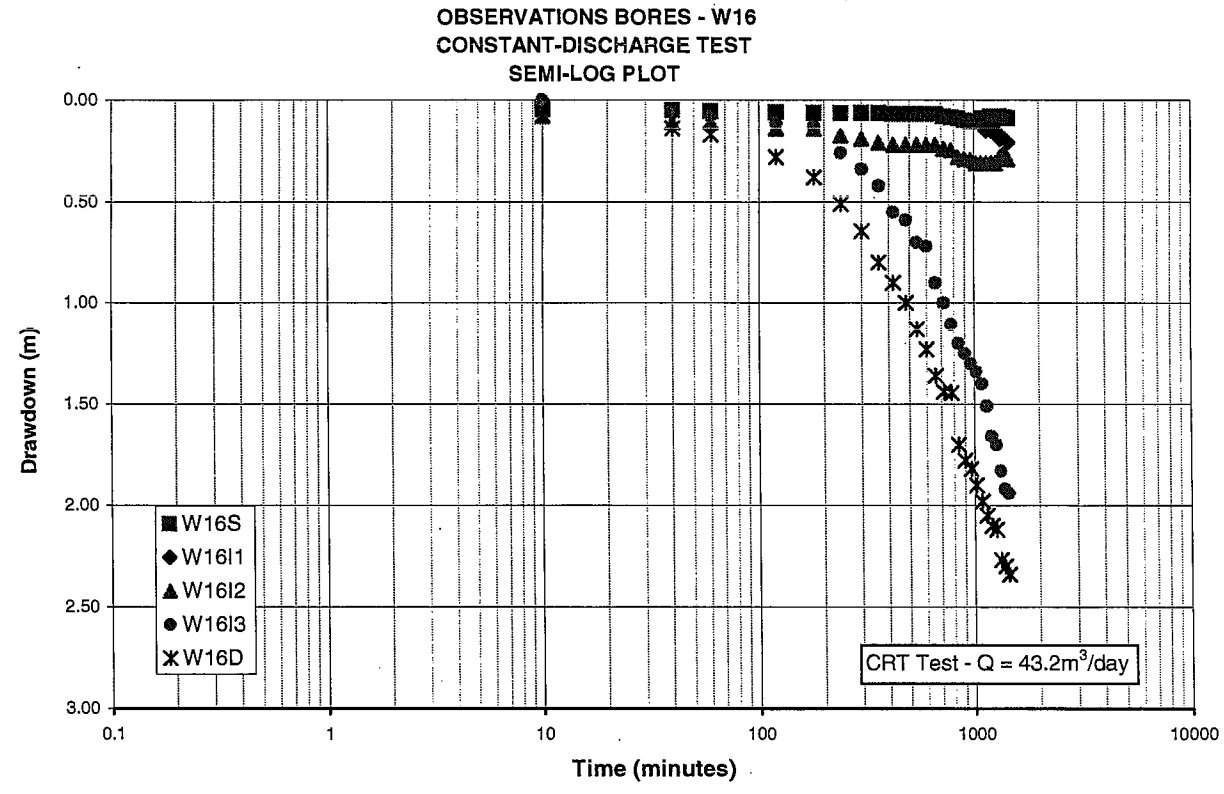


Job No.	44047-021-071		Iluka Resources Limited
Prep. By	SCH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.		0	**WLB1 CONSTANT DISCHARGE TEST**

FIGURE C13

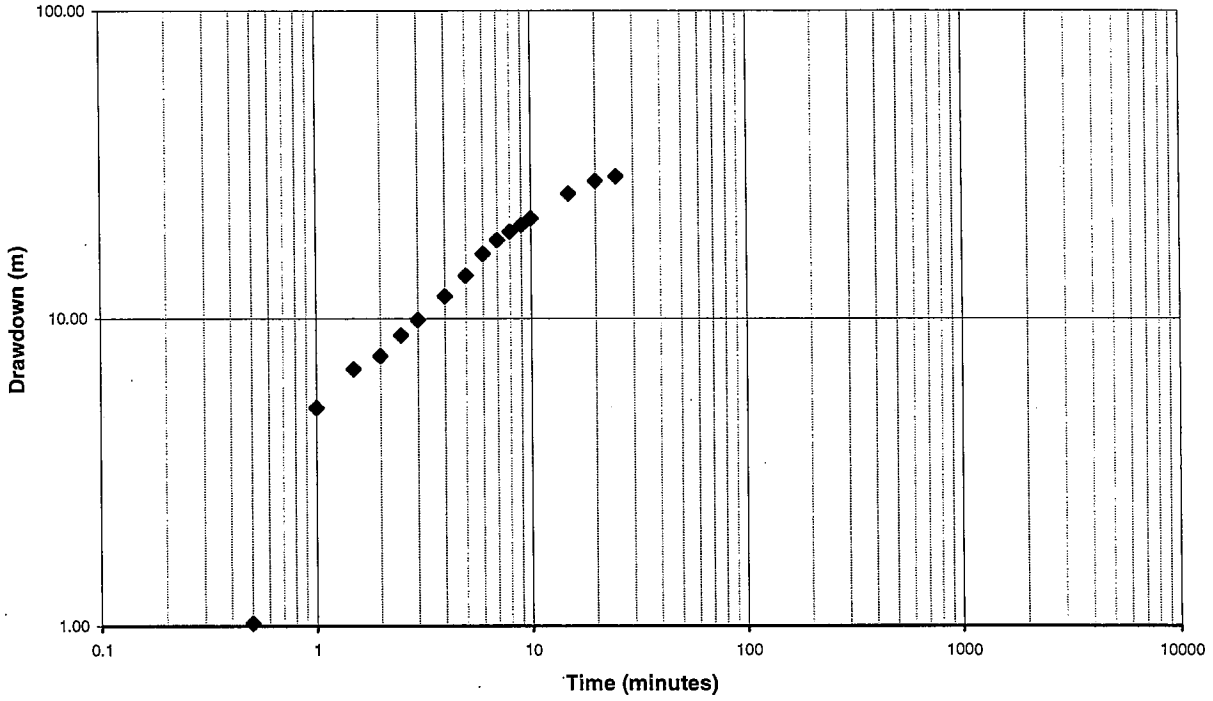
URS



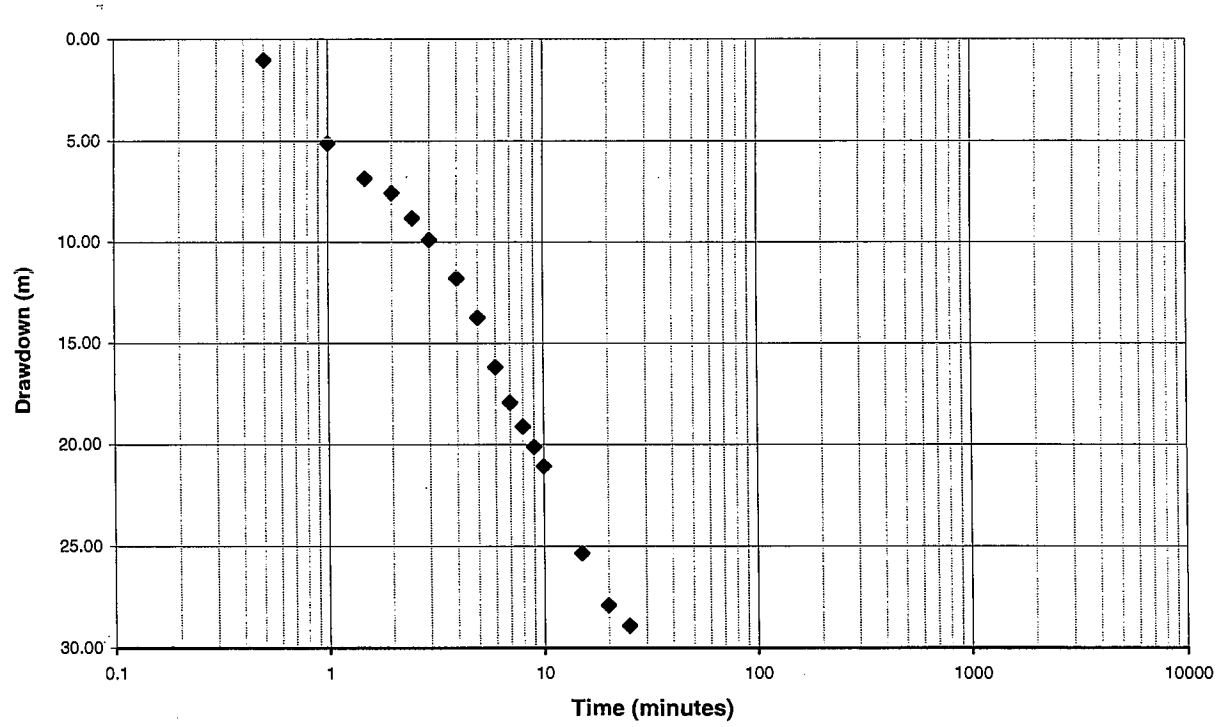


Job No.	44047-021-071		Iluka Resources Limited	FIGURE C14
Prep. By	SCH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.		0	**WLB1 CONSTANT DISCHARGE TEST**	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

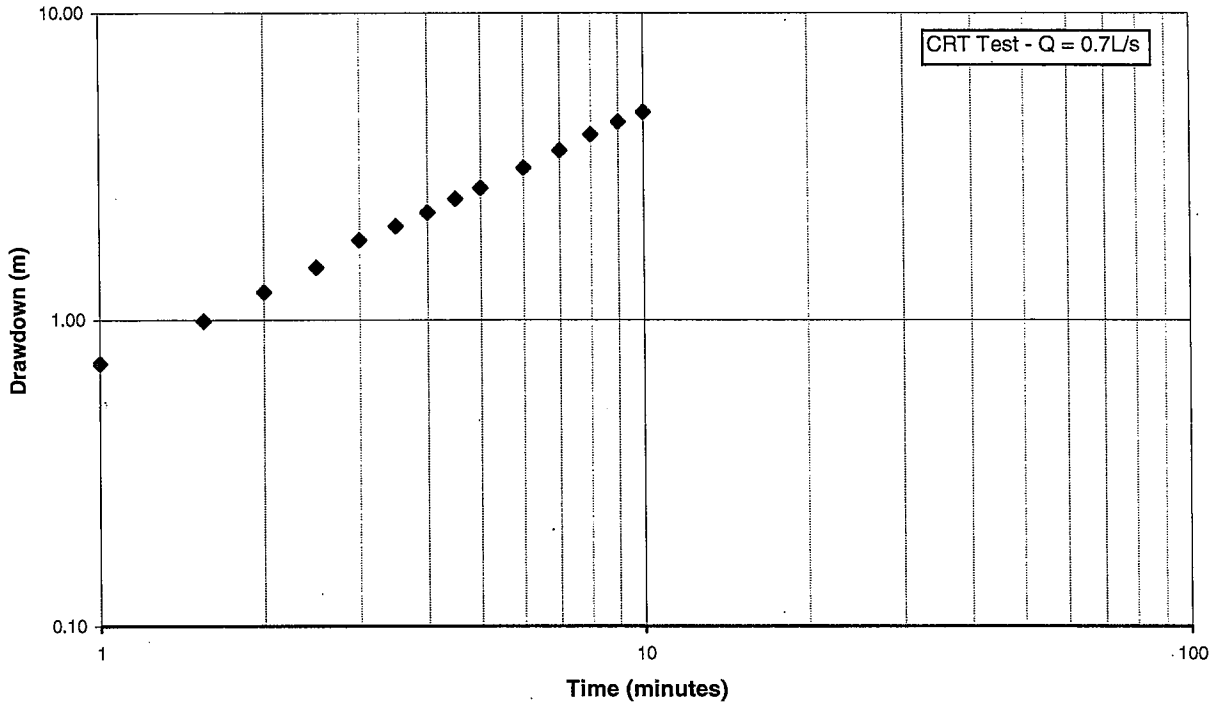


Job No.	44047-021-071		Iluka Resources Limited	FIGURE C15
Prep. By	SCH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.		0	**WLB2 CONSTANT DISCHARGE TEST**	

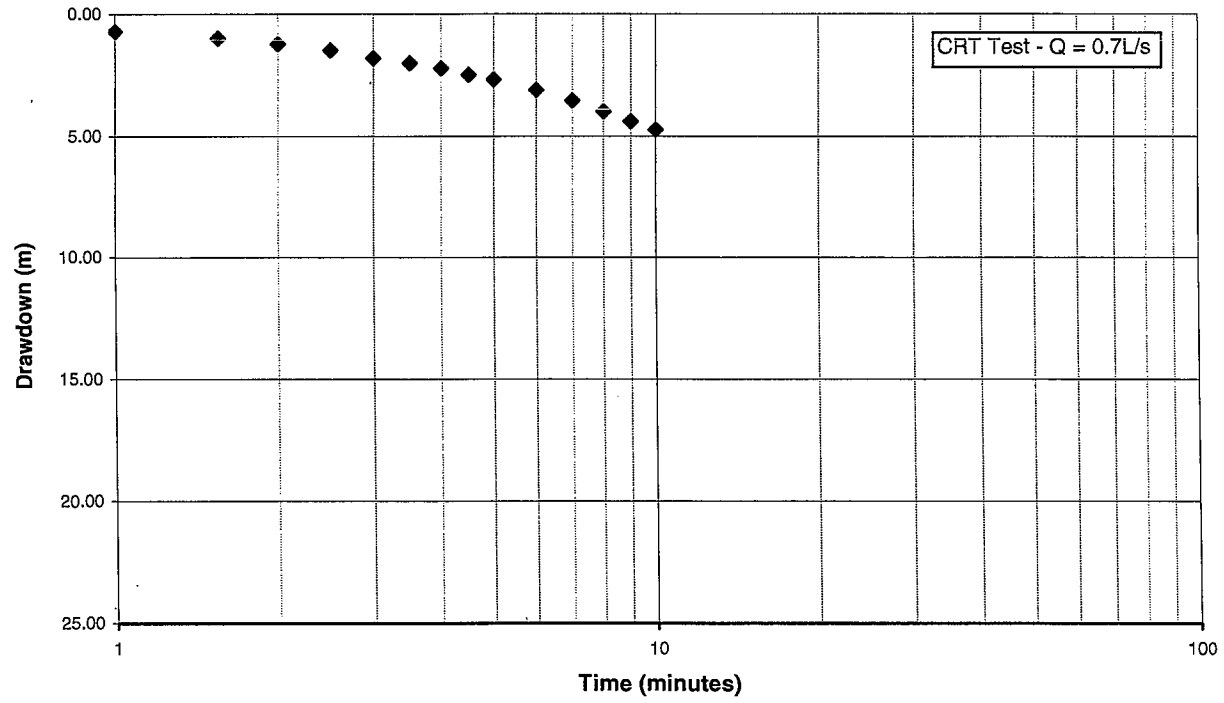
Appendix D
Multipiezometer Bore Aquifer Test Plots

D1	W10S Test
D2	W10M Test
D3	W10D Test
D4	W12S Test
D5	W12D Test
D6	W13S Test
D7	W13D Test
D8	W15S Test
D9	W15M1 Test
D10	W15M2 Test
D11	W15D Test
D12	W16S Test
D13	W16M1 Test
D14	W16M2 Test
D15	W16M3 Test
D16	W16D Test
D17	W17S Test
D18	W17D Test
D19	W18S Test
D20	W18D Test
D21	W20S Test
D22	W20M1 Test
D23	W20M2 Test
D24	W20M3 Test
D25	W20M4 Test
D26	W20D Test
D27	W21M Test
D28	W21D Test
D29	W22S Test
D30	W22D Test
D31	W23S Test
D32	W23M Test
D33	W23D Test
D34	W24 Test
D35	W25D Test
D36	W26S Test

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

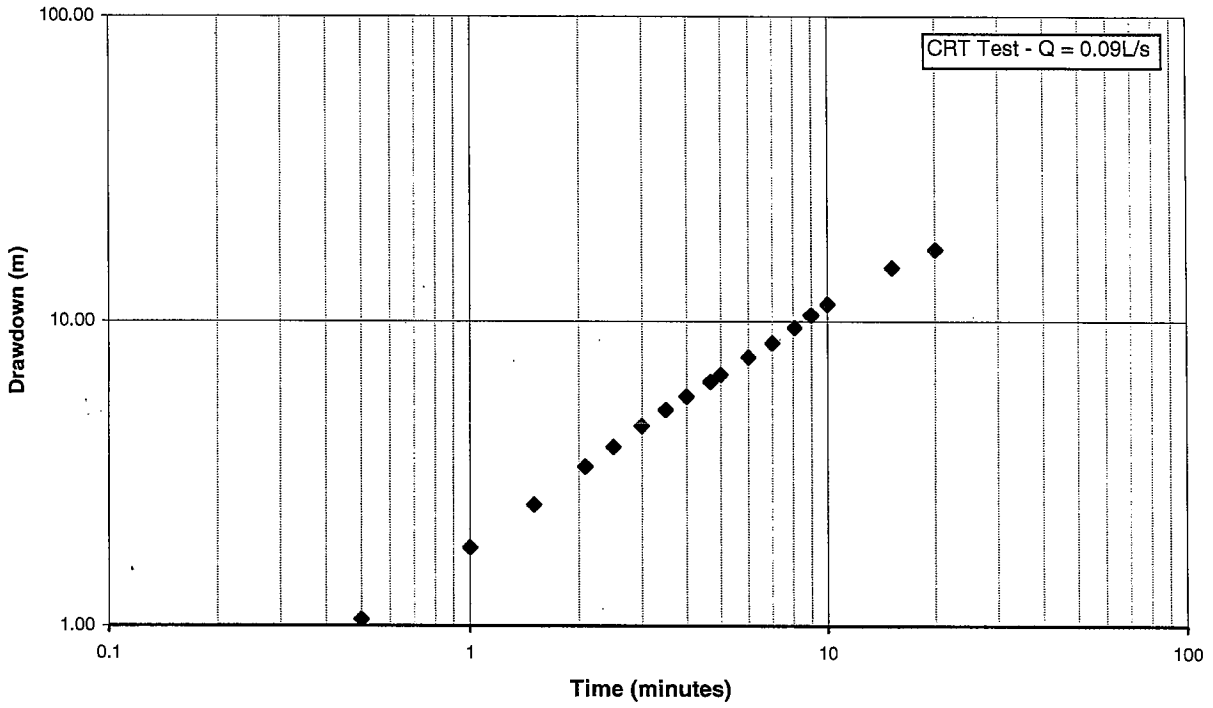


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

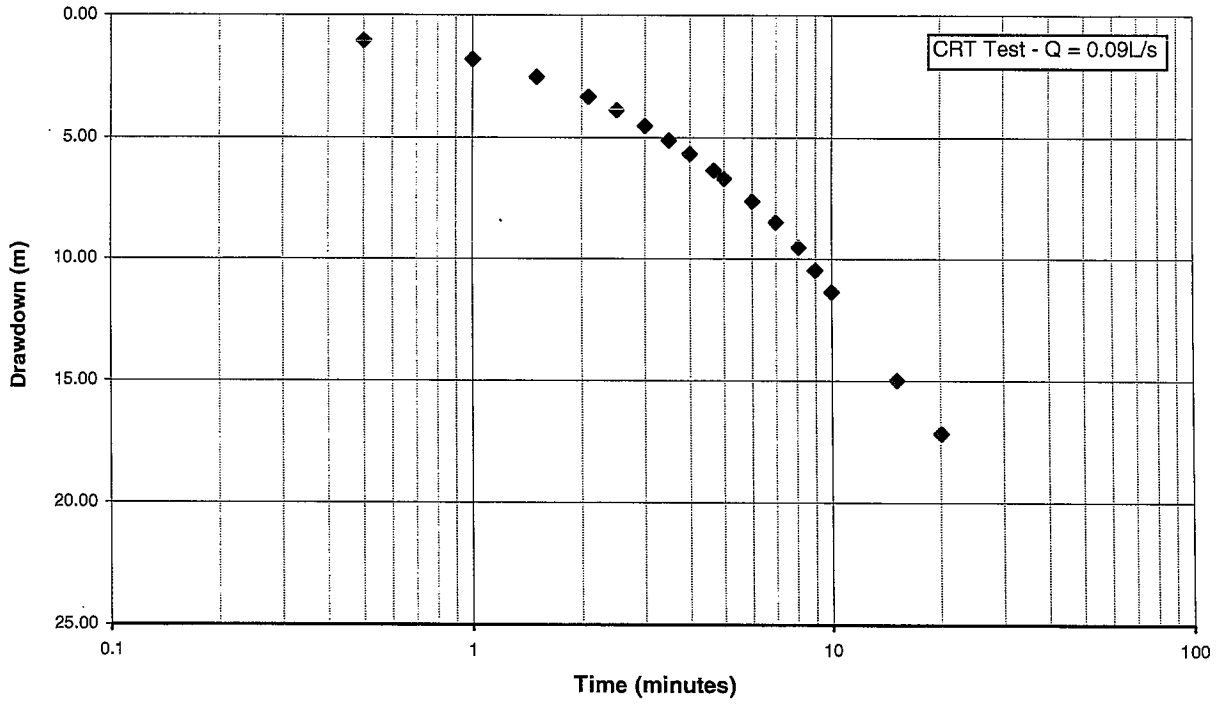


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D1
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			**W10S CONSTANT RATE TEST**	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT



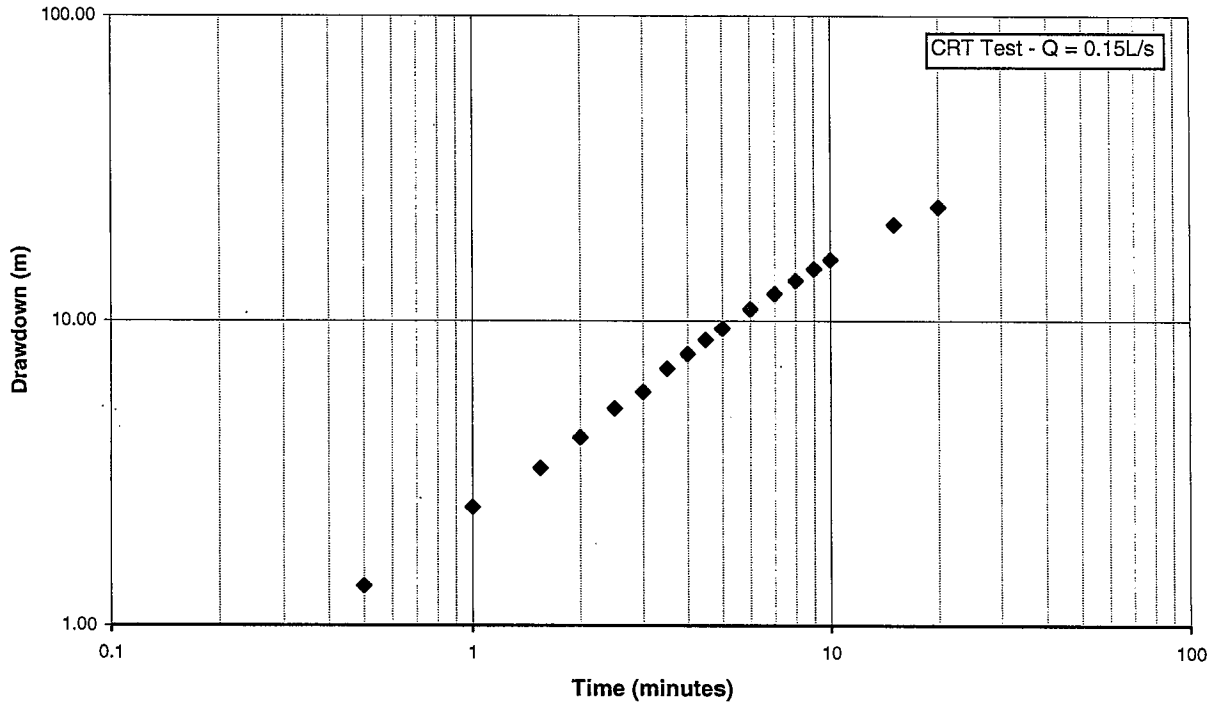
Job No.	44047-021-071	
Prep. By	NRH	22 May. '01
Chk'd By	IGB	23 May. '01
Revision No.		

Iluka Resources Ltd
WAROONA DEPOSIT
IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
W10M CONSTANT RATE TEST

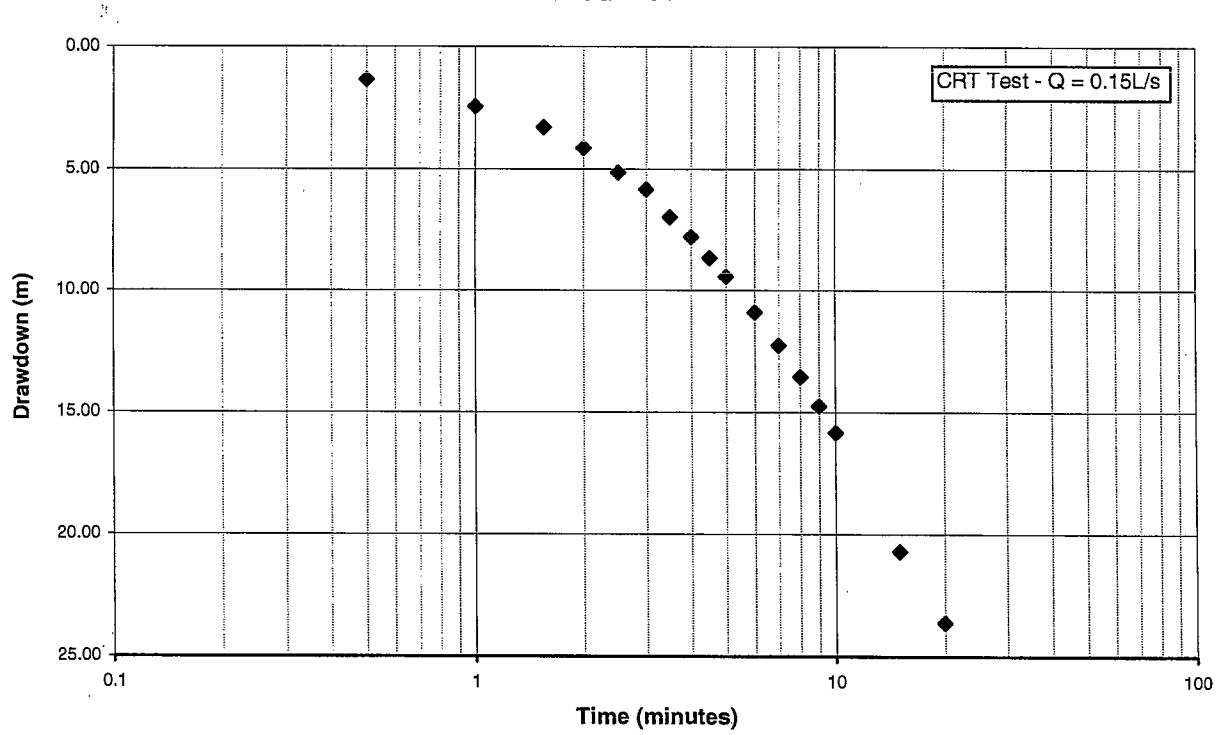
FIGURE D2

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

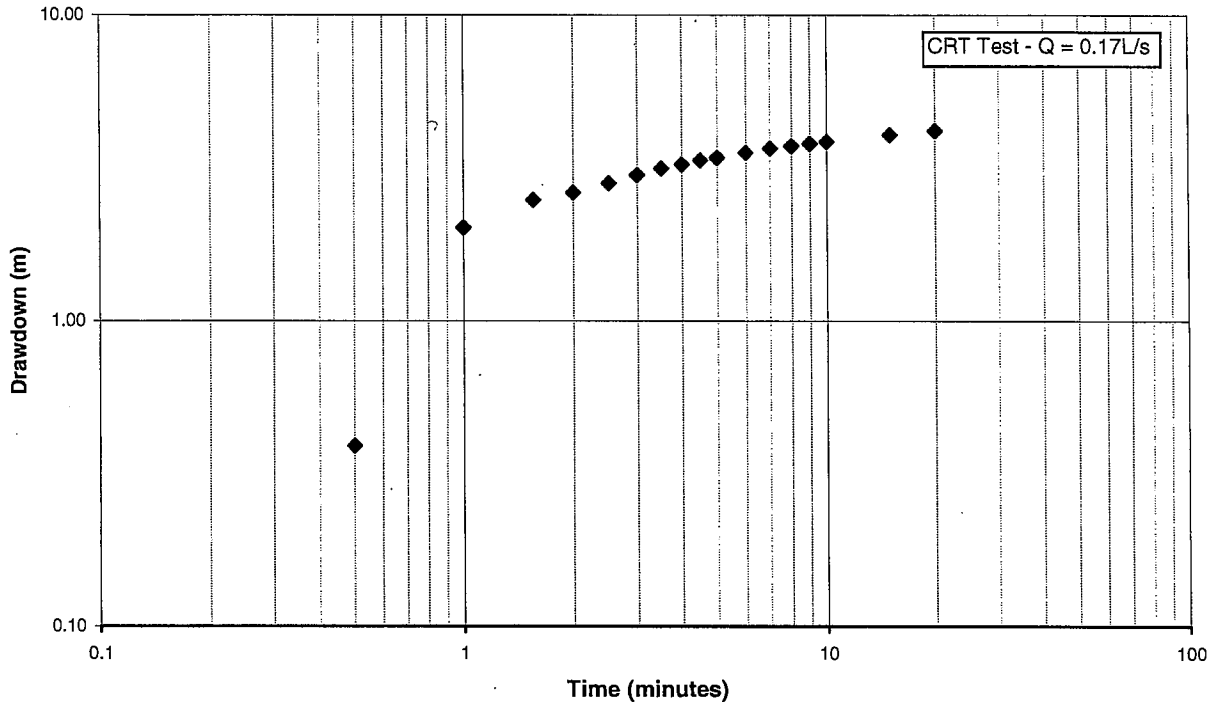


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

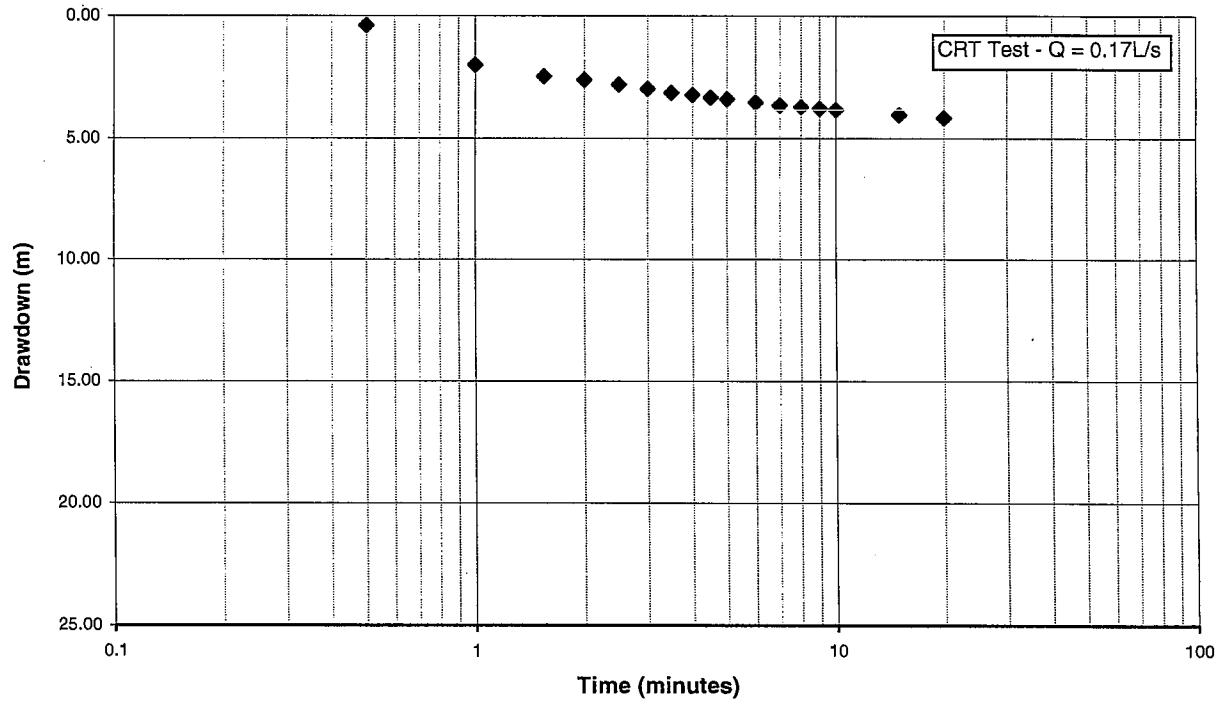


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D3
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			W10D CONSTANT RATE TEST	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

