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Roper Bar Iron Ore Project

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Executive Summary

Western Desert Resources intends developing the Roper Bar Iron Ore Project. The Roper Bar Iron Ore Province is a large intracratonic sedimentary basin, with an exposed area of about 180,000 km^2. Within the Province, the dominant stratigraphy comprises relatively un-metamorphosed and un-deformed sediments of the Mesoproterozoic Roper Group. Near the top of this sequence, iron ore occurs in outcrop and under a shallow cover of oolitic ironstone, known as the Sherwin Ironstone Formation (SIF), which hosts all the known iron mineralisation and deposits. The project lies within the Towns River catchment system.

Local information and earlier studies are limited. Accordingly, the primary objectives of the hydrogeological investigations within and around the vicinity of the proposed mining areas include:

- Describe the in-situ geological features and interpret hydrogeological characteristics and regimes underlying the proposed open pits.
- Ascertain the hydraulic properties of the underlying weathered and fractured geological strata.
- Obtain and review all relevant geologic, hydrologic and geomorphologic maps, reports and data.
- Direct and supervise drilling and implementation of groundwater monitoring bores and/or production/ dewatering bores in accordance with the Minimum Construction Requirements for Water Bores in Australia (LWBC, 2003).
- Implementation of a bore pump testing program to define the extent of the aquifers and characterize them for their hydraulic parameters.
- Groundwater modelling to ascertain influx into the proposed open pits.
- Collect baseline groundwater quality data and devise ongoing monitoring and sampling programs.
- Assess the impacts on surface and groundwater resources, including their interactions, as a result of mining activities.
- Compile a report on the investigations and provide recommendations pertaining to the ongoing characterization and management of ground water for operations.

The above scope of works was achieved by means of bore drilling, testing, modeling and sampling. The locations of the bores were selected employing topographical, aerial photography, geological information and mapping.

The bore testing program was implemented to obtain data and principally facilitate investigations to ascertain aquifer hydraulic parameters. Data is also anticipated to be used to define aquifer behaviour upon mining development and define capacities and the long term sustainability of water resources to further inform ground water management during mining.

The salient observations from the investigations indicate that the geology of the area is characterised by a sequence of laterised soils overlying thick sequences of weathered interlayered siltstones and sandstones, siltstones and mudstones with minor bands of sandstones. Underlying these is a thin layer of extremely weathered siderite, which in turn overlies the hematitic iron ore body. The iron ore layer is normally interlayered with fine to medium grained sandstones, grey to dark grey siltstones with thin layers of mudstones.

Drilling did not encounter high water bearing/yielding zones and there are no indications that the existing multiple water strikes are interconnected. Water strikes occurred predominantly in the sandstones interbedded with siltstones and in the hematitic iron interbedded with silicified sandstones, mudstones and siltstones. The shallowest water strike was found at about 9.5m below ground level and the deepest at about 107m below ground level. Whilst groundwater levels imitate the local and regional topography, groundwater behaviour indicates that most of the shallow groundwater levels at deeper than 9m below surface are not hydraulically interconnected with surface water bodies. Existing interactions are limited to slow leakage from the Towns and Mangaranyi rivers.

Ground water level drawdown and subsequent recovery and discharge rates were recorded during slug and step-drawdown and constant rate discharge tests. Samples of ground water were obtained for field measurements (pH and Electrical Conductivity) and detailed laboratory analyses. The salient findings of the hydrogeological investigations and assessments are:

- The geology of the area is characterised by a sequence of laterised soils overlying thick sequences of

weathered interlayered siltstones and sandstones, siltstones and mudstones with minor bands of sandstones. Underlying these is a thin layer of extremely weathered whitish siderite, which in turn overlies the hematitic iron ore body. The iron ore layer is normally interlayered with fine to medium grained sandstones, grey to dark grey siltstones with thin layers of mudstones.

- Whilst groundwater levels imitate the local and regional topography and are deeper than 9m below surface, groundwater level behaviour indicates that the shallow groundwater levels are not hydraulically interconnected with surface waters. Any existing interaction including potential groundwater dependent ecosystems are limited to a spring west of the Mangaranyi River where rain recharges surficial fracture systems.
- In general, the time-drawdown/falling head curves display decreases in groundwater flows over the short term. Recovery of the groundwater level after discharge was incomplete, indicating that systems are dewatered during abstraction with no or little replenishment indicative of minor fractures in a low yielding environment. It is thus likely that bores will not maintain yields and that water influx into open pits will decrease with time.
- The hydraulic testing indicates a range in permeability of about two orders of magnitude. This is typical of fractured rock aquifers, where the permeability is controlled by a combination of primary porosity from the pore space matrix and secondary porosity resulting from fractures and bedding plains.
- Aquifer hydraulic parameters in the sandstones and siltstones and the hematite iron ore are low, with transmissivities in the order of 0.1m^2/day to 4.0m^2/day. The lower transmissivity pertains to the dominantly ferruginous sandstone materials and the highest to the quartzite sandstone interbedded with ferruginous sandstones. The hematite iron ore interbedded with sandstones, mudstones and siltstones have an average transmissivity of 0.4m^2/d.
- Based on the field observations and slug/drawdown curves, the investigated area can be defined as having two well defined near surface systems:

Depth (m)	System	Description
to 30	Aquitard	A shallow unconfined aquitard system located at between 25 to 30m depth among a highly weathered sequence of sandstone interbedded with siltstones.
50 - 60	Semi-confined to confined aquifer	A shallow semi-confined to confined aquifer system among the Sherwin Ironstone Formation (SIF) located between 50 to 60m below ground level, particularly where the shallow dipping reserves were observed to exist. Deeper systems seem to be a continuity of this aquifer system and water appears to move downwards throughout primary conduits within the coarser Sherwin Iron Formation.

- Groundwater influxes are relatively small: for the F East mine pit, the predicted side inflow rate increases from 4,000kL/d in year one, to about 4,500kL/d in year three and then decreases to less than 2,000kL/d in year seven. For the E East and E South mine pits, the predicted side inflow rate increases from about 1,500kL/d in year five to about 3,000kL/d in year seven.
- The extent of the 5.0m and 1.0m drawdown contours are likely to be within 0.9km and 1.2km from the edges of the pits respectively. The localised impact is due to low hydraulic conductivities i.e. relatively impermeable formations at the mine site.
- The impact on surface watercourses from dewatering is considered to be insignificant as the regional groundwater level is well below the levels of the streambeds.
- Groundwater has a near circum-neutral pH, with an average of 6.5 ranging from 4.6 to 7.6.
- Among major cations, sodium concentrations are relatively high indicating localised water bodies are relatively saline waters. Sulfate and chloride concentrations are also very high in these waters.
- The majority of filtered trace metals are below of their limits of reporting (LoRs). Arsenic, barium, copper, manganese, nickel and zinc are mostly above of their LoRs but below of their NEPM-Health Investigation Levels.
- On the basis of calcium and magnesium concentrations, groundwaters can be classified as ranging from very soft to very hard waters. Whilst Group 1 waters are classified as very hard, Groups 2 and 3

are ranging from very soft to moderately soft waters.

- All groundwater samples are waters of the Cl + SO_4 type.
- Short term groundwater quality behaviour suggests that with time, pH in shallow groundwater particularly those hosted within the quartz sandstone and siltstone and mudstone sequences may increase to become slightly alkaline. However, groundwater in deeper lithological domains, particularly those hosted by the hematite iron ore body may remain circum-neutral or decrease with time to become slightly acidic waters.
- Risks pertaining to groundwater and surface-groundwater interactions are considered low due to the prevailing hydrological-hydrogeological environment:
  - It is unlikely that possible ground water contamination will migrate off site during mining as infrastructure such as most ore stockpiles and WRDs are located upstream of the open pits. Modelling has demonstrated that groundwater flow will be towards the open pits which will intercept pre- and post-mining contamination, if any.
  - Mine infrastructure such as the waste rock dump and ore stockpiles are to be constructed in accordance with best practice to inhibit infiltration and release of potentially contaminated waters. The geological profile is relatively impermeable, as evidenced by surface ponding whilst the ground water level is well below the surface, which provides ample opportunity to collect and treat contaminated waters from these facilities. There is no direct hydraulic connection between surface and ground waters and surface waters may slowly leak into underlying aquifers.
  - Monitoring of groundwater level behaviour (i.e. rising levels may indicate seepage) coupled with deteriorating water qualities in strategically located shallow and deep bores will be used (trend diagrams, detailed tabulations with statistical parameters and mass transport modelling) to assess whether contamination is taking place. The cause of such potential contamination is to be ascertained to determine the most appropriate remediation and preventative action. Where current measures are inadequate, additional and/or new measures are to be implemented to prevent further and possible future contamination.
  - Contingency measures will include ascertaining of cause of contamination by detailed assessment and site specific investigations to determine the most appropriate remediation and preventative action. Where current measures and treatment trains are inadequate, provide and implement additional and/or new measures and treatment trains to remediate and prevent further and possible future contamination.
  - Groundwater impacts relating to aquifer yield and ground water level drawdowns will be restricted to within 1.2km from the edges of the open pits as a result of the relative impermeability of the geological formations, limited fracturing and low yields that will not be sustained over the long term coupled with groundwater levels deeper than 9m below surface.
  - Following rehabilitation and closure ground water levels are expected to return to their pre-mining levels and the open pits are expected to behave as sinks since evaporation exceeds influx including rainfall, with possible slow migration of ground water towards the north and east along pre-mining flow directions.

To direct and ensure appropriate long term mitigation and management of potential impacts on the groundwater regime as a result of mining activities, the following are relevant:

- Groundwater monitoring and sampling in accordance with this document.
- Further drilling and testing to assess continuity of the aquifer system hosted by the Sherwin Iron Ore or whether an independent deeper aquifer system exists. Bores should be designed to attain average 120 m depths below natural ground level.
- Additional environmental monitoring bores around and within the vicinity of planned mine infrastructure to gather site wide baseline data and facilitate monitoring of potential impacts during mining operations.
- Frequent updating of the groundwater flow model using the results of ongoing monitoring including further modelling on predicting post-mining water levels, pit water qualities and possible migration of any contamination off site.

1 Introduction

1.1 Background

Western Desert Resources is proposing to develop the Roper Bar Iron Ore Project. The project area is located about 240km east of Mataranka, in the Gulf Country of the Northern Territory. The Roper Bar iron ore province is a large intracratonic sedimentary basin, with an exposed area of about 180,000 km^2. Within the province, the dominant stratigraphy comprises relatively un-metamorphosed and un-deformed sediments of the Mesoproterozoic Roper Group. Near the top of this sequence, iron ore occurs in outcrop and under a shallow cover of oolitic ironstone, known as the Sherwin Ironstone Formation (SIF), which hosts all the known iron mineralisation and deposits.

Regional and local groundwater data for the Roper Bar Iron Ore Project are limited. However, regional assessments (Tickell et al., 2005) indicate that two major aquifers are relevant to the Roper River region:

- Cambrian Limestone aquifer system formed in the Wiso, Georgina and Daly Basins. It represents the source of the majority of the base flow in the Roper River and also the Katherine, Flora and Douglas Rivers.
- Dook Creek aquifer system which provides base flow to the major tributaries to the north of the Roper River namely Flying Fox Creek, the Mainoru River and the Wilton River and also the Blyth and Goyder Rivers which drain to the Arafura Sea.

The Limmen Bight River system lies to the south of the project area, which drains into the Limmen Bight tidal wetlands at Port Roper. Near the coast, this system includes intertidal mud flats, saline coastal flats and estuaries with high volumes of freshwater inflow.

The project area lies within the Towns River catchment, for which available local studies are very limited. Accordingly, the primary objectives of the hydrogeological investigations within and around the vicinity of the proposed mining areas are to:

- Describe the in-situ geological features and assess hydrogeological characteristics and regimes underlying the proposed pit sites.
- Ascertain the hydraulic properties of the underlying weathered and fractured geological strata.

1.2 Scope of Works

The scope of this study was to:

- Obtain and review all relevant available geologic, hydrologic and geomorphologic maps, reports and data.
- Direct and supervise drilling and implementation of groundwater monitoring and/or production and dewatering bores in accordance with the Minimum Construction Requirements for Water Bores in Australia (LWBC, 2003).
- Implementation of a bore pump-testing program to define the extent of aquifers and characterize their hydraulic parameters.
- Modelling to ascertain groundwater influx into the proposed Area F, Area E East and Area E South pits.
- Groundwater quality sampling to gather baseline data.
- Compile a report on the investigations and provide recommendations pertaining to the ongoing characterization of ground water for operations.

2 Physical Characteristics

2.1 Location

The Roper Bar iron ore Province is located in the "Gulf Country" of the Northern Territory, 50 km inland from the Gulf of Carpentaria (Figure 1). The nearest settlement is at Roper Bar, 80 km to the northwest. Roper Bar is about a seven hour drive from Darwin on a sealed road. The main population center is the aboriginal community of Ngukurr, with a population of about 900.

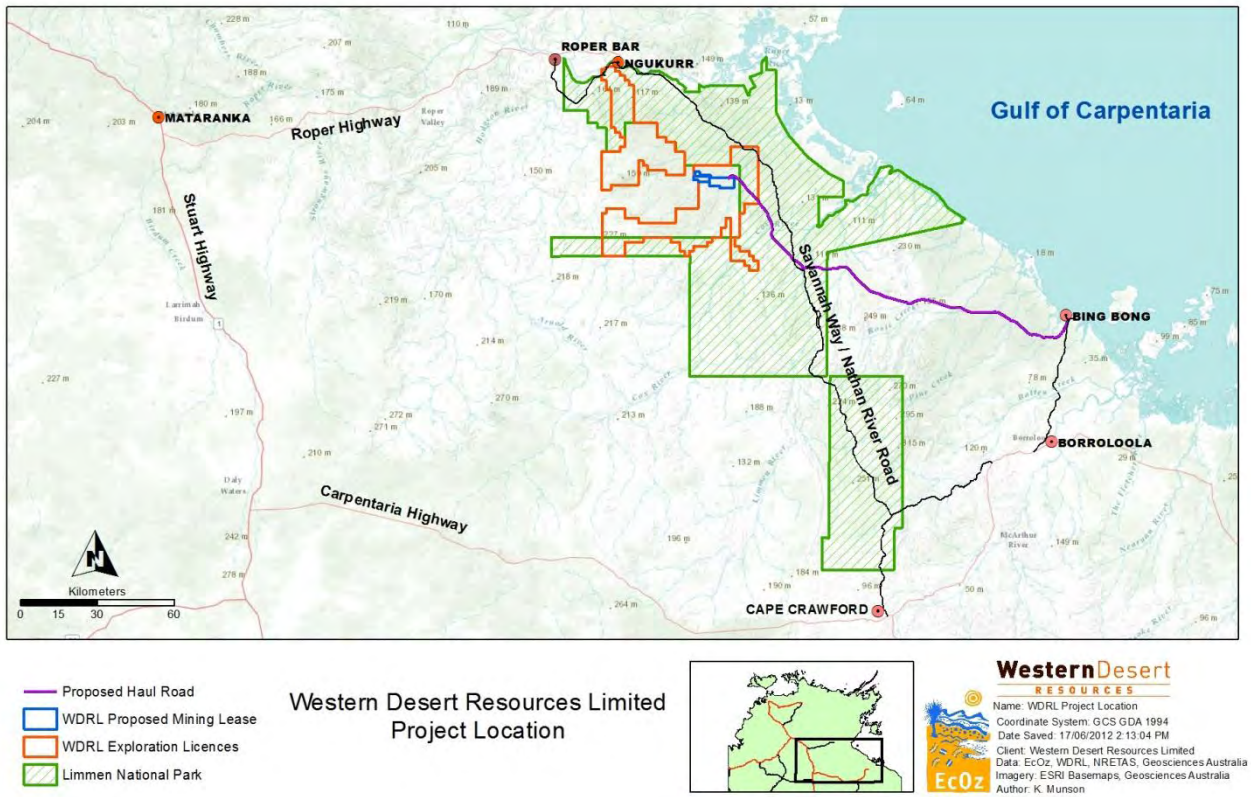


Figure 1: Location of the Roper Bar Iron Ore Deposits.

2.2 Climate and Topography

The climate is tropical, with a mild dry season (May – October) and hot, humid wet season (November – April), often with monsoonal rains or cyclones. The average annual rainfall is 788 mm (Figure 2) and the wet season renders the area almost inaccessible for several months. Weather stations are located at the Roper Bar Store and in Ngukurr. Mean minimum temperatures range between a minimum of 14.3°C for the month of July to a maximum of 25.2°C for the month of December. Mean maximum annual temperatures are about 34.9°C ranging between a minimum of 30.2°C and a maximum of 39.3°C. The highest temperature of 45.0°C was recorded in November 1990. The Ngukurr weather station has recorded an average annual rainfall of 814mm. The average annual pan evaporation is 2409mm, which exceeds rainfall by about three times.