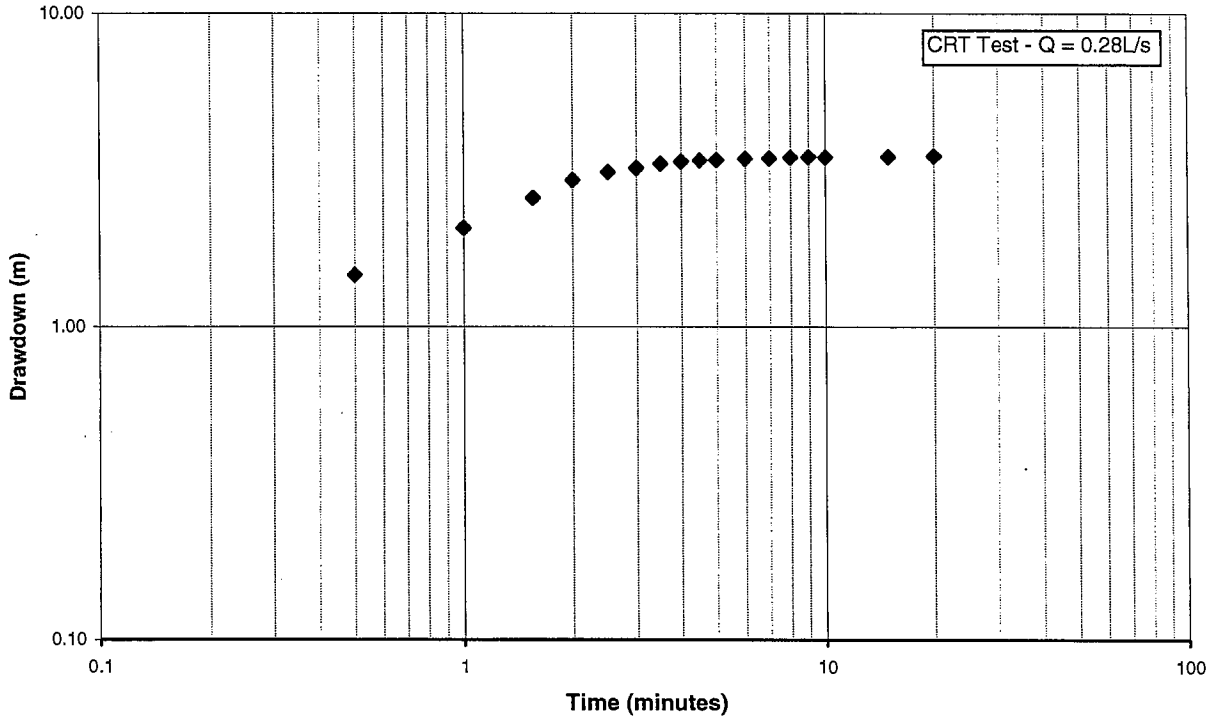


Job No.	44047-021-071		Iluka Resources Ltd
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.			**W12S CONSTANT RATE TEST**

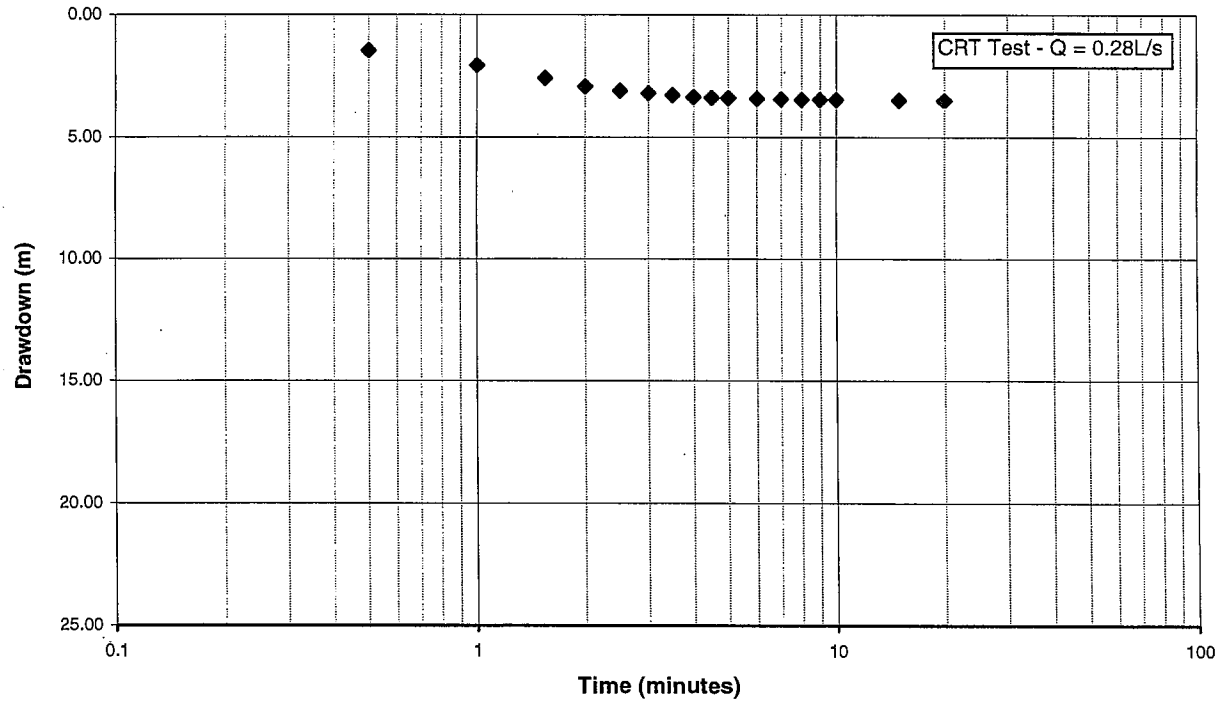
FIGURE D4

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

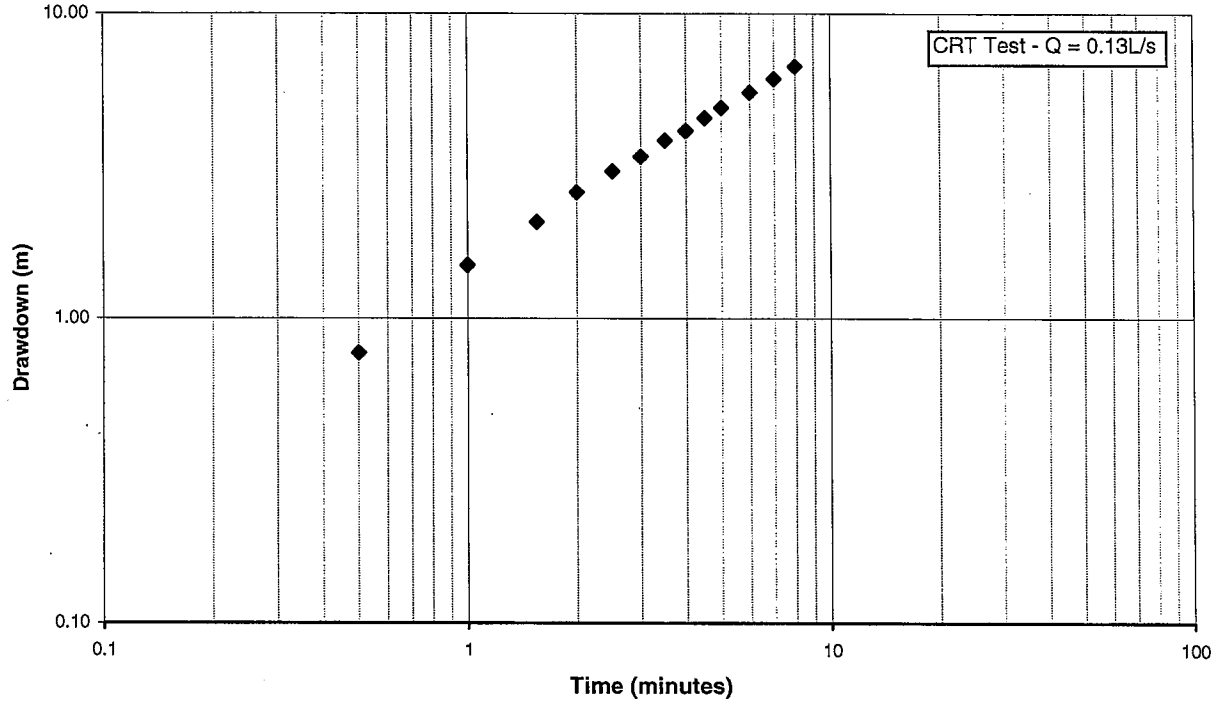


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

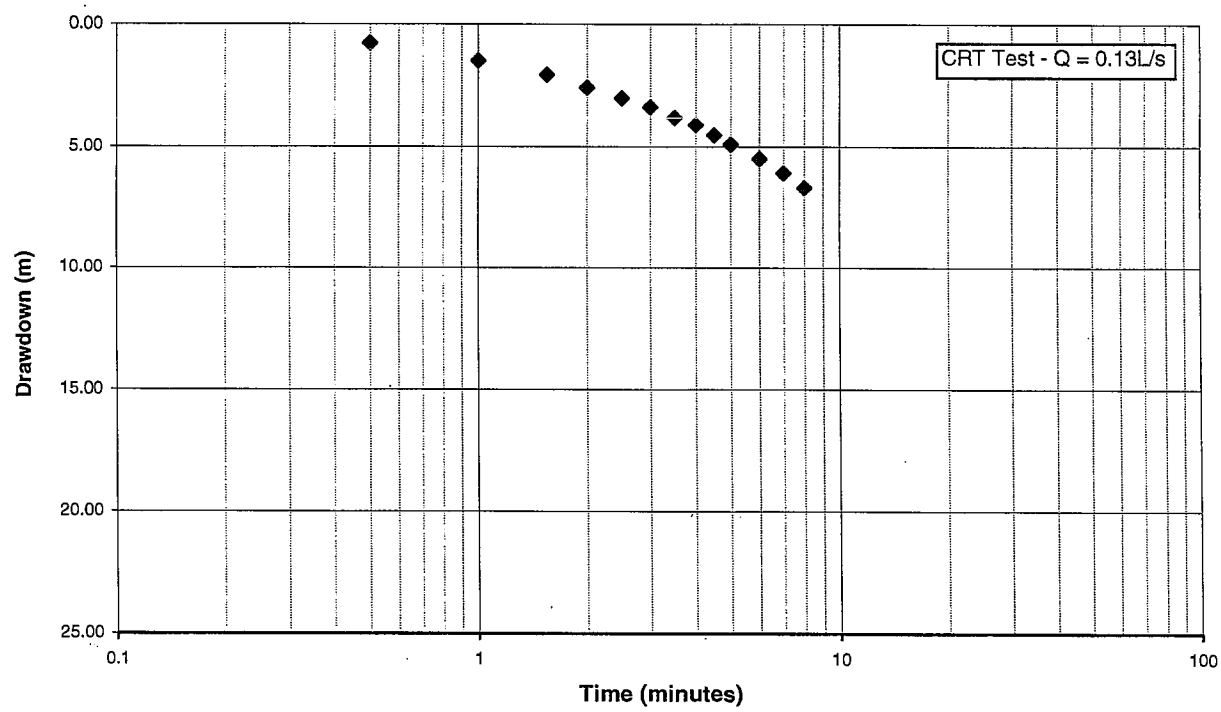


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D5
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			W12D CONSTANT RATE TEST	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

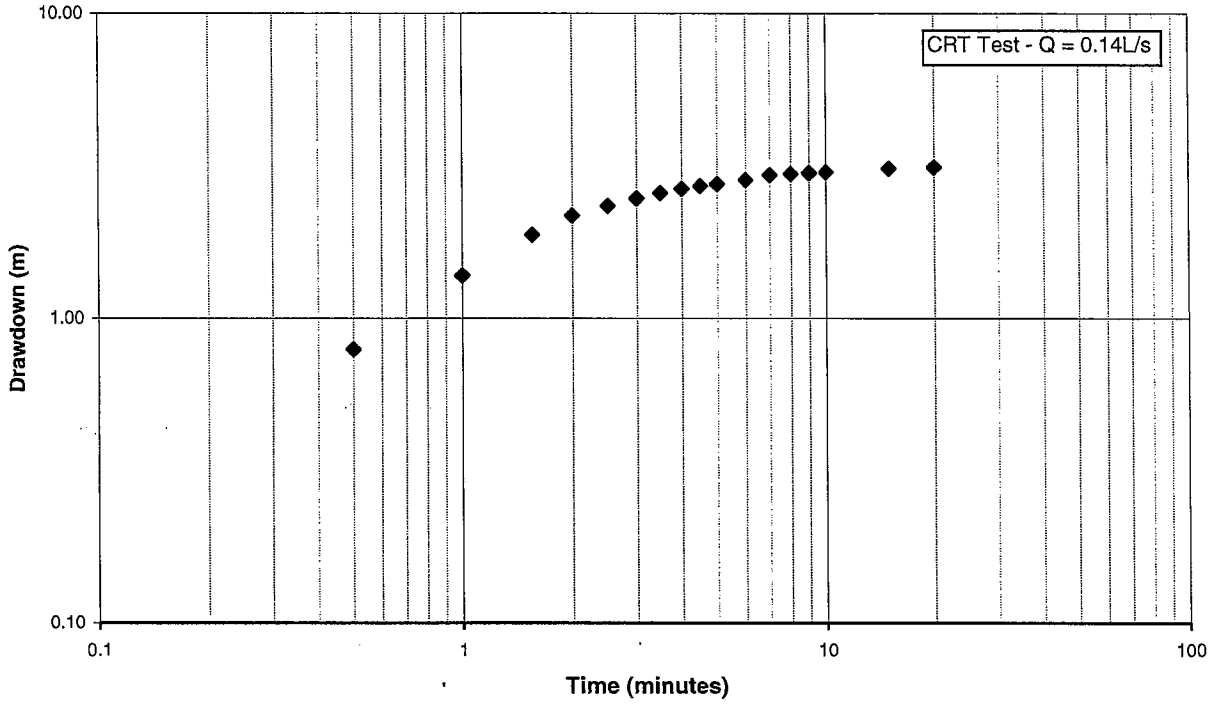


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

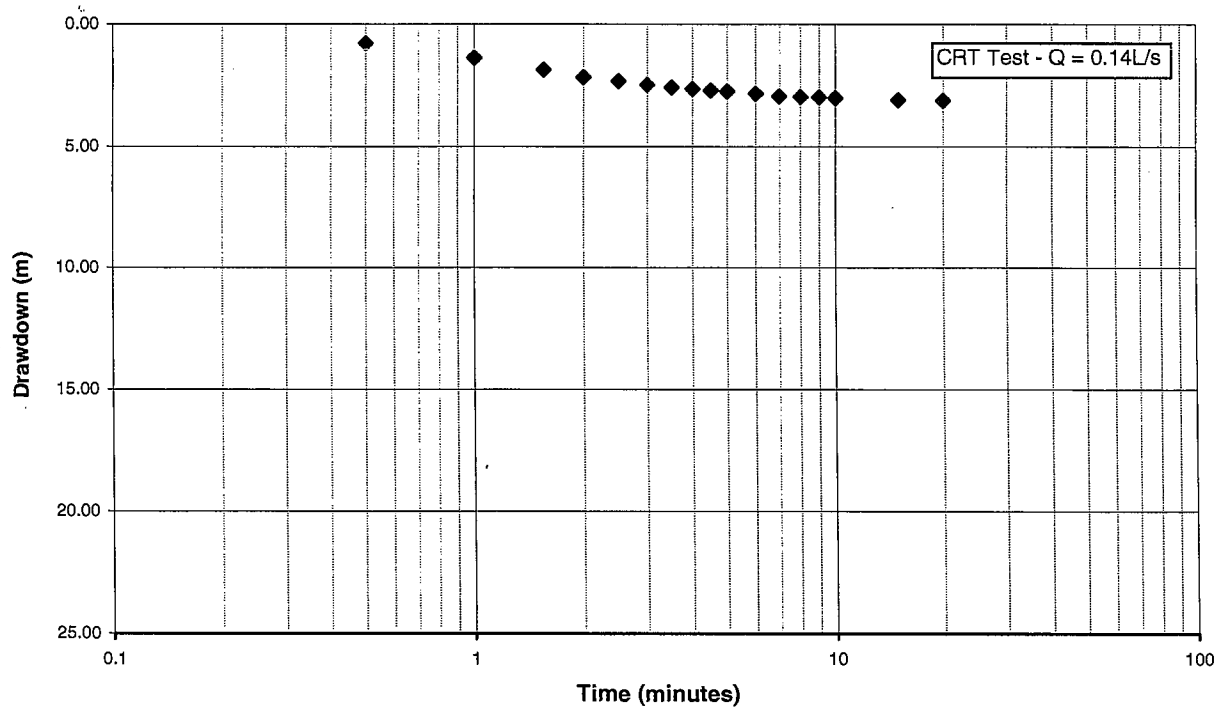


Job No.	44047-021-071		Iluka Resources Ltd	**FIGURE D6**
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			**W13S CONSTANT RATE TEST**	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

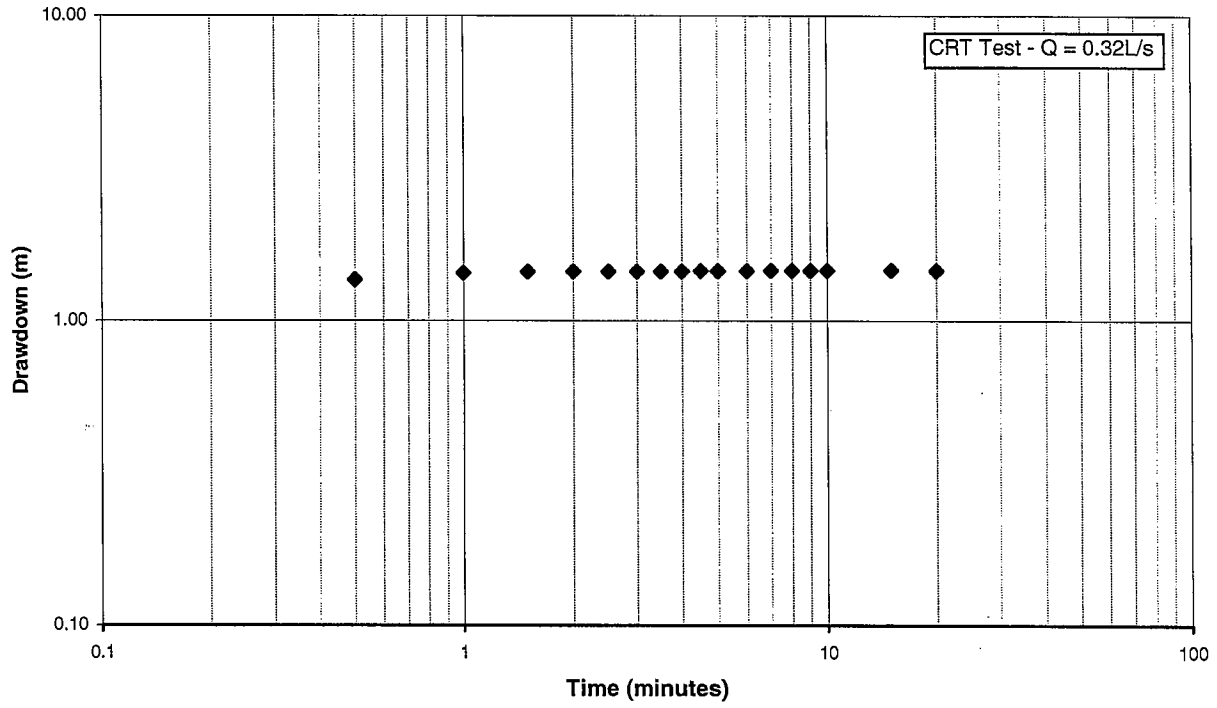


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

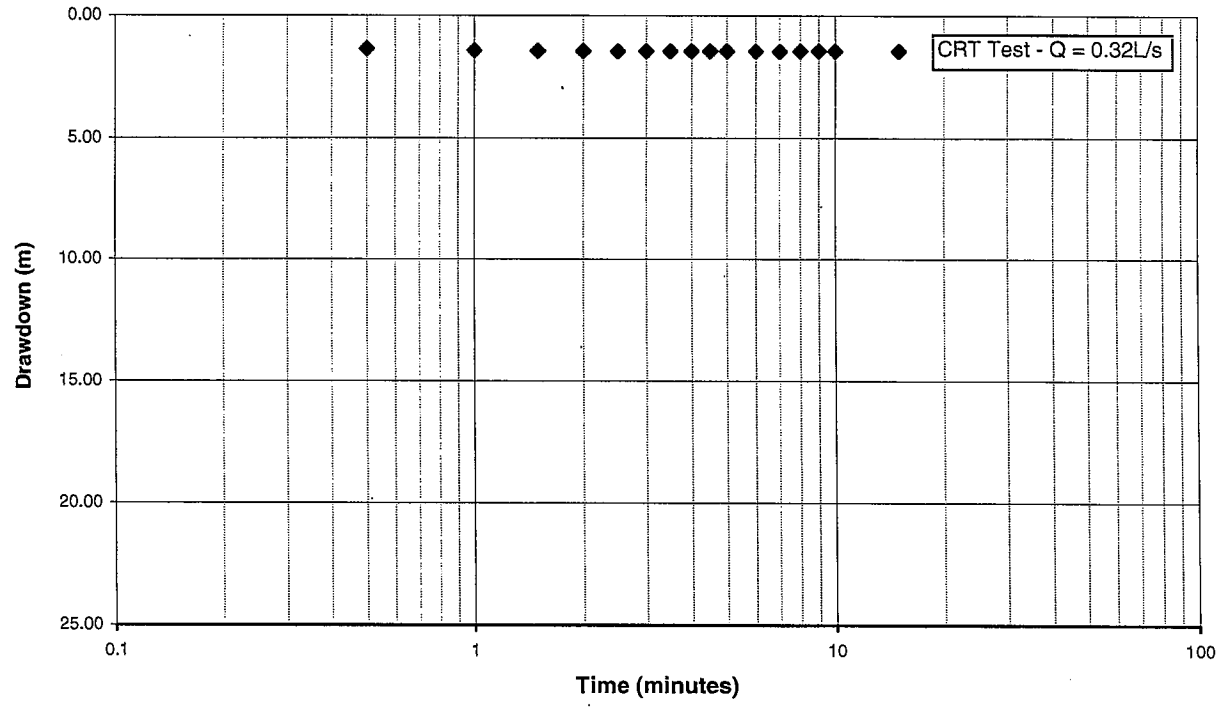


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D7
Prep. By	NRH	.22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			W13D CONSTANT RATE TEST	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

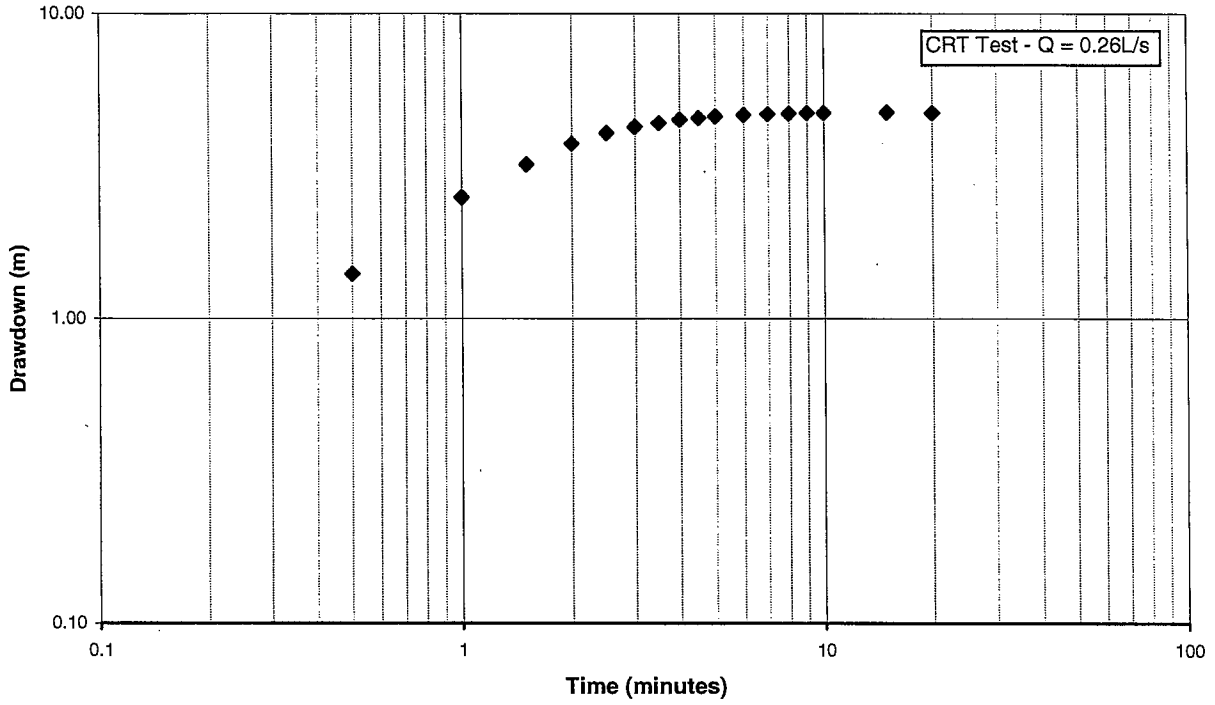


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

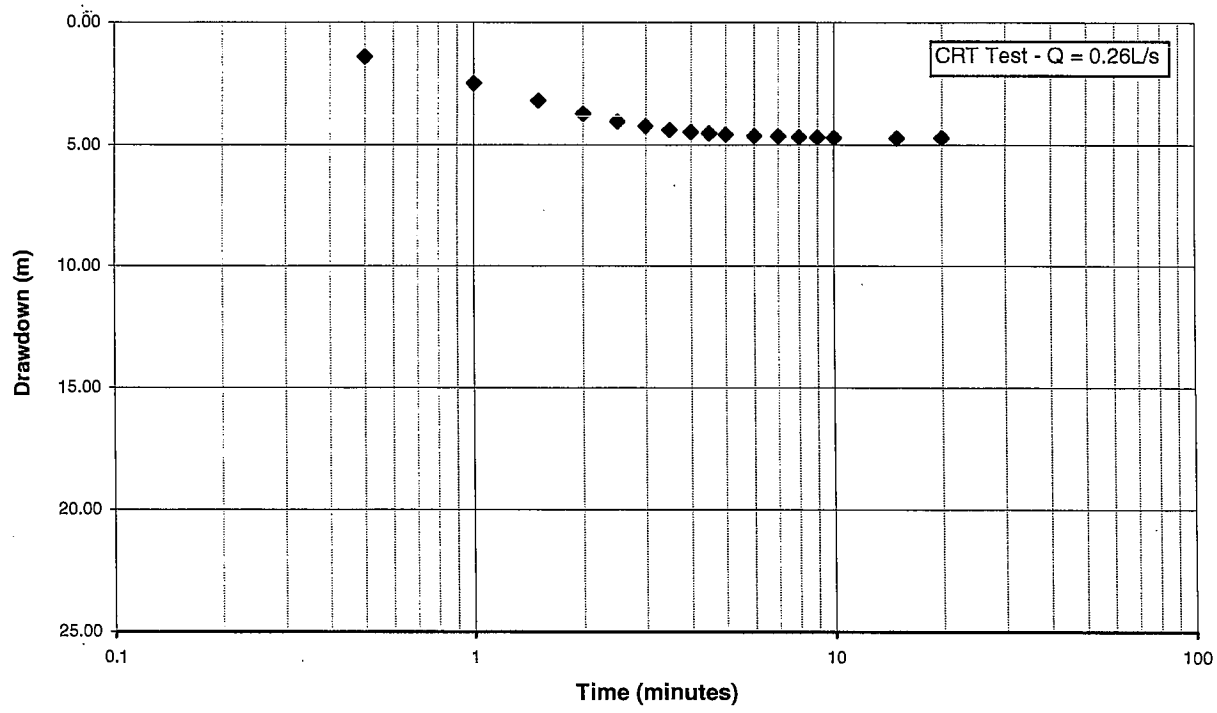


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D8
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			W15S CONSTANT RATE TEST	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

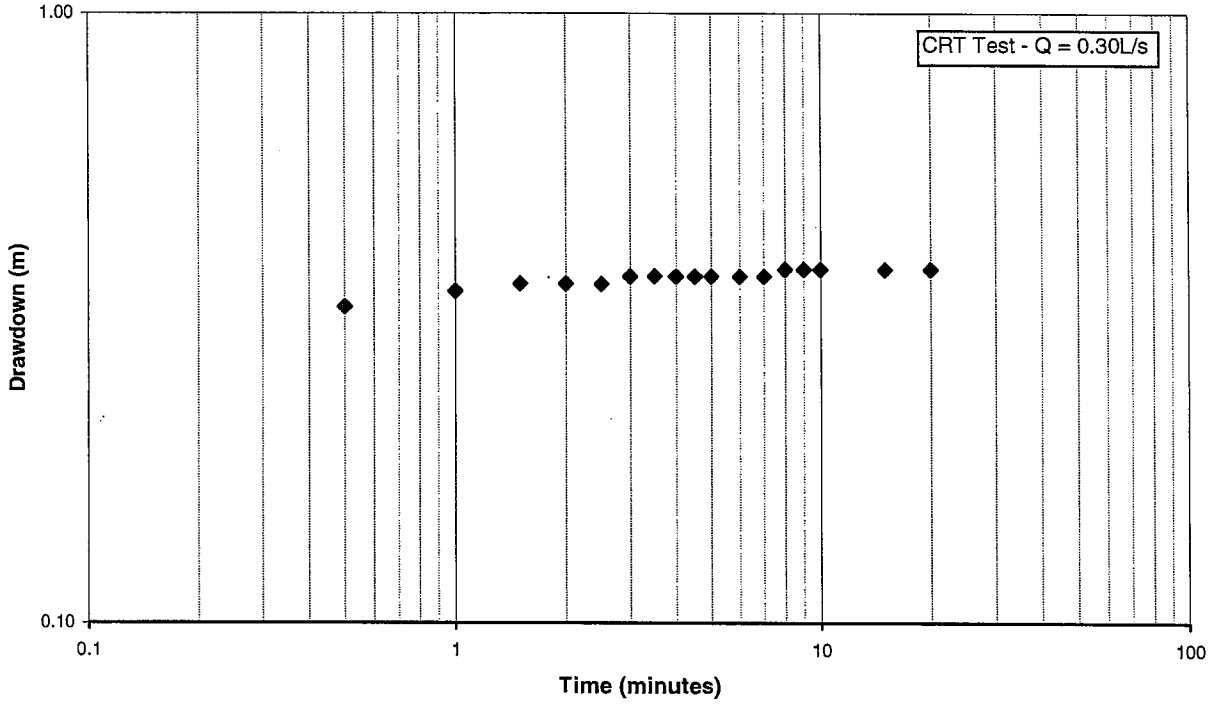


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

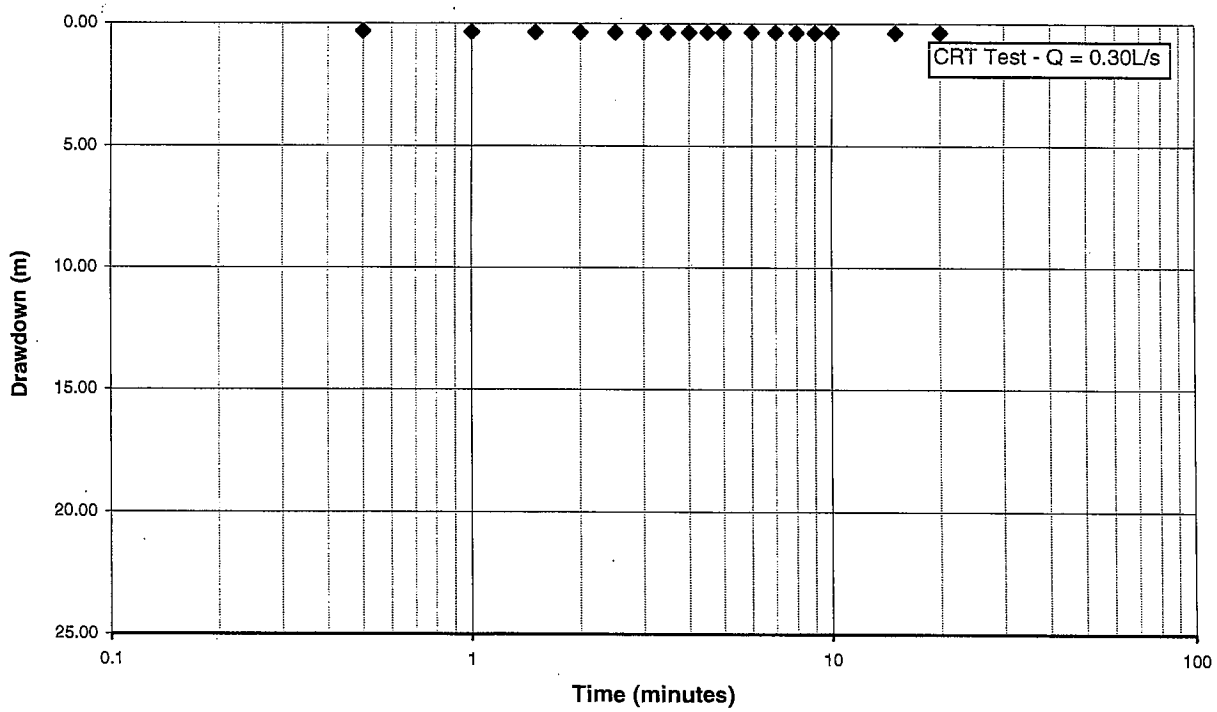


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D9
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			W15M1 CONSTANT RATE TEST	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

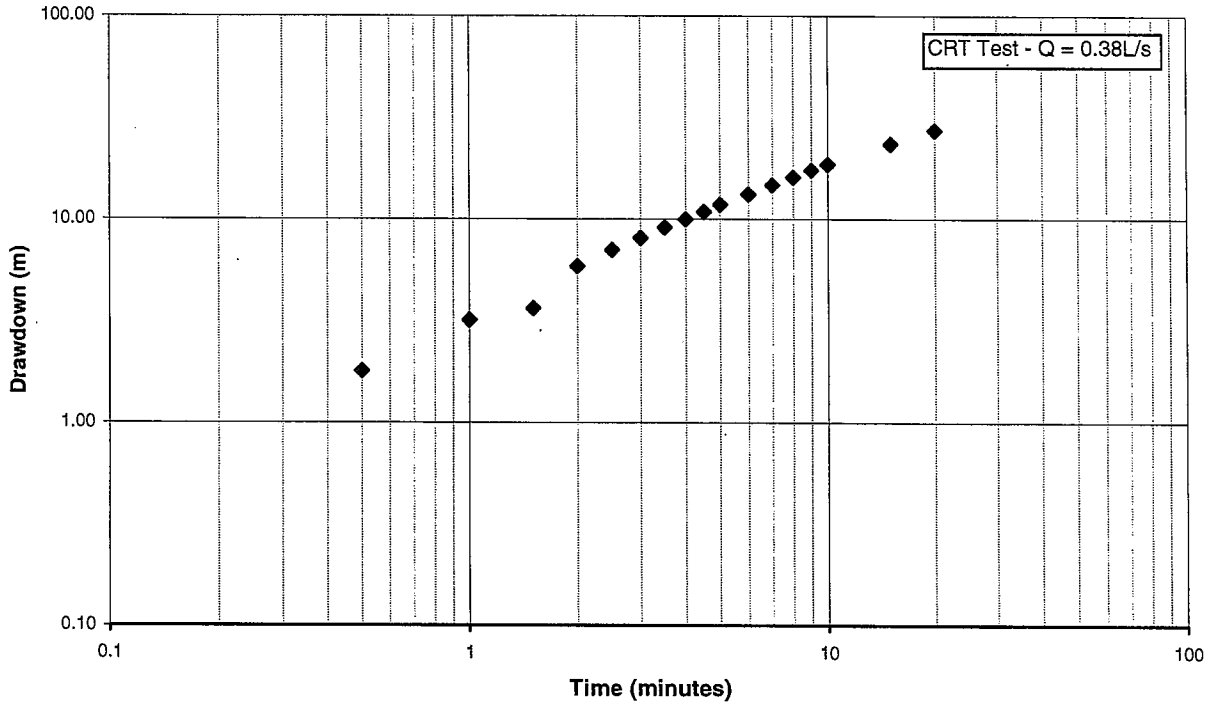


Job No.	44047-021-071		Iluka Resources Ltd
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.			**W15M2 CONSTANT RATE TEST**

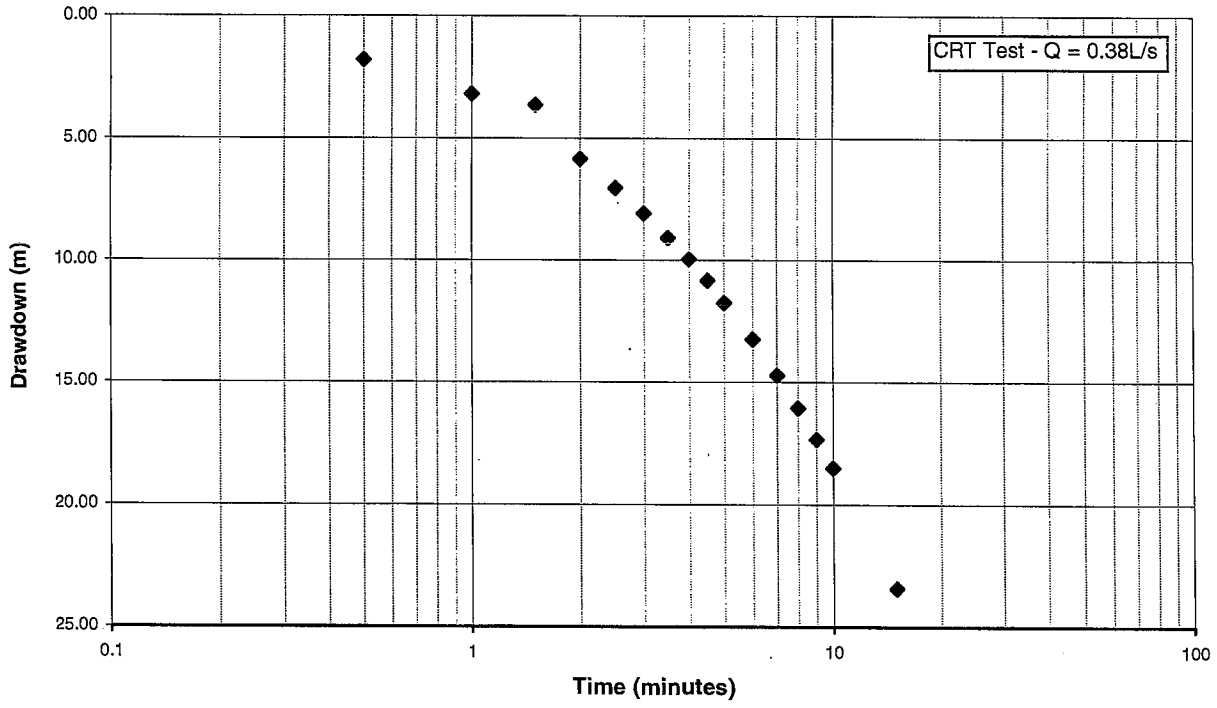
FIGURE D10

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

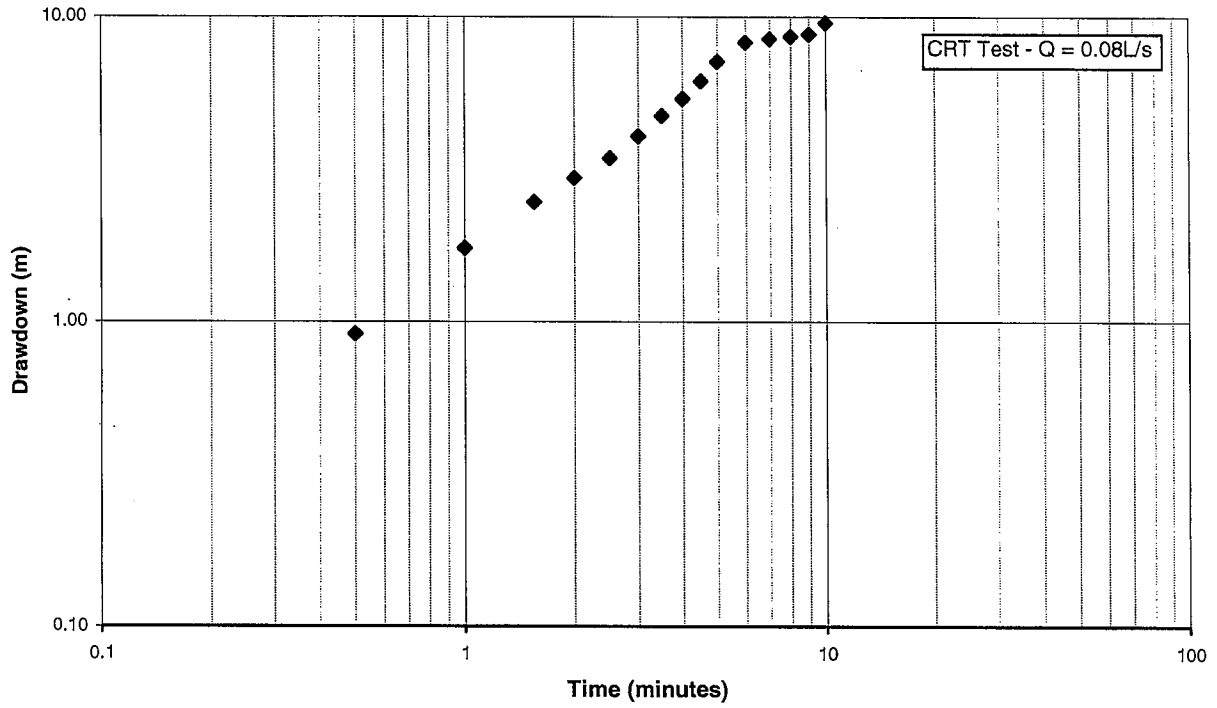


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

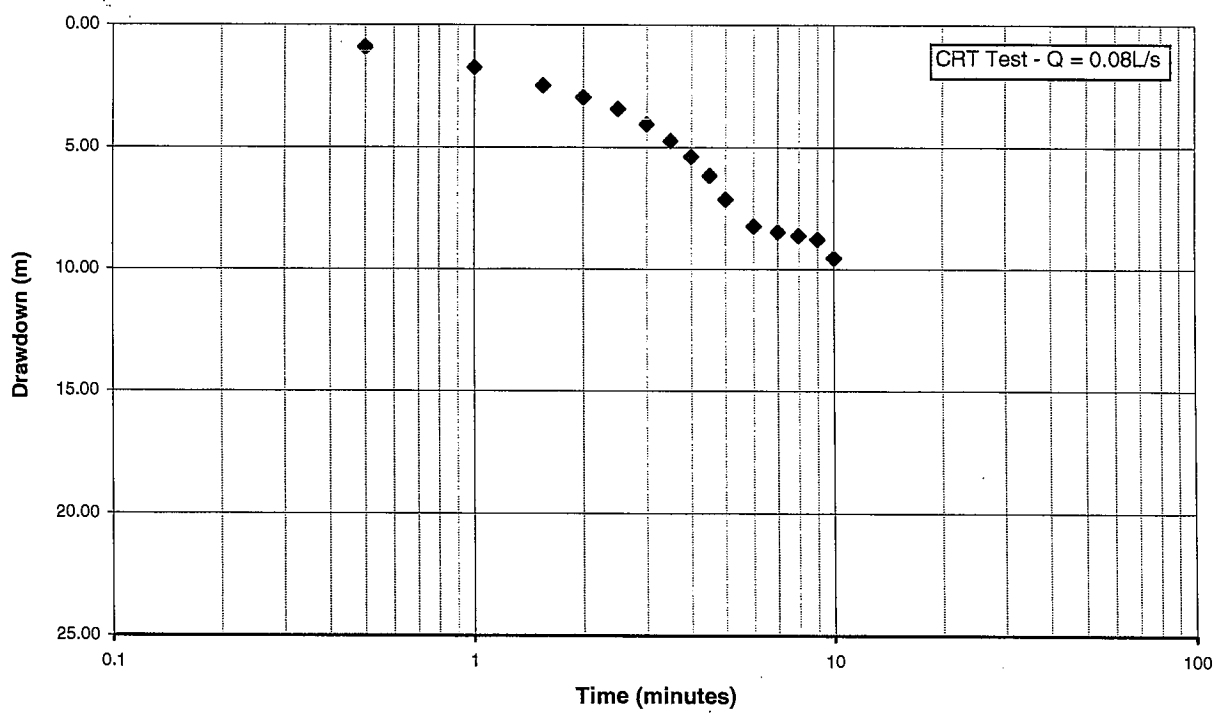


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D11
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			W15D CONSTANT RATE TEST	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

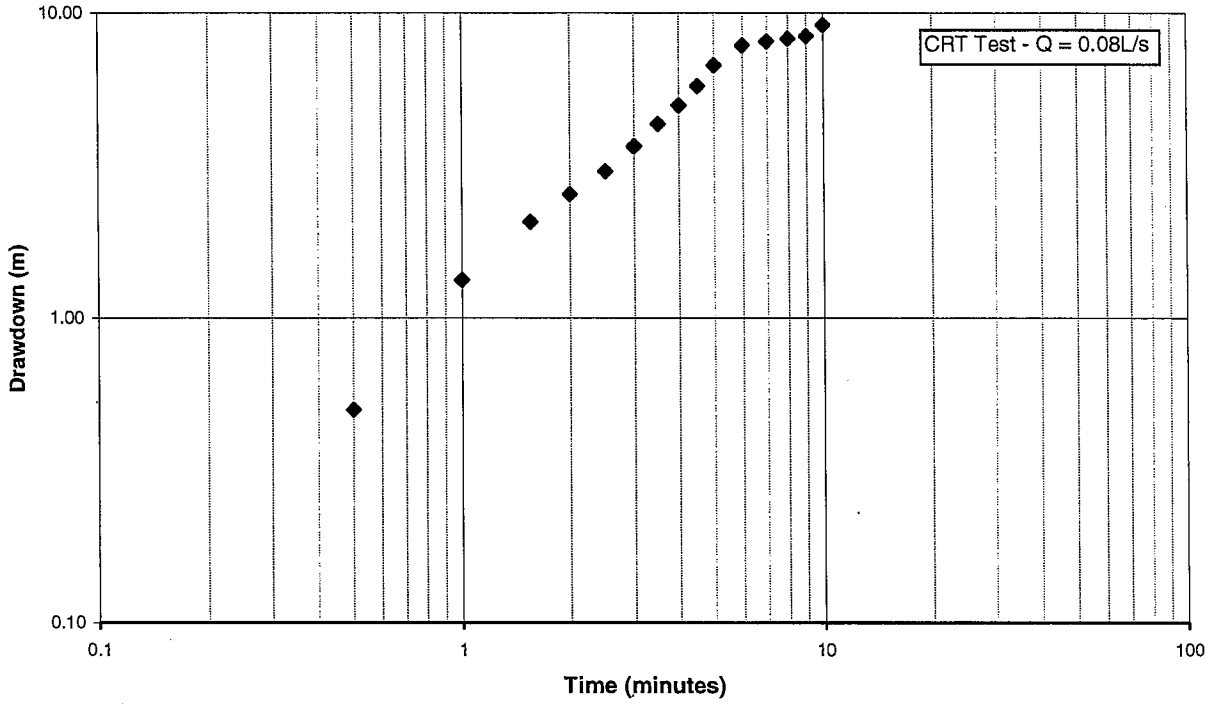


Job No.	44047-021-071		Iluka Resources Ltd
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.			**W16S CONSTANT RATE TEST**

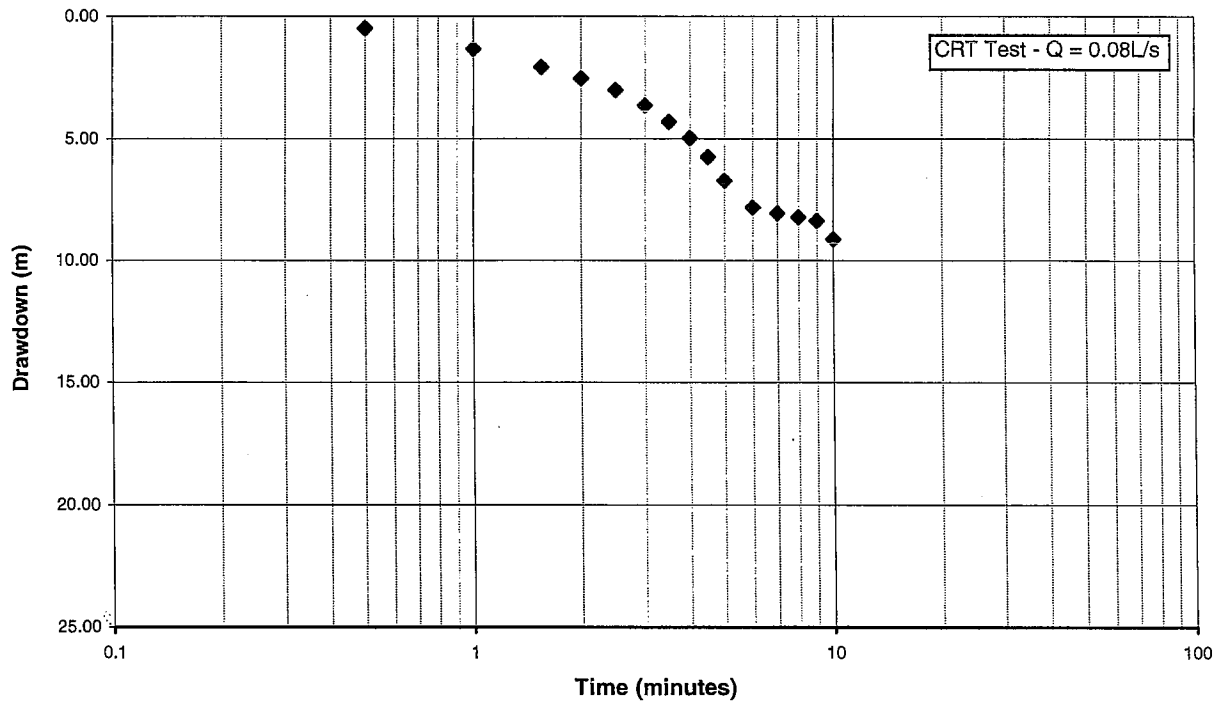
FIGURE D12

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

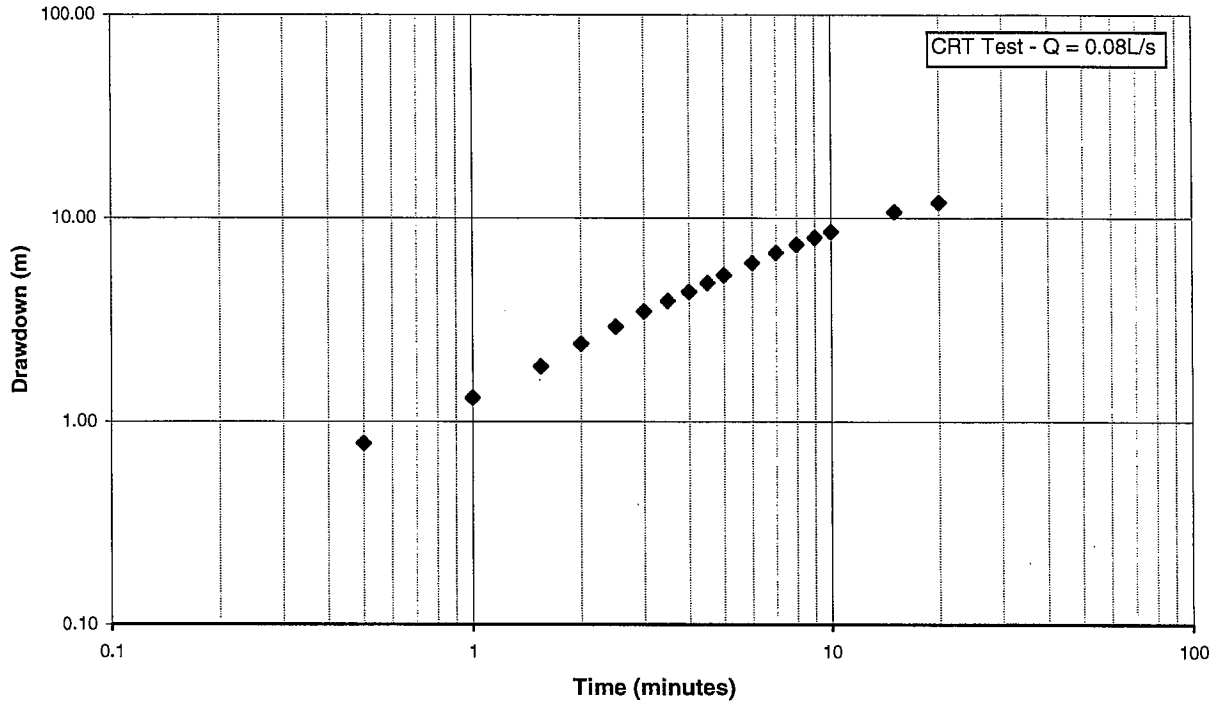


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

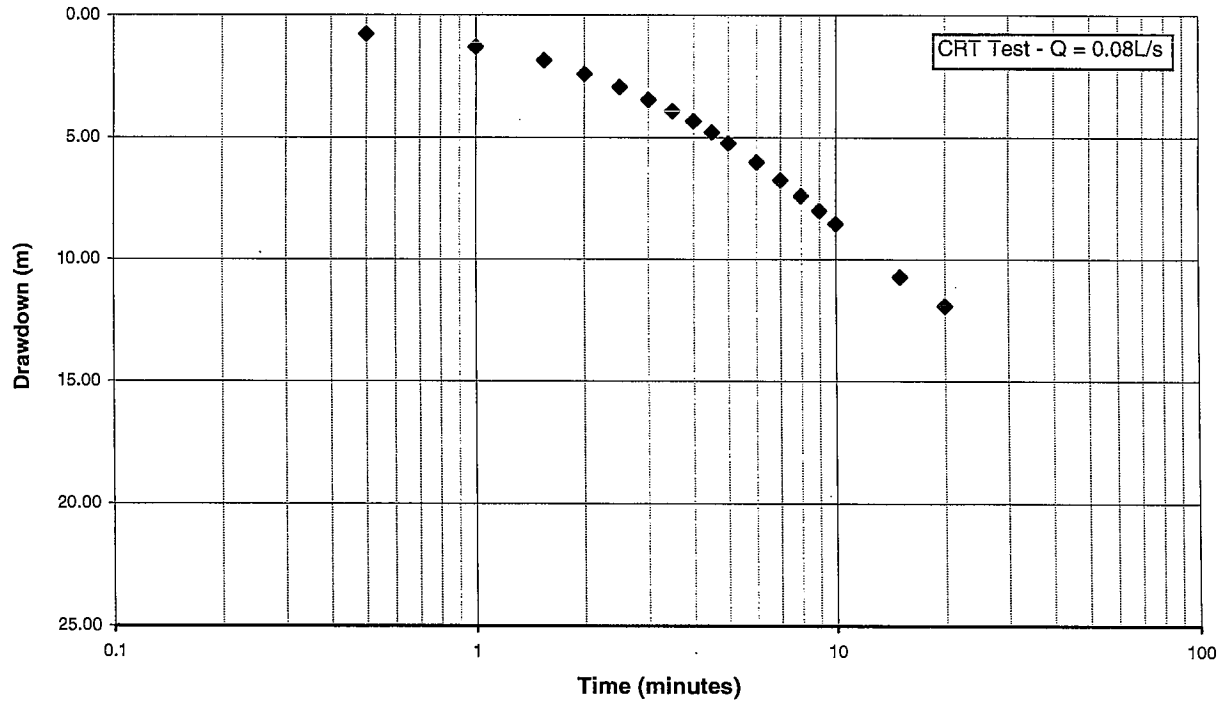


Job No.	44047-021-071		Iluka Resources Ltd	**FIGURE D13**
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			**W16M1 CONSTANT RATE TEST**	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

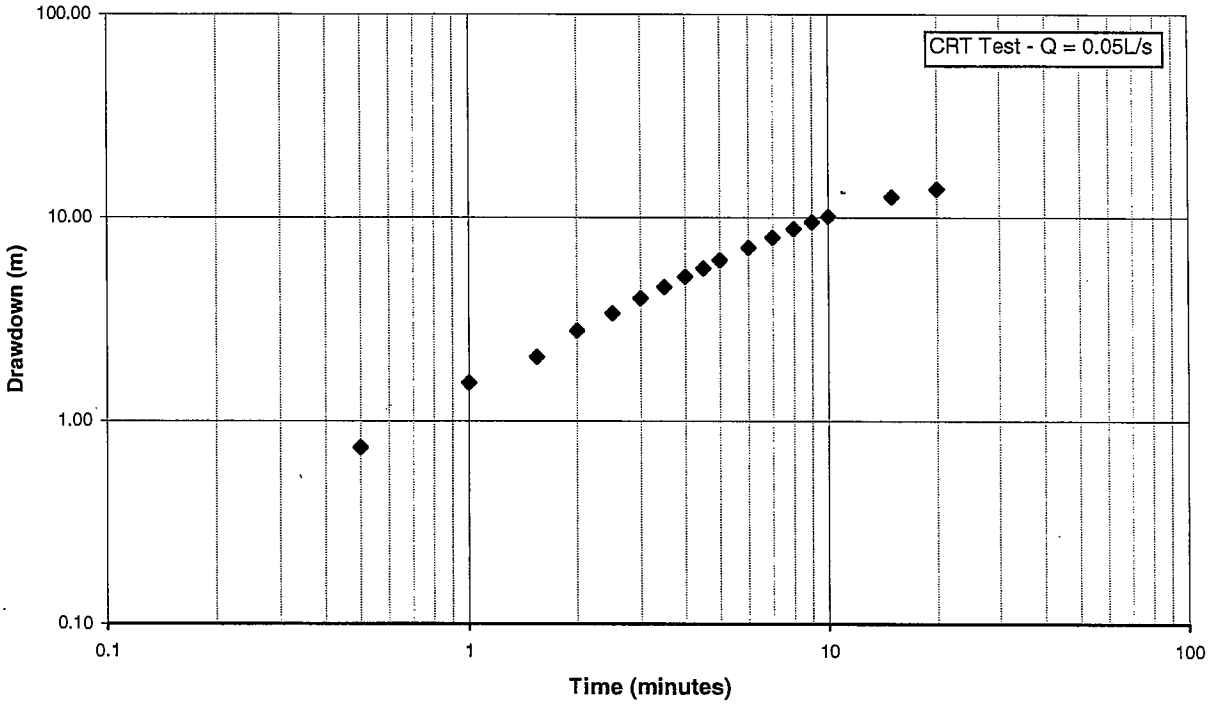


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

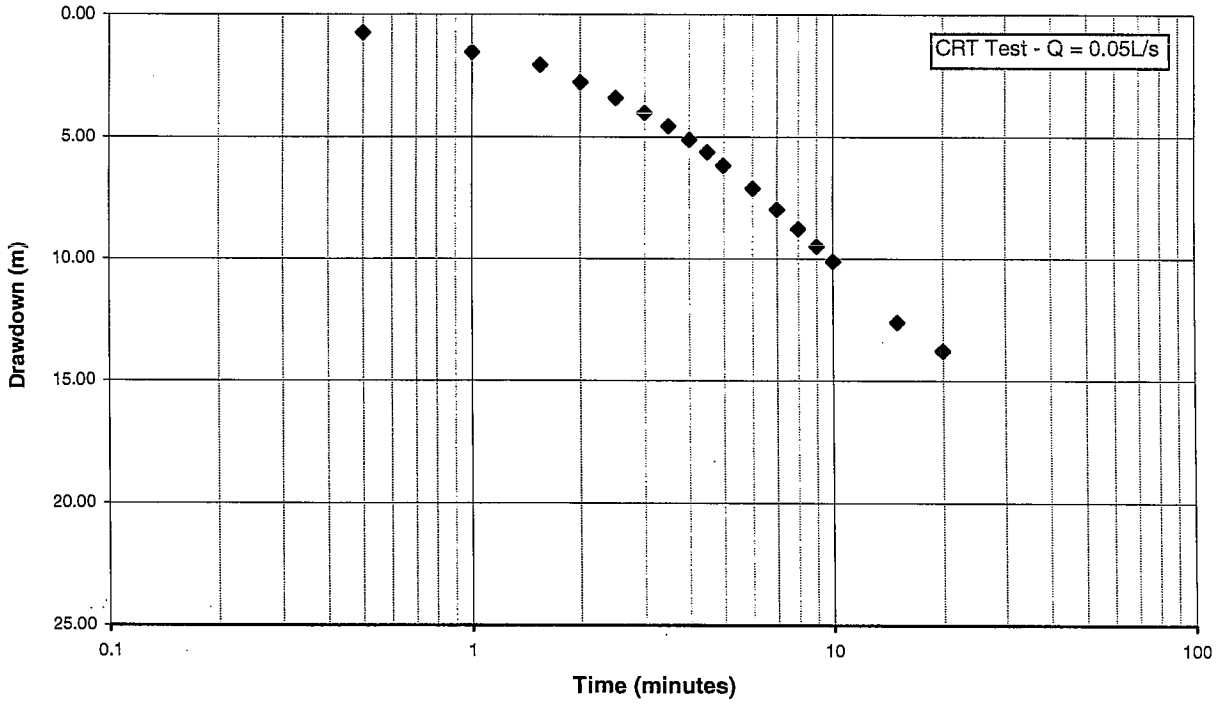


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D14
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			**W16M2 CONSTANT RATE TEST**	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

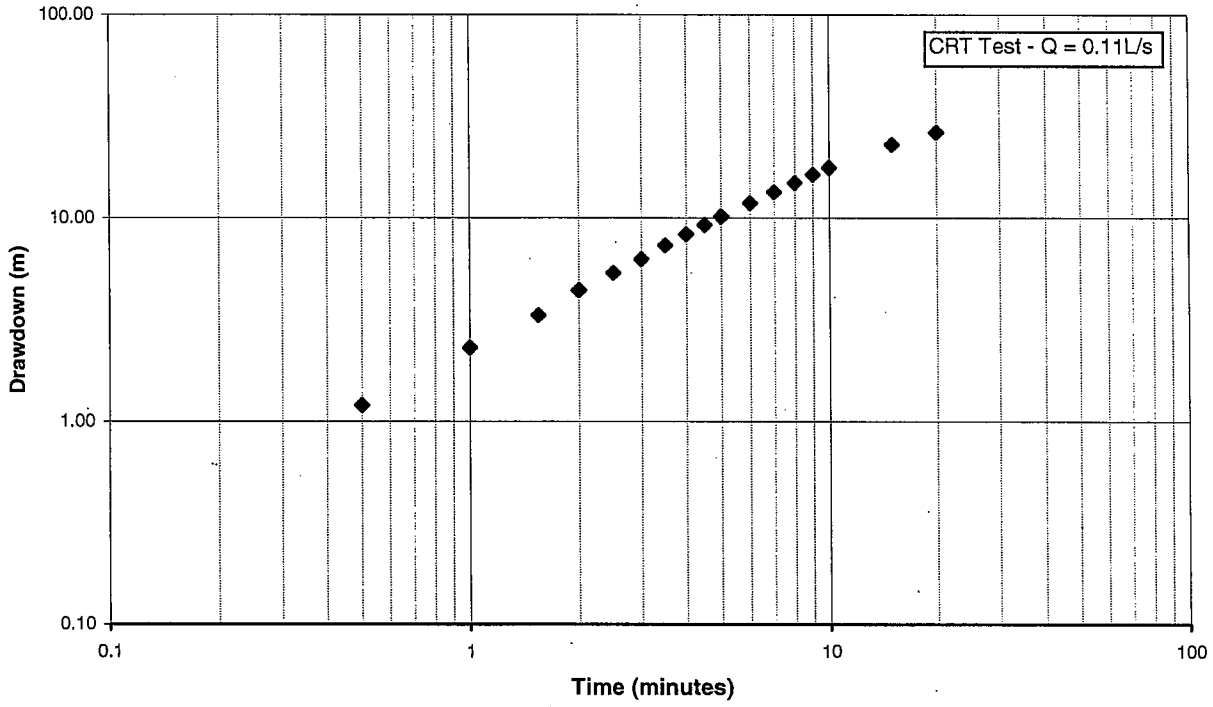


Job No.	44047-021-071		Iluka Resources Ltd
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.			**W16M3 CONSTANT RATE TEST**