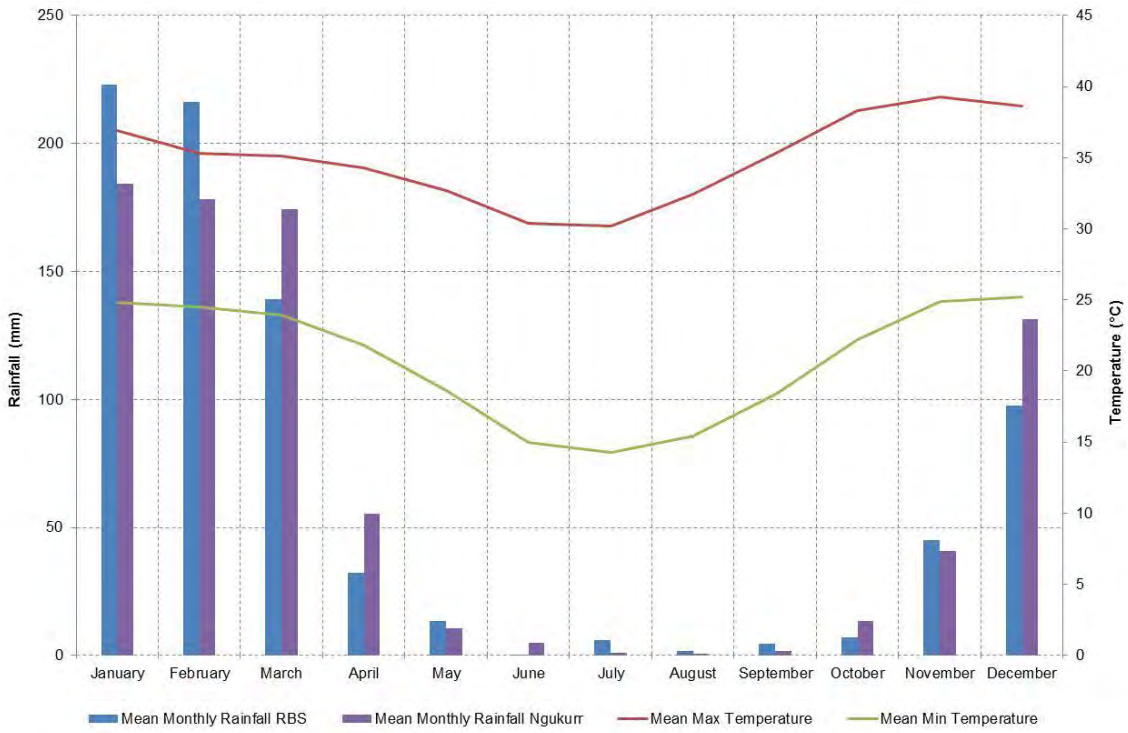


Figure 2: Climate Data Roper Bar Store.

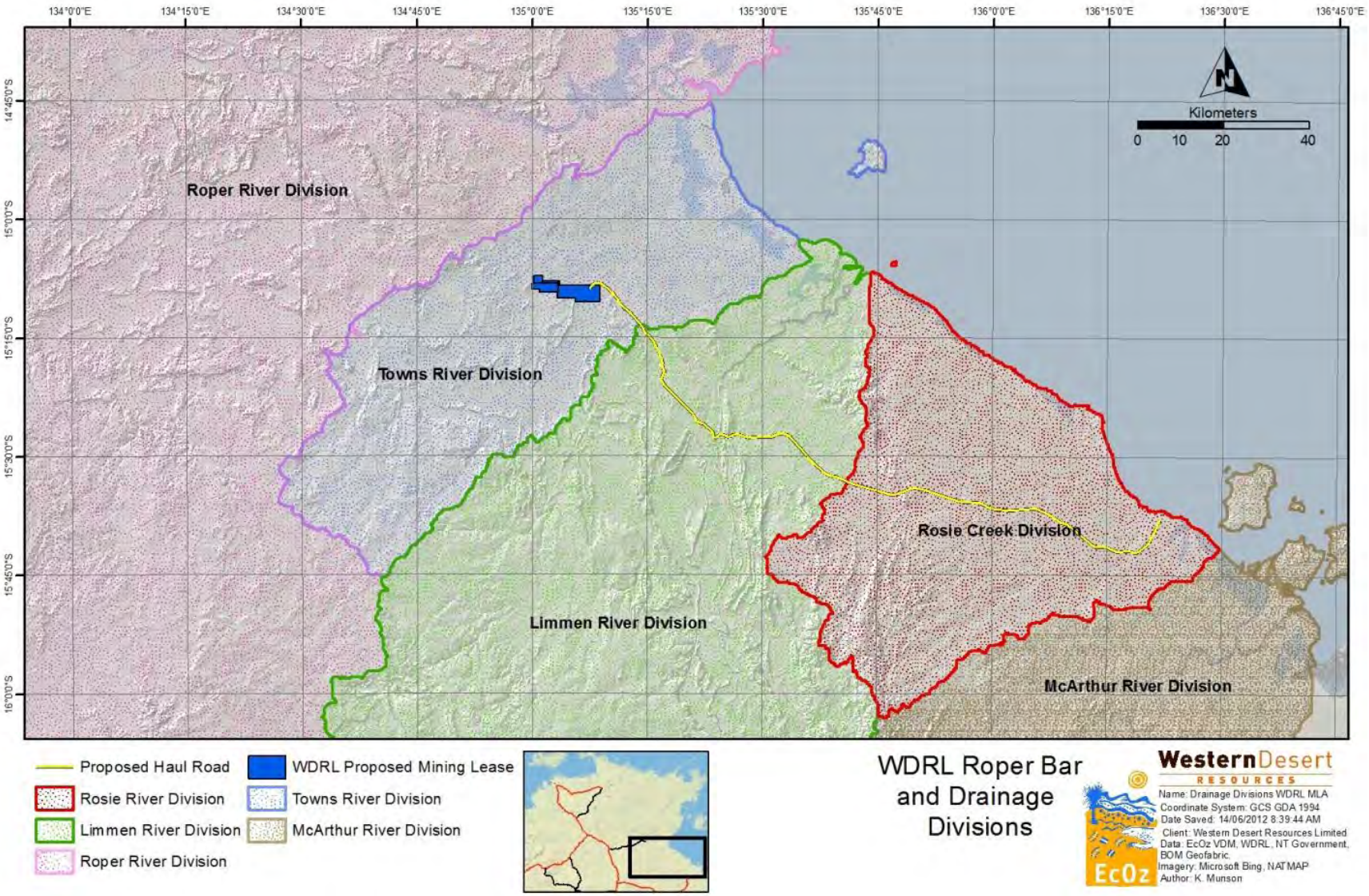


Figure 3: Towns River Catchment.

(Note: The red outline indicates the WDRL Exploration Leases; the dark blue area is the subject of this investigation and report.)

The main topographic features are low escarpments, formed by a sequence of sandstones and siltstones. Away from the escarpments, outcrops are scarce and limited to occasional boulders, rubble and sands of the underlying sub-outcrop. The maximum elevations of the Roper Bar project area, located to the south of the proposed mine footprint, is 126m above mean sea level.

2.3 Hydrology and Drainage

The region hosts numerous rivers and water courses, including the Roper River to the north of the Project Area, which drains the basins through a dendritic tributary system. Other significant surface water features draining within to the southern part of the project area are the Towns, Cox and Limmen Bight Rivers. The Project Area lies within the Towns River Catchment (Figure 3). All of the catchments drain north-eastwards towards the Gulf of Carpentaria.

2.4 Geology

2.4.1 Regional Geology

The Roper Bar Iron Ore Province is a large intracratonic sedimentary basin with an exposed area of about 180,000km^2. The basin contains thick marine and non-marine sedimentary rocks, which were deposited from the late Paleoproterozoic to the early Mesoproterozoic eras (1,800 to 1,430 Ma). Some volcanic rocks and related intrusive igneous rocks can also be found occasionally (Western Desert Resources, 2011).

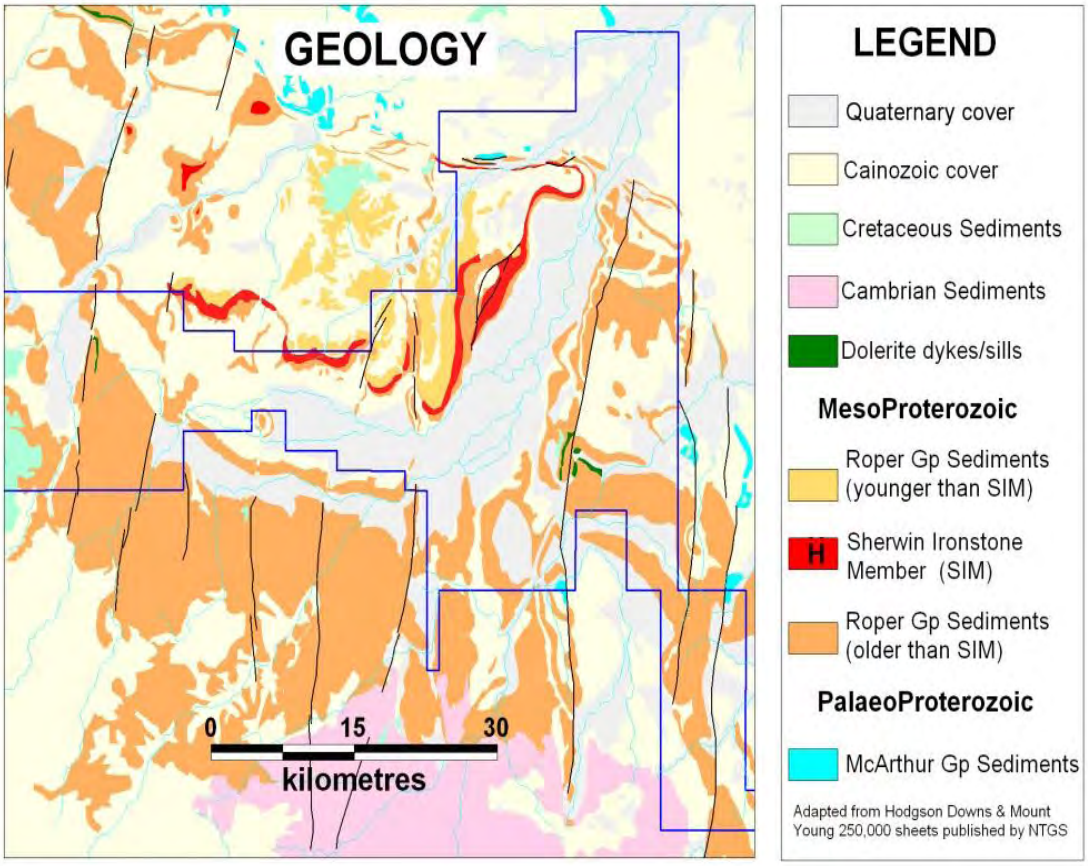


Figure 4: Regional Geological Sequences of the Roper Bar Iron Ore Province.

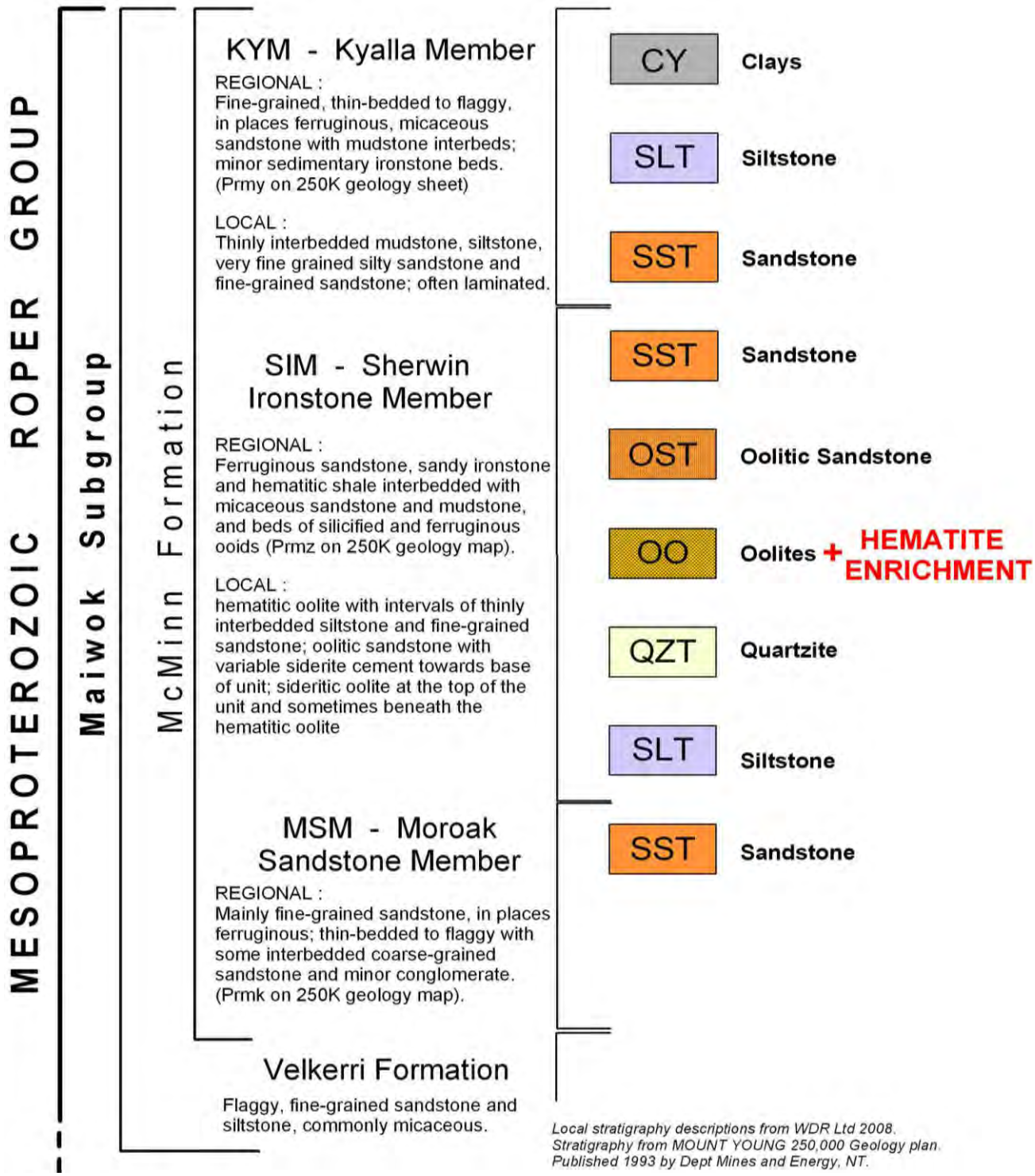


Figure 5: Local Stratigraphic Sequence of the Roper Group.

Within the Iron Ore Province, the dominant stratigraphy comprises relatively un-metamorphosed and un-deformed sediments of the Mesoproterozoic Roper Group (Figures 4 and 5). Near the top of this sequence, iron ore occurs in outcrop and under shallow cover of oolitic ironstone referred to as the Sherwin Ironstone Formation (SIF), which hosts all the known iron mineralisation and deposits (Western Desert Resources 2011). North-south striking faults are common, although a major east-west structure referred to as the Hells Gate Hinge Line, transects the area.

Other than rare dolerite sills, there are no volcanics in the area.

2.4.2 Local Geology

The mineralisation occurs as an oolitic hematitic sandstone in the Sherwin Ironstone Member of the Maiwok Sub-group, in the Mesoproterozoic Roper Group (Figure 5). The hematitic sandy sandstone is commonly interbedded with sandy ironstones, mudstones and beds of silicified and ferruginous ooids (Figure 6). The host unit, which contains zones of enrichment, is referred to as a sedimentary iron formation. By classification, the deposit is best described as a SCOS-IF (Sandy, Clayey, and Oolitic Shallow-inland sea Iron Formation) (Western Desert Resources, 2011).

Locally, the sequence is covered by laterised soils with thicknesses ranging from 2.0m to approximately 10.0m to the north-western end of the E east Beneficial Ore (BFO). Underlying this is a sequence of siltstones and sandstones, interlayered siltstones and mudstones/shales with minor bands of sandstones (the overall sequence belong to the Kyalla Member of the McMinn Formation).

To the south-west, sedimentary rocks of the Kyalla member overly a thin layer of extremely weathered siderite which in turn overlies the hematitic iron ore body. The hematite iron ore of the Sherwin Ironstone Member is relatively fine grained to the top of the sequence with layers of fine silicified sandstones, siltstones and mudstone becoming coarse with depth (Figure 6). Interlayered fine to medium grained sandstones and grey to dark grey siltstones with thin layers of mudstones occur below this sequence (Figures 6 and 7). This sequence is typical of the Velkerri Formation, which locally underlies the thin beds of the fine to coarser grained Moroak Sandstone Member.

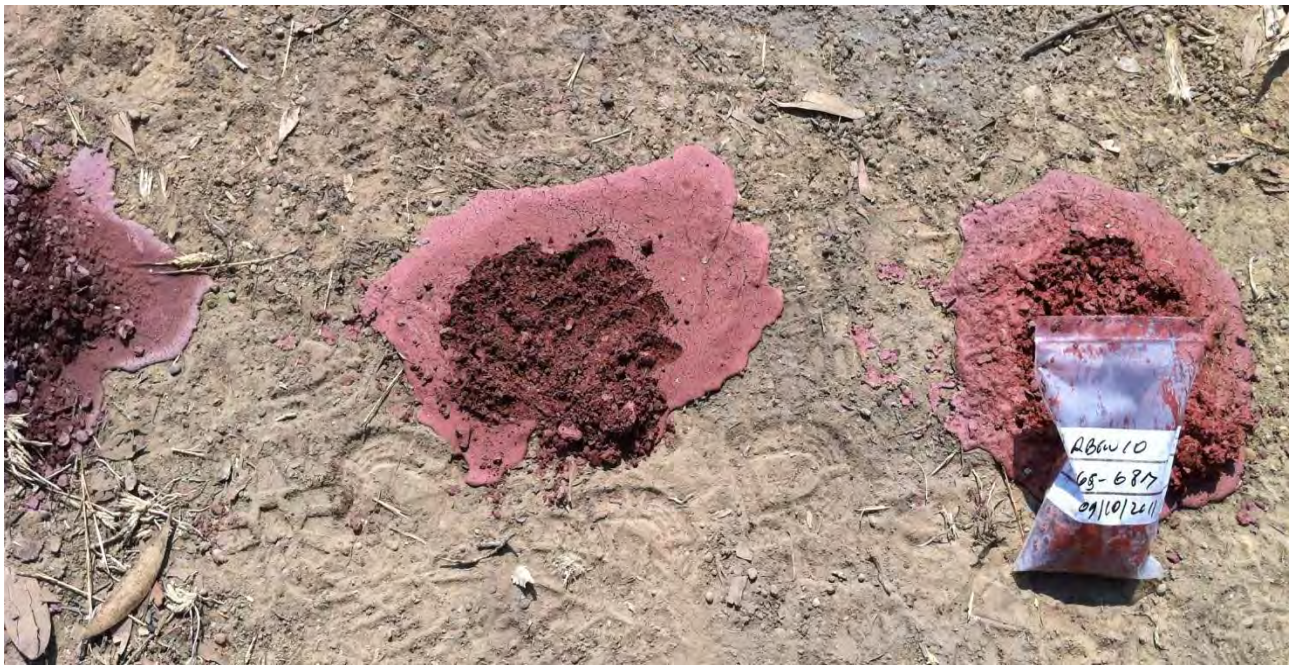


Figure 6: Saturated Hematitic Iron Ore.
(Note: 65m to 68m depth at RBGW10; changes in grain size distribution with depth).