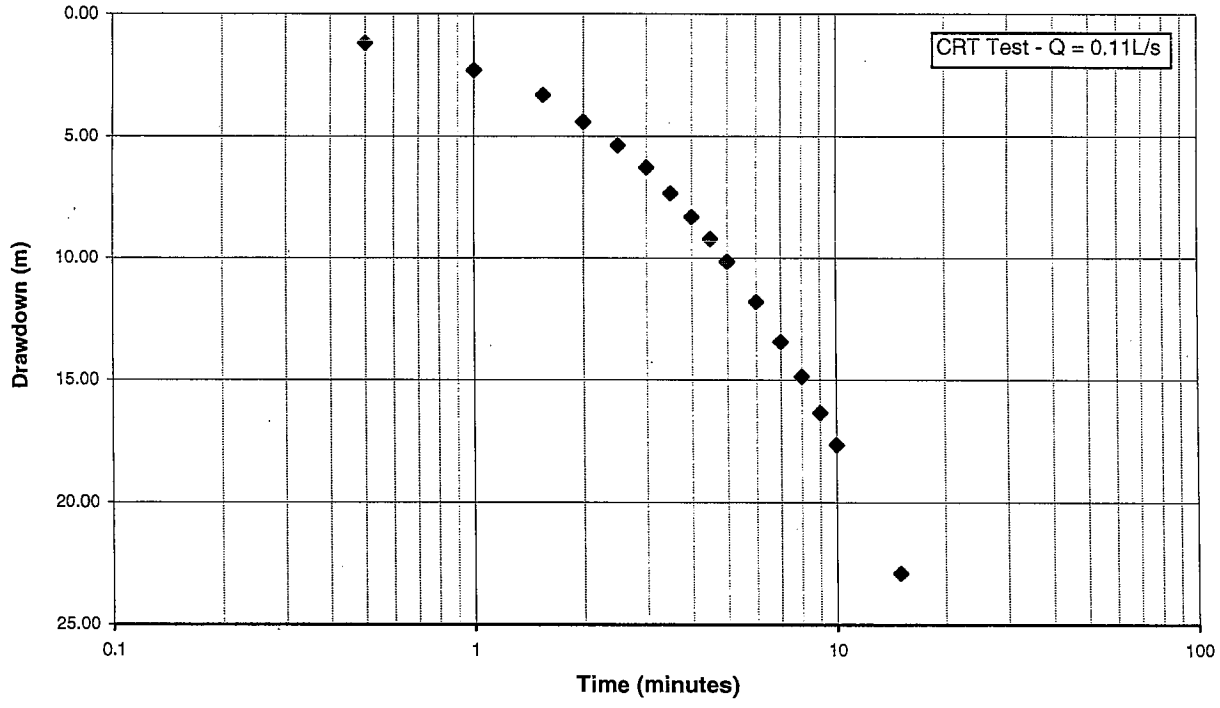
FIGURE D15

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

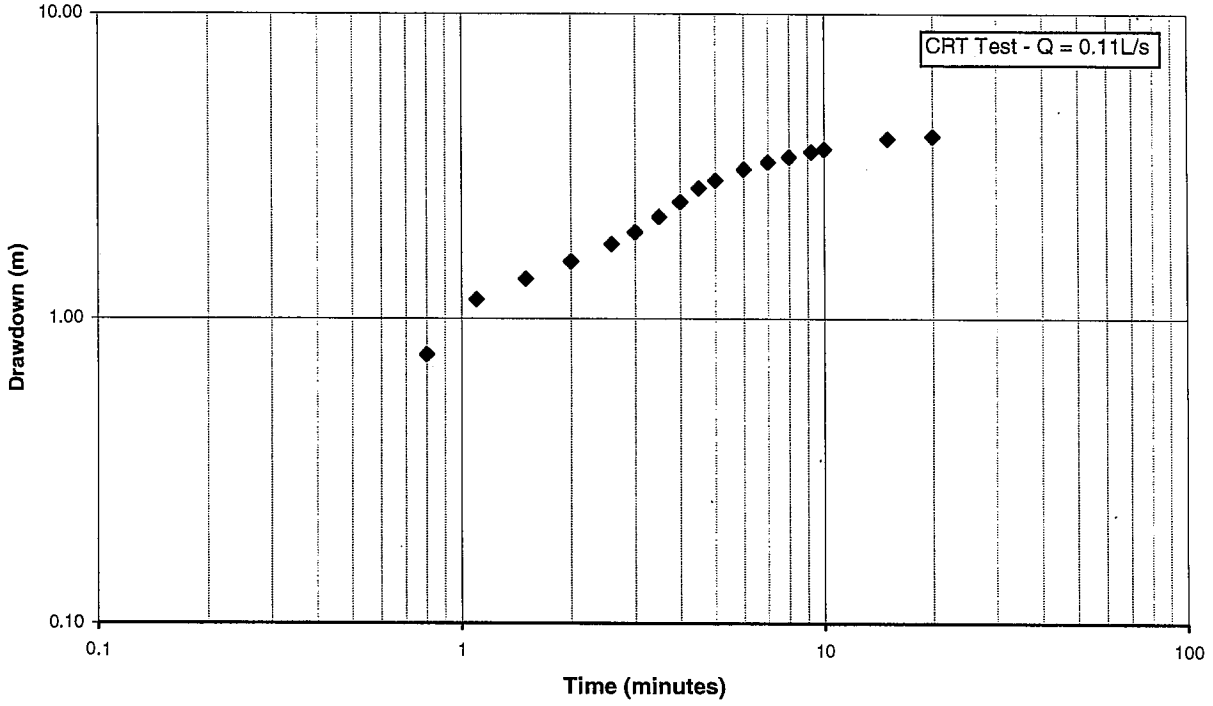


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

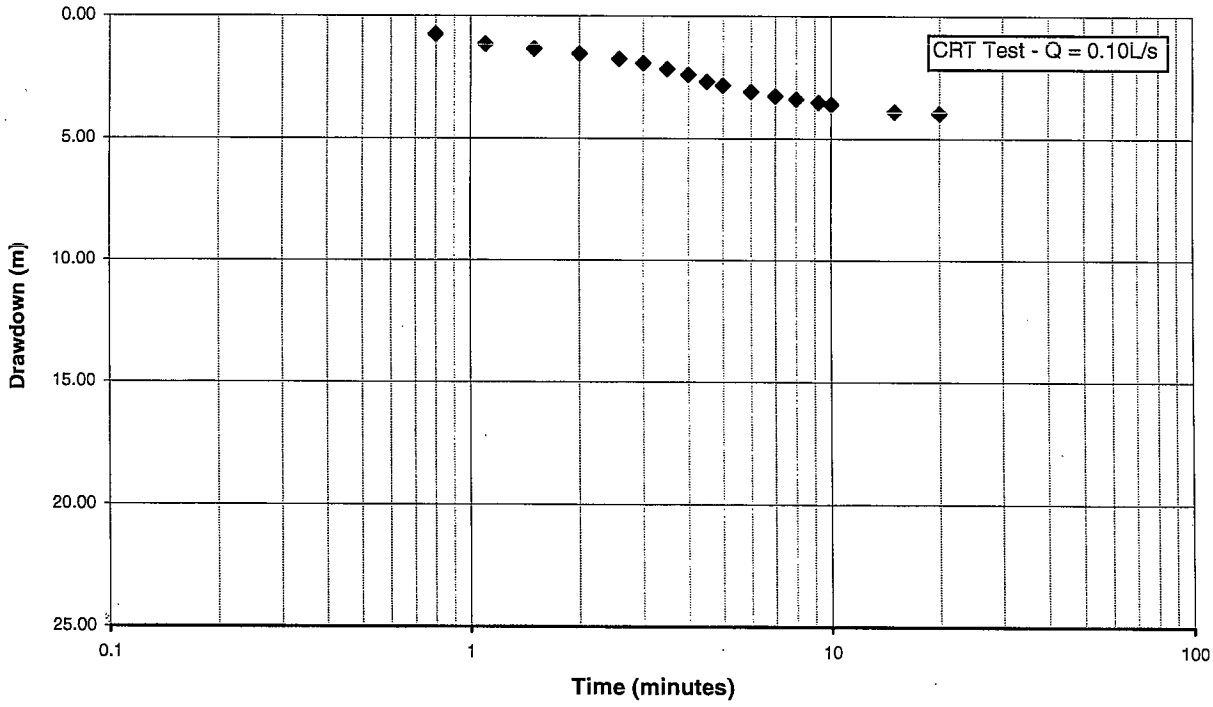


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D16
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			W16D CONSTANT RATE TEST	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

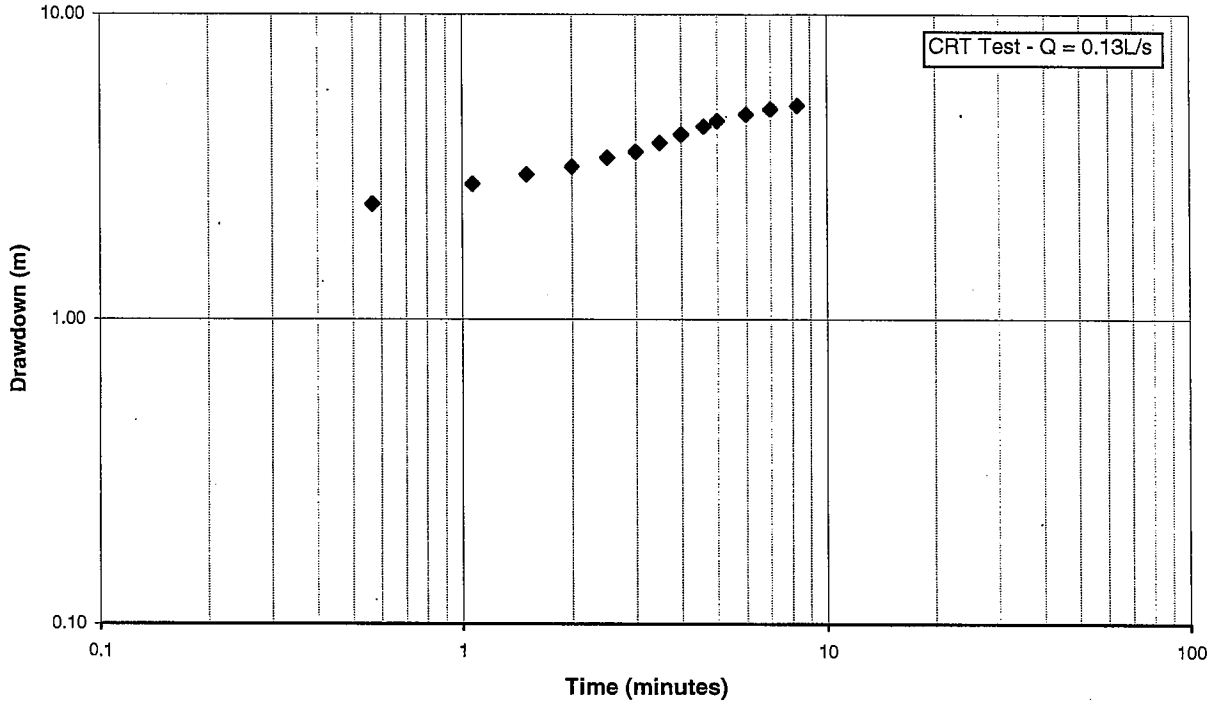


Job No.	44047-021-071		Iluka Resources Ltd
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.			**W17S CONSTANT RATE TEST**

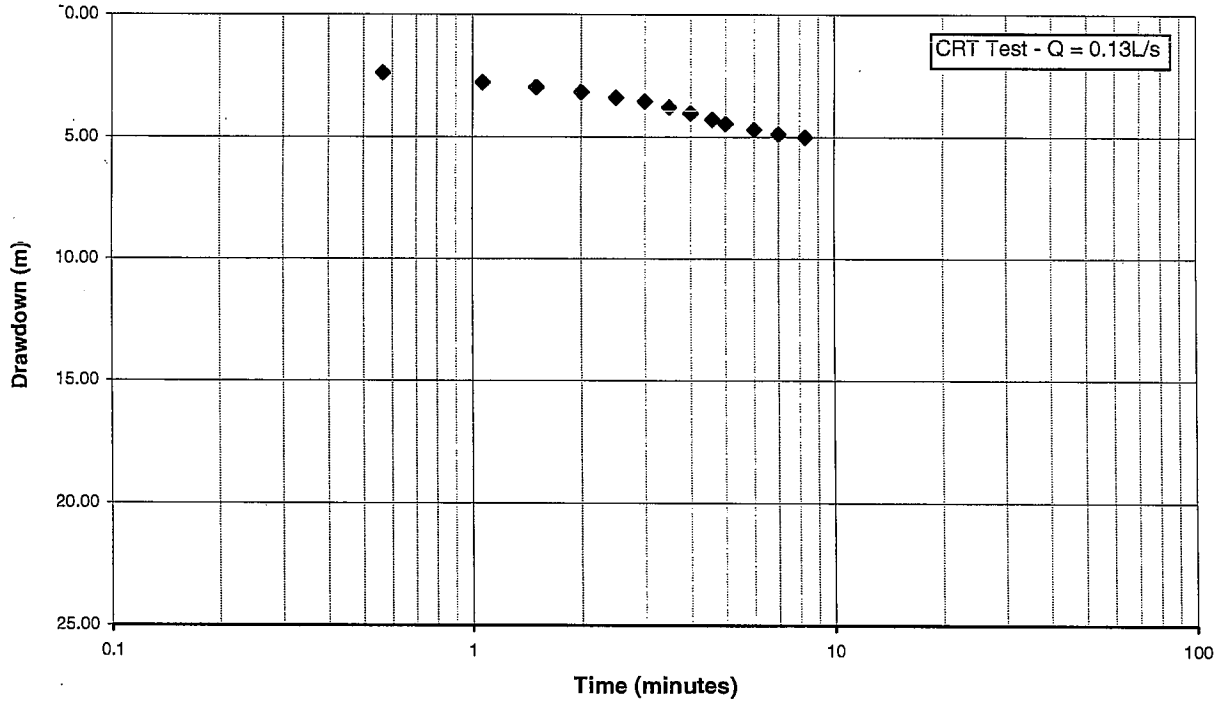
FIGURE D17

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

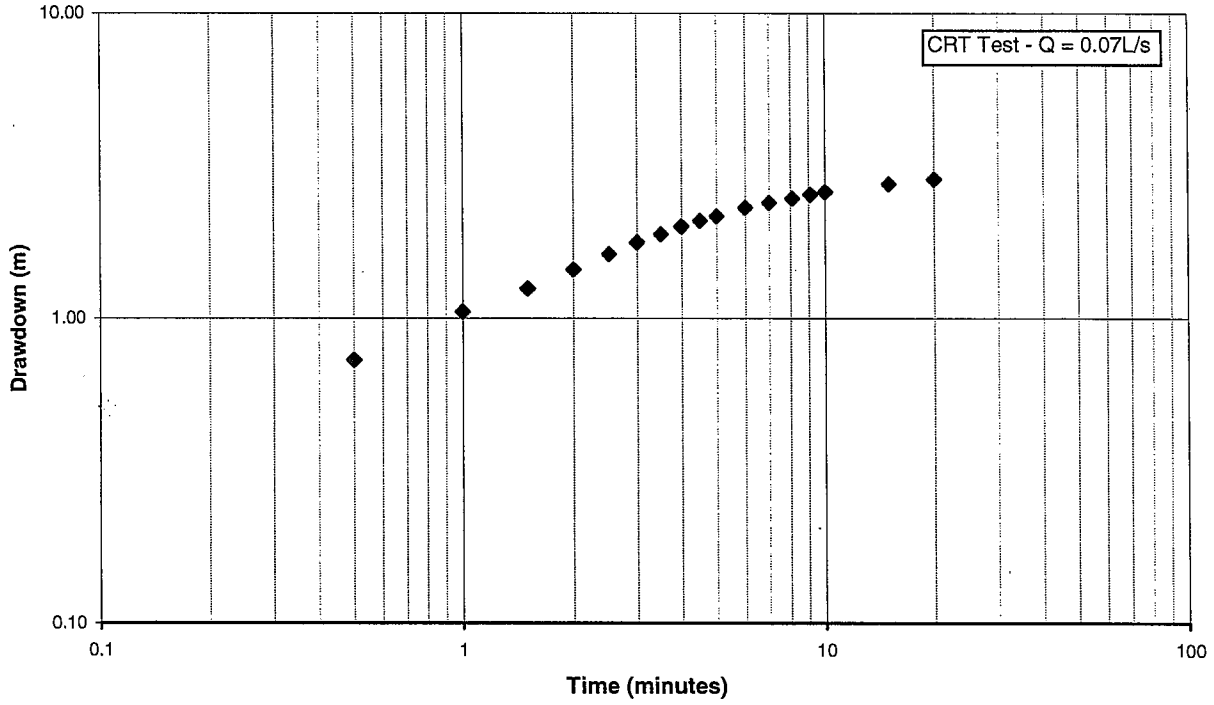


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

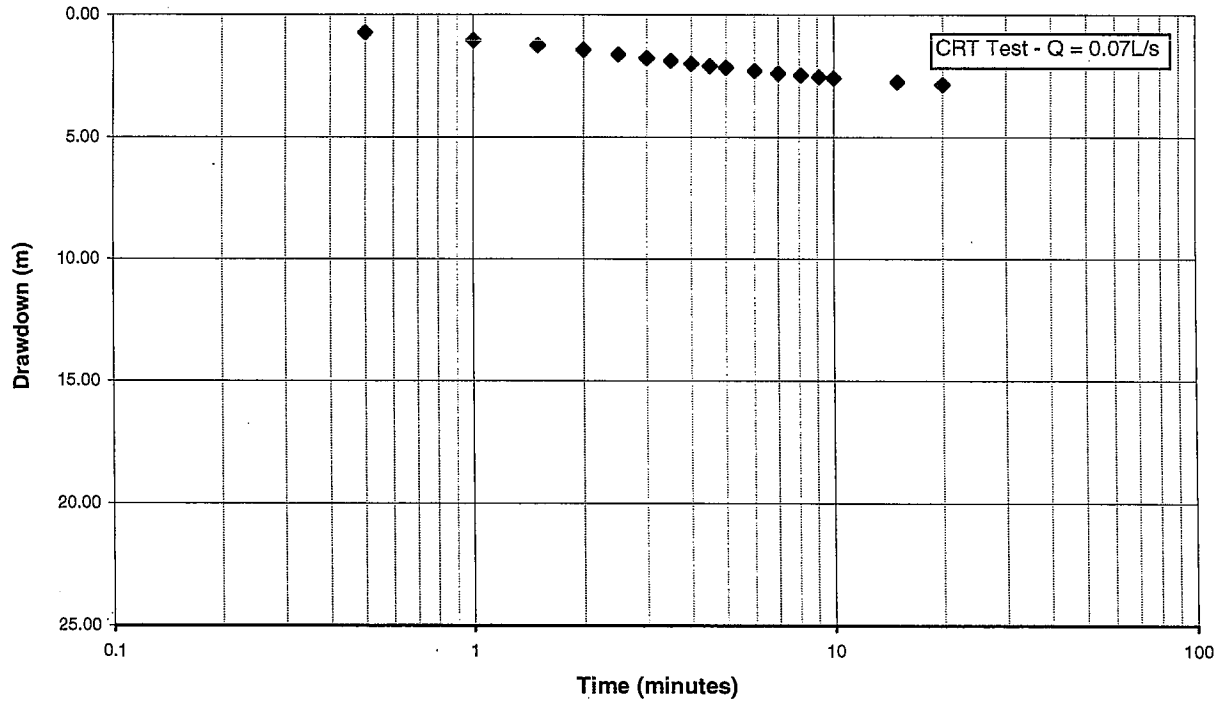


Job No.	44047-021-071		Iluka Resources Ltd	**FIGURE D18**
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			**W17D CONSTANT RATE TEST**	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

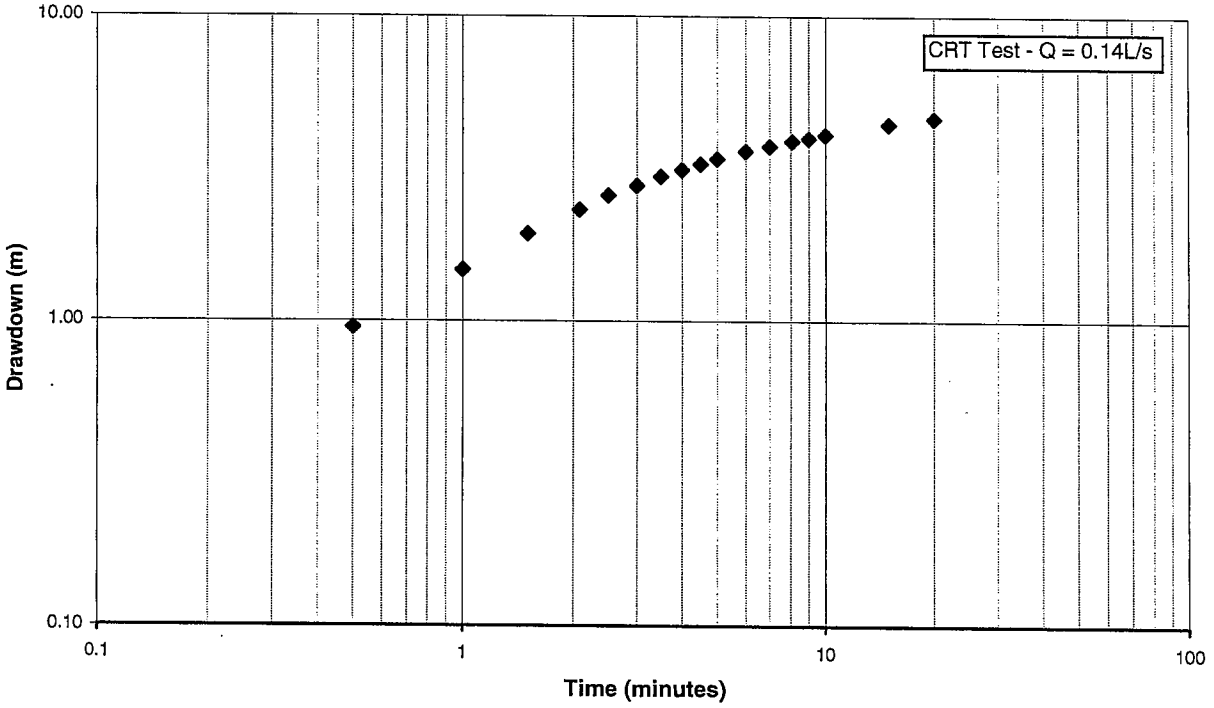


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

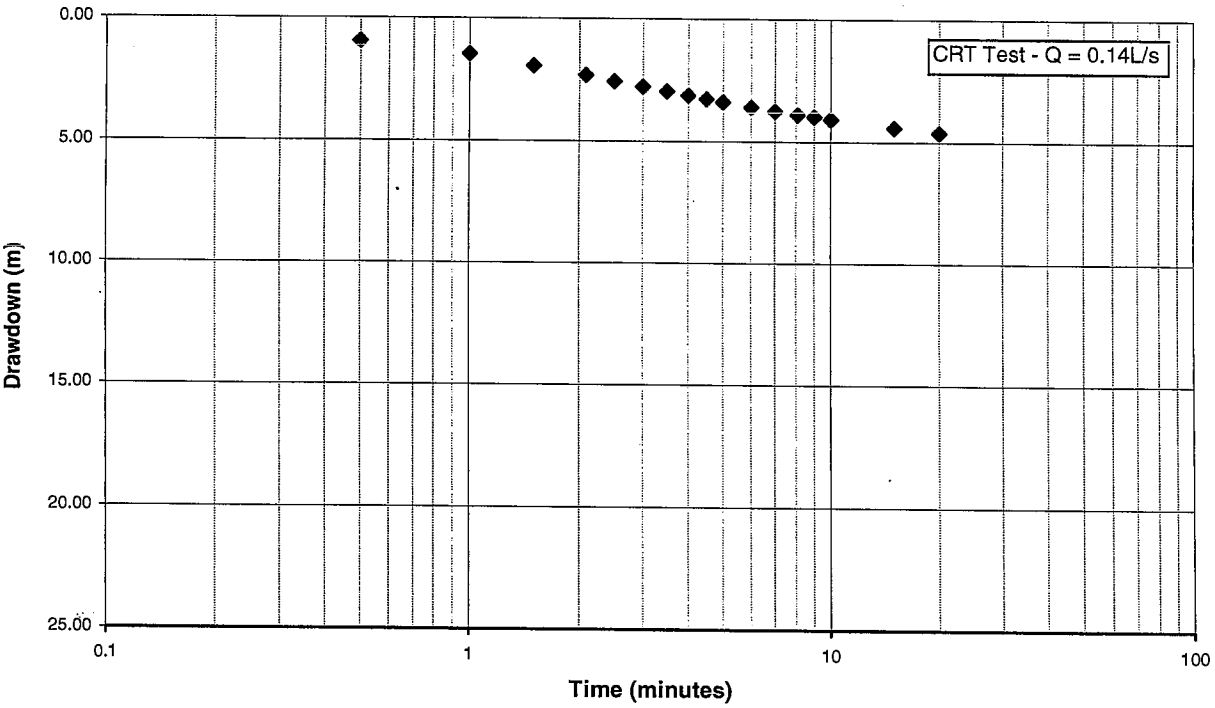


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D19
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			W18S CONSTANT RATE TEST	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

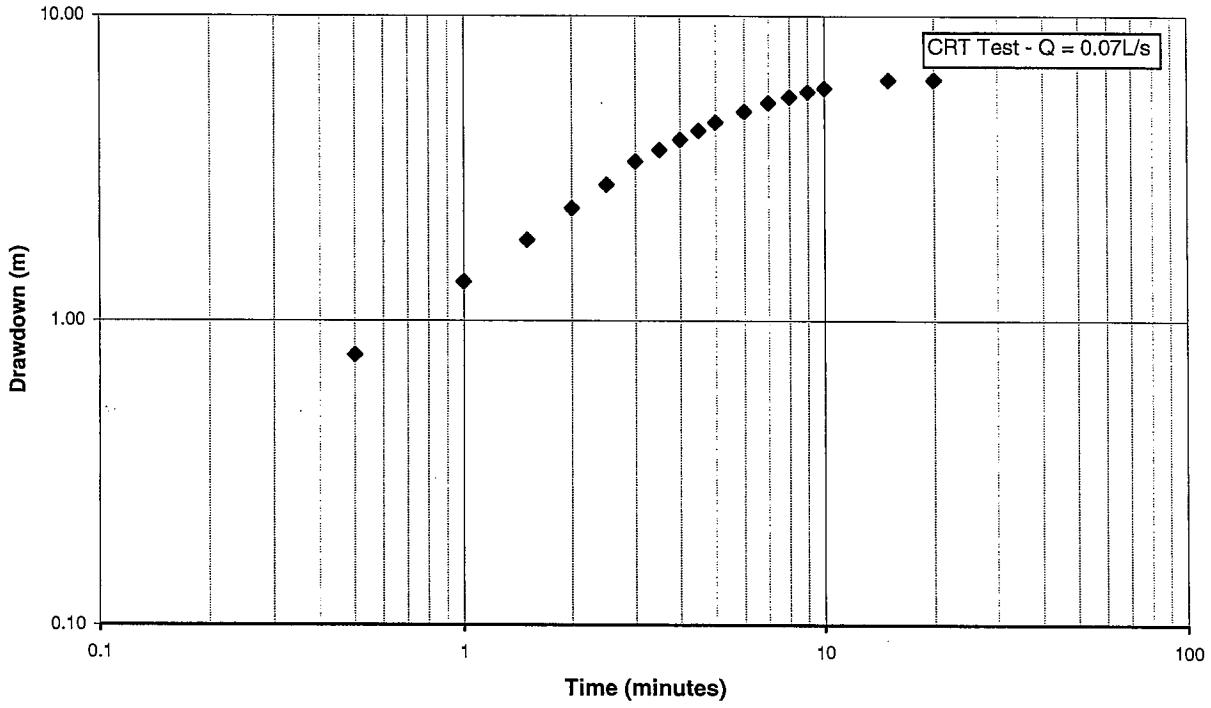


Job No.	44047-021-071		Iluka Resources Ltd
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.			**W18D CONSTANT RATE TEST**

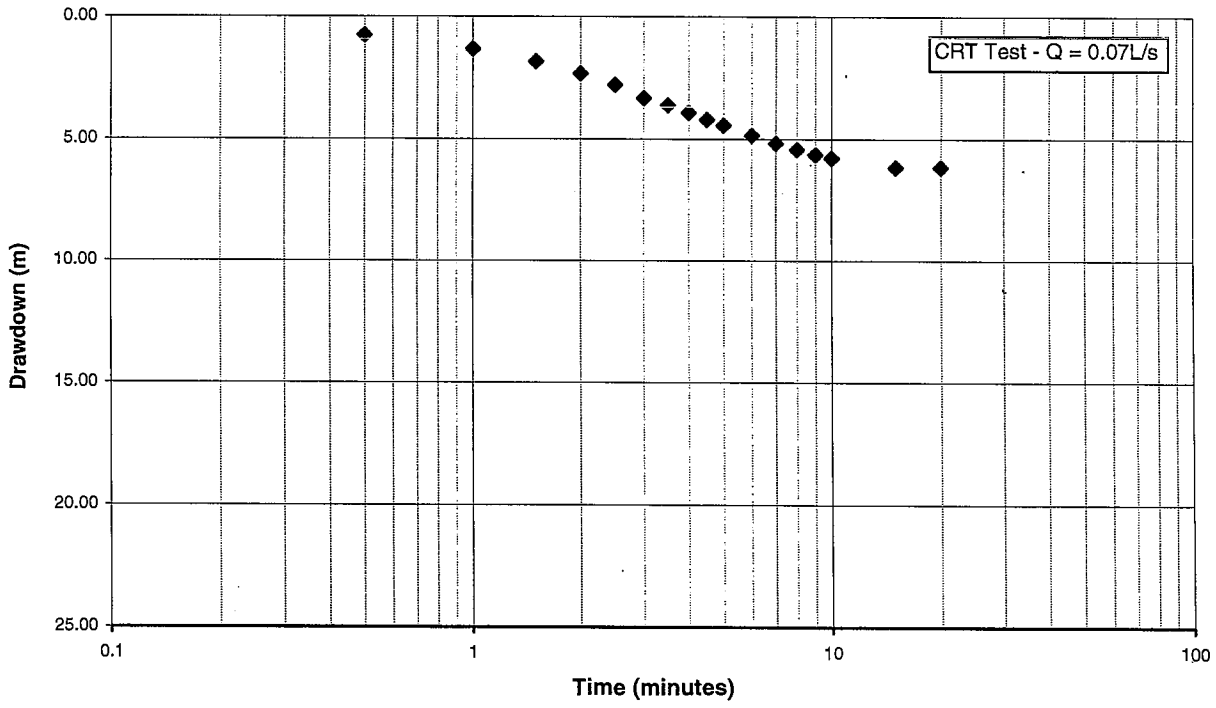
FIGURE D20

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

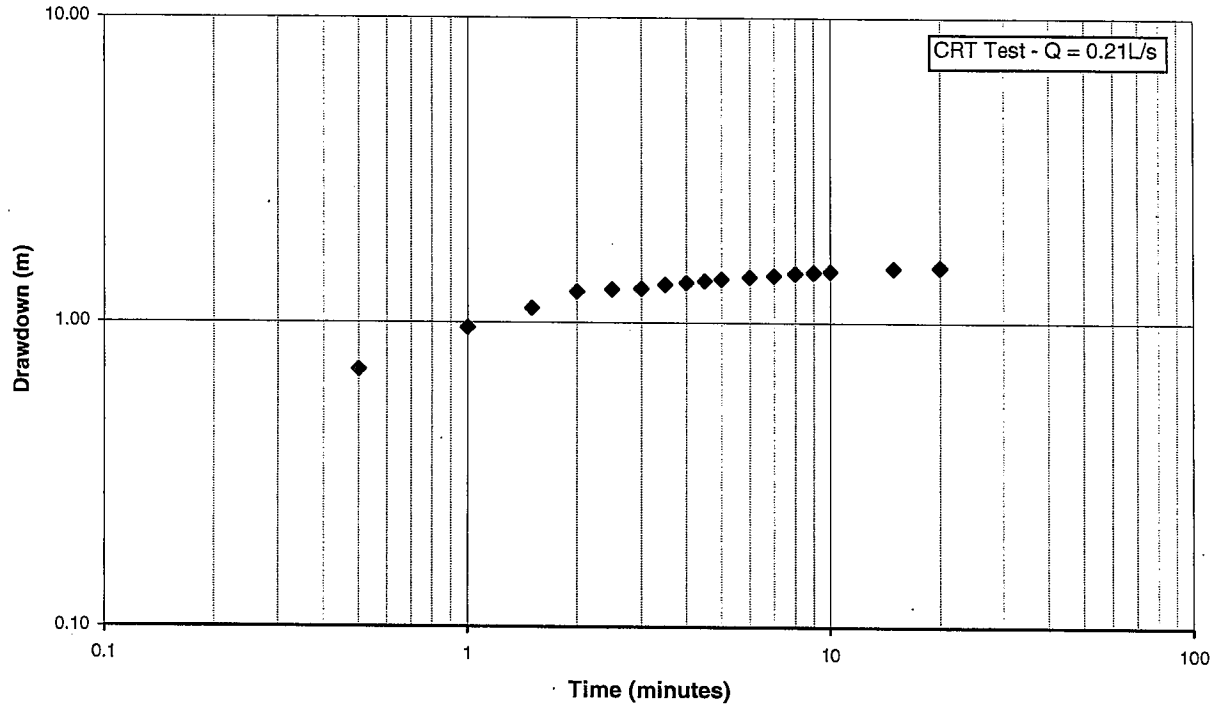


Job No.	44047-021-071		Iluka Resources Ltd
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.			**W20M1 CONSTANT RATE TEST**

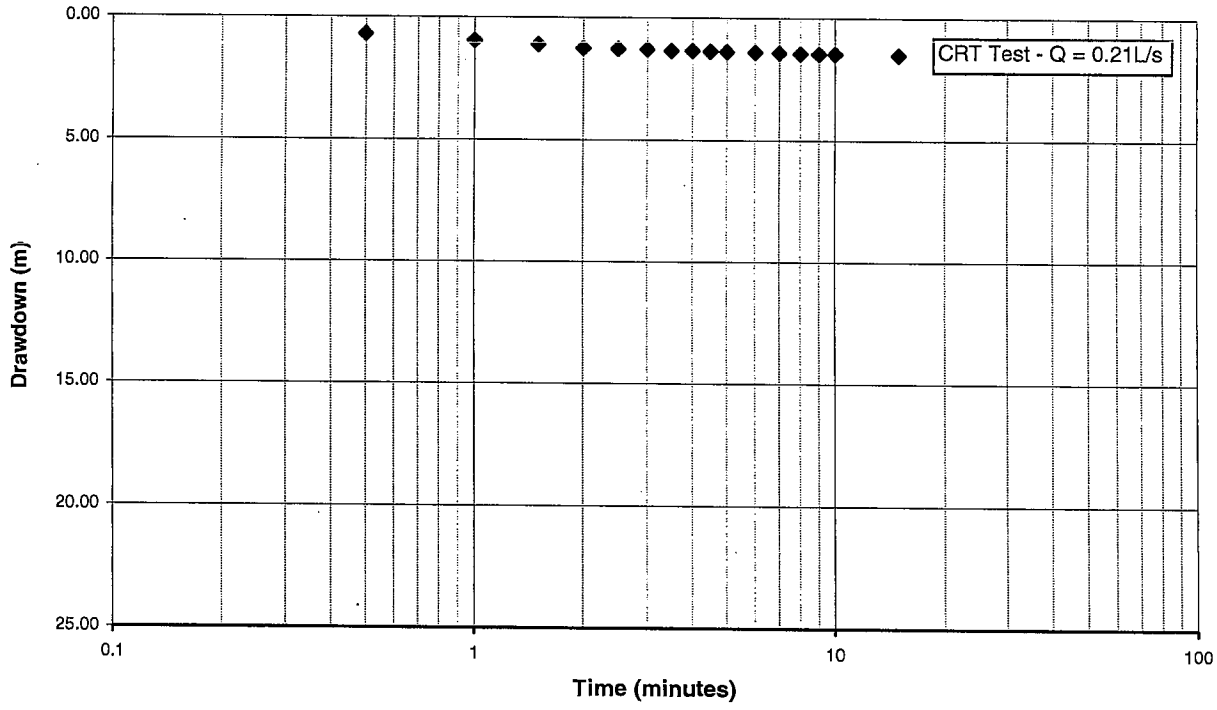
FIGURE D22

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

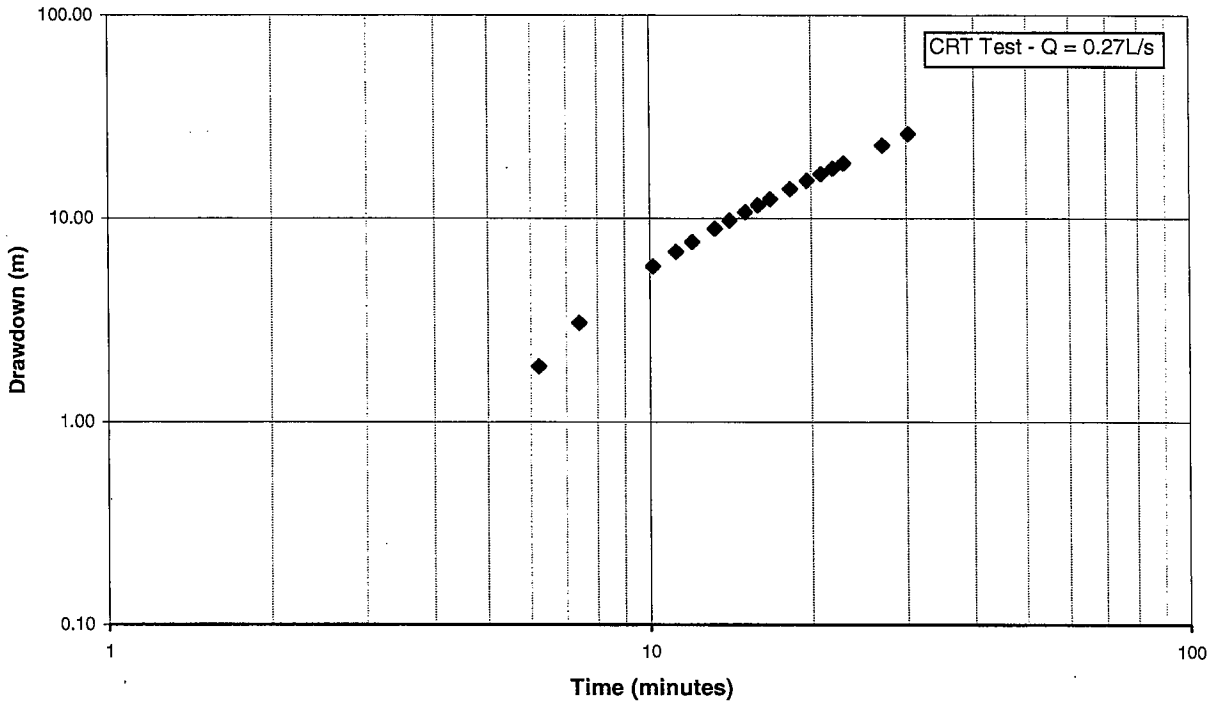


Job No.	44047-021-071		Iluka Resources Ltd
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.			**W20M2 CONSTANT RATE TEST**

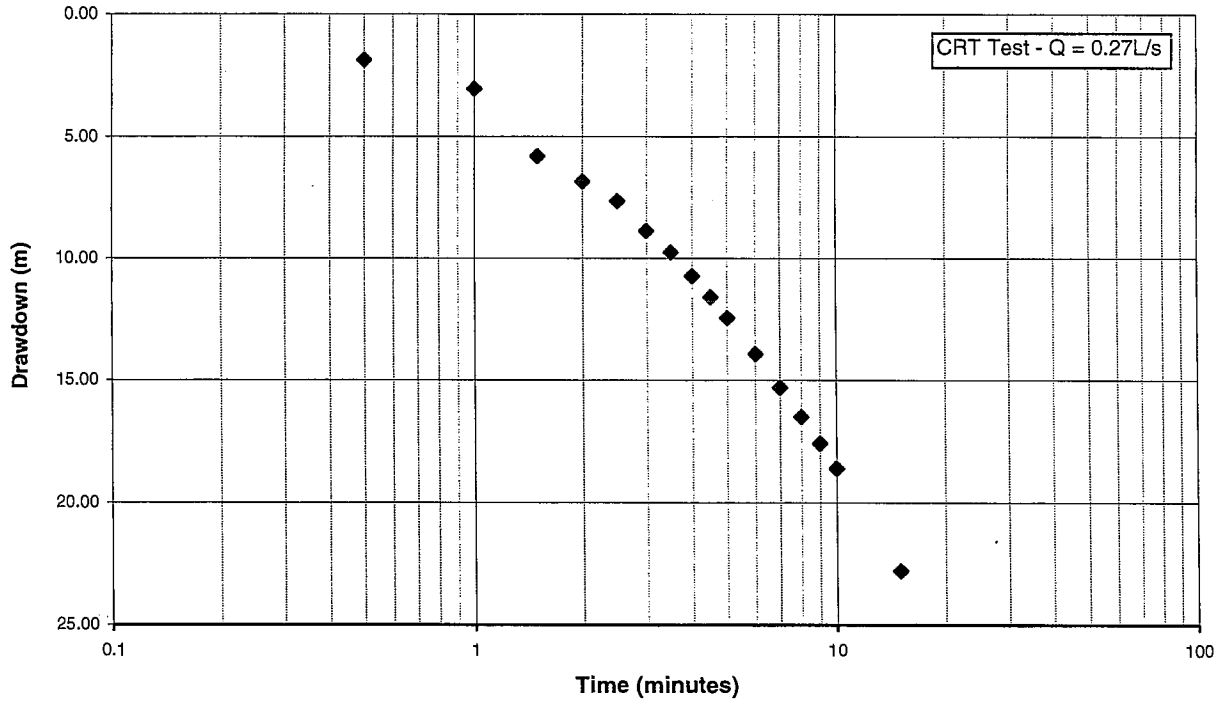
FIGURE D23

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

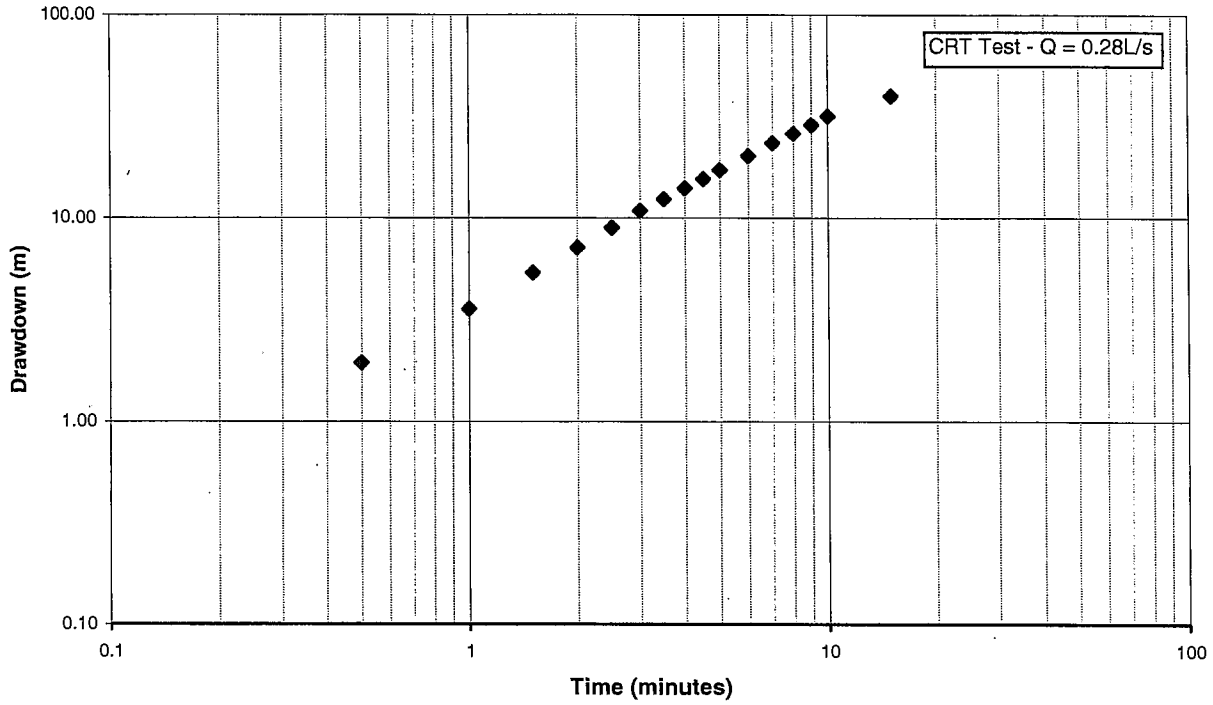


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

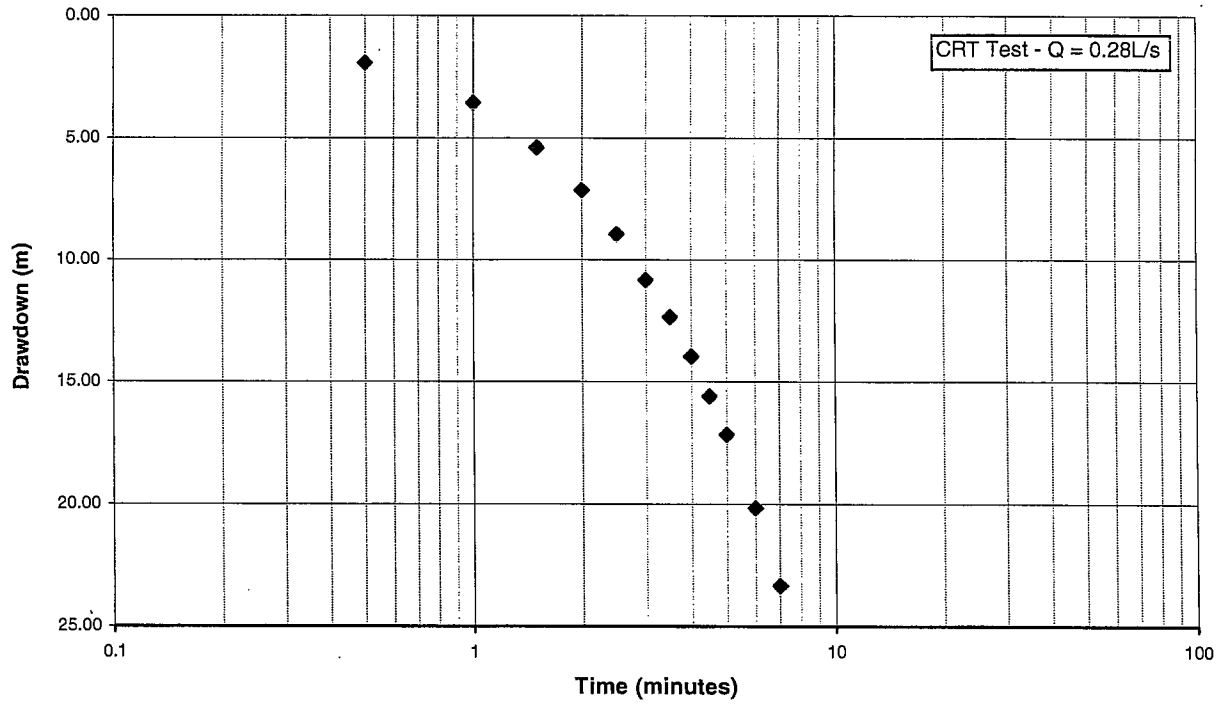


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D25
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			W20M4 CONSTANT RATE TEST	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

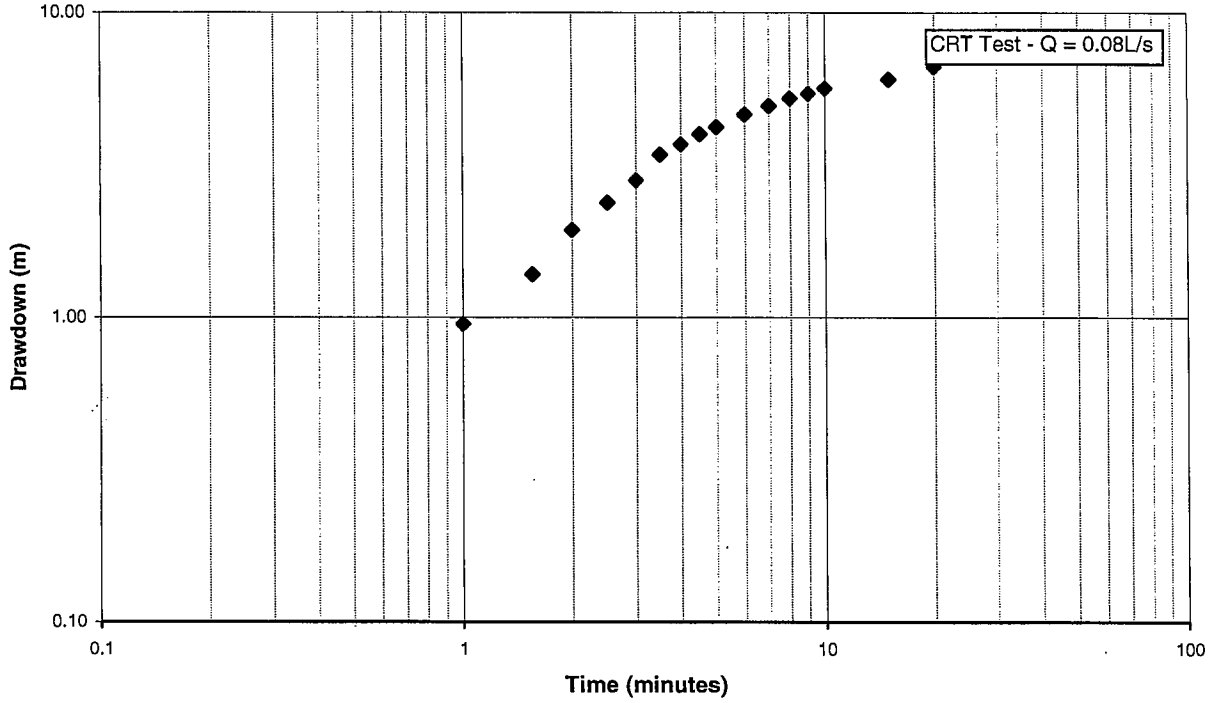


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

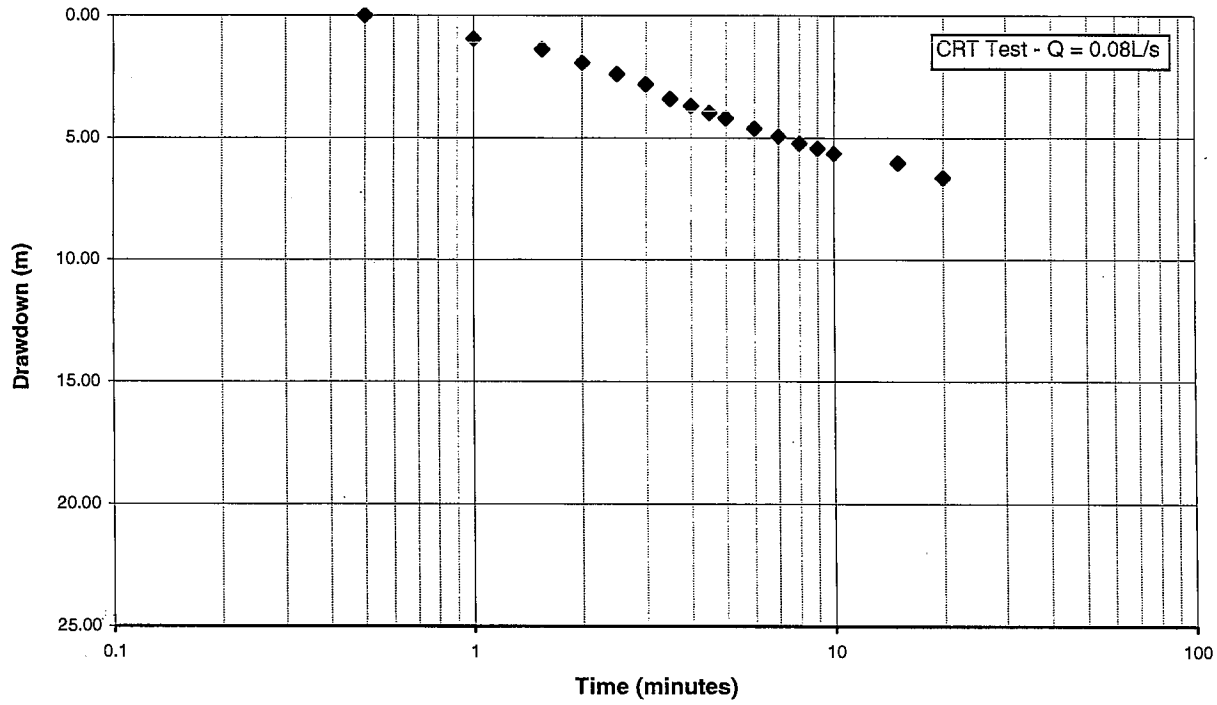


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D26
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			W20D CONSTANT RATE TEST	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

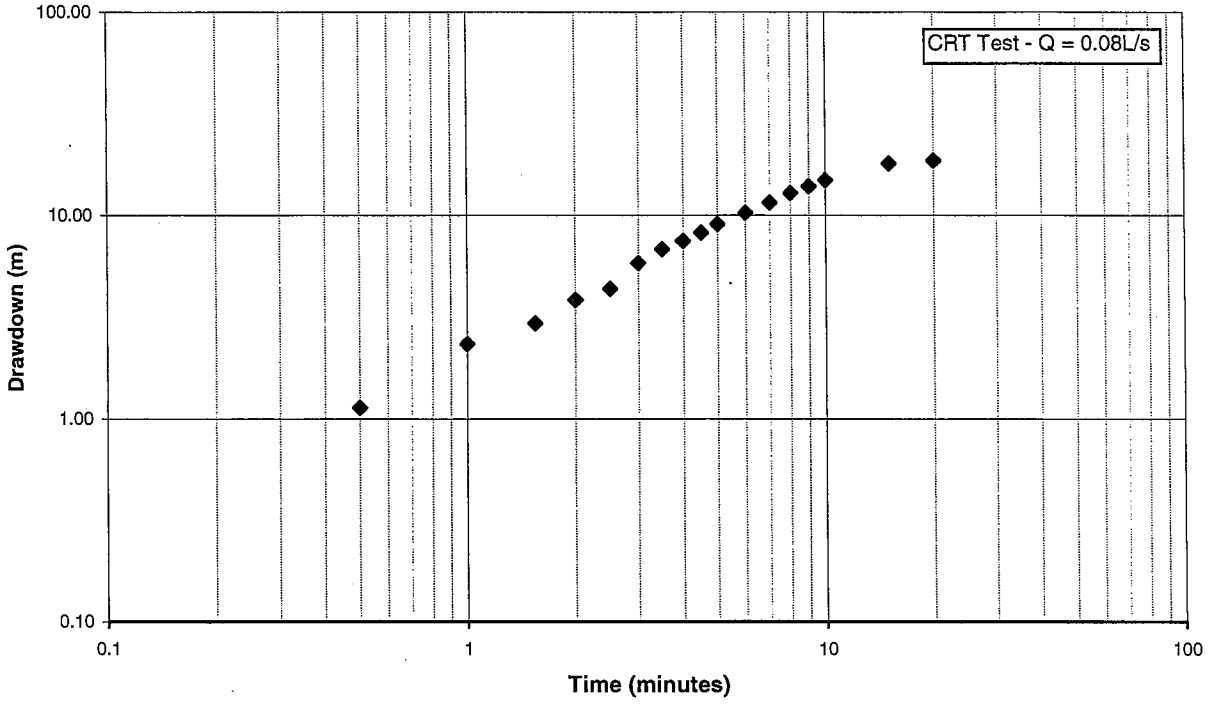


Job No.	44047-021-071		Iluka Resources Ltd
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.			**W21M CONSTANT RATE TEST**

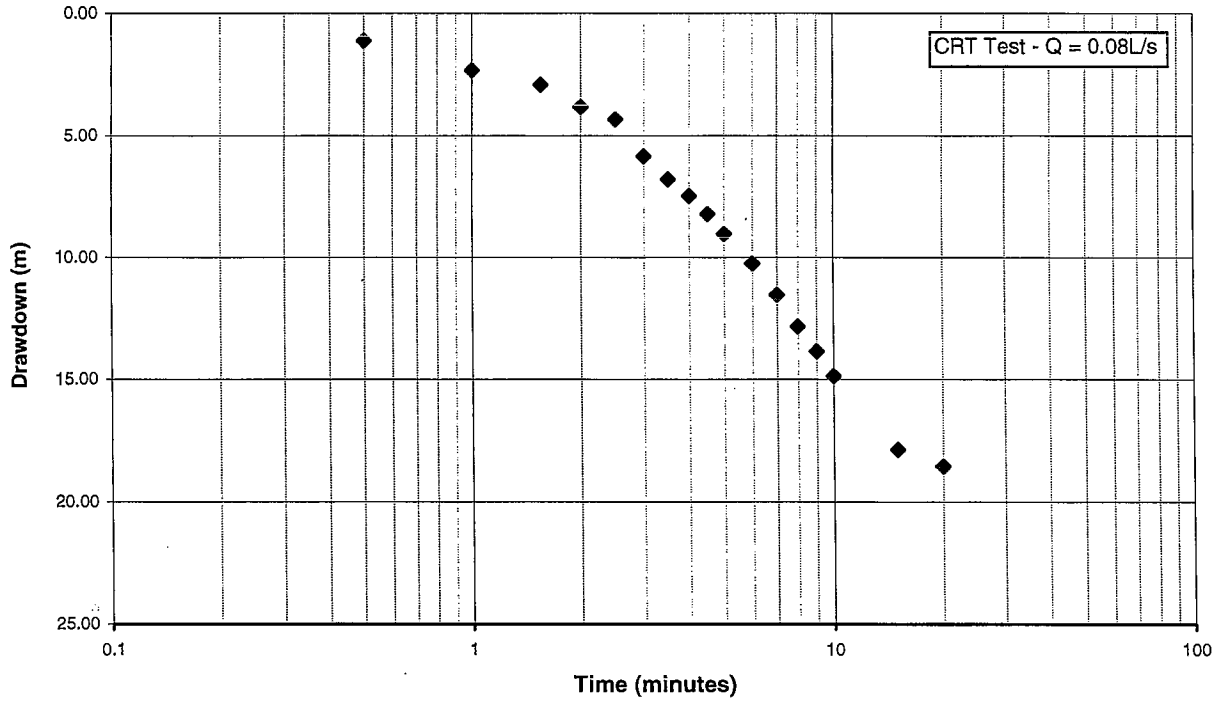
FIGURE D27

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

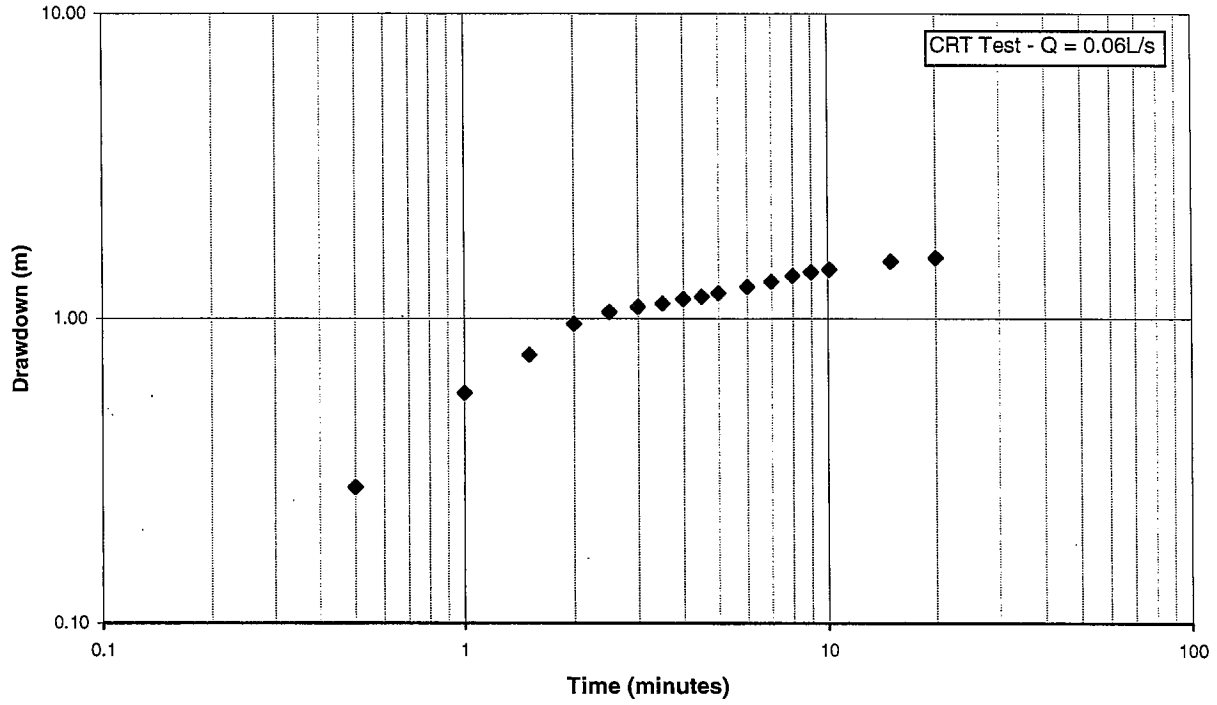


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

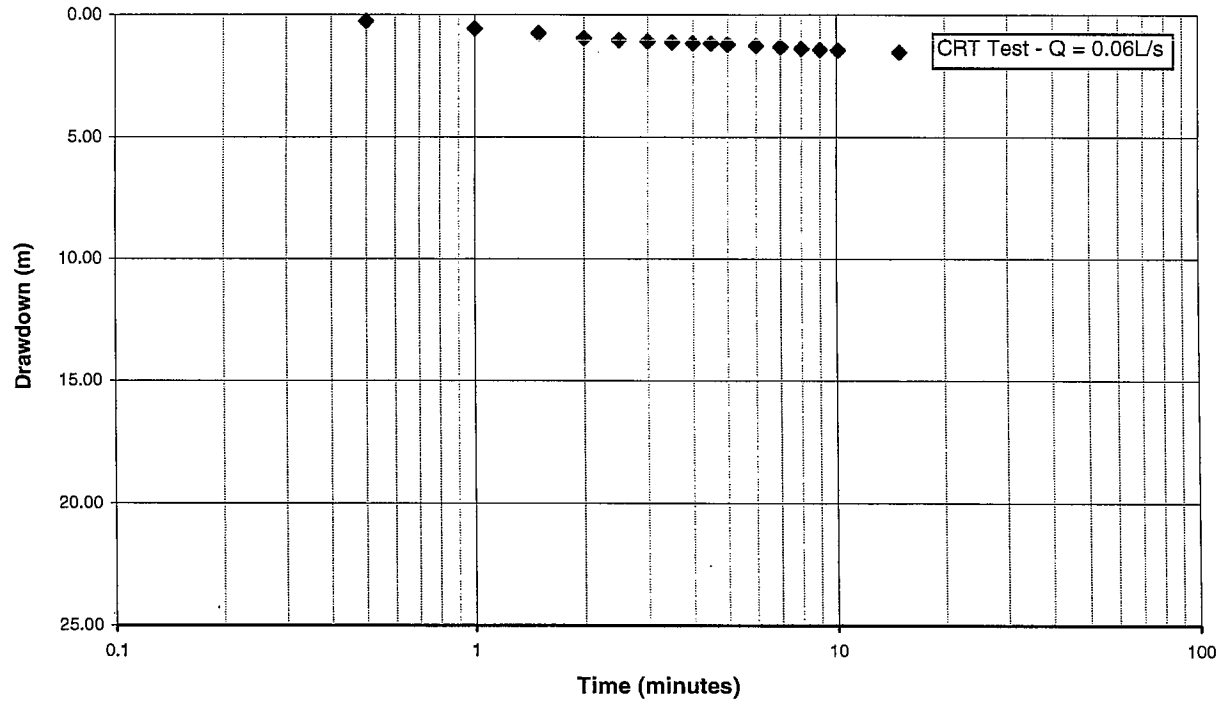


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D28
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			W21D CONSTANT RATE TEST	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