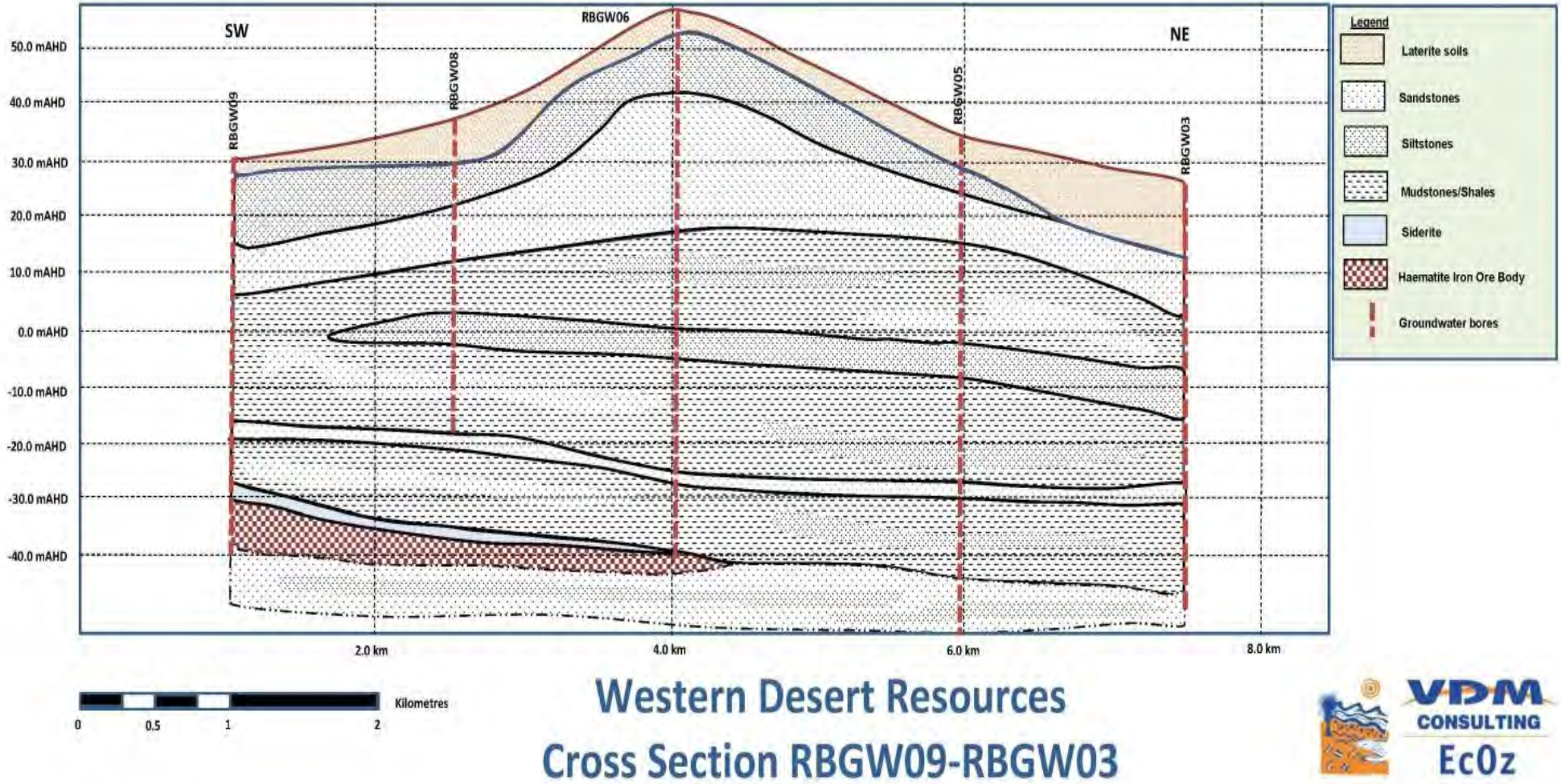


Figure 7: Geological Cross Section.

3 Hydrogeological Investigations and Assessments

3.1 Regional Hydrogeology

Regional groundwater studies for the project area are limited. Recent studies to the north of the project area indicate that the major aquifers in the Roper region are in the Tindall Limestone, Dook Creek Formation and Cretaceous sediments (Tickell 2009). These systems, particularly the Tindall aquifer, normally recharge in areas where the aquifer intercepts the surface throughout karstic conduit systems such as sinkholes and caves originating due to deep weathering (Knapton 2009).

Two other catchment systems, namely the Towns River and Limmen Bight rivers, are located within and to the south of the project area respectively. The Limmen Bight region was reported to host an aquifer system located in the north-east among shallow calcrete lithotypes (Northern Territory of Australia 2009). The aquifer is a likely source of baseflow to the Nathan River. Although it has been reported that systems such as the Rosie River have minimal connection between surface and groundwater, the Towns River have permanent waterholes along its course. These water bodies are anticipated to be surface reflections of shallow localised groundwater systems that are fed via baseflows originating within exposed high lying grounds.

3.1.1 Groundwater Dependant Ecosystems (GDEs)

GDEs are areas where groundwater plays a key role on both vegetation dynamics and soil water balances. These areas are of particular interest for several reasons, including their relatively high richness both in animal and plant species and their ability to sequester and store carbon (Mitsch and Gosselink, 2000). GDEs here are defined as: *natural ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their ecological functions*. Six types of GDEs are conventionally recognised in Australia:

- **Terrestrial vegetation** that relies the availability of shallow groundwater.
- **Wetlands** such as paperbark swamp forests and mound springs ecosystems.
- **River base flow systems** where groundwater discharge provides a base flow component to the river's discharge.
- **Aquifer and cave ecosystems** where life exists independent of sunlight.
- **Terrestrial fauna**, both native and introduced that rely on groundwater as a source of drinking water.
- **Estuarine and near shore marine systems**, such as some coastal mangroves, salt marshes and sea grass beds, which rely on the submarine discharge of groundwater.

Of these only terrestrial vegetation is likely to occur within the project area. Table 1 details the criteria for discerning zones and sites which may fit the definition of a GDE.

Table 1: Criteria for Defining Water Dependent Ecosystems.

Environmental Aspect	Criteria	Indicators of Ground Water Dependence
Level 1: Locate zones with potential for groundwater dependence		
Potential for groundwater fed systems	Status of inundation, submergence, seeps and springs, ground water aquifers, geology and topography	Soil and surface/ground water surveys indicate water at (inundation, submergence, seeps, springs) or close (dampness) to the surface which vegetation can readily tap into or there is potential for expression of this water to the surface based on geology and topography.
Level 2: Assess specific areas where ground water dependence potential is high		
Indications of water at inundation, submergence, seeps, springs) or close (dampness) to the surface	Soil moisture Expression of ground water Source of surface water	Greater than 15% following at least 7 days of no rain. Shallow ground water levels, extent of ponding or flowing (frequency; rainfall relationship) Drainage/topographic characteristics

	Refer to vegetation criteria	Surface/ground water quality characteristics Refer to vegetation structure
Vegetation Characteristics	Vegetation structure Plant Species composition	Structure (large trees) suggests reliance on a long term available water source. Species composition suggests a dependence on a shallow ground water table. Presence of species dependent on (near) permanent water.

These GDEs are also areas where groundwater plays a key role both on vegetation dynamics and on the soil water balance. The dynamics of these ecosystems including riparian zones, peatlands, and unsubmerged wetlands are controlled by the soil water balance and are affected by water table depth and soil water content.

Whilst there is a potential for GDEs within estuarine areas, the Bing Bong port facilities have not been assessed because groundwater systems will not be disturbed. Within the proposed mining area, the depth to groundwater (**Error! Reference source not found.Error! Reference source not found.**) is generally deeper than 9m below natural ground level, which suggests that GDEs are unlikely to be present within the mine project area. However, a small spring has been observed in the south-east corner of the project area, to the west of the Magaranyi River and upstream of surface water sites RBSW11 and 12 (Figure 8). This surface expression of shallow ground water seeps originates from rain infiltration into locally exposed and shallow fractured sandstone ridges. The limited extent of the sandstone outcrop, coupled with the impermeability or hydraulic disconnection from deeper weathering and/or fracturing causes infiltrated rain to seep out along the lower reaches of the ridge. These seeps are likely to diminish and/or cease during prolonged periods of drought. The impact on a small pocket of these communities at WDRL is not regarded as regionally significant.

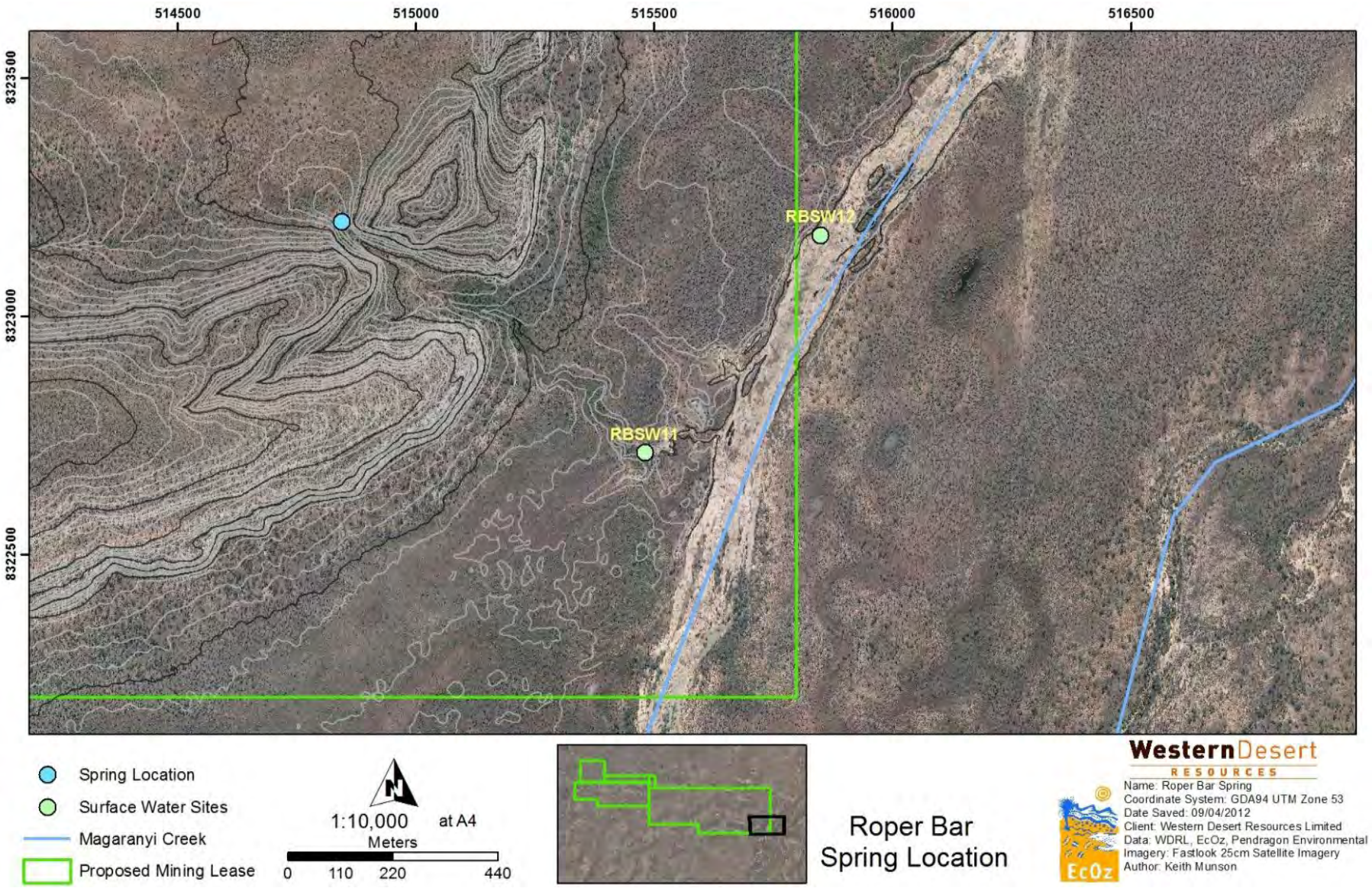


Figure 8: Location of the Spring in relation to the Sandstone Ridges.

3.2 Bore Drilling and Hydraulic Testing

3.2.1 Bore Drilling

A total of eleven investigative and environmental monitoring bores were installed to investigate the hydrogeological characteristics and their variability around the proposed open-cut pits (Figure 9):

The bores were constructed in accordance with the Minimum Construction Requirements for Water Bores in Australia (LWBC, 2003) and were screened to capture all intersected water strikes. Construction summaries are provided in Table 2. Detailed lithological descriptions and construction logs may be found in Appendix A.

Table 2: Bore Construction Details.

Hole ID	Coordinates		Ground Elevation	Top of Casing	Groundwater Level (Nov 2011)	Bore Depth	Screen Interval (mAHD)	
	East	North	mAHD	mAHD	mAHD	m	From	To
RBGW01	508851	8325252	24.3	25.01	14.87	79	-24.7	-54.7
RBGW02	510617	8325804	23.1	23.80	10.80	102	-48.9	-78.9
RBGW03	513995	8324801	25.2	25.90	9.71	79	-23.8	-53.8
RBGW04	513832	8322687	52.5	53.25	34.74	71	5.0	-18.5
RBGW05	512772	8323863	30.0	30.75	21.38	87	-32.9	-56.9
RBGW06	511029	8322996	55.8	56.62	47.24	56	11.8	-0.2
RBGW07	509942	8323656	26.8	27.54	15.22	123	-72.2	-96.2
RBGW08	509981	8321938	38.9	39.58	33.52	56	16.96	-17.0
RBGW09	508527	8321313	31.8	32.27	20.15	71	-21.7	-39.7
RBGW10	508433	8322638	26.8	27.26	17.93	72	-33.2	-45.2
RBGW11	504539	8325139	27.3	27.96	14.50	71	-14.2	-44.2

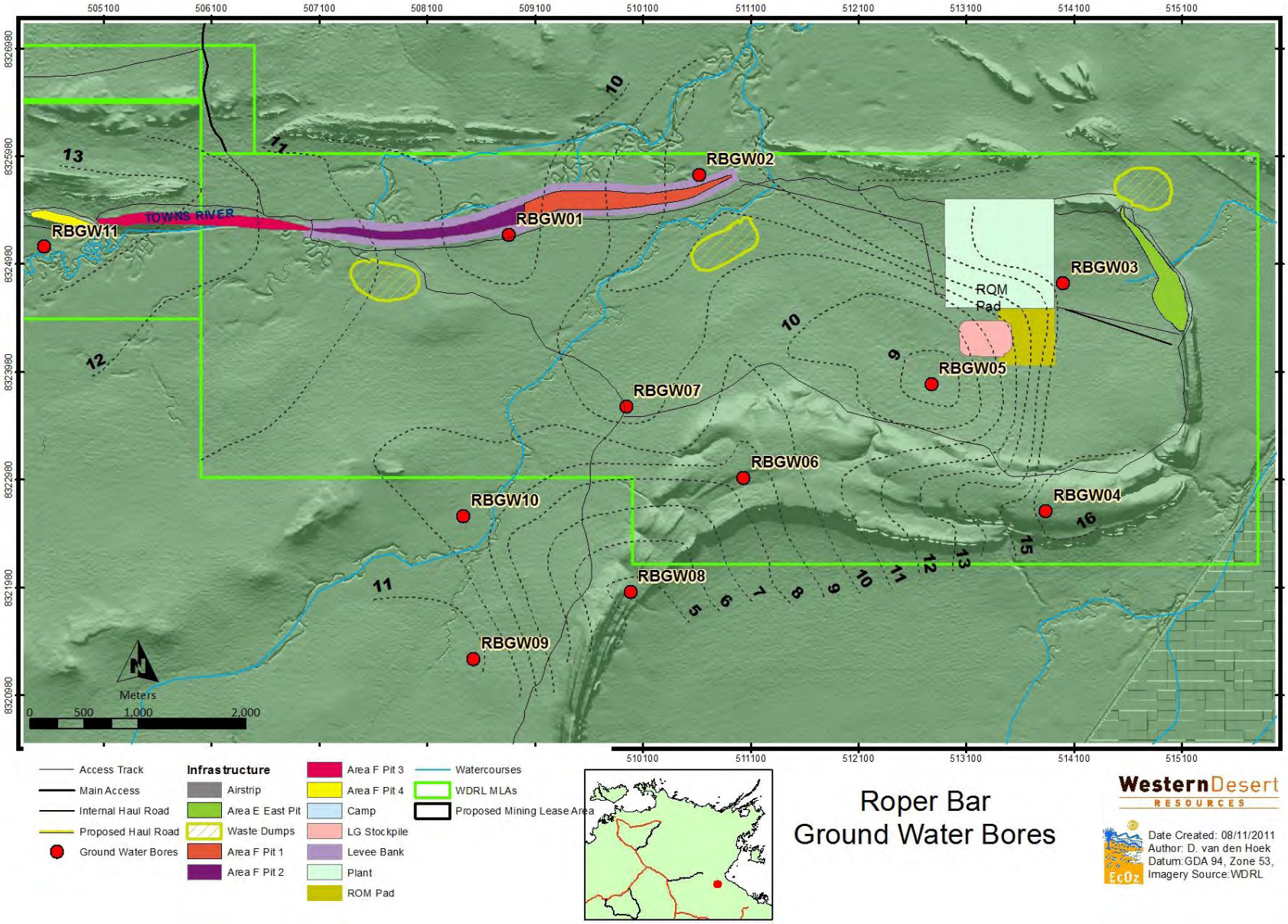


Figure 9: Locations of Investigative and Monitoring Bores.

The construction of bores employed an air rotary percussion technique drilling the first 6.0m of the bore at 250mm to install a 208mm diameter solid steel casing grouted in place with cement. Once the steel casing was installed, a 203mm diameter drill bit was used to continue drilling and install 150mm solid Class 12 PVC casings with screens across the primary water bearing zones. During drilling, samples of the drill cuttings were obtained at 1.0m intervals and used to prepare detailed lithological descriptions and bore construction logs (Appendix A). Changes in moisture content of the drill cuttings, depths at which ground water were encountered; ground water levels and airlift yields were observed and recorded.