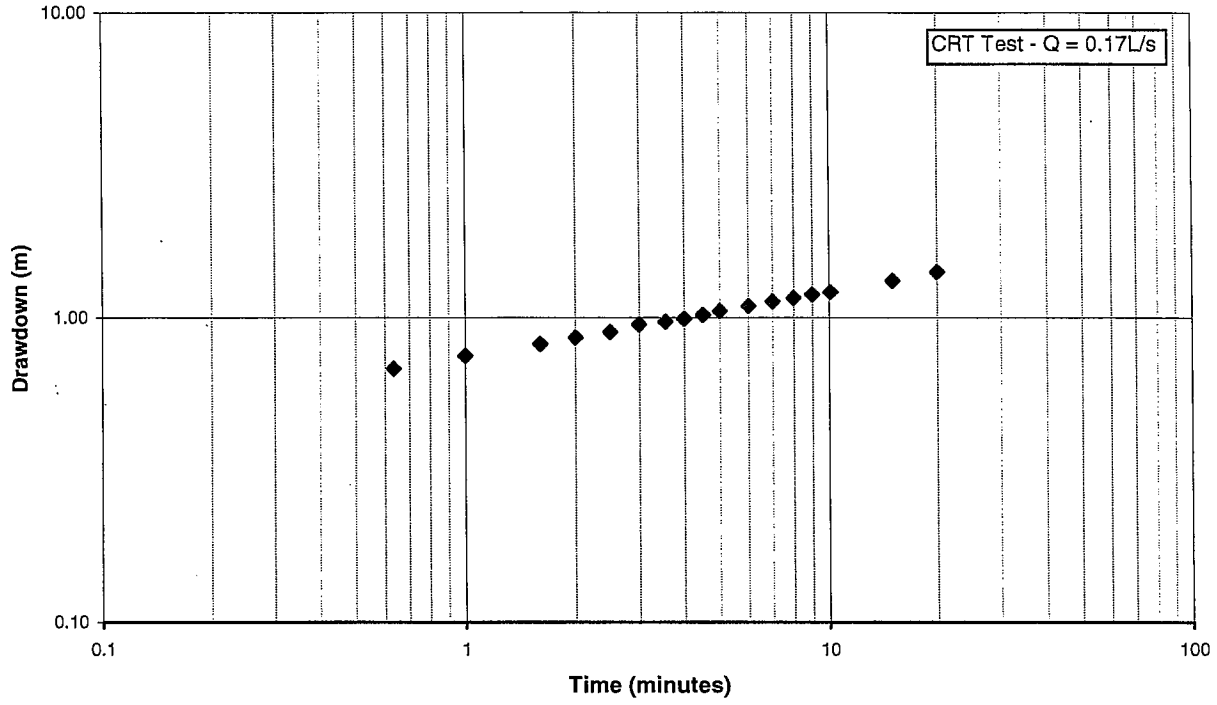


Job No.	44047-021-071		Iluka Resources Ltd
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.			**W22S CONSTANT RATE TEST**

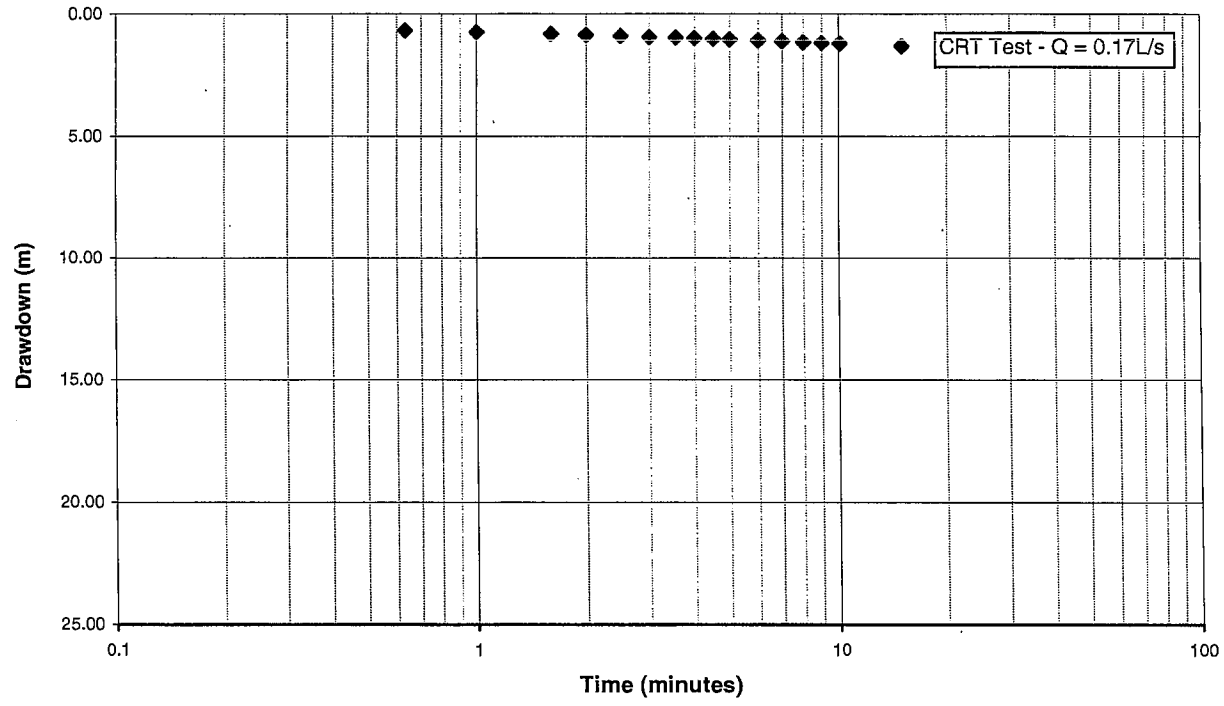
FIGURE D29

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

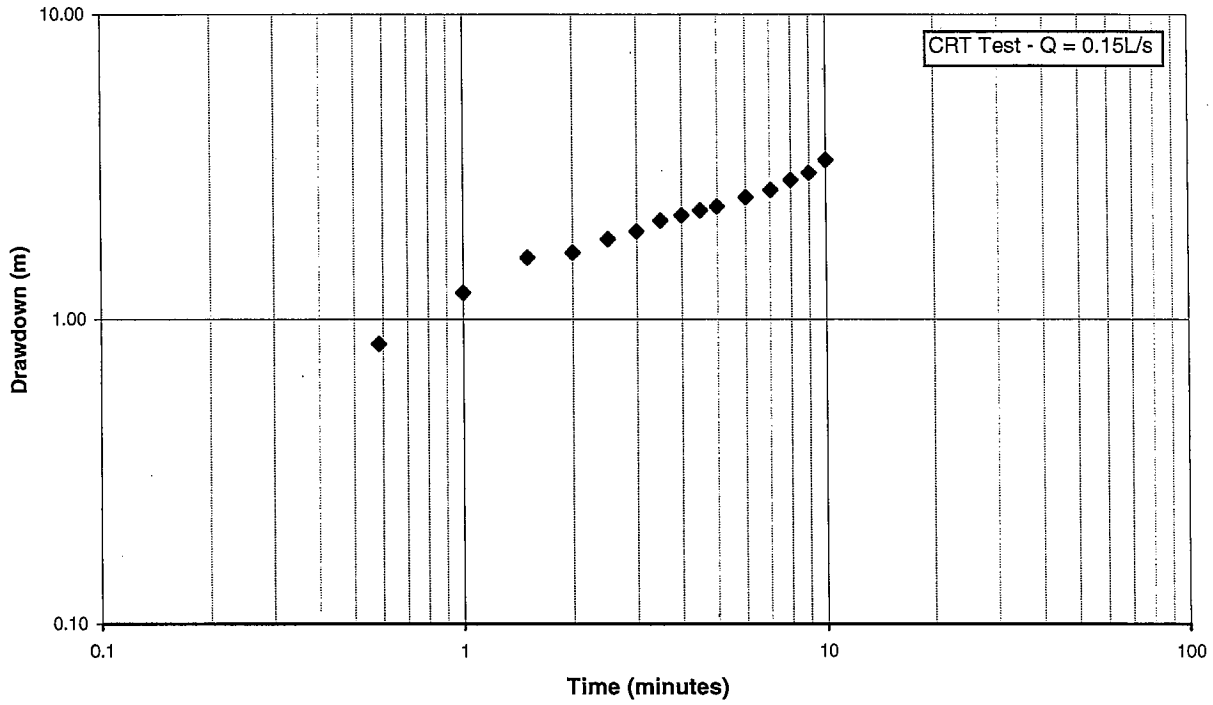


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

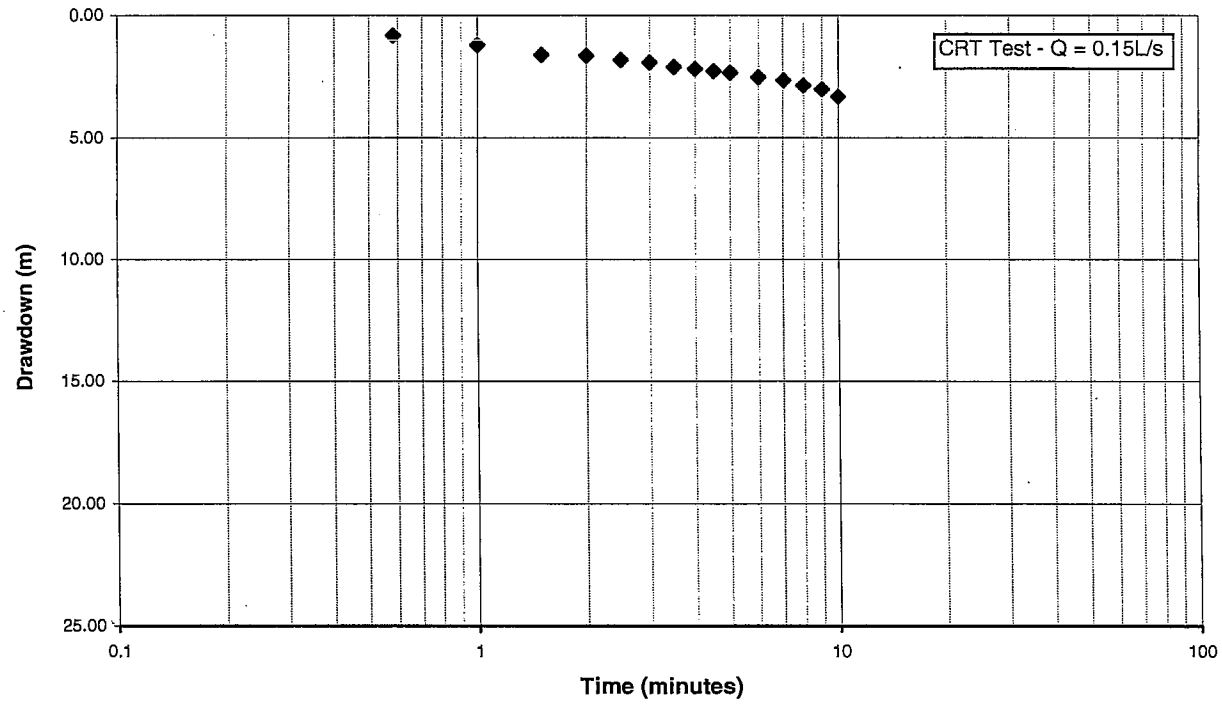


Job No.	44047-021-071		Iluka Resources Ltd	**FIGURE D30**
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			**W22D CONSTANT RATE TEST**	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

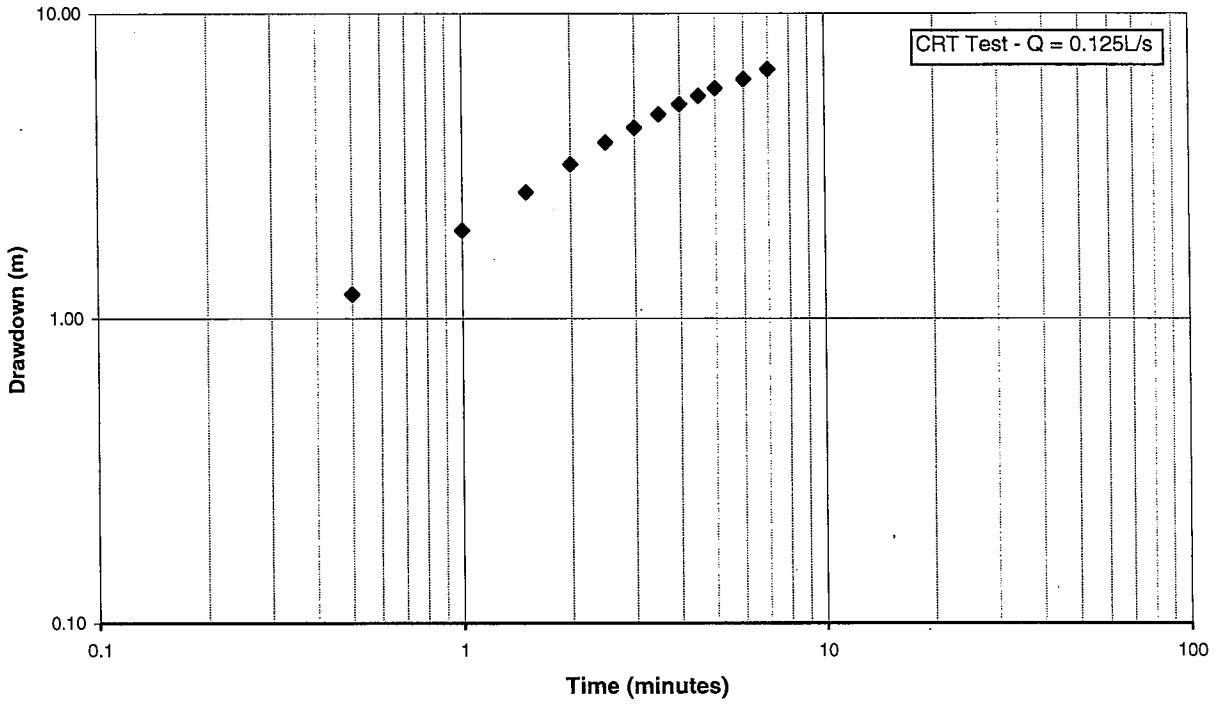


Job No.	44047-021-071		Iluka Resources Ltd
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.			**W23S CONSTANT RATE TEST**

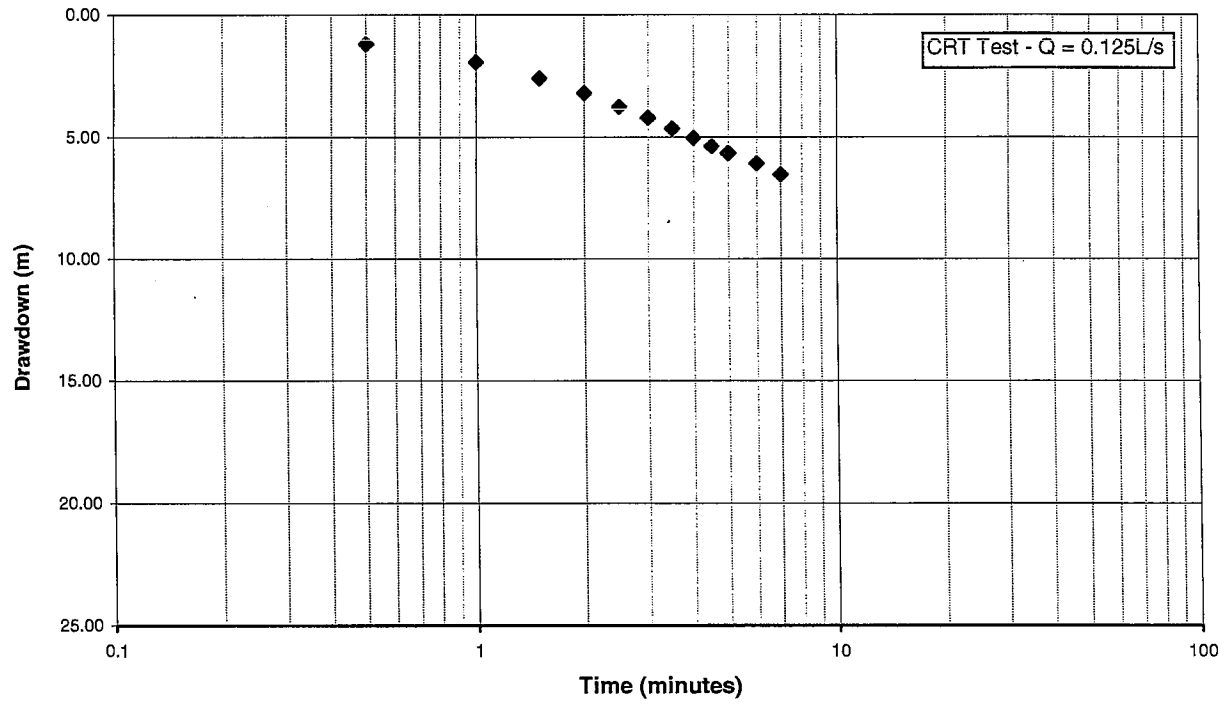
FIGURE D31

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

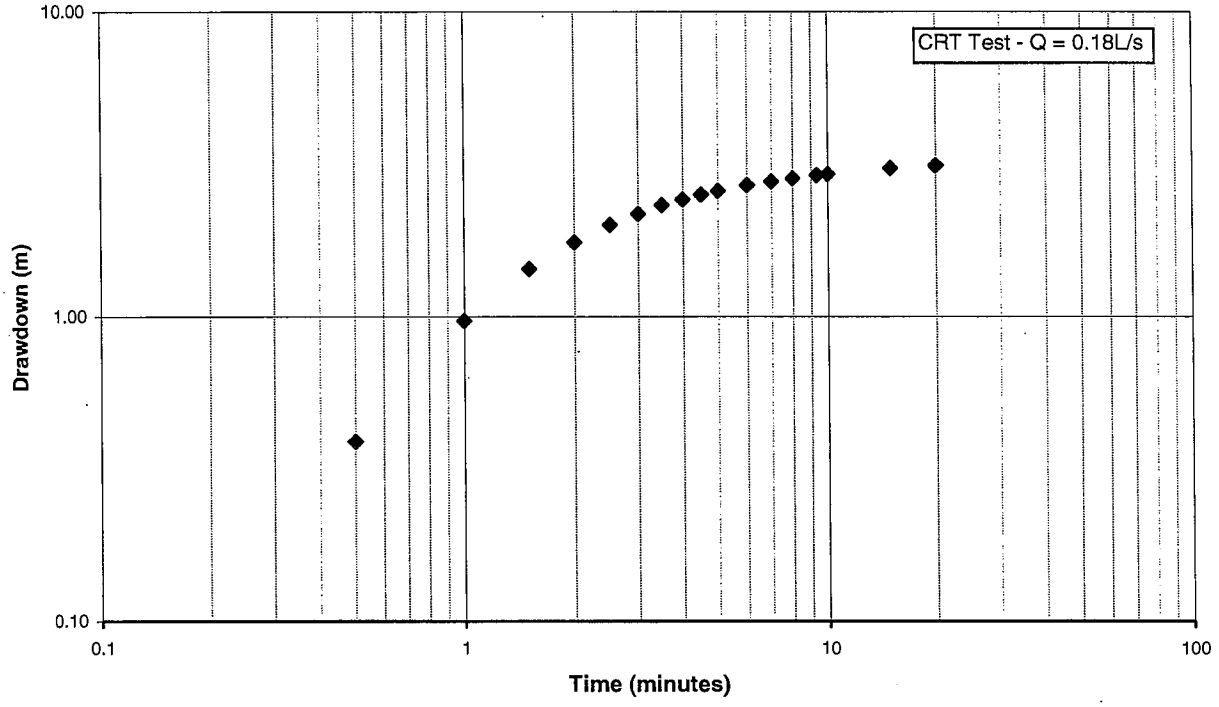


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

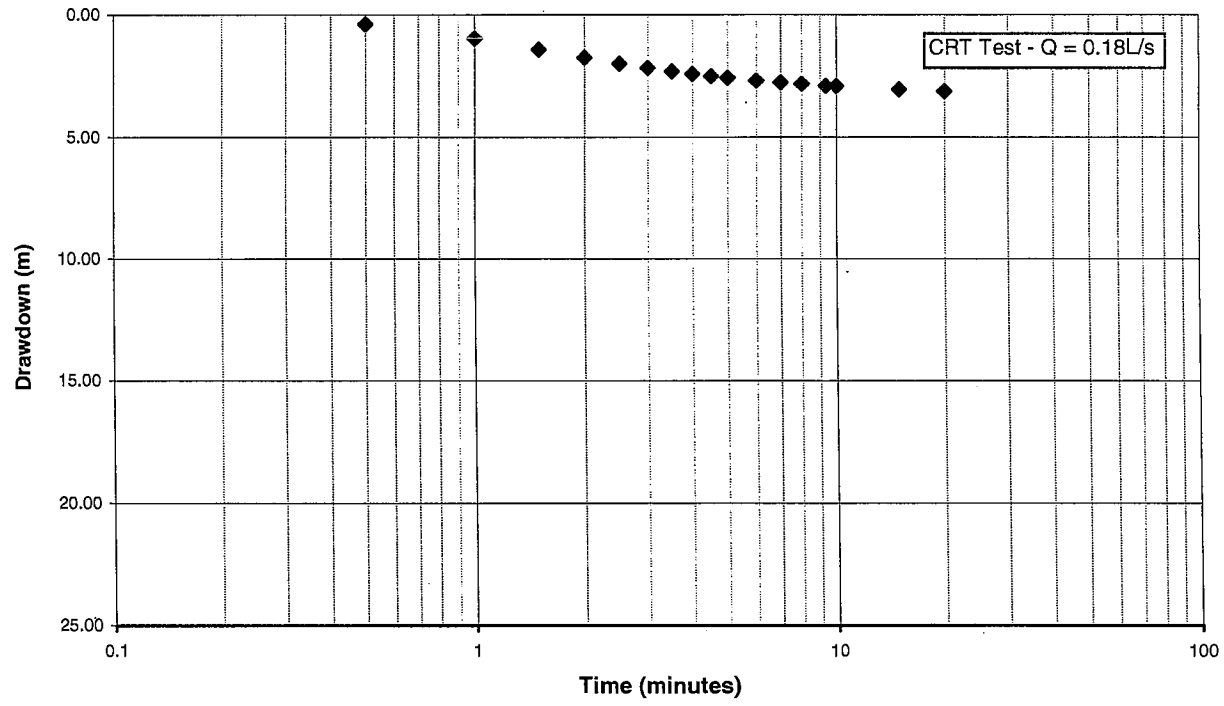


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D32
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			W23M CONSTANT RATE TEST	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

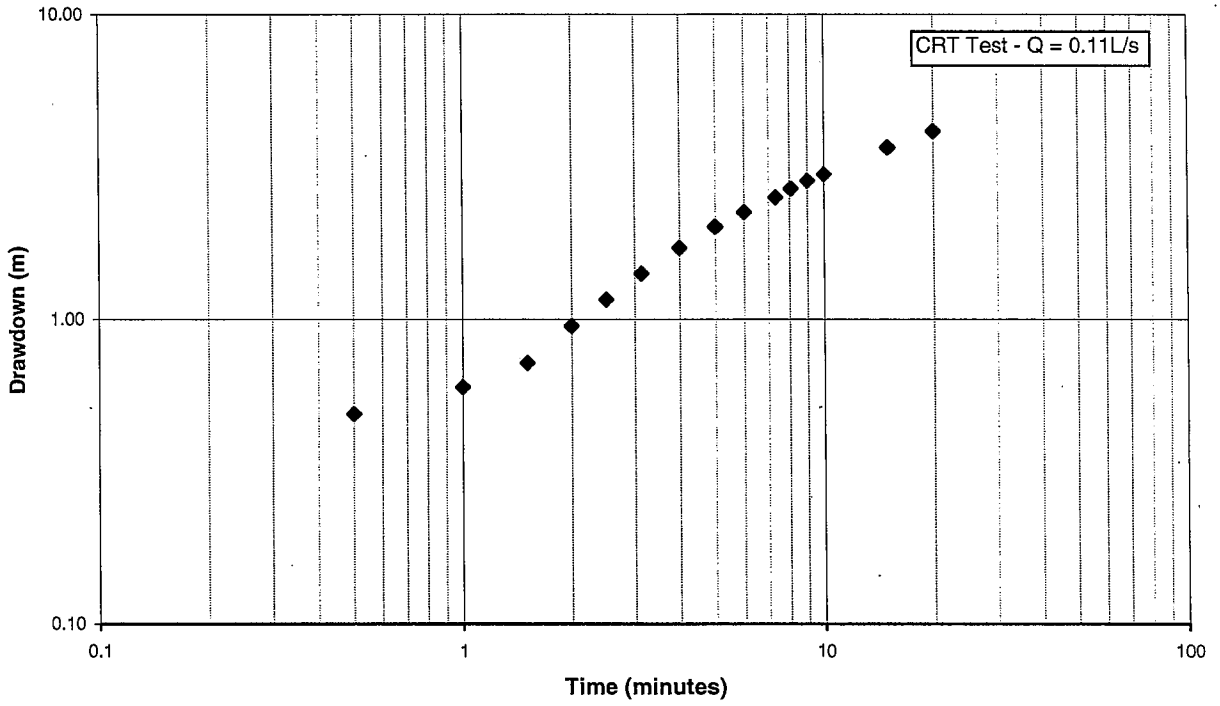


Job No.	44047-021-071		Iluka Resources Ltd
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.			**W23D CONSTANT RATE TEST**

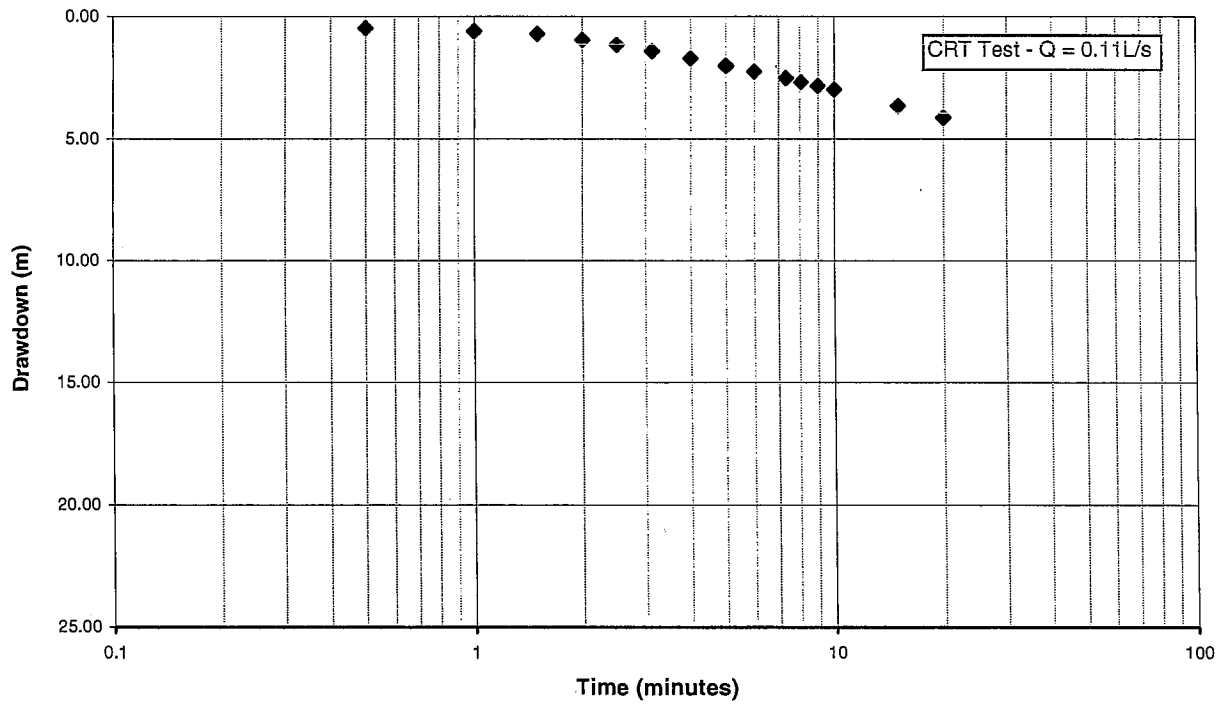
FIGURE D33

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT

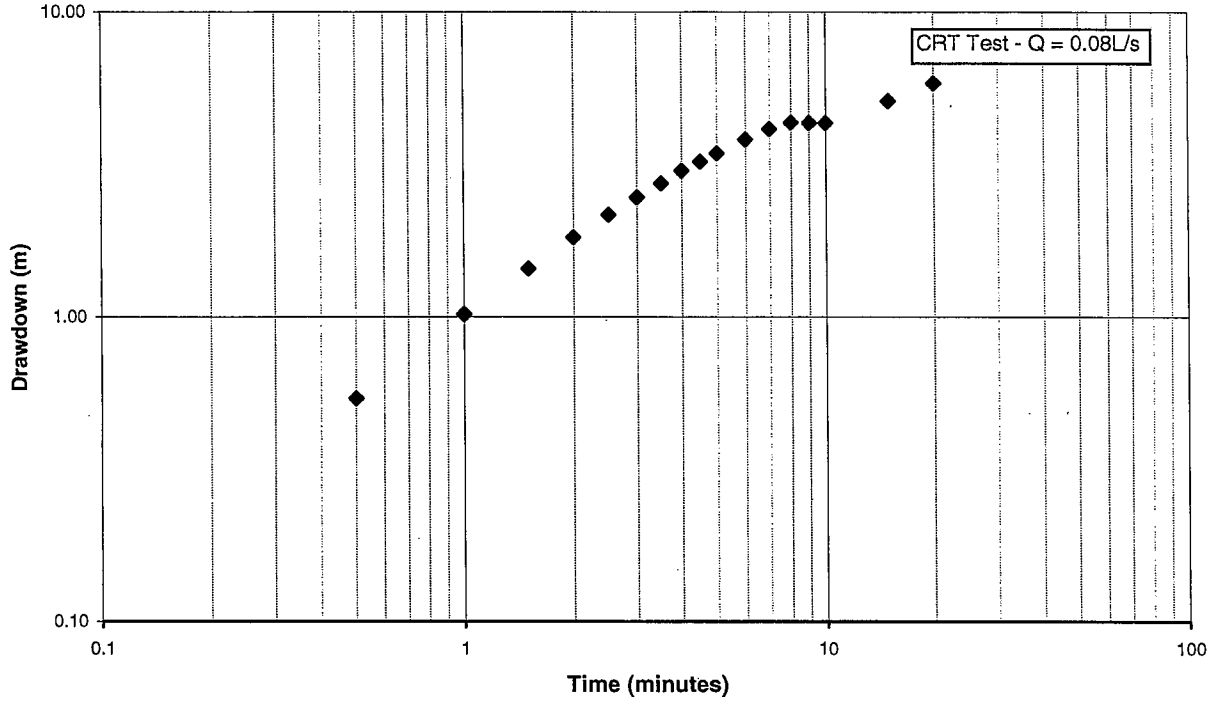


CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT

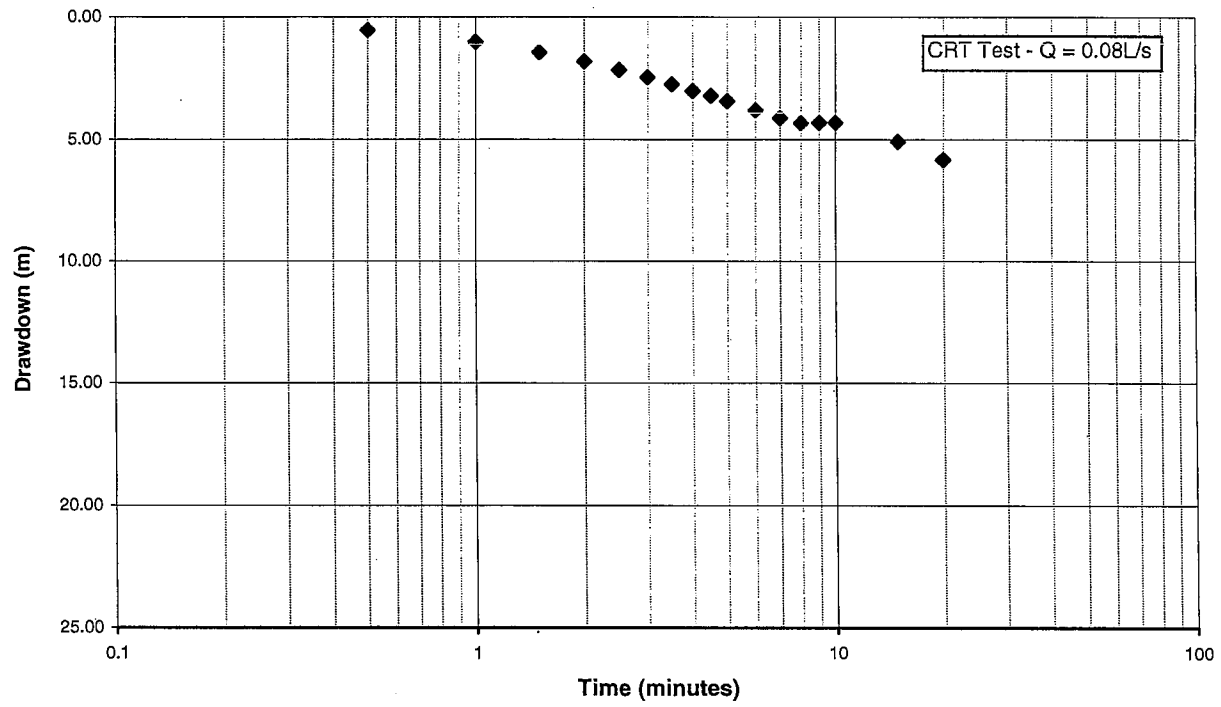


Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D34
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			W24 CONSTANT RATE TEST	

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMi-LOG PLOT

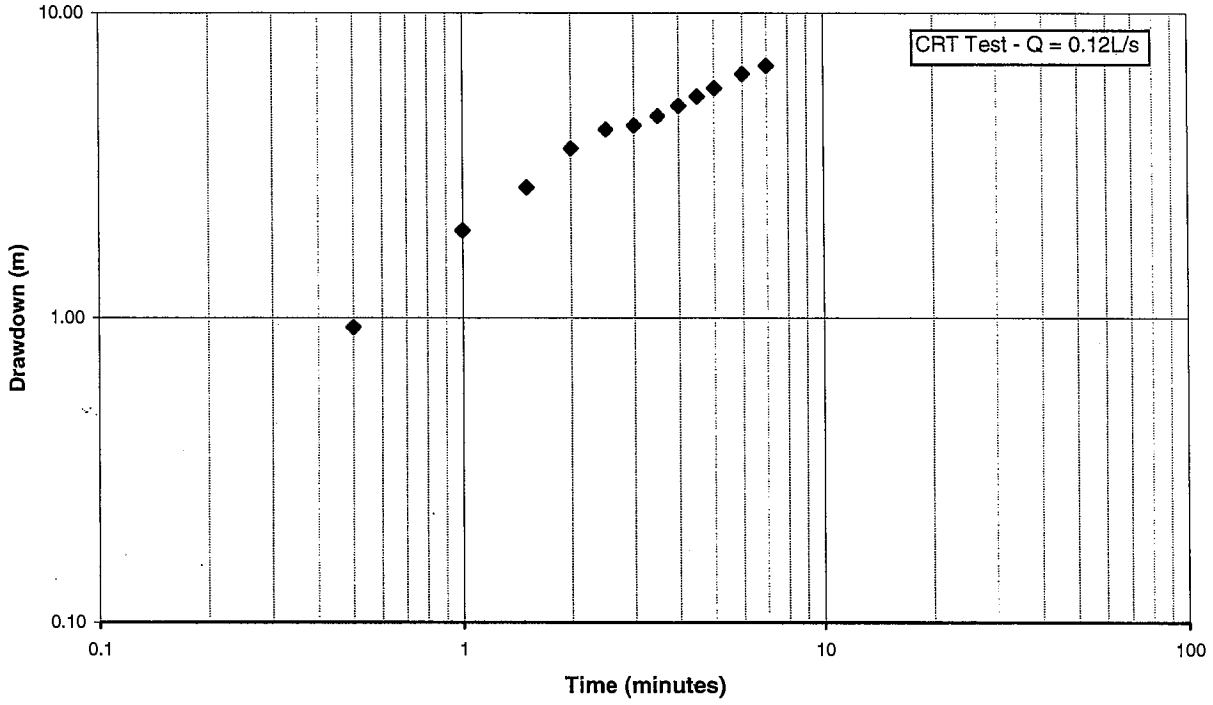


Job No.	44047-021-071		Iluka Resources Ltd
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES
Revision No.			**W25D CONSTANT RATE TEST**

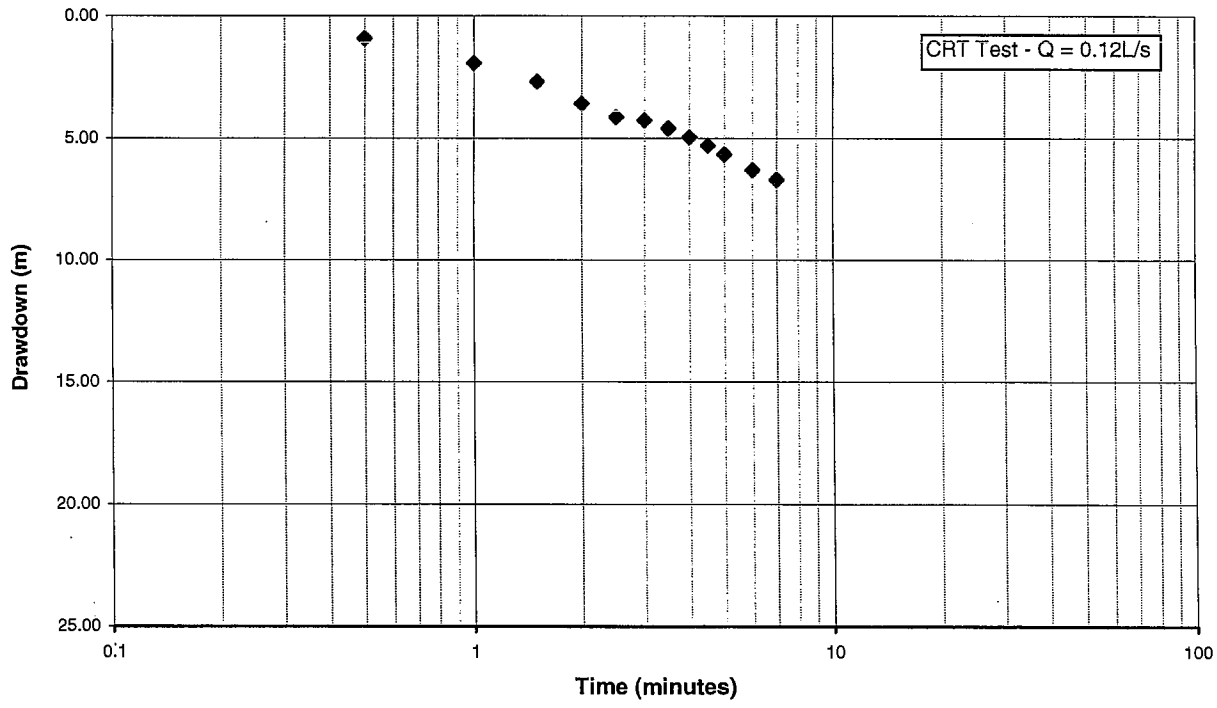
FIGURE D35

URS

CONSTANT-DISCHARGE TEST
LOG-LOG PLOT



CONSTANT-DISCHARGE TEST
SEMI-LOG PLOT



Job No.	44047-021-071		Iluka Resources Ltd	FIGURE D36
Prep. By	NRH	22 May. '01	WAROONA DEPOSIT	
Chk'd By	IGB	23 May. '01	IMPACTS OF MINING ON SHALLOW GROUNDWATER RESOURCES	URS
Revision No.			W26S CONSTANT RATE TEST	

Appendix E
Groundwater Quality - Reports of Analysis

ANALYTICAL REFERENCE LABORATORY (W.A.) PTY. LTD.

LABORATORY REPORT

ARL LAB No: 25527-35
DATE: 21 December 2000

CLIENT: U.R.S
Hyatt Centre, 20 Terrace Road
East Perth WA 6004

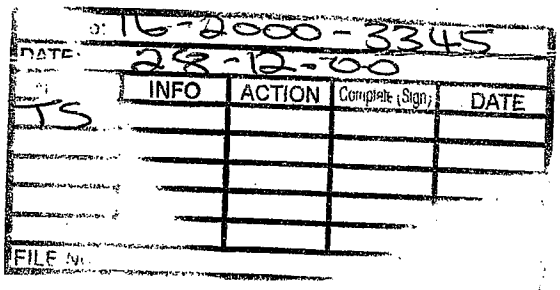
ATTENTION: Tenille Scott

SAMPLE DESCRIPTION: Nine water sample as received for analysis of chemical potability.

DATE RECEIVED: 30 November 2000

JOB NUMBER: 44047-021-071

METHODS:		
	Alkalinity	APHA 18th ed 2320
	Chloride	ARL No 018
	Conductivity	ARL No 019
	Heavy Metals	ARL No 029
	Nitrate-N	ARL No 031 4500E
	pH	ARL No 014
	Sulphate	ARL No 028
	Total Dissolved Solids	ARL No 017
	Turbidity	APHA 18th ed 2130B



55 Wittenoom Street, East Perth, Western Australia 6004
Telephone: (08) 9221 1415 Facsimile: (08) 9325 2398
Email: arlwa@wanet.com.au

Tenille Scott
U.R.S
ARL LAB No: 25527-35
21 December 2000

RESULTS:

Lab No	25527	25528	25529	25530	25531
Sample Marks	W18S	W18D	W22D	W22S	W23S
pH	5.9	6.1	6.4	6.5	6.6
Conductivity (mS/cm)	0.91	0.92	0.36	0.57	0.55
			mg/l		
Alkalinity($mgCaCO_3/L$)	110	170	70	140	180
Chloride	240	220	55	75	50
Nitrate-N	<0.01	<0.01	<0.01	0.22	<0.01
Sodium	130	130	80	140	120
Potassium	11	4.5	1.2	1.2	0.6
Calcium	21	25	0.7	0.5	3.6
Magnesium	32	30	2.1	4.7	7.4
Iron	0.21	2.1	0.17	5.5	0.54
Manganese	0.51	0.59	0.02	0.01	<0.01
Hardness (mg $CaCO_3/L$)	180	190	10	21	39
Sulphate	19	15	37	58	54
Total Dissolved Solids	620	660	320	760	520
Silica	29	28	25	34	41
Fluoride	0.7	0.1	1.3	2.2	1.0

Tenille Scott
U.R.S
ARL LAB No: 25527-35
21 December 2000

Lab No	25532	25533	25534	25535
Sample Marks	W23M	W23D	W24	W25D
pH	6.6	6.5	6.5	6.1
Conductivity (mS/cm)	0.54	0.58	0.61	1.4
			mg/l	
Alkalinity($mgCaCO_3/L$)	170	170	110	130
Chloride	50	60	130	340
Nitrate-N	<0.01	<0.01	<0.01	<0.01
Sodium	110	110	130	260
Potassium	1.4	1.9	1.5	3.5
Calcium	6.1	7.9	4.8	6.3
Magnesium	11	14	8.9	19
Iron	1.6	<0.01	0.03	0.22
Manganese	<0.01	0.03	<0.01	0.74
Hardness (mg $CaCO_3/L$)	60	77	49	94
Sulphate	56	64	26	90
Total Dissolved Solids	770	440	480	920
Silica	37	28	37	38
Fluoride	1.3	0.8	0.6	1.1

Kim Rodgers
Laboratory Manager

AGAL

REPORT OF ANALYSIS

Report No. RN214747

Client	: URS (WA) LEVEL 3 HYATT CENTRE 20 TERRACE ROAD EAST PERTH WA 6004	**Job No.**	: URS01_W/010326
		Quote No.	: QT-00747
		Order No.	: PER-06605
		Date Sampled	: 23-MAR-2001
		Date Received	: 23-MAR-2001
Attention	: J McNamara	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: OANA CHIRILA	**Phone**	: (08) 9384 1511

Lab Reg No.	Sample Ref	Sample Description
W01/006691	W5	WATER 23/03/01 ILUKA WAROONA

Lab Reg No.		W01/006691				
Sample Reference	Units	W5				Method
Trace Elements						
Manganese - Filterable	mg/L	<0.005				VL250
Silicon - Filterable (as Si02)	mg/L	11				VL250

Signed:

Stavros Tzardis, Trace Elements - Vic

Date: 2-APR-2001

Lab Reg No.		W01/006691				
Sample Reference	Units	W5				Method
Inorganics						
Bicarbonate as CaCO3	mg/L	6				WL122
Calcium - Filterable	mg/L	<1				WL125
Carbonate as CaCO3	mg/L	<1				WL122
Chloride	mg/L	50				WL119
Conductivity at 25C	uS/cm	210				WL121
Fluoride	mg/L	<0.2				WL218
Iron - Filterable	mg/L	0.2				WL124
Magnesium - Filterable	mg/L	3.8				WL125
Nitrate as NO3	mg/L	<1				WL119WL239
pH		5.7				WL120
Potassium - Filterable	mg/L	<1				WL125
Sodium - Filterable	mg/L	30				WL125
Sulfate	mg/L	16				WL119
Total Dissolved Solids (Evap)	mg/L	110				WL123

16200-746.
4.4.01.
J. McNamara
DATE

AUSTRALIAN GOVERNMENT ANALYTICAL LABORATORIES
3 Clive Road, Cottesloe WA 6011 PO Box 83 Cottesloe WA 6011
Tel: +61 8 9384 1511 Fax: +61 8 9384 1132 www.agal.gov.au

AGAL

REPORT OF ANALYSIS

Report No. RN214747

Lab Reg No.		W01/006691				
Sample Reference	Units	W5				Method

Signed:

Oana Chirila, Environmental - WA

Date: 2-APR-2001

This Laboratory is accredited by the National Association of Testing Authorities, Australia.
[Accreditation No 2474, 89].
The tests reported herein have been performed in accordance with its terms of accreditation.

Sample/s analysed as received.
This Report supersedes reports: *RN214473* *RN214494*

AUSTRALIAN GOVERNMENT ANALYTICAL LABORATORIES
3 Clive Road, Cottesloe WA 6011 PO Box 83 Cottesloe WA 6011
Tel: +61 8 9384 1511 Fax: +61 8 9384 1132 www.agal.gov.au

Client: URS WA
Level 3 Hyatt Centre
20 Terrace Rd
East Perth WA 6004

Attention: Nathan Henderson

BATCH No. : 006691
Job No. :
Lab Reg Nos. : W01/006691

QUALITY CONTROL REPORT

Laboratory Identification Number	Client Identification Number	pH	Conductivity uS/cm	TDS mg/L	Alkalinity as CaCO3 mg/L	HCO3 as CaCO3 mg/L	CO3 as CaCO3 mg/L	Ca mg/L	Cl mg/L	F Fe mg/L	Mg mg/L	K mg/L	Na mg/L	SO4 mg/L	SiO2 mg/L
Recovery of reference material		-	-	99%	-	-	-	99%	98%	91%	102%	100%	100%	100%	-
Blank		-	-	<10	-	-	-	<1	<10	<0.1	<1	<1	<10	<5	-
Acceptability Criteria (%)		-	-	90-110	-	-	-	85-110	90-110	85-110	85-110	85-110	85-110	85-115	90-110

OANA CHIRILA
Senior Euvironmental Chemist
AGAL WA Inorganic Section
Date: 30/03/01

THIS COLUMN FOR LAB USE ONLY

CHAIN OF CUSTODY FORM

FROM: JMcNamara DATE:23/3/01 TO: AGAL

URS (AUSTRALIA)
ACN 000 691 690
Level 3, 20 Terrace Road, East Perth, WA 6004
Ph: 9221 1630 Fax: 9221 1639

FAXED

Job Code:

Due Date: 7 days

Project No: 44047-021-071
Iluka Waroona
Project Manager: JMM
Agreement No:

Sampler(s):K Wintergreen
Signature(s):
Checked:

Container Size, Type, Preservative, and Analysis

Container Identification

Custody seal intact? YES NO

Sample cold? YES NO

Released for URS by: JMc
Date: 23/3 Time: 2pm

Received for Laboratory by: KRAINBOT
Date: 23/3/01 Time: 1600

Lab identification	Date	Time	Matrix	Sample Identification	Analytes
wo 1/00869 1	23/3/01		water	W5	pH, EC, TDS, Fe, Na, K, Ca, Mg, Cl, CO3, HCO3, SO4, NO3, F, Mn and SiO2.
				TOTAL	

Comments:

Courier Job No:

Remarks:

NOTE: SAMPLES MAY CONTAIN DANGEROUS AND HAZARDOUS SUBSTANCES

URS

Level 3, Hyatt Centre, 20 Terrace Road, East Perth, Western Australia 6004
In Australia Telephone: 08 9221 1630 Facsimile: 08 9221 1639
International Telephone: 618 9221 1630 Facsimile: 618 9221 1639
URS Australia Pty Ltd A.C.N. 000 691 690 and A.B.N. 46 000 691 690 Dames & Moore Pty Ltd A.C.N. 003 293 696

TO: AgAL

PURCHASE ORDER No: PER-06605

THIS NUMBER MUST APPEAR ON ALL CORRESPONDENCE, INVOICES AND PACKAGES

ATTENTION: Oana Chirila

DATE ORDERED: 3/23/01

FROM: JMM

DATE REQUIRED: 4/2/01

AUTH BY: JMM

Signature

JOB No: 44047-021-071

PLEASE SUPPLY ITEMS OR SERVICES LISTED BELOW IN ACCORDANCE WITH SERVICE AGREEMENT NO: SA027	UNIT PRICE	TOTAL AMOUNT
Laboratory analysis as described in COC		$180.00

Distribution: Original - Vendor **Copy** ☒ **Project Finance File** **Others: (specify)**

REG No:	602001-84			
DATE:	15.1.01			
NAME	INFO	ACTION	Complete (Sign)	DATE
TScott				
FILE No				

AGAL

REPORT OF ANALYSIS

Report No. RN200702

Client	: URS (WA) LEVEL 3 HYATT CENTRE 20 TERRACE ROAD EAST PERTH WA 6004	**Job No.**	: URS01_W/001228_1
		Quote No.	: QT-00747
		Order No.	:
		Date Sampled	: 30-NOV-2000
		Date Received	: 22-DEC-2000
Attention	: TENILLE SCOTT	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: OANA CHIRILA	**Phone**	: (08) 9384 1511

Lab Reg No.	Sample Ref	Sample Description
W00/028605	W10M	WATER JOB 44047-021-071 WAROONA
W00/028606	W15M	WATER JOB 44047-021-071 WAROONA
W00/028607	W17M	WATER JOB 44047-021-071 WAROONA
W00/028608	W17S	WATER JOB 44047-021-071 WAROONA

Lab Reg No.		W00/028605	W00/028606	W00/028607	W00/028608	
Sample Reference	Units	W10M (2)	W15M ?	W17M? W17D	W17S W17S	Method
Inorganics						
Bicarbonate as CaCO3	mg/L	16 41	5	17	19	WL122
Calcium - Filterable	mg/L	3 4	<1	9	<1	WL125
Carbonate as CaCO3	mg/L	<1 <1	<1	<1	<1	WL122
Chloride	mg/L	360 360	40	540	39	WL119
Conductivity at 25C	uS/cm	1280 1370	192	1990	216	WL121
Fluoride	mg/L	<0.2 <0.2	<0.2	<0.2	<0.2	WL218
Iron - Filterable	mg/L	1.4 2.2	<0.1	<0.1	0.2	WL124
Magnesium - Filterable	mg/L	16 16	3	26	3	WL125
Manganese - Filterable	mg/L	<0.1 <0.1	<0.1	<0.1	<0.1	WL128
Nitrate as NO3	mg/L	<1 <1	<1	<1	5	WL119WL239
pH		5.5 5.6	5.7	6.3	7.6	WL120
Potassium - Filterable	mg/L	3 3	<1	6	<1	WL125
Silica as SiO2	mg/L	15	6.5	36	5.4	WL239
Sodium - Filterable	mg/L	230	30	360	30	WL125
Sulfate	mg/L	42	22	110	16	WL119
Total Dissolved Solids (Evap)	mg/L	820 830	120	1140	140	WL123

Signed:

Oana Chirila, Environmental - WA

Date: 11-JAN-2001

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AGAL

REPORT OF ANALYSIS

Report No. RN200702

Client	: URS (WA) LEVEL 3 HYATT CENTRE 20 TERRACE ROAD EAST PERTH WA 6004	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: URS01_W/001228_1 : QT-00747 : : 30-NOV-2000 : 22-DEC-2000
Attention	: TENILLE SCOTT	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: OANA CHIRILA	**Phone**	: (08) 9384 1511

Lab Reg No.	Sample Ref	Sample Description
W00/028609	W15S	WATER JOB 44047-021-071 WAROONA
W00/028610	W10S	WATER JOB 44047-021-071 WAROONA

Lab Reg No.		W00/028609	W00/028610			
Sample Reference	Units	W15S (2)	W10S (2)			Method
Inorganics						
Bicarbonate as CaCO3	mg/L	6	23			WL122
Calcium - Filterable	mg/L	<1	2			WL125
Carbonate as CaCO3	mg/L	<1	<1			WL122
Chloride	mg/L	24	79			WL119
Conductivity at 25C	uS/cm	120	486			WL121
Fluoride	mg/L	<0.2	<0.2			WL218
Iron - Filterable	mg/L	<0.1	0.1			WL124
Magnesium - Filterable	mg/L	2	4			WL125
Manganese - Filterable	mg/L	<0.1	<0.1			WL128
Nitrate as NO3	mg/L	<1	5			WL119WL239
pH		5.9	6.4			WL120
Potassium - Filterable	mg/L	<1	<1			WL125
Silica as SiO2	mg/L	5.9	15			WL239
Sodium - Filterable	mg/L	20	80			WL125
Sulfate	mg/L	15	74			WL119
Total Dissolved Solids (Evap)	mg/L	90	300			WL123

Signed:

Oana Chirila, Environmental - WA

Date: 11-JAN-2001

This Laboratory is accredited by the National Association of Testing Authorities, Australia.
[Accreditation No 2474].
The tests reported herein have been performed in accordance with its terms of accreditation.

Sample/s analysed as received.

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Tel: +61 8 9384 1511 Fax: +61 8 9384 1132 www.agal.gov.au

Client: URS WA
Level 3 Hyatt Centre
20 Terrace Rd
East Perth WA 6004

Attention: Nathan Henderson

BATCH No. : 28605
Job No. :
Lab Reg Nos. : W00/028605 - 28610

QUALITY CONTROL REPORT

Laboratory Identification Number	Client Identification Number	pH	Conductivity uS/cm	TDS mg/L	Alkalinity as CaCO3 mg/L	HCO3 as CaCO3 mg/L	CO3 as CaCO3 mg/L	Ca mg/L	Cl mg/L	F Fe mg/L	Mg mg/L	K mg/L	Na mg/L	SO4 mg/L	SiO2 mg/L
W00/028610-D	444065-D	6.4	486	300%		23	<1	2	78	0	4	<1	90	74	15
Recovery of reference material		-	-	101%	-	-	-	101%	103%	100%	102%	100%	100%	97%	100%
Blank		-	-	<10	<1	<1	<1	<1	<10	<0.1	<1	<1	<10	<5	<0.002
Acceptability Criteria (%)		-	-	90-110	-	-	-	85-110	90-110	85-110	85-110	85-110	85-110	85-115	90-110

OANA CHIRILA
Senior Environmental Chemist
AGAL WA Inorganic Section
Date: 14/01/01

HYATT CENTRE, 20 TERRACE ROAD, EAST PERTH, WA 6004
IN AUSTRALIA TELEPHONE: 08-9221 1630 FACSIMILE: 08-9221 1639
INTERNATIONAL TELEPHONE: 61-8-9221 1630 FACSIMILE: 61-8-9221 1639

CHAIN OF CUSTODY RECORD DM-FORM-43

Job No.: 44047-021-071		Send Results to: Tenille Scott			Date: 21.12.00	CoC No.: 44-2000 145
Site or Client: Waroona		Turnaround Time: 7-10 days			Sample Destination:	
Sample No.	Sampling Date	Type	Preservation	No. of Containers	Tests Required	
W1OM	30.11.00		ICE	1	For all samples: pH, EC, TDS, Fe, Na, k, Ca, Mg, Cl, CO_3, HCO_3, SO_4, NO_3, F, Mn, SiO_2	WO0/028605
W1SM	30.11.00					WO0/028606
W17D	30.11.00					WO0/028607
W17S	30.11.00					WO0/028608
W1SS	30.11.00					WO0/028609
W1OS	30 11.00					WO0/028610

SAMPLED BY: TJS

RELINQUISHED BY (NAME): Tenille Scott (URS) SIGN: [signature] DATE/TIME 22.12.00

RECEIVED BY (COMPANY): AGAR NAME: K RAINBIRD SIGN [signature] DATE/TIME 22/12/00 1400

Important: **Validity of the analytical results require that the recipient of this form fax it to URS Fax No. (08) 9221 1639 within 24 hours of receipt of the samples**

* PLEASE ADVISE AGAR QUOTE NUMBER ASAP *

162001-365
22-2-01
J. McNamara (Sign) DATE

AGAL

REPORT OF ANALYSIS

Report No. RN207408

Client	: URS (WA) LEVEL 3 HYATT CENTRE 20 TERRACE ROAD EAST PERTH WA 6004	**Job No.**	: URS01_W/010214_1
		Quote No.	: QT-00747
		Order No.	: 44047-021-071
		Date Sampled	: 8-FEB-2001
		Date Received	: 13-FEB-2001
Attention	: JILL McNAMARA	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: OANA CHIRILA	**Phone**	: (08) 9384 1511

Lab Reg No.	Sample Ref	Sample Description
W01/003063	W-13 S	ILUKA WAROONA WATER 08/02/01
W01/003064	W-13 D	ILUKA WAROONA WATER 08/02/01
W01/003065	W-21 S	ILUKA WAROONA WATER 08/02/01
W01/003066	W-21 I	ILUKA WAROONA WATER 08/02/01

Lab Reg No.		W01/003063	W01/003064	W01/003065	W01/003066	
Sample Reference	Units	W-13 S	W-13 D	W-21 S	W-21 I	Method
Trace Elements						
Manganese - Filterable	mg/L	<0.005	0.027	0.19	0.016	VL250

Signed:

Roger Cromie, Trace Elements - Vic

Date: 21-FEB-2001

Lab Reg No.		W01/003063	W01/003064	W01/003065	W01/003066	
Sample Reference	Units	W-13 S	W-13 D	W-21 S	W-21 I	Method
Inorganics						
Bicarbonate as CaCO3	mg/L	24	29	35	6	WL122
Calcium - Filterable	mg/L	1	7	3	2	WL125
Carbonate as CaCO3	mg/L	<1	<1	<1	<1	WL122
Chloride	mg/L	100	420	80	170	WL119
Conductivity at 25C	uS/cm	479	1493	519	1149	WL121
Fluoride	mg/L	0.2	0.2	<0.2	<0.2	WL218
Iron - Filterable	mg/L	0.1	0.3	1.8	0.5	WL124
Magnesium - Filterable	mg/L	7	25	5	6	WL125
Nitrate as NO3	mg/L	28	<1	<1	<1	WL119WL239
pH		6.4	5.8	5.9	4.9	WL120
Potassium - Filterable	mg/L	<1	5	1	2	WL125
Silica as SiO2	mg/L	14	32	49	88	WL239
Sodium - Filterable	mg/L	80	230	90	200	WL125
Sulfate	mg/L	22	36	79	240	WL119
Total Dissolved Solids (Evap)	mg/L	300	840	430	790	WL123

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AGAL

REPORT OF ANALYSIS

Report No. RN207408

Lab Reg No.		W01/003063	W01/003064	W01/003065	W01/003066	
Sample Reference	Units	W-13 S	W-13 D	W-21 S	W-21 I	Method

Signed:

Oana Chirila, Environmental - WA

Date: 21-FEB-2001

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REPORT OF ANALYSIS

Report No. RN207408

Lab Reg No.		W01/003067	W01/003068	W01/003069	W01/003070	
Sample Reference	Units	W-21 D	W-16 6M	W-16 15M	W-16 27M	Method

Signed:

Oana Chirila, Environmental - WA

Date: 21-FEB-2001

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REPORT OF ANALYSIS

Report No. RN207408

Client	: URS (WA)	**Job No.**	: URS01_W/010214_1
	LEVEL 3 HYATT CENTRE	**Quote No.**	: QT-00747
	20 TERRACE ROAD	**Order No.**	: 44047-021-071
	EAST PERTH WA 6004	**Date Sampled**	: 9-FEB-2001
		Date Received	: 13-FEB-2001
Attention	: JILL McNAMARA	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: OANA CHIRILA	**Phone**	: (08) 9384 1511

Lab Reg No.	Sample Ref	Sample Description
W01/003071	W-16 66M	ILUKA WAROONA WATER 09/02/01
W01/003072	W-16 80M	ILUKA WAROONA WATER 09/02/01
W01/003073	W-10 9M	ILUKA WAROONA WATER 09/02/01
W01/003074	W-10 25M	ILUKA WAROONA WATER 09/02/01

Lab Reg No. / Sample Reference	Units	W01/003071 W-16 66M ML	W01/003072 W-16 80M D	W01/003073 W-10 9M S	W01/003074 W-10 25M M	Method
Trace Elements						
Manganese - Filterable	mg/L	0.55	0.047	0.043	0.028	VL250

Signed:

Roger Cromie, Trace Elements - Vic

Date: 21-FEB-2001

Lab Reg No. / Sample Reference	Units	W01/003071 W-16 66M	W01/003072 W-16 80M	W01/003073 W-10 9M ✓	W01/003074 W-10 25M	Method
Inorganics						
Bicarbonate as CaCO3	mg/L	120	77	42	41	WL122
Calcium - Filterable	mg/L	79	57	2 ✓	4	WL125
Carbonate as CaCO3	mg/L	<1	37	<1	<1	WL122
Chloride	mg/L	1700	1700	130 ✓	360	WL119
Conductivity at 25C	uS/cm	5580	5610	802	1370	WL121
Fluoride	mg/L	0.4	0.6	<0.2	0.2	WL218
Iron - Filterable	mg/L	0.3	<0.1	0.9	2.2	WL124
Magnesium - Filterable	mg/L	45	26	4 ✓	15	WL125
Nitrate as NO3	mg/L	<1	<1	<1	<1	WL119WL239
pH		6.8	9.2	6.2 ✓	5.6	WL120
Potassium - Filterable	mg/L	20	28	<1	3	WL125
Silica as SiO2	mg/L	15	12	48	55	WL239
Sodium - Filterable	mg/L	1030	1070	150 ✓	230	WL125
Sulfate	mg/L	15	20	120 ✓	38	WL119
Total Dissolved Solids (Evap)	mg/L	3130	3190	590 ✓	930	WL123

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REPORT OF ANALYSIS

Lab Reg No.		W01/003071	W01/003072	W01/003073	W01/003074	
Sample Reference	Units	W-16 66M	W-16 80M	W-10 9M	W-10 25M	Method