3.2.2 Bore Airlift Yields and Hydraulic Testing

Low bore yields were encountered during drilling (Table 3). Consequently, a combination of pump and slug testing was utilized to interpret aquifer properties, specifically hydraulic conductivity (K, m/d), transmissivity (T, m^2/d) and storativity (S, no dimensions).

Slug tests were used to assess bores with very low yield capabilities (<0.5L/s). These tests are often regarded as an accurate method to determine the permeability of an aquifer when conducted carefully and interpreted with consideration of site hydrogeological conditions (Hamilton and Li, 2003).

Bore pump testing was used at bores RBGW07 and RBGW08. Both bores have yields greater than 0.5L/s and tests included stepped and constant rate discharge tests. A pressure transducer (Schlumberger CERA-Diver) was used to measure rising and falling heads during testing.

3.3 Hydrogeology of the Roper Group

3.3.1 Water Strikes

Drilling did not encounter high water bearing/yielding zones and there is no indication that any of the multiple water strikes are interconnected. Water strikes occurred predominantly in the sandstones interbedded with siltstones and in the hematitic iron interbedded with silicified sandstones, mudstones and siltstones (Table 3 and Figure 6).

Table 3: Water Bearing Zones and Airlift Yields.

Hole ID	Water Strikes		Lithology	Airlift Water Yields (L/s)
	mbgl	mAHD		
RBGW01	33.5; 62.0; 70.0	-9.2; -37.7; -45.7	Sandstone interbedded with siltstone	0.5
RBGW02	33.0	-9.9	Contact weathered mudstone/sandstone	<0.1
RBGW03	70.0	-44.8	Siltstone interbedded with mudstone	<0.1
RBGW04	9.5	43.0	Laterite/Extremely weathered siltstone and sandstone	0.3
RBGW05	61.0	-31.0	Red ferrugionous sandstone	<0.1
RBGW06	23.2	32.6	Quartzite sandstone	0.3
RBGW07	56.0; 107.0	-29.2; -80.2	Quartz sandstone and siltstone	0.5 - 0.7
RBGW08	18.0; 21.0	20.9; 17.9	Quartz sandstone interbedded with ferruginous layers	1.0 – 1.5
RBGW09	30.0	1.8	Siltstone and shales/mudstones	0.3
	57.0	-25.2	Intensely weathered siderite	
	62.0	-30.2	Hematitic shale interbeded with silicified sandstones and mudstones	
RBGW10	30.0	-3.2	Finely laminated siltstone with shale/mudstones	0.2
	58.0	-31.2	Intensely weathered siderite	
	60.0	-33.2	Hematitic iron ore body	
RBGW11	30.0	-2.7	Siltstone interbedded with sandstone	<0.1

Locally, the near-ground surface comprises of extremely to slightly weathered quartz sandstones and at depths between 20.0m and 30.0m below the natural ground surface, contains significant moisture concentrations (Figure 10). Localised moisture would indicate that these zones comprise an aquitard system with limited extent and low direct recharge from seasonal rainfall. Recharge flows would occur through

preferential pathways such as fractures, bedding planes and conduits forming among exposed iron ore bodies. Whilst laterites and highly weathered and fractured sequences of interbedded iron sandstones and siltstones overlay this system, medium to finely grain weathered and relatively compacted sandstones underlie this system.

Figure 10: Moisture in Hematite Iron Ore, Siltstone and Sandstones.
(Note: ~20 m depth RBGW04).

Importantly, the investigation indicates that in relation to water strikes:

- They are low-yielding in the range between 0.10L/s and 1.5L/s and generally less than 0.5L/s.
- Low yield systems, with an average of less than 0.5L/s are normally located at the bottom level of the proposed depth of mining (70.0m below ground level).
- The highest water strike, some 1.5L/s after bore development, was encountered at 21.0m below ground level in bore RBGW08 in quartz sandstones interbedded with a ferruginous layer (Table 2).
- The hematite iron ore body localised at an average 60m deep (Figure 11), dipping east-west, is interbedded with porous silicified siltstones and sandstones and has an average yield of 0.25L/s (Table 2). A previous study (SKM 2010) suggested that this is a shallow semi-confined to confined aquifer system controlled by primary porosity.

Figure 11: Drill Cuttings (RBGW10).

3.3.2 Groundwater levels

Groundwater levels are relatively deep and imitate the local topography (Figure 12 and Table 2). Ground water levels range from the shallowest of 9.39m to the deepest of 16.18m below ground level.

Groundwater flows within the proposed mine footprint are preferentially to the north, north-west with radial flow from the water mound in the sandstone-siltstone ridges located to the south, south-eastern side of E-East and South prospect areas (Figure 12). Groundwater levels to the western flank of the ridges are very steep, whilst this slightly flattens to the eastern flanks towards the Magaranyi River.

Within the western portion of the site, near and within the vicinity of the Towns River, water levels are shallower and follow the gently undulated topographical pattern of the land surface. Shallower water levels within the area seem to occur during the wet season, following saturation of the normally low conductivity overlying laterised soils. During the dry season, these systems are probably recharged by waters draining preferentially throughout primary and secondary porosity structures from higher gradient recharging areas. A spring located to the west of the Magaranyi River; i.e. up gradient of site RBSW12 for surface water assessment (see Figure 8) accommodates this assessment and it is likely that during prolonged drought periods, this surface expression of shallow ground water will dry out. The system is probably fed by waters draining throughout the exposed and locally fractured sequence of sandstone/ siltstone ridges and is limited in extent.

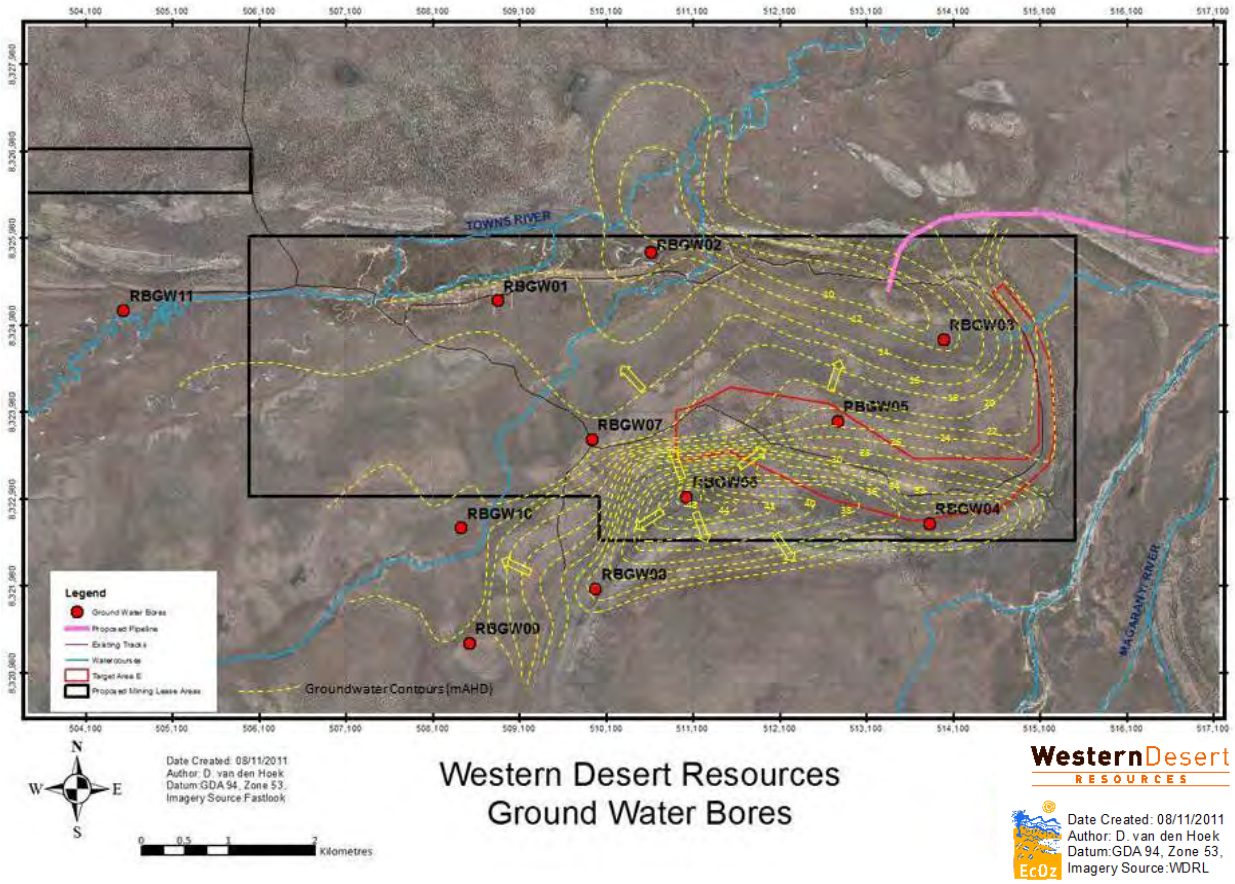


Figure 12: Groundwater Level (mAHD) Contours and Flow Direction.

3.3.3 Hydraulic Parameters

Bore pump test data are provided in Appendix B. A detailed summary, time-drawdown/falling head graphs and preliminary estimates of the hydraulic parameters of the aquifers are provided in Table 4 and Appendix C.

The falling head data was analysed by various methods including the Hvorslev, Bouwer and Rice and Cooper-Brendehoeft-Papadopoulos. The Bouwer and Rice (1976) data analysis method use a modified version of the Theim equation and was developed to analyse fully or partially penetrating wells in unconfined aquifers. Regardless of the differences between field conditions and theory, the data resulting from the

pump testing was analysed using the Boulton and Theis methods for confined aquifers. Both data sets were analysed using Aquifer Test Version 2011.1 software.

The results of the rising head permeability tests undertaken on the bores are summarised in Table 4. The testing indicates a hydraulic conductivity ranging from 1.12E-08m/s to 1.40E-07m/s with an average of 6.20E-08m/s.

The range of attained permeabilities (about two orders of magnitude difference) is typical for slightly fractured rock aquifers, where the permeability at a particular site is controlled by a combination of primary porosity from the pore space matrix and secondary porosity created by features such as fractures and bedding plains. Rapid initial slug falls can be attributed to influences/interferences provided by bore/well storages whilst the later gradual falls appears to be typical of water flow through materials controlled by primary porosity systems located among undisturbed parts of the aquifer system.

Test pumping was undertaken at bores RBGW07 and RBGW08 (refer Appendices B and C for data). Whilst a three-staged step test and a constant rate discharge test were undertaken at RBGW08, only a constant rate discharge test was undertaken at RBGW07. Preliminary airlift yields indicated low yields for both bores, in the order of 0.5L/s to 1.0L/s.

Bore RBGW07 recorded about 70.0m drawdown in 127.5min of constant discharge at 0.5L/s. Pumping time was relatively low as available water decreased to the minimum depth at which the pump was placed. Fast water level decrease indicates that initial water yields may have been provided from localised lenses hosted by water strikes located between 60.0 to 80.0m among the siltstones and mudstones. The bore which provided the highest yield (>0.15 L/s) was encountered between 105m to 117m below ground level.

Table 4: Hydraulic Parameters.

Bore ID	Bouwer and Rice		Hvorslev		Cooper-Bredehoeft-Papadopoulos		Averages		Aquifer Thickness
	K (m/s)	T (m^2/s)	K (m/s)	T (m^2/s)	K (m/s)	T (m^2/s)	K (m/s)	T (m^2/s)	m
RBGW01	1.24E-07	9.04E-06	1.54E-07	1.12E-05	1.44E-07	1.05E-05	1.40E-07	1.03E-05	73.0
RBGW02	1.37E-08	1.31E-06	1.70E-08	1.63E-06	2.89E-09	2.78E-07	1.12E-08	1.07E-06	96.0
RBGW03	8.47E-08	6.23E-06	1.06E-07	7.76E-06	1.92E-07	3.16E-06	1.27E-07	5.72E-06	73.5
RBGW04	6.82E-08	4.47E-06	8.59E-08	5.63E-06	7.25E-08	4.75E-06	7.55E-08	4.95E-06	65.5
RBGW05	4.06E-09	3.29E-07	5.12E-09	4.14E-07	1.02E-07	1.02E-06	3.69E-08	5.86E-07	81.0
RBGW06	2.14E-08	1.08E-06	2.75E-08	1.39E-06	1.77E-07	8.97E-06	7.53E-08	3.81E-06	50.5
RBGW09	1.52E-08	7.20E-07	1.92E-08	9.13E-07	4.72E-09	2.25E-07	1.30E-08	6.19E-07	47.5
RBGW10	5.06E-08	2.40E-06	6.52E-08	3.10E-06	4.93E-08	6.60E-06	5.50E-08	4.03E-06	47.5
RBGW11	1.84E-08	1.19E-06	3.10E-08	2.00E-06	2.00E-08	1.28E-06	2.31E-08	1.49E-06	64.5
Average	4.44E-08	2.97E-06	5.67E-08	3.79E-06	8.48E-08	4.08E-06	6.20E-08	3.61E-06	66.6
Maximum	1.24E-07	9.04E-06	1.54E-07	1.12E-05	1.92E-07	1.05E-05	1.40E-07	1.03E-05	96.0
Minimum	4.06E-09	3.29E-07	5.12E-09	4.14E-07	2.89E-09	2.25E-07	1.12E-08	5.86E-07	47.5
Pump Test Analysis									
	Boulton		**Theis**		**Averages**				
Bore	**K (m/s)**	**T (m^2/s)**	**K (m/s)**	**T (m^2/s)**	**K (m/s)**	**T (m^2/s)**			
RBGW07	1.52E-08	1.05E-06	2.27E-08	1.56E-06	1.89E-08	1.30E-06			69.0
RBGW08	6.78E-07	4.68E-05	6.22E-07	4.28E-05	6.50E-07	4.48E-05			49.5
RBGW08A	4.00E-07	1.98E-05	4.00E-07	1.98E-05	4.00E-07	1.98E-05			49.5
Average	**3.65E-07**	**2.25E-05**	**3.48E-07**	**2.14E-05**	**3.56E-07**	**2.20E-05**			
Maximum	**6.78E-07**	**4.68E-05**	**6.22E-07**	**4.28E-05**	**6.50E-07**	**4.48E-05**			
Minimum	**1.52E-08**	**1.05E-06**	**2.27E-08**	**1.56E-06**	**1.89E-08**	**1.30E-06**			

Bore RBGW08 recorded 35.0m drawdown after about 870.0min of constant discharge at 0.6L/s. Available drawdown for RBGW08 bore is about 50.0m and percentages of drawdown utilised during the stepped tests (0.5, 0.8 and 1.0L/s) are 14%, 26% and 39% respectively. The two initial flow rates were successively used

for 240.0 min of continuous pumping (each flow rate per 120.0min). The later flow rate (1.0L/s) used all available drawdown (an approximate 20.0m) after about 33.0min.

Observations indicate that preliminary water yields are relatively high but water availability will not be sustainable in the long-term. High initial discharges may have been derived from water bodies hosted among fracture zones or from near surface lenses of sand within highly weather sandstones and siltstones and the overlying laterite sequences.

Recovery of the groundwater level after discharge testing was in the order of 90%. The relatively slow recovery of water levels shows that recharge throughout fracture systems and primary porosity domains are probably reduced and controlled by boundary conditions that gradually reduce the supply of water into the investigated system. These processes are typical of semi-confined to confined aquifer systems with limited areal and vertical extent.

The relatively poor water permeation and recovery in the slugged and pump-tested bores also indicates that the deep waters are within an aquifer system with low recharge rates from overlying and underlying zones in the formation. Thus, sustainable yields will not be maintained and dewatering rates are likely to be reduced and steadily decrease with time.

Table 5: Estimations of Transmissivity.

Hole ID	Lithology	Airlift Water Yields (L/s)	T (m^2/d)
RBGW01	Quartz sandstone interbedded with siltstone	0.5	0.886
RBGW02	Mudstone/Sandstone	<0.1	0.093
RBGW03	Siltstone interbedded with mudstone	<0.1	0.494
RBGW04	Laterite/Siltstone/Sandstone	0.3	0.427
RBGW05	Ferruginous sandstone	<0.1	0.051
RBGW06	Quartzite sandstone	0.3	0.33
RBGW07	Quartz sandstone/Siltstone/Iron ore body	0.2	0.113
RBGW08	Quartz sandstone intebedded with ferruginous layers	1.0	3.9 and 1.7; ~2.97
RBGW09	Siltstone and shales/mudstones	0.3	0.053
	Intensely weathered siderite		
	Hematitic iron ore interbedded with silicified sandstones and mudstones		
RBGW10	Finely laminated siltstone with shale/mudstones	0.2	0.348
	Intensely weathered siderite		
	Hematitic iron ore interbedded with siltstone and mudstone		
RBGW11	Siltstone interbedded with sandstone	<0.1	0.129

Aquifer hydraulic parameters, particularly aquifer transmissivity (Tables 4 and 5), in the sandstones and siltstones and the hematite iron ore body are low; in the order of 0.1m^2/day to 4.0m^2/day. The lower transmissivity pertains to the dominantly ferruginous sandstone materials and the highest to the quartzite sandstone interbedded with ferruginous sandstones. The hematite iron ore body sandstones interbedded with mudstones and siltstones sequence have an average transmissivity of 0.4m^2/d. The higher transmissivities were normally calculated from short term (less than 100mins) data, before gradual flow change or the likely presence of barrier boundaries was established. Based on the field observations and slug/drawdown curves, the investigated area can be defined as having two well defined near-surface systems:

1. A shallow, highly localised unconfined aquitard system, located at between 25.0 to 30.0m depth, among a highly weathered sequence of sandstone interbedded with siltstones. A moisture-laden layer was observed in two bores (i.e. RBGW01 and RBGW08).
2. A shallow, semi-confined to confined aquifer system among the Sherwin Ironstone Formation (SIF), located between 50.0 to 60.0m below ground level, particularly where the shallow dipping ore reserves were observed to exist. Deeper systems, as that observed in bore RBGW07; appear to be

a continuity of this aquifer system. Recharge of water into this system appears to occur downwards throughout conduits within the higher porosity sections of the SIF. A previous investigation by SKM (2010) indicates that where the SIF outcrops, aquifers hosted by the formation are expected to be unconfined, whilst in flat lying areas, they are expected to be semi-confined to confined.

4 Groundwater Modelling

4.1 Introduction

To ascertain influx of ground water into the proposed F East, E East and E South open pits (Figure 9), groundwater modeling was undertaken. The scope of work entailed:

- Data collection and the creation of a conceptual hydrogeological model.
- Numerical groundwater model set up and calibration in steady-state to incorporate available ground water measurements.
- Prediction of groundwater inflow and drawdown due to mine dewatering.
- Sensitivity analysis on predictions by varying aquifer parameters.
- Completion of report that provides the results and uncertainty.
- Detailing the results of models and/or predictive tools used, including inputs, sensitivity analyses, justification of any assumptions used in the development of the model(s), and general conformance with the Northern Territory Natural Resources, Environment, The Arts and Sport (NRETAS) groundwater flow modelling guidelines.

4.2 Data Sources and Conceptualisation

A report on Groundwater Flow Modelling prepared by RPS (Australia Asia Pacific) appears in Appendix D. The numerical model was developed, based on:

- Geological and hydrogeological maps.
- Geological and lithological information from the drilling program.
- Digital layouts of the proposed open pits.
- Rainfall, evaporation and ground water level data.
- Bore test data and interpretations.

4.3 Conceptual Model

Consistent with the groundwater investigation and information gleaned from the regional geological map, a conceptual model representing the study area was developed (Figure 13). In this model, the top layer primarily consists of the weathered zone (some 12m to 28m thick) underlain by the Kyalla Member (up to 160m thick), the Sherwin Ironstone Member (up to 25m thick) and the Moroak Sandstone (about 60m thick).

The Sherwin Ironstone outcrops near the mine site and dips down towards the west. It is hypothesized that the Hell's Gate Hingeline (a major fault) has moved the Ironstone Formation near the surface in Area F-East.

Figure 14 presents the fence diagram of the various formations encountered during the drilling of the eleven investigative groundwater bores.

Input of water in the model is considered to be from rainfall recharge, up-gradient groundwater inflow and from river leakage (where the groundwater table is below the level of the river). Output from the model is considered to be via evapo-transpiration (ET), groundwater outflow down-gradient and groundwater discharge to the river (where the groundwater table is above the level of the river). Across the study area, groundwater is generally expected to be below the level of the streambed; hence the rivers are likely to provide groundwater input, if any, rather than output.

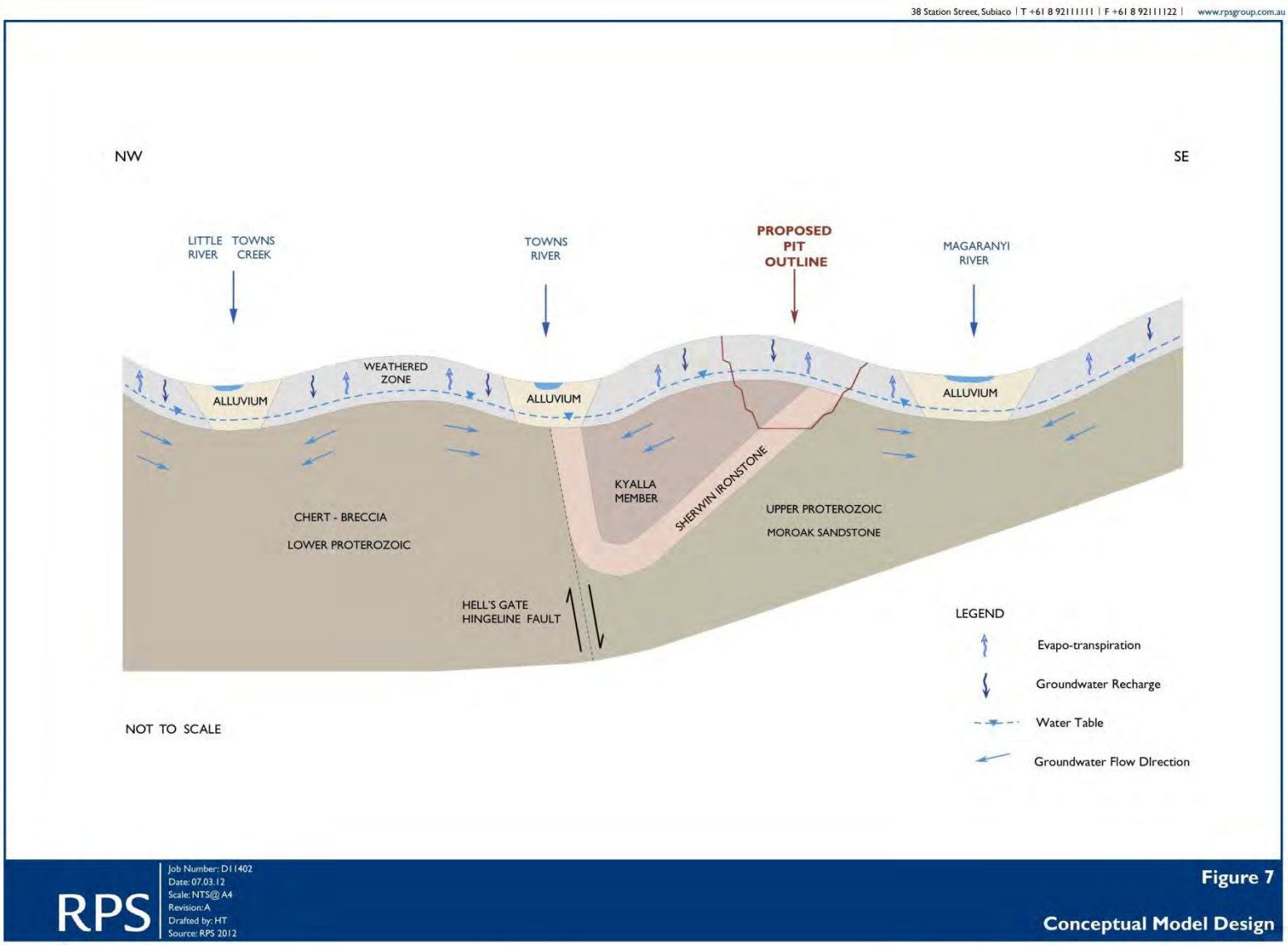


Figure 13: Conceptual Model (RPS, 2012).

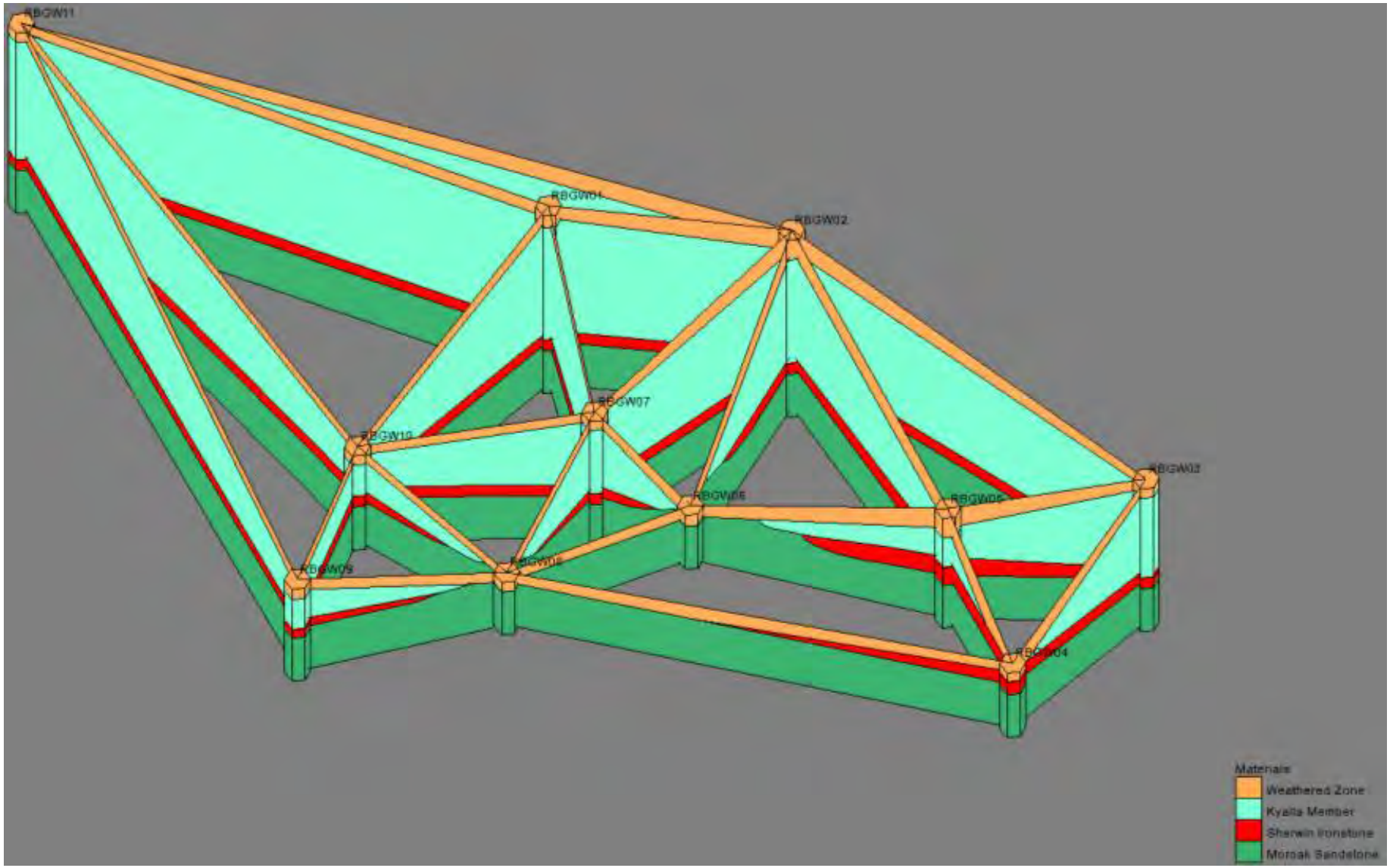


Figure 14: Fence Diagram (RPS, 2012).

4.4 Numerical Model Set Up and Calibration

4.4.1 Selection of Modelling Code

The MODFLOW-SURFACT (Version 3, Hydrogeologic Inc.) modelling code was selected instead of the industry-standard MODFLOW code for this study. This is because MODFLOW-SURFACT can better handle dry cells related to mine dewatering. Groundwater Vistas (Version 6.1, Rumbaugh, J. and Rumbaugh, D.) was used for pre- and post-processing of the data.

4.4.2 Grid Design

The numerical model has been set up with four layers, 370 rows and the 360 columns with total model nodes of 532,800. The grid size ranges from 50m near the mine site to 200m towards the boundaries. The grid spacing increases by a maximum factor of 1.2, which is less than the maximum factor of 1.5 suggested by Anderson and Woessner (2002) for numerical accuracy. The model origin in GDA 94 Zone 53 is at (50,500mE, 8,290,000mN). The model extends 45,000m in both row and column directions. The grid was rotated 35 degrees to align it with the primary flow direction. Figure 15 shows the model grid in section and plan views.

4.4.3 Boundary Conditions

The flow model was developed with the following boundary conditions:

- The Magaranyi, Towns and Little Towns rivers were assigned river boundary conditions in Layer 1.
- Small creeks within the model domain have been modelled with drain boundary conditions.
- Eastern boundaries: constant hydraulic head in all layers with head values ranging from 4m to 25m (approximately 5m below topography).
- The south-western corner of Magaranyi River flood plain has been assigned constant head boundaries in all four layers with the head value of 33m (approximately 5m below topography).
- Where no boundary conditions have been assigned, no-flow boundary conditions apply.
- No-flow boundary at the base of the model.
- Specified flow as rainfall recharge at the top of the model.

The model domain and boundary conditions are presented in Figure 16.

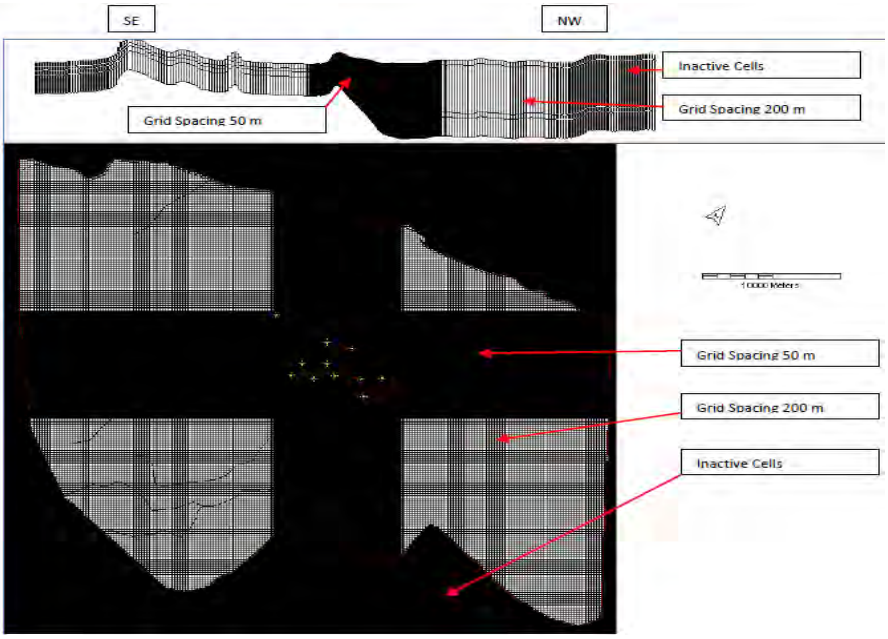


Figure 15: Model Grid Design (Top: Section View; Bottom: Plan View; RPS, 2012).

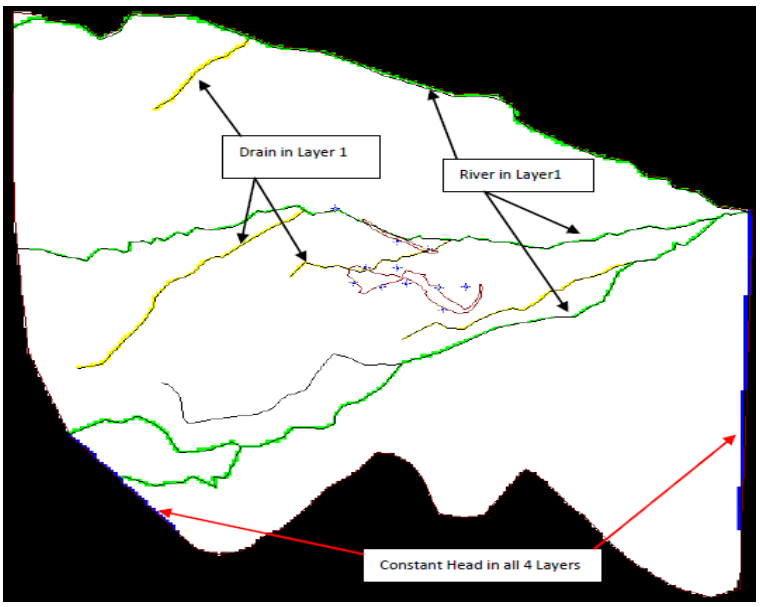


Figure 16: Model Boundary Conditions (RPS, 2012).

4.4.4 Model Calibration

The groundwater flow model was calibrated by comparing computed groundwater heads with observed groundwater heads from the 11 observation wells within the model domain (Figure 12). These observation wells are shown in Figures 17 and 18. The calibration was conducted via trial and error.

A measure of the calibration error is the mean absolute residual head (MARH), which is the mean absolute difference between measured and simulated groundwater levels across the site. Another measure is the root mean square residual head error (RMS) and scaled root mean square error (SRMS). The calibration process provided a SRMS for the steady-state simulation of 9.4% (RMS error of 3.62 m) (for November 2011 measured head). The steady-state calibration graph (or scattergram) is presented in Figure 19.

The calibration process required the assigning of an evapotranspiration (ET) extinction depth of 10m, with a maximum evaporation rate of 0.0003m/d (or 5% of Pan Evaporation). Initial trial and error modelling was conducted without ET, by varying recharge between 1.0mm/yr to 60mm/yr and varying the K values of the Formations within the measured ranges (0.001m/d to 0.05m/d). This resulted in a higher SRMS; hence the introduction of ET was required in the model to calibrate it.

When the groundwater table closely follows the topography, as is the case at this site, ET is generally considered to be a major controlling factor on the groundwater flow system. The calibration results improved with increasing the ET extinction depth to 12m or higher. However, a higher extinction depth is not supported by the literature. The height of capillary rise in fine silt material has been reported as 7.5m by Fetter (1994). Even higher values of more than 7.5m of capillary rise are possible for finer grain sizes than silt. Also, in a semi-tropical area like the study area, dry soil near the ground surface has a high matrix potential which means it can lift water in the vapour phase from greater depths.

The modelled head distribution for the steady-state calibration is presented in Figures 17 and 18. As shown in these figures, the modelled head closely follows the topography.

4.5 Calibrated Model Parameters

4.5.1 Recharge

The calibrated model used recharge values as follows (also shown in Figure 20 and within the ranges provided by the Geo Science MapConnect data base):

- 36.5mm/year (or 4.5% of rainfall) at the ridge top where fractured/weathered Sherwin Ironstone and Moroak Sandstone outcrop.
- 8.8mm/ year (or 1.1% of rainfall) on areas of alluvium.
- 2.9mm/year (or 0.35% of rainfall) at the rest of the weathered zone.

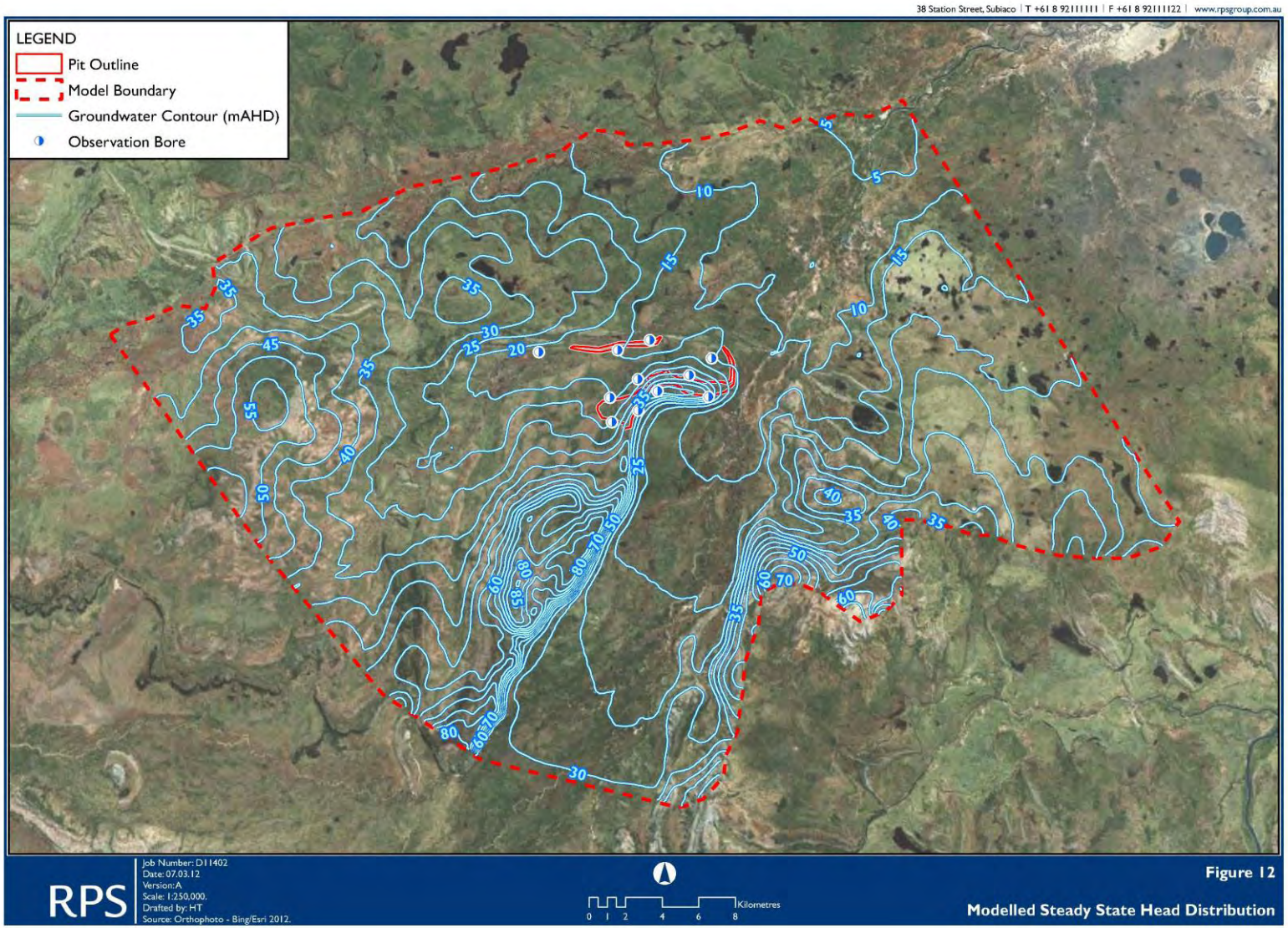


Figure 17: Modelled Steady State Regional Head Distribution (RPS, 2012).

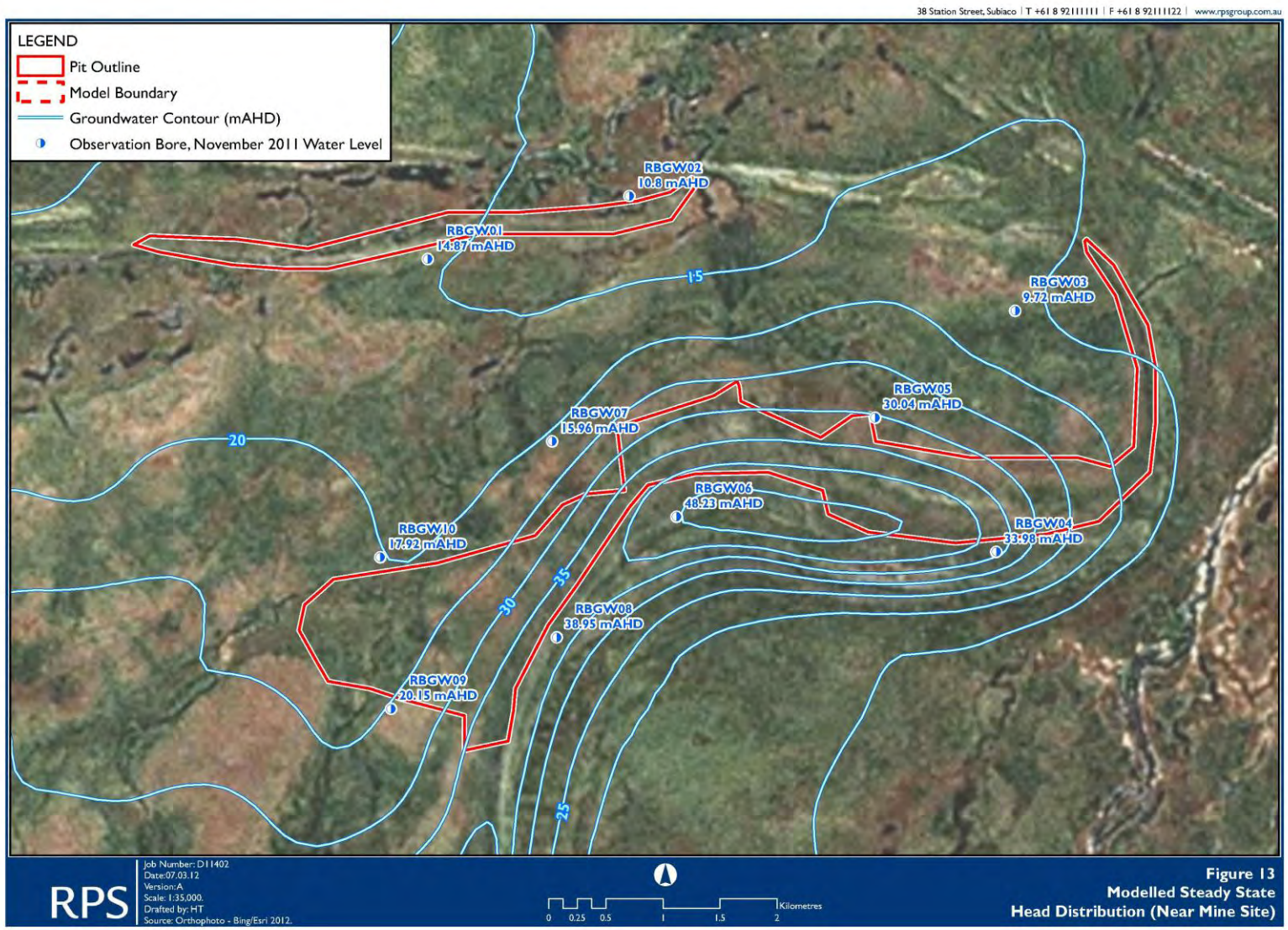


Figure 18: Modelled Steady State Head Distribution at Mine (RPS, 2012).

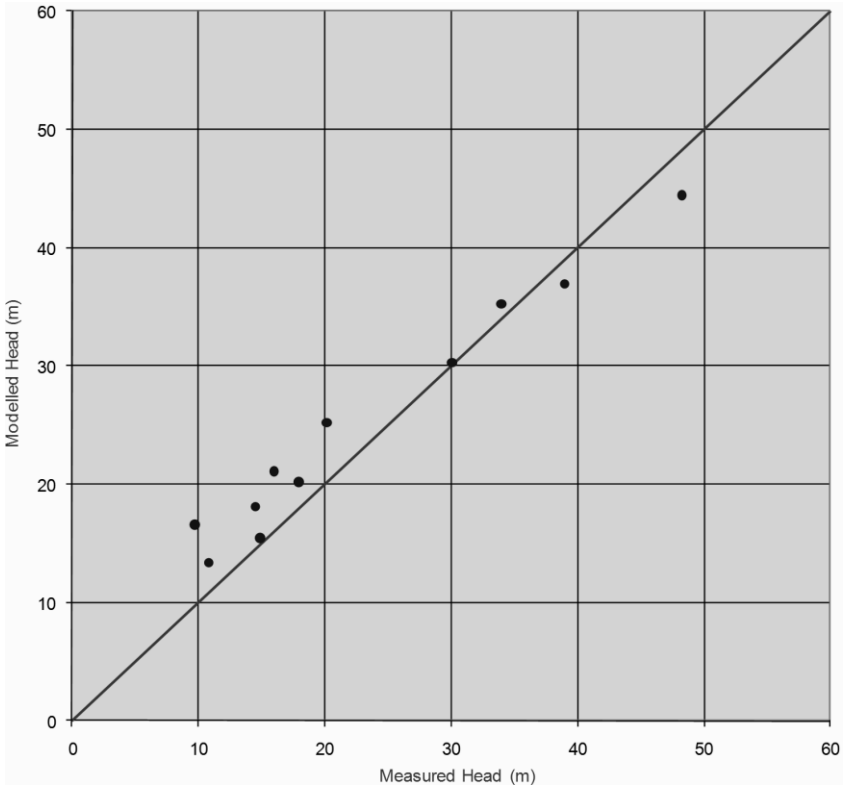


Figure 19: Steady State Calibration Scattergram (RPS, 2012).

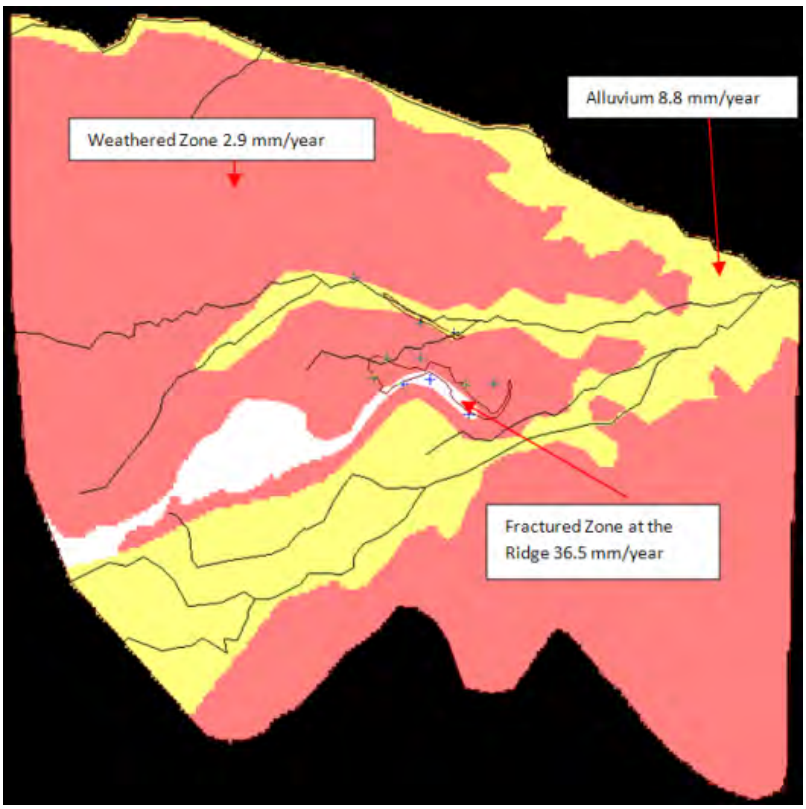


Figure 20: Modelled Recharge Distribution (RPS, 2012).

4.5.2 Hydraulic Conductivity

The horizontal and vertical hydraulic conductivity (Kh and Kv) values from the steady-state model calibration are as follows (as shown in Figures 21 to 24):

- Alluvium along river channels (Kh - 1m/d) and (Kv) - 0.1 m/d).
- Weathered and Fractured Zone (Kh - 0.1 m/d) and (Kv - 0.01 m/d).
- Kyalla Member (Kh and Kv - 0.005 m/d).
- Sherwin Ironstone Formation (Kh and Kv - 0.02 m/d).
- Moroak Sandstone Member (Kh and Kv - 0.005 m/d).
- Chert/Brecia – (Kh and Kv - 0.005 m/d).

It should be noted that the Sherwin Ironstone Formation extent shown (Layer 3) in Figure 23 is as an extensive layer (coloured red). However, this model area represents a hydro-stratigraphic layer rather than the extent of ironstone mineralisation.

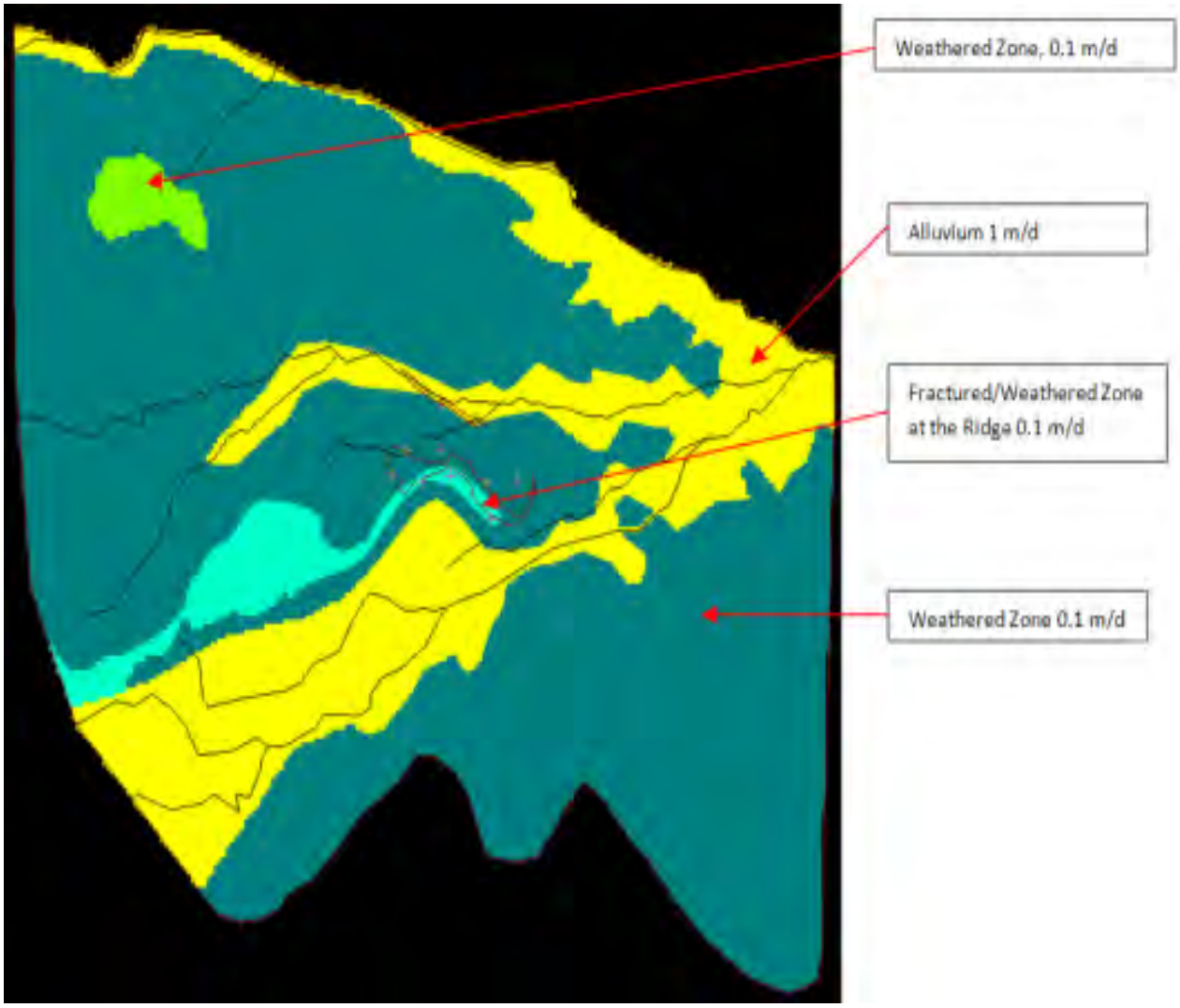


Figure 21: Modelled Horizontal Conductivity Distribution Layer 1 (RPS, 2012).

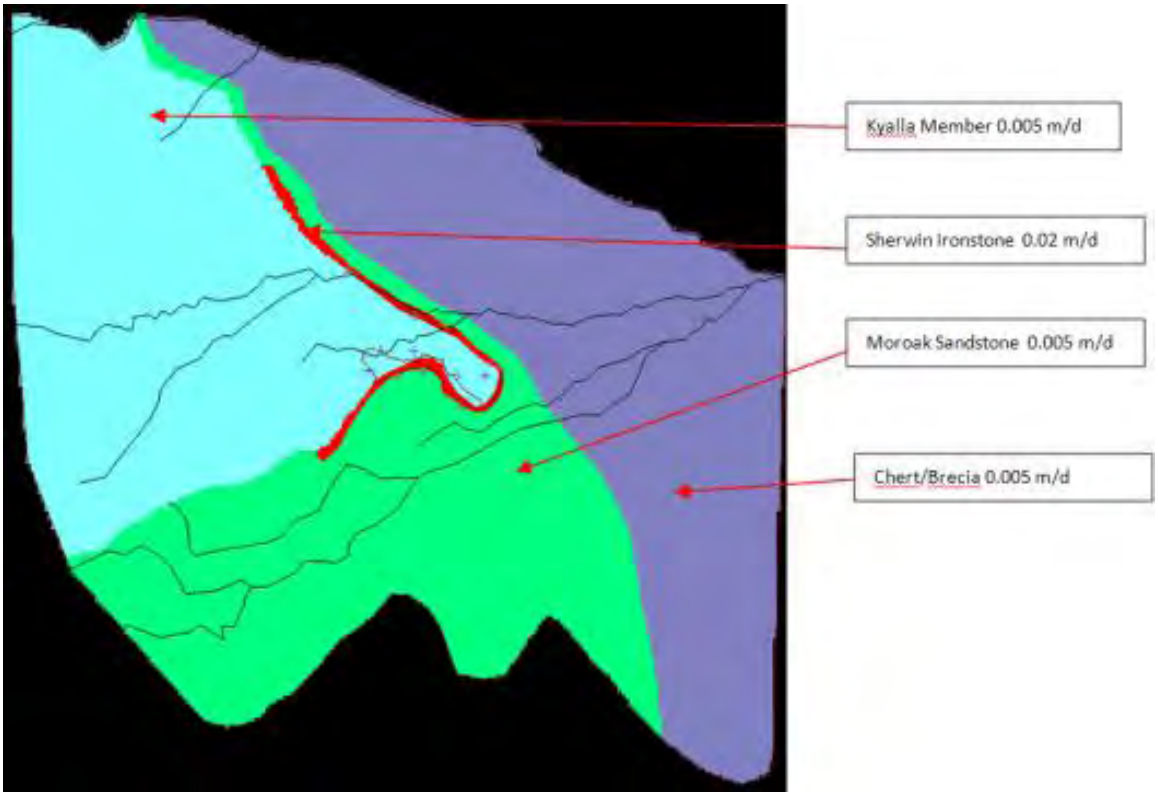


Figure 22: Modelled Horizontal Conductivity Distribution Layer 2 (RPS, 2012).

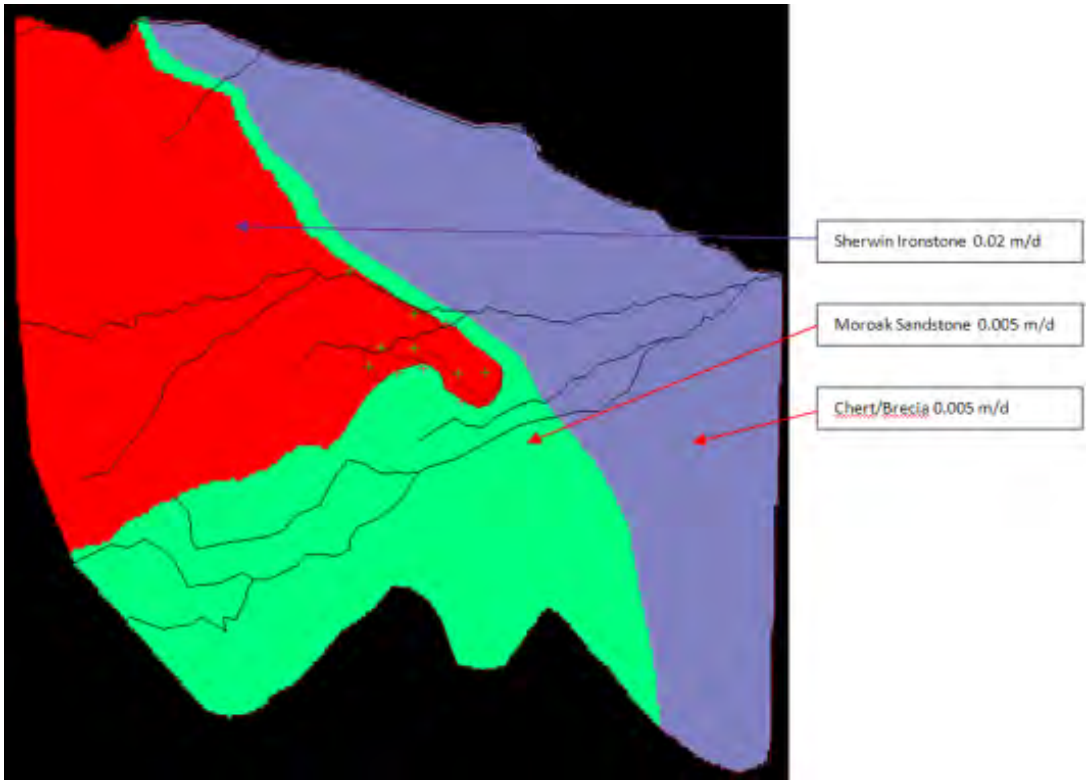


Figure 23: Modelled Horizontal Conductivity Distribution Layer 3 (RPS, 2012).

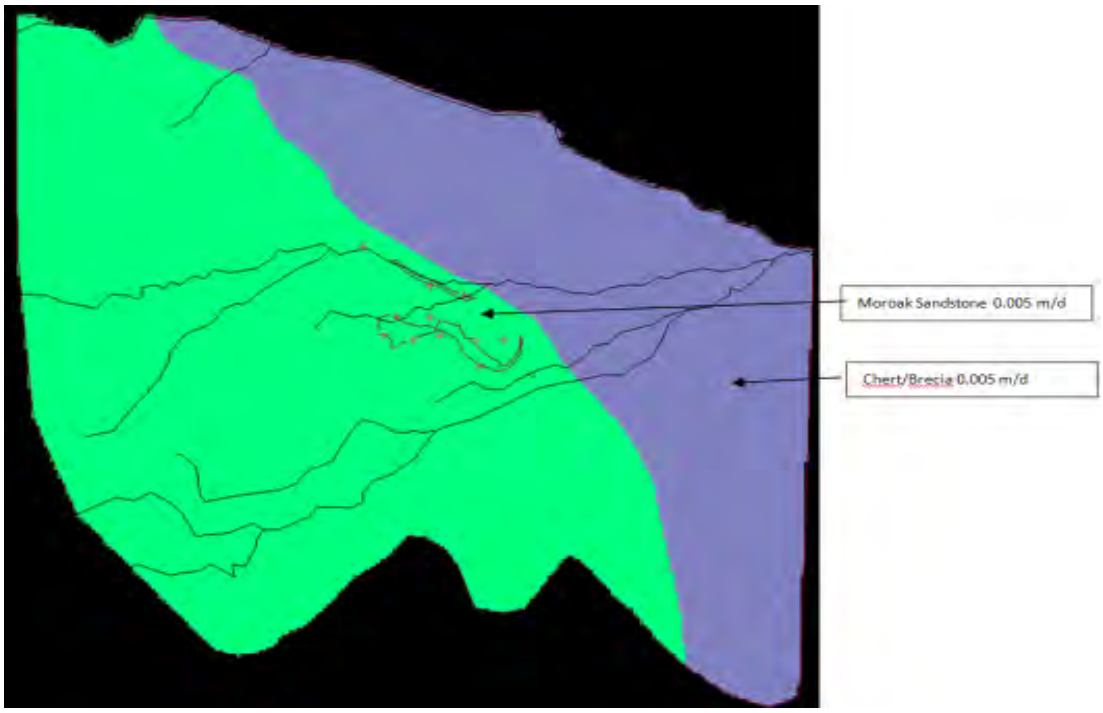


Figure 24: Modelled Horizontal Conductivity Distribution Layer 4 (RPS, 2012).

4.5.3 Proposed Storage Parameters

Storage parameters are not required for a steady-state calibration but are necessary for the transient prediction run of the model. Based on the low K of the materials on site (refer Table 3), the following storage parameters have been used:

- Storage Coefficient: 10^{-5} (for all layers and all formations).
- Specific Yield: Alluvium 0.1.
- Specific Yield: Weathered Zone 0.05.
- Specific Yield: Sherwin Ironstone Formation 0.02.
- Specific Yield: Kyalla Member, Moroak Sandstone and Chert/Brecia 0.01.

4.6 Water Balance

The water balance for the steady-state model is provided in Table 6. According to the model results, the water balance error for the entire model domain is less than 0.1%; the error specified by Konikow (1978) that is considered ideal.

Table 6: Water Balance from Steady-State Calibration.

Flow Component	Flow In (m^3/d)	Flow Out (m^3/d)
Specified Head Boundaries	1,121	192
Recharge	19,173	0
ET	0	23,849
River Leakage	3,762	15
Drain	0	0
Total	**24,056**	**24,056**
Flow In – Flow Out	0	
Per Cent Discrepancy (%)	0.00	

As shown in Table 6, most of the water is input to the system via recharge (80%), and river leakage (15%). Most of the water exits the system via ET (99%).

4.7 Predictions

4.7.1 Overview

The steady-state model was used as the basis for the transient modelling predictions. The purpose of the modelling predictions is to estimate the groundwater inflow into the proposed pits and the extent of drawdown during mining.

4.7.2 Predictive Model Assumptions

The predictive model used the same model parameters as the steady-state model, except for the following modifications:

- In order to simulate inflow of water into the proposed pit, drains were assigned to the relevant location with the drain elevation corresponding to the mining elevation.
- The preliminary mine plan indicates that Area F will be mined from one to three years to a depth of 60m (20m depth per year); Area E East will be mined from one to seven years to a depth of 70m (10m depth per year) and Area E South will be mined from five to seven years to a depth of 45m (approximately 15m depth per year). The locations of Areas E and F are shown on Figures 9 and 25.
- The predictive model was run for seven years with yearly stress periods. Each stress period was divided into 12 time steps (i.e. monthly).
- The initial heads for the transient predictions were based on the steady-state model outputs.
- Storage parameters as described in Section 4.5.3.
- The drain boundary conditions used in the steady-state conditions were removed for the transient predictions, as these were not removing any groundwater, hence were inactive.
- The small section of Towns River that crosses the mine site at Area F East was removed from the model as the river will have to be diverted to allow mining.

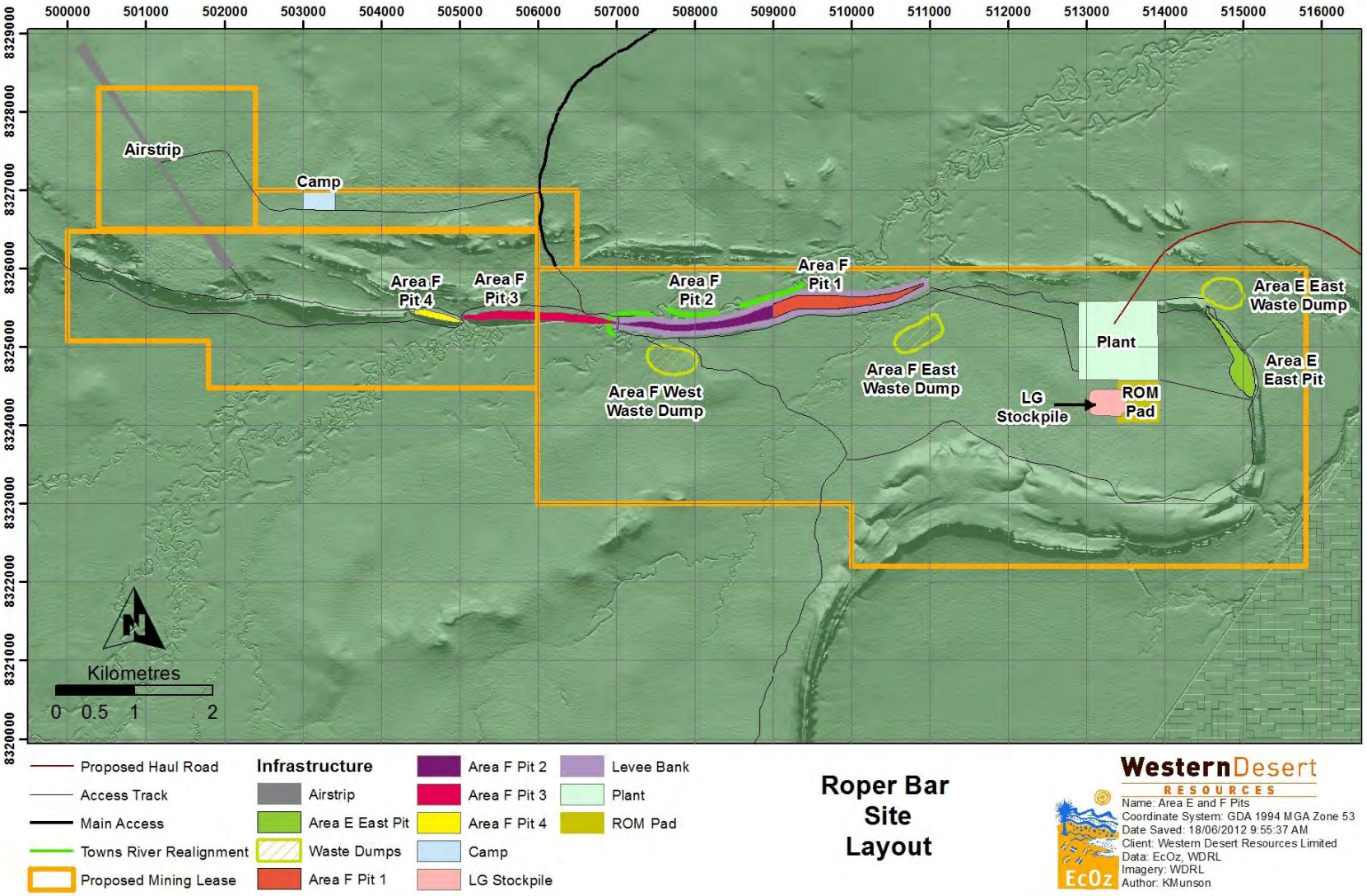


Figure 25: Proposed Mining Areas E and F (Western Desert Resources Limited).

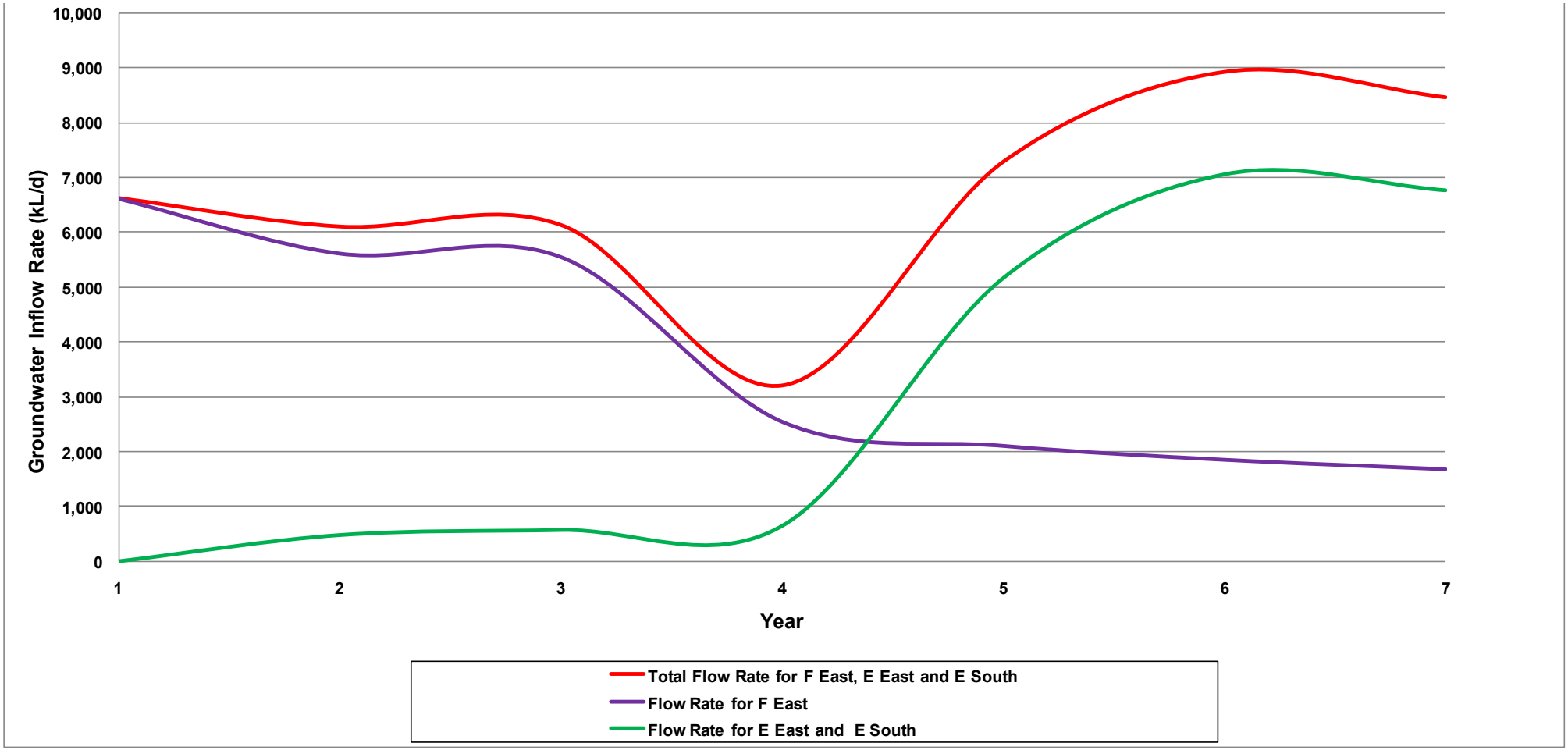


Figure 26: Base Case Model Predicted Groundwater Inflow (Influx plus Initial Storage).

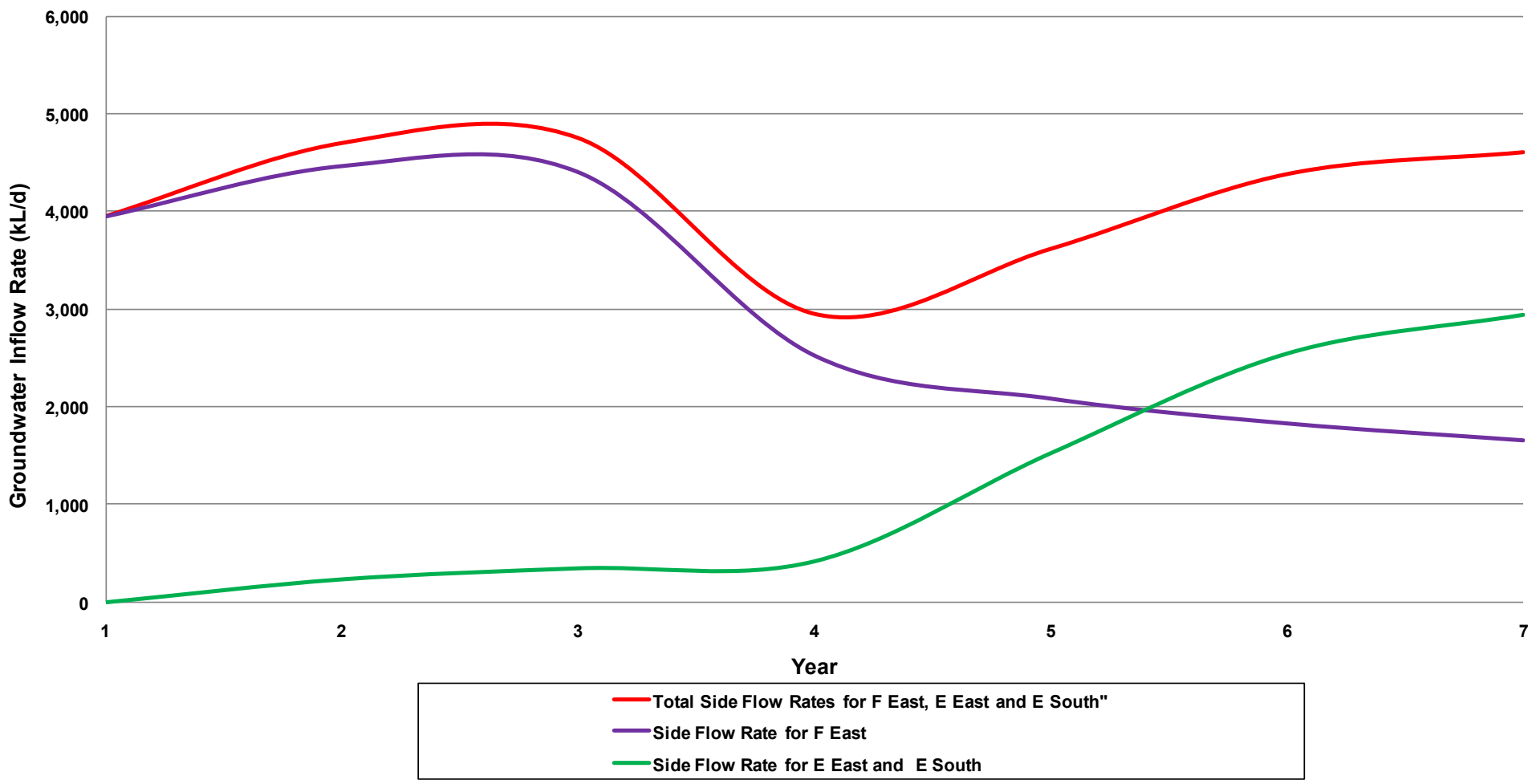


Figure 27: Base Case Model Predicted Groundwater Inflow (Influx and Floors of the Pits).

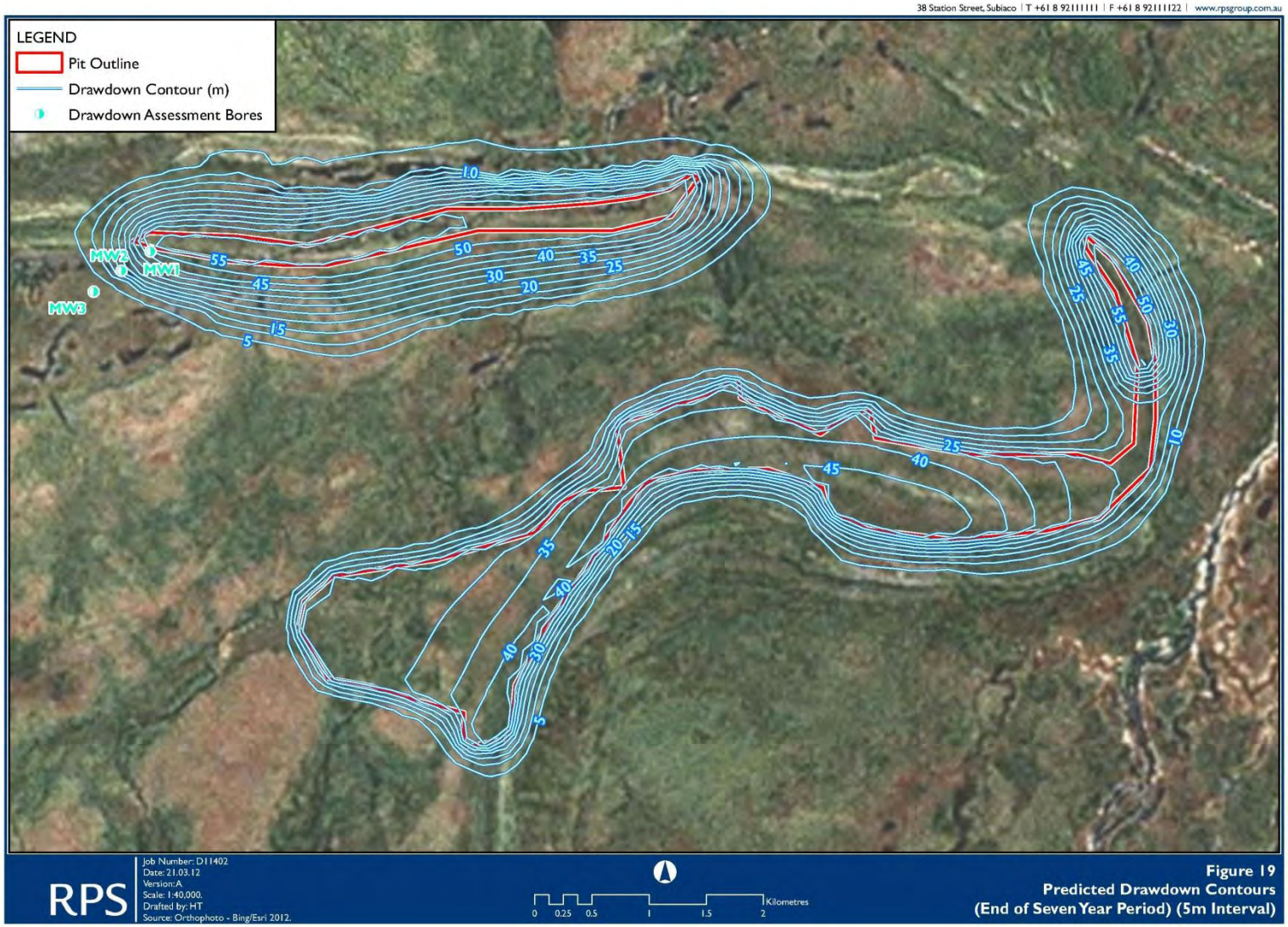


Figure 28: Predicted Drawdown Contours (end of seven year period - 5.0m interval).

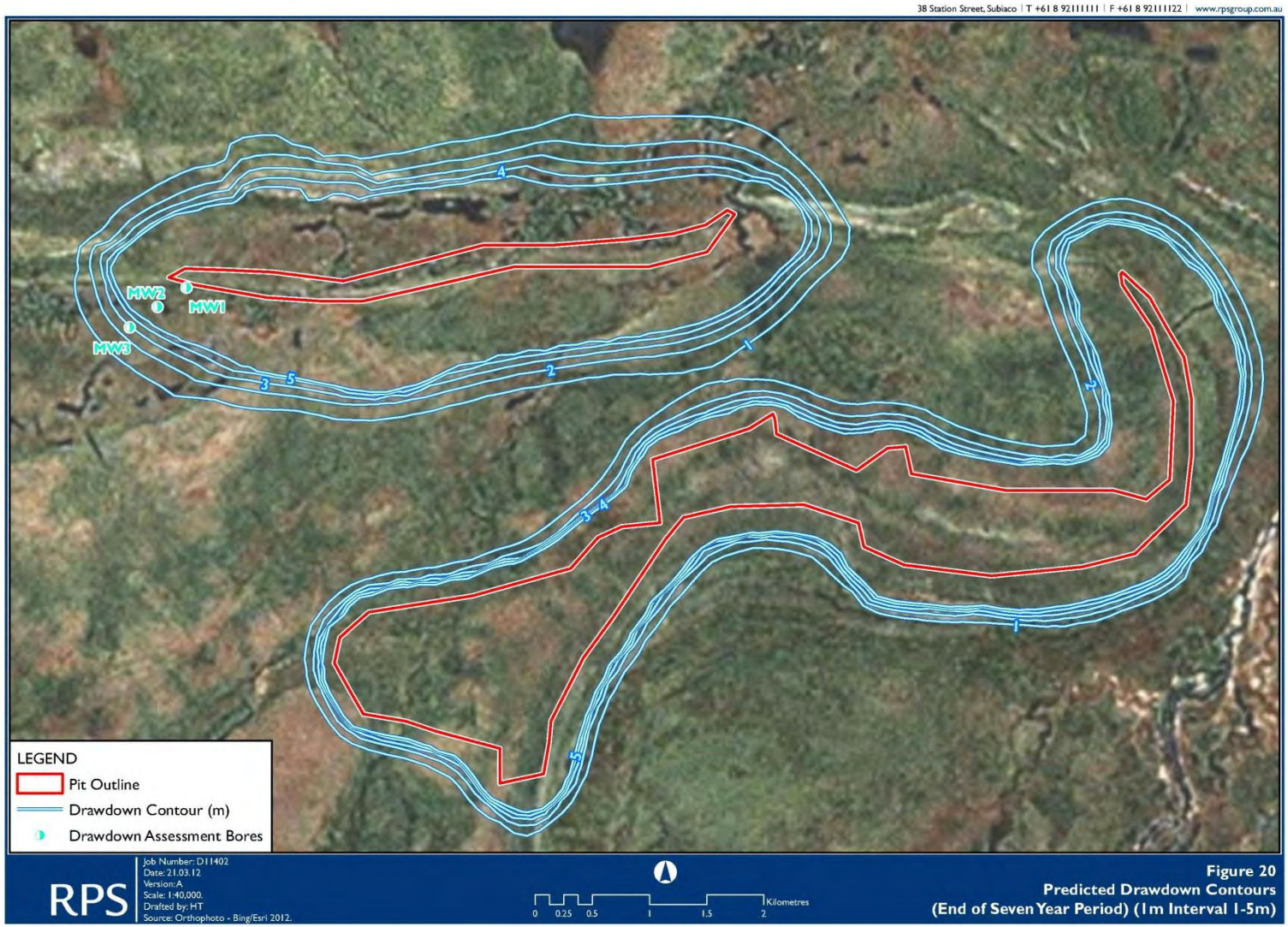


Figure 29: Predicted Drawdown Contours (end of seven year period – 1.0m interval).

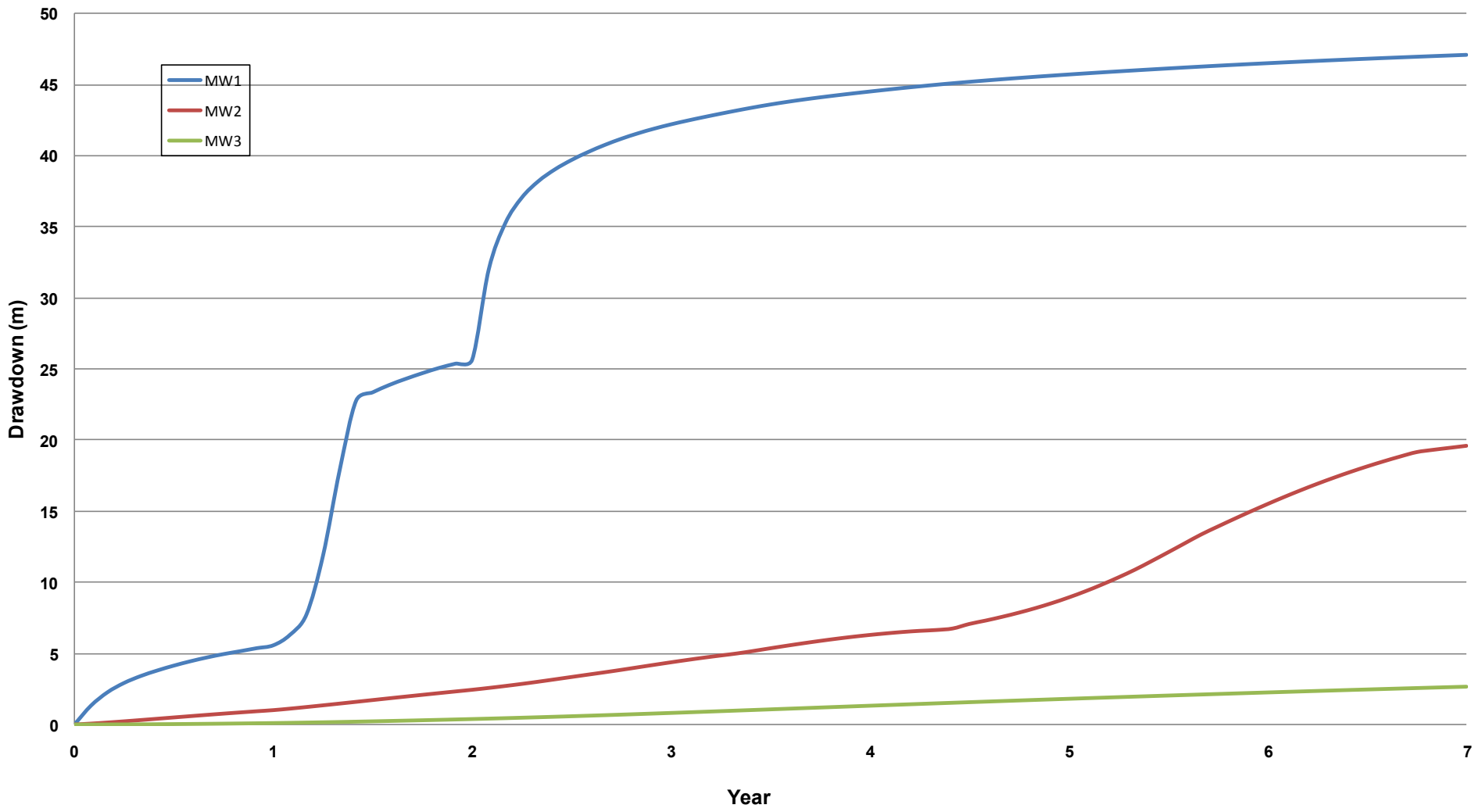


Figure 30: Base Case Model Predicted Time-Drawdown Plot at Three Selected Locations.

4.7.3 Results

Predicted Mine Inflow Rate

The base-case prediction shows that the total groundwater inflow rate changes from 6,600kL/d for the first year of mining, decreasing to about 3,200kL/d in year four and increasing to about 8,900kL/d in year six (Figure 26). The reduction in groundwater flow rate in year four is because pumping of Pit F East has declined due to the water level already being dewatered to the base of the pit in year three. Also, E South pit dewatering does not commence until year five. The flow rates presented in Figure 26 include groundwater that is stored within the rock-mass of the ore body, as well as groundwater entering from the sides and floors of the pits. Groundwater inflow into the pits from the sides and floors for both pits are presented in Figure 27.

Given the size of the pit void and evaporation rates in the area, most of the water is expected to evaporate from the pit surface. Effective dewatering by using dewatering bores is likely to be limited, unless fractured zones with higher hydraulic conductivity values are discovered during mining. The dewatering will most likely be undertaken by pumping from in-pit sumps.

Predicted Groundwater Drawdown

Figure 28 shows the 5.0m drawdown contour interval and Figure 29 shows the 1.0m drawdown contour interval (from 1.0 to 5.0m drawdown only). The predicted drawdown values of 5.0m and 1.0m are located within 0.9km and 1.2km respectively from the edge of the mine pits at the end of a seven year period. Hence, the model predicts that the impact of mining on lowering the regional water table is minimal and localised. The localised impact on lowering the water table is primarily due to the low permeability (K) of the material surrounding the mine site.

The time-drawdown graph at three selected locations (MW1, MW2 and MW3) (Figures 28 and 29) near Pit F East is presented in Figure 30.

Predicted Impact on Surface Water Courses

The potential impact on surface water bodies due to pit dewatering is predicted to be limited.

The impact on rivers from mine dewatering has been assessed by comparing the net river leakage rate pre- and post-mining. The pre-mining steady-state net river leakage rate was 3,747 kL/d, which only reduces to 3,642 kL/d post-mining. This small reduction in river leakage reflects the removal of the Towns River Creek from the model during mine dewatering, as this section will have to be diverted during mining. The reduction in net river leakage of 2.8% is considered to be minor in terms of impact to the surface water course. This is consistent with the conceptual understanding of the site, where the regional water table is located below the river bottom elevation, which means further reduction in water table elevation does not induce more leakage from the river to the aquifer.

The model-predicted base case flow rates are also provided in Table 7, together with the sensitivity analysis (Section 4.4.3). It should be noted that the groundwater flow rates presented in Table 7 and in Section 4.4.3 include initial storage, as well as the groundwater coming from the sides (pit walls and floor) of the pits.

4.8 Sensitivity and Uncertainty Analyses

4.8.1 Sensitivity Analysis Method

A sensitivity analysis was undertaken to determine the effect of varying a range of parameter values on the predicted groundwater inflow rate and the extent of drawdown. The sensitivity analysis was conducted by varying one parameter (globally) at a time within its expected range, while maintaining all other parameters constant.

Using the Murray Darling Basin Commission (MDBC 2000) and the American Society for Testing and Materials (ASTM) D5611 (1994) methodology, the sensitivity grade of the model to each parameter can be classified as follows:

Type 1 sensitivity: Variation of parameter causes an insignificant change in the model calibration and conclusions. Type I sensitivity is of no concern because the modelling conclusion will remain the same regardless of the value of the parameter input.

Type 2 sensitivity: Variation of parameter causes a significant change in the model calibration but insignificant changes to model conclusions. Type II sensitivity is of no concern because the modelling conclusion will remain the same regardless of the value of the parameter input.

Type 3 sensitivity: Variation of parameter causes a significant change in both the model calibration and conclusions. Type III sensitivity is of no concern because, although the modelling conclusions change as a result of varying the parameter input, the parameter values result in the model being uncalibrated.

Type 4 sensitivity: Variation of a parameter causes a significant change in the model conclusions but produces an insignificant change to the calibration. Type IV sensitivity can invalidate model results as the modelling conclusions can change despite the model being considered to be calibrated.

The Relative Percent Difference (RPD) of groundwater discharge rates between the base-case simulation