Signed:

Oana Chirila, Environmental - WA

Date: 21-FEB-2001

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AGAL

REPORT OF ANALYSIS

Report No. RN207408

Client	: URS (WA) LEVEL 3 HYATT CENTRE 20 TERRACE ROAD EAST PERTH WA 6004	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: URS01_W/010214_1 : QT-00747 : 44047-021-071 : 9-FEB-2001 : 13-FEB-2001
Attention	: JILL McNAMARA	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: OANA CHIRILA	**Phone**	: (08) 9384 1511

Lab Reg No.	Sample Ref	Sample Description
W01/003075	W-10 40M	ILUKA WAROONA WATER 09/02/01
W01/003076	W-12 40M	ILUKA WAROONA WATER 09/02/01
W01/003077	W-12 25M	ILUKA WAROONA WATER 09/02/01
W01/003078	W-15 25M	ILUKA WAROONA WATER 12/02/01

Lab Reg No.	Units	W01/003075	W01/003076	W01/003077	W01/003078	Method
Sample Reference		W-10 40M D	W-12 40M W12S	W-12 25M W12D	W-15 25M	
Trace Elements						
Manganese - Filterable	mg/L	0.14	0.042	0.017	<0.005	VL250

Signed:

Roger Cromie, Trace Elements - Vic

Date: 21-FEB-2001

Lab Reg No.	Units	W01/003075 ✓	W01/003076 ✓	W01/003077 ✓	W01/003078 ✓	Method
Sample Reference		W-10 40M	W-12 40M	W-12 25M	W-15 25M M2	
Inorganics						
Bicarbonate as CaCO3	mg/L	300	65	32	5	WL122
Calcium - Filterable	mg/L	20	5	2	<1	WL125
Carbonate as CaCO3	mg/L	<1	<1	<1	<1	WL122
Chloride	mg/L	740	210	150	35	WL119
Conductivity at 25C	uS/cm	2830	894	571	174	WL121
Fluoride	mg/L	0.2	0.2	<0.2	<0.2	WL218
Iron - Filterable	mg/L	0.4	0.9	2.2	0.4	WL124
Magnesium - Filterable	mg/L	38	10	8	3	WL125
Nitrate as NO3	mg/L	<1	<1	<1	<1	WL119WL239
pH		7.0	6.0	5.7	5.2	WL120
Potassium - Filterable	mg/L	10	3	3	<1	WL125
Silica as SiO2	mg/L	23	38	43	14	WL239
Sodium - Filterable	mg/L	530	150	90	30	WL125
Sulfate	mg/L	31	28	11	19	WL119
Total Dissolved Solids (Evap)	mg/L	1500	560	380	90	WL123

AGAL

REPORT OF ANALYSIS

Lab Reg No.		W01/003075	W01/003076	W01/003077	W01/003078	
Sample Reference	Units	W-10 40M	W-12 40M	W-12 25M	W-15 25M	Method

Signed:

Oana Chirila, Environmental - WA

Date: 21-FEB-2001

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AGAL

REPORT OF ANALYSIS

Report No. RN207408

Client	: URS (WA) LEVEL 3 HYATT CENTRE 20 TERRACE ROAD EAST PERTH WA 6004	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: URS01_W/010214_1 : QT-00747 : 44047-021-071 : 12-FEB-2001 : 13-FEB-2001
Attention	: JILL McNAMARA	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: OANA CHIRILA	**Phone**	: (08) 9384 1511

Lab Reg No.	Sample Ref	Sample Description
W01/003083	W-20 6M	ILUKA WAROONA WATER 12/02/01
W01/003084	W-20 12M	ILUKA WAROONA WATER 12/02/01
W01/003085	W-20 32M	ILUKA WAROONA WATER 12/02/01
W01/003086	W-20 26M	ILUKA WAROONA WATER 12/02/01

Lab Reg No. / Sample Reference	Units	W01/003083 W-20 6M	W01/003084 W-20 12M	W01/003085 W-20 32M	W01/003086 W-20 26M	Method
Trace Elements						
Manganese - Filterable	mg/L	0.054	0.034	0.19	0.08	VL250

Signed:

Roger Cromie, Trace Elements - Vic

Date: 21-FEB-2001

Lab Reg No. / Sample Reference	Units	W01/003083 W-20 6M	W01/003084 W-20 12M	W01/003085 W-20 32M	W01/003086 W-20 26M	Method
Inorganics						
Bicarbonate as CaCO3	mg/L	260	44	180	23	WL122
Calcium - Filterable	mg/L	1	5	14	5	WL125
Carbonate as CaCO3	mg/L	<1	<1	<1	<1	WL122
Chloride	mg/L	300	590	830	710	WL119
Conductivity at 25C	uS/cm	1704	2280	3050	2470	WL121
Fluoride	mg/L	1	<0.2	0.2	<0.2	WL218
Iron - Filterable	mg/L	12.5	3.0	3.2	6.8	WL124
Magnesium - Filterable	mg/L	15	23	35	31	WL125
Nitrate as NO3	mg/L	<1	<1	<1	<1	WL119WL239
pH		7.0	5.9	6.8	5.6	WL120
Potassium - Filterable	mg/L	4	4	8	5	WL125
Silica as SiO2	mg/L	67	42	40	50	WL239
Sodium - Filterable	mg/L	340	410	610	390	WL125
Sulfate	mg/L	110	130	67	65	WL119
Total Dissolved Solids (Evap)	mg/L	1270	1300	1680	1420	WL123

AGAL

REPORT OF ANALYSIS

Report No. RN207408

Lab Reg No.		W01/003083	W01/003084	W01/003085	W01/003086	
Sample Reference	Units	W-20 6M	W-20 12M	W-20 32M	W-20 26M	Method

Signed:

Oana Chirila, Environmental - WA

Date: 21-FEB-2001

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AGAL

REPORT OF ANALYSIS

Report No. RN207408

Client	: URS (WA) LEVEL 3 HYATT CENTRE 20 TERRACE ROAD EAST PERTH WA 6004	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: URS01_W/010214_1 : QT-00747 : 44047-021-071 : 12-FEB-2001 : 13-FEB-2001
Attention	: JILL McNAMARA	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: OANA CHIRILA	**Phone**	: (08) 9384 1511

Lab Reg No.	Sample Ref	Sample Description
W01/003087	W-20 48M	ILUKA WAROONA WATER 12/02/01
W01/003088	W-20 80M	ILUKA WAROONA WATER 12/02/01

Lab Reg No.		W01/003087	W01/003088			
Sample Reference	Units	W-20 48M	W-20 80M			Method
Trace Elements						
Manganese - Filterable	mg/L	0.26	0.058			VL250

Signed:

Roger Cromie, Trace Elements - Vic

Date: 21-FEB-2001

Lab Reg No.		W01/003087	W01/003088			
Sample Reference	Units	W-20 48M	W-20 80M			Method
Inorganics						
Bicarbonate as CaCO3	mg/L	370	250			WL122
Calcium - Filterable	mg/L	47	30			WL125
Carbonate as CaCO3	mg/L	<1	<1			WL122
Chloride	mg/L	1300	1200			WL119
Conductivity at 25C	uS/cm	4910	4160			WL121
Fluoride	mg/L	0.2	0.2			WL218
Iron - Filterable	mg/L	0.5	0.2			WL124
Magnesium - Filterable	mg/L	72	25			WL125
Nitrate as NO3	mg/L	<1	<1			WL119WL239
pH		6.9	6.7			WL120
Potassium - Filterable	mg/L	15	15			WL125
Silica as SiO2	mg/L	34	16			WL239
Sodium - Filterable	mg/L	970	870			WL125
Sulfate	mg/L	120	77			WL119
Total Dissolved Solids (Evap)	mg/L	2890	2390			WL123

AGAL

REPORT OF ANALYSIS

Report No. RN207408

Lab Reg No.		W01/003087	W01/003088			
Sample Reference	Units	W-20 48M	W-20 80M			Method

Signed:

Oana Chirila, Environmental - WA

Date: 21-FEB-2001

This Laboratory is accredited by the National Association of Testing Authorities, Australia. [Accreditation No 2474, 89].
The tests reported herein have been performed in accordance with its terms of accreditation.

Sample/s analysed as received.
This Report supersedes reports: *RN207381*

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Client: URS WA
Level 3 Hyatt Centre
20 Terrace Rd
East Perth WA 6004

Attention: Nathan Henderson

BATCH No. : 003063
Job No. :
Lab Reg Nos. : W01/003063 - 3088

QUALITY CONTROL REPORT

Laboratory Identification Number	Client Identification Number	pH	Conductivity uS/cm	TDS mg/L	Alkalinity as CaCO3 mg/L	HCO3 as CaCO3 mg/L	CO3 as CaCO3 mg/L	Ca mg/L	Cl mg/L	F Fe mg/L	Mg mg/L	K mg/L	Na mg/L	SO4 mg/L	SiO2 mg/L
W01/003070-D	W-16 27M	6.2	2600	1450		100	<1	8	690	0.8	31	5	470	91	
W01/003080-D	W-15 15M	5.6	128	70%		8	<1	<1	23	1	2	<1	20	15	
Recovery of reference material		-	-	100%	-	-	-	100%	99%	102%	102%	99%	101%	101%	-
Blank		-	-	<10	<1	<1	<1	<1	<10	<0.1	<1	<1	<10	<5	<0.002
Acceptability Criteria (%)		-	-	90-110	-	-	-	85-110	90-110	85-110	85-110	85-110	85-110	85-115	90-110

OANA CHIRILA
Senior Environmental Chemist
AGAL WA Inorganic Section
Date: 20/02/01

6125-3757

6125_3764 - SiO_2

HYATT CENTRE, 20 TERRACE ROAD, EAST PERTH, WA 6004
IN AUSTRALIA TELEPHONE: 08-9221 1630 FACSIMILE: 08-9221 1639
INTERNATIONAL TELEPHONE: 61-8-9221 1630 FACSIMILE: 61-8-9221 1639

CHAIN OF CUSTODY RECORD DM-FORM-43

Job No.: 44047-021-071 | Send Results to: [illegible] | Date: 13/2/01 | CoC No.:

Site or Client: Iluka Waroona | Turnaround Time: 7 days | Sample Destination: ALS

Tests Required (FOR ALL SAMPLES): pH, EC, TDS, Fe, Na, K, Ca, Mg, Cl, CO_3, HCO_3, SO_4, NO_3, F, Mn, SiO_2

Sample No.	Sampling Date	Type	Preservation	No. of Containers	WO
W-13 S	8/2/2001	Water	Ice	2	WO 1/003063
W-13 D	"		"	2	WO 1/003064
W-21 S	"		"	2	WO 1/003065
W-21 I	"		"	2	WO 1/003066
W-21 D	"		"	2	WO 1/003067
W-16 6M	9/2/2001		"	2	WO 1/003068
W-16 15M	"		"	2	WO 1/003069
W-16 27M	"		"	2	WO 1/003070
W-16 66M	"		"	2	WO 1/003071
W-16 80M	"		"	2	WO 1/003072
W-10 9M	"		"	2	WO 1/003073
W-10 25M	"		"	2	WO 1/003074
W-10 40M	"		"	2	WO 1/003075
W-12 40M	"		"	2	WO 1/003076
W-12 25M	"	✓	"	2	WO 1/003077

SAMPLED BY: B HAGAN

RELINQUISHED BY (NAME): B HAGAN (URS) SIGN: [signature] DATE/TIME 13/2/01 [illegible]

RECEIVED BY (COMPANY): ALS ACOAL NAME: K RAINBOW SIGN [signature] DATE/TIME 13-2-01 1720

COLD

Important: Validity of the analytical results require that the recipient of this form fax it to URS Fax No. (08) 9221 1639 within 24 hours of receipt of the samples

FAXED

HYATT CENTRE, 20 TERRACE ROAD, EAST PERTH, WA 6004
IN AUSTRALIA TELEPHONE: 08-9221 1630 FACSIMILE: 08-9221 1639
INTERNATIONAL TELEPHONE: 61-8-9221 1630 FACSIMILE: 61-8-9221 1639

CHAIN OF CUSTODY RECORD DM-FORM-43

Job No.: 44047-021-07 | Send Results to: Sillian McNamara | Date: 13/2/2001 | CoC No.:

Site or Client: Iluka Waroona | Turnaround Time: 7 days | Sample Destination: ALAL

Tests Required (FOR ALL SAMPLES): pH, EC, TDS, Fe, Na, K, Ca, Mg, Cl, CO_3, HCO_3, SO_4, NO_3, F, Mn, SiO_2

FOR ALL SAMPLES

Sample No.	Sampling Date	Type	Preservation	No. of Containers	WO
W-15 25M	12/2/2001	water	Ice	2	WO 1/003078
W-15 34M	"		"	2	WO 1/003079
W-15 15M	"		"	2	WO 1/003080
W-15 10M	"		"	2	WO 1/003081
W-26 9M	"		"	2	WO 1/003082
W-20 6M	"		"	2	WO 1/003083
W-20 12M	"		"	2	WO 1/003084
W-20 32M	"		"	2	WO 1/003085
W-20 26M	"		"	2	WO 1/003086
W-20 48M	"		"	2	WO 1/003087
W-20 80M	"		"	2	WO 1/003088

SAMPLED BY: B HAGAN

RELINQUISHED BY (NAME): B HAGAN (URS) SIGN: [signature] DATE/TIME: 13/2/2001

RECEIVED BY (COMPANY): ARLAGAR NAME: K RAINBOW SIGN [signature] DATE/TIME: 13 2 01 1720

COLD

Important: Validity of the analytical results require that the recipient of this form fax it to URS Fax No. (08) 9221 1639 within 24 hours of receipt of the samples

AGAL

REPORT OF ANALYSIS

Report No. RN207408

Client	: URS (WA) LEVEL 3 HYATT CENTRE 20 TERRACE ROAD EAST PERTH WA 6004	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: URS01_W/010214_1 : QT-00747 : 44047-021-071 : 12-FEB-2001 : 13-FEB-2001
Attention	: JILL McNAMARA	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: OANA CHIRILA	**Phone**	: (08) 9384 1511

Lab Reg No.	Sample Ref	Sample Description
W01/003079	W-15 34M	ILUKA WAROONA WATER 12/02/01
W01/003080	W-15 15M	ILUKA WAROONA WATER 12/02/01
W01/003081	W-15 10M	ILUKA WAROONA WATER 12/02/01
W01/003082	W-26 9M	ILUKA WAROONA WATER 12/02/01

Lab Reg No.		W01/003079	W01/003080	W01/003081	W01/003082	
Sample Reference	Units	W-15 34M	W-15 15M	W-15 10M	W-26 9M	Method
Trace Elements						
Manganese - Filterable	mg/L	0.013	<0.005	<0.005	1.1	VL250

Signed:

Roger Cromie, Trace Elements - Vic

Date: 21-FEB-2001

Lab Reg No.		W01/003079	W01/003080	W01/003081	W01/003082	
Sample Reference	Units	W-15 34M KD	W-15 15M 15M1	W-15 10M 15S	W-26 9M	Method
Inorganics						
Bicarbonate as CaCO3	mg/L	13	8	7	130	WL122
Calcium - Filterable	mg/L	<1	<1	<1	8	WL125
Carbonate as CaCO3	mg/L	<1	<1	<1	<1	WL122
Chloride	mg/L	55	24	22	400	WL119
Conductivity at 25C	uS/cm	273	128	117	1705	WL121
Fluoride	mg/L	<0.2	<0.2	<0.2	0.5	WL218
Iron - Filterable	mg/L	0.3	1.2	0.2	<0.1	WL124
Magnesium - Filterable	mg/L	3	2	2	25	WL125
Nitrate as NO3	mg/L	<1	<1	<1	<1	WL119WL239
pH		5.6	5.6	5.8	6.4	WL120
Potassium - Filterable	mg/L	<1	<1	<1	5	WL125
Silica as SiO2	mg/L	20	12	13	82	WL239
Sodium - Filterable	mg/L	50	20	20	300	WL125
Sulfate	mg/L	27	15	14	86	WL119
Total Dissolved Solids (Evap)	mg/L	210	70	70	1010	WL123

AGAL

REPORT OF ANALYSIS

Lab Reg No.		W01/003079	W01/003080	W01/003081	W01/003082	
Sample Reference	Units	W-15 34M	W-15 15M	W-15 10M	W-26 9M	Method

Signed:

Oana Chirila, Environmental - WA

Date: 21-FEB-2001

AUSTRALIAN GOVERNMENT ANALYTICAL LABORATORIES
3 Clive Road, Cottesloe WA 6011 PO Box 83 Cottesloe WA 6011
Tel: +61 8 9384 1511 Fax: +61 8 9384 1132 www.agal.gov.au

Appendix F
Water Resources Census

Appendix F
Water Resources Census

Resident Name	Resident Address	Interview	Resident Use	Water Sources Used						Other Issues	Comments
				Groundwater				Surface Water			
				Bore	Bore Details	Volume Used	Soak	Body	Volume Used		
Woodley	257 Patterson Rd	N					Soak excavated in middle of paddock for stock water. Groundwater level near surface.				
Mrs Daou	258 Patterson Rd	Y	Stock and garden irrigation				Excavated soak in front paddock equipped with pump. Pumped soak level low.				
Vergone	317 Patterson Rd	N	Vines and orchids contained on property				Large groundwater fed soak on front slopes of property.				
Terry Woodley	265 McDowell St	N		Y	5-6m deep	17,000-18,000L/day					Town sites on a coffee-rock shelf that discharges into the southern slopes of the Nanga Brook. Therefore different flow system to the mine area.
Greg and Julia Gribble	93 or 94 Gribble St	Y	Irrigation	N				Pump seasonally from Nanga Brook. Supply supplemented with rainwater.	20,000 gallon tank, which is filled via a 1.1kW pump.	Concerned about dust, noise and potential spread of noxious weed (Kapungi) from Vince Pinscoti's Dam	Would like more water but limited, particularly in summer, by current streamflow. Would like a bore to supplement their current supply
Greg and Lucy Fury	57 Patterson Rd	Y	Bore - garden irrigation and chooks. Dam - planning to plant fruit trees and graze cattle	Y	21m deep	1.1kW pump operates for about 10hours per week. Sustainable supply.		Dam from harvesting Nanga Brook. All year around excepting period of 3-week non-flow. Dam discussed and coordinated with DEWCP (possibly Rachel Nicholl). Dam is 4.5m deep and has underdrain to supplement flow to downstream users.		Dust and noise	Other residents had concerns about their dam.
Bob and Mrs Jones	259 Patterson Rd	Y	Irrigation and stock	Y	Windmill	Supply problems at				Dust, noise and visual impacts	

Appendix F
Water Resources Census

Resident Name	Resident Address	Interview	Resident Use	Water Sources Used						Other Issues	Comments
				Groundwater				Surface Water			
				Bore	Bore Details	Volume Used	Soak	Body	Volume Used		
						end of summer. Can supply about 8 cows and few orchard trees. Rest of property supplied from the mains.					
Josie and Chris Davis	96 Brandford St	Y								Dust	Scheme water used for all irrigation. Have been promised a bore next year.
Terry Males	60 Patterson Rd	Y	Irrigation - lawns and garden	Y	18m deep	Not equipped - to be equipped by next summer				Noise, dust	Previously wanted to use the streamflow in Nanga Brook. Dries in summer. Currently sprinklers are on mains. Operate 14hrs per week during establishment.
Rick and Teresa Uren	92 Patterson Rd	Y	Pool and garden irrigation	N				Reticulation from Nanga Brook, though scheme supplement is required during summer.	Single phase 1.7kW pump operated twice per week	Dust, noise and end landuse	Pumping direct from streamflow to sprinklers. Pumping out is causing an erosion hole in the streambed.
Mr O'Donnel	244 Patterson Rd	Y	Limited irrigation and sheep previously	Y	Windmill	1,500L per week during summer					Groundwater too saline for fruit trees and lawns.
Mrs Peters	106 Patterson Rd	Y	Summer Irrigation	Y	12m deep	Pumped 3hrs per week using 1.6kW centrifugal pump					Well fills up during winter - water level rises to near ground level. Well struggles to provide sustainable supply late in summer. Owners looking to install replacement well.
Mr Lea (interviewed daughter)	101 Dallas St	Y	Irrigation	Y	N/A	N/A					
Nigel Brown	91 Dallas St	Y						Nanga Brook	Centrifugal pump (1.6kW) drawing from a lined sump connected directly to brook. Pumped 3hrs per week.	Noise	Property on west side of Dallas Rd, south of Lot 5 has a windmill.
Riggio	277 Dallas St	N		N							

Appendix F
Water Resources Census

Resident Name	Resident Address	Interview	Resident Use	Water Sources Used						Other Issues	Comments
				Groundwater				Surface Water			
				Bore	Bore Details	Volume Used	Soak	Body	Volume Used		
Bill and Mary Ward	93 Dallas St	Y	Seasonal Irrigation	Y - just installed	16.2m deep	110-120L/minute				They like the aesthetics of the flowing creek in their garden	Lots of paper-bark and other mature trees - lowering of the water table may cause some vegetation stress
Mullins	270/276 Dallas St (160 acres)	Y	Domestic, sheep (140), heifers (120), springs	y	17m deep	0.75Hp Davey Centrifugal Pump				Impacts of the dewatering on the springs and along the toe of the dune (discharge water is fresh)	Looking at replacing existing bore
Murray and Wendy Cooke	58 Patterson Rd	Y	Irrigation	Y	100mm diam, 18m deep	Pumps dry in 15mins (1 hp)		Nanga Brook			Other users have diminished the supply such that they connected to mains
Dennis and Jenny Tyler	98 Bradford St	Y	Garden irrigation	N				Nanga Brook	Seasonal use - pumped 3hrs per week at 3hp	Dust, noise, water	Diminished surface water supply over last few years, would like a bore.
John Brett	59 Patterson Rd	Y	Irrigation - fruit and lawns	N				Nanga Brook	Seasonal flow - pumped 24 to 30hrs per week.		No groundwater use but Iluka drilled a bore 3-4yrs ago. The groundwater level indicates there would be a groundwater baseflow component to the observed streamflow
Wayne and Karen Gogdon	97 Bradford St	Y	Orchard irrigation	Y		2,000L to 5,000L per week		Nanga Brook	10,000-15,000L/week	Having trouble selling house due to mine, dust generation	Creek dry 2-3 months per year.
Michelle Borserio and Vince Vitale	245 Patterson Rd	Y								Dust and noise and impact on brook	
Hull	Nanga Brook Rd	N									Other residents have concerns that the Hull daming of the Nanga Brook reduces Nanga Brook flow.

Notes: Y = Yes
N = No
NA = not available

Appendix G
Groundwater Abstraction Licence Application

WATER AND RIVERS COMMISSION

OFFICE USE ONLY

FORM A

Rights in Water and Irrigation Act 1914

☐ APPLICATION FOR A 5C LICENCE TO TAKE GROUNDWATER

AND/OR

☐ APPLICATION FOR A 26D LICENCE TO CONSTRUCT OR ALTER WELLS (Tick applicable)

1. DETAILS OF INDIVIDUAL OR COMPANY SEEKING LICENCE

(a) Name MR ☐ MRS ☐ MS ☐ MISS ☐ OTHER:

SURNAME OR FAMILY NAME:

GIVEN OR FIRST NAMES:

OR

Name of company

COMPANY NAME: ILUKA RESOURCES LIMITED

ABN:

ACN: 34 008 675 018

Details on contact for company MR ☒ MRS ☐ MS ☐ MISS ☐ OTHER:

SURNAME OR FAMILY NAME: ALGUIRE

GIVEN OR FIRST NAMES: JOHN

POSITION IN COMPANY: MINE PLANNING SUPERINTENDENT

OR

Are you a licensed water service provider? YES ☐ NO ☐

If yes, WATER SERVICE PROVIDER NAME:

LICENCE NUMBER (under *Water Services Coordination Act 1995*):

(b) Postal address of individual or company

NUMBER OR PROPERTY NAME: PO Box 96

STREET:

SUBURB OR TOWN: CAPEL POSTCODE: 6271

TELEPHONE/MOBILE NUMBER: 9780 3200 FAX NUMBER: 9727 2310

EMAIL ADDRESS:

2. DETAILS OF PROPERTY FROM WHICH WATER IS TO BE TAKEN

If there is an existing 5C or 26D licence(s) for this property please enter licence no(s).

ATTACH COPY OF CERTIFICATE OF TITLE IF YOU ARE THE OWNER ATTACHED ☐

TOTAL AREA OF PROPERTY (ha): DOLA PIN:

PROPERTY DESCRIPTION (Lot number, street and suburb/locality):

IF INSUFFICIENT ROOM, PLEASE CONTINUE ON SEPARATE SHEET OF PAPER

Please retain a copy of this form for your records

OR

MINE NAME: WAROONA DEPOSIT

MINING TENEMENT NUMBER(S): M70/735 ; M70/798

MINING FIELD:

ZONING (Circle applicable) RURAL/SPECIAL RURAL/RESIDENTIAL/INDUSTRIAL/COMMERCIAL

What is the nature of your access to the land on which the water is located?

An applicant for a section 5C licence must satisfy the requirements of clause 3 of Schedule 1 of the RIWI Act to show access to the land. A section 26D licence is deemed to be held by and operate for the benefit of the lawful owner and occupier of the land on which the well is to be sunk. (Tick applicable)

- ☐ OWN THE LAND
- ☐ LEASE THE LAND FROM THE CROWN
- ☐ APPROVAL OF LANDHOLDER TO USE LAND (attach copy of written approval of landholder)
- ☒ MINING TENEMENT
- ☐ NEGOTIATING TO PURCHASE OR LEASE THE LAND (provide owner's name and anticipated date of completion of sale/lease)

Name: Date:

- ☐ OTHER (PLEASE SPECIFY) (attach approval of owner where appropriate)

Which of the following categories match your application? (Tick applicable)

- ☐ CONSTRUCT A NEW WELL/BORE/EXCAVATION/SOAK

HOW MANY? DEPTH, IF KNOWN

NAME OF SOURCE/ ARTESIAN/NON-ARTESIAN

- ☐ ENLARGE OR DEEPEN AN EXISTING WELL/BORE/EXCAVATION/SOAK

HOW MANY? DEPTH, IF KNOWN

NAME OF SOURCE/ ARTESIAN/NON-ARTESIAN

- ☐ DRAW WATER FROM AN EXISTING WELL/BORE/EXCAVATION/SOAK

HOW MANY? DEPTH, IF KNOWN

- ☐ EXPLORATORY DRILLING
- ☐ OTHER (Please explain) DEWATERING FROM SUMPS IN OPEN

NAME OF DRILLING CONTRACTOR(S). IF AVAILABLE, PLEASE ATTACH ANY SUPPORTING INFORMATION (E.G. DRILL LOGS, TEST PUMPING DATA, WATER QUALITY ETC.) ATTACHED ☒

3. DETAILS OF PROPERTY WHERE WATER IS TO BE USED (if different from above)

ATTACH COPY OF CERTIFICATE OF TITLE IF YOU ARE THE OWNER ATTACHED ☐

TOTAL AREA OF PROPERTY (ha):

PROPERTY DESCRIPTION (Lot number, street and suburb/locality):

ZONING (circle applicable) RURAL/SPECIAL RURAL/RESIDENTIAL/INDUSTRIAL/COMMERCIAL

OR

MINE NAME: WAROONA DEPOSIT

MINING TENEMENT NUMBER(S): M70/735, M70/798

MINING FIELD:

4. DETAILS OF WATER USE

(Complete only those sections relevant to your application. Where applicable, please attach copies of necessary approvals, e.g. Shire, DEP, AgWA, CALM, etc. For multiple uses, set out on a separate sheet, the information requested below for each use.)

(a) Non-commercial use

ESTIMATED ANNUAL QUANTITY (kL) [ ] IS WATER TO BE USED IN THE HOUSE? YES ☐ NO ☐

IS WATER TO BE USED ON A HOUSE GARDEN/LAWN? YES ☐ NO ☐

IF YES, WHAT IS THE AREA OF THE GARDEN/LAWN? (ha) [ ]
(Average domestic gardens range from 0.1 – 0.2 ha)

OTHER PROPOSED WATER USAGE (e.g., vegetable, pasture) [ ]

AREA [ ]

(b) Commercial use (Please state if existing or proposed)

ESTIMATED ANNUAL QUANTITY (kL) [ ] AREA (ha) [ ]

WATER USAGE (e.g., specific crop, turf, bowling green) [ ]

PLANTING DENSITY FOR ORCHARDS, TREE FARMS, ALL VINES (plants per ha) [ ]

IRRIGATION METHOD (e.g. trickle, sprinkler) [ ]

STOCK TYPE (e.g. cattle, sheep, pigs, poultry, horses, etc.) [ ] NUMBER OF STOCK [ ]

DESCRIPTION OF OPERATION (e.g. meat production, egg production, breeders, agistment, etc.) [ ]

IS THE OPERATION FREE RANGE OR INTENSIVE? [ ]

IF THE OPERATION IS AN ABBATOIR, HOW MANY ANIMALS ARE PROCESSED DAILY? [ ]

AQUACULTURE TYPE (e.g. yabbies, marron, fish, etc.) [ ]

IF THE OPERATION IS AQUACULTURE, ATTACH DETAILS OF POND DIMENSIONS, HOLDING FACILITIES, EVAPORATION, SEEPAGE AND DISCHARGE ATTACHED ☐

ARE THE PONDS EMPTIED? YES ☐ NO ☐ HOW MANY TIMES PER YEAR? [ ]

(c) Mining or industrial use

HOW IS THE WATER TO BE USED? (e.g. processing, dewatering, dust suppression, camp purposes, rehabilitation, care and maintenance) [DEWATERING. DUST SUPRESSION AND PROCESSING]

ESTIMATED ANNUAL QUANTITY PER USE (kL) [ ] SALINITY PER USE (TDS) [attached]

IF DEWATERING, WILL WATER BE DISCHARGED TO THE ENVIRONMENT? YES ☐ NO ☐

IF YES, PLEASE PROVIDE A COPY OF THE ENVIRONMENTAL PROTECTION APPROVAL

(d) Other water uses (e.g. fire fighting, road verge watering, bottling, public water supply, road construction, ablutions, public open spaces, recreation reserves, dewatering)

WHAT IS THE WATER TO BE USED FOR? [ ]

ESTIMATED ANNUAL QUANTITY PER USE (kL) [ ] AREA OF PROPOSED AND EXISTING WATER USE (ha) [ ]

5. RESOURCES

DO YOU HAVE THE RESOURCES, INCLUDING FINANCIAL TO UNDERTAKE THE PROPOSED ACTIVITIES? YES ☒ NO ☐

IF NO, WHAT STEPS ARE YOU TAKING TO UNDERTAKE THE ACTIVITIES

6. DEVELOPMENT TIMETABLE FOR PROPOSED USE

Please provide a proposed timetable for the development **ATTACHED** ☒

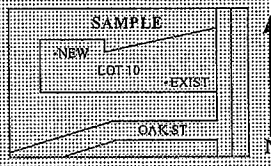
7. PROPOSED DURATION OF USE AND LICENCE (For licences issued under section 26D only)

8. LOCATION PLAN

In the box below, please sketch a plan showing:

LOCATION OF ALL WETLANDS/WATERCOURSES/WELLS/SOAKS (EXISTING AND PROPOSED)
MAJOR IMPROVEMENTS (HOUSE, LARGE SHEDS, ETC.
SHADED SECTIONS TO INDICATE AREAS UNDER DEVELOPMENT

For mining leases, please also include a tenement map showing the location within Western Australia and the MGA co-ordinates ATTACHED ☒



9. APPLICATION

By signing this form you are declaring that the statements on this form are true and correct

DATE .....

I ..... (NAME OF APPLICANT) APPLY FOR A LICENCE UNDER SECTION 5C/26D* OF THE RIGHTS IN WATER AND IRRIGATION ACT 1914. (*delete as applicable)

..... SIGNATURE OF APPLICANT OR A PERSON DULY AUTHORISED TO SIGN FOR AND ON BEHALF OF APPLICANT, INCORPORATED BODY OR COMPANY

OR

THE COMMON SEAL OR COMPANY SEAL OF .....
(name of incorporated association or company)

WAS HEREBY AFFIXED IN THE PRESENCE OF .....
(authority to sign)

This application should be forwarded to: Water and Rivers Commission
Region
Address

FOR FURTHER INFORMATION PLEASE CALL (08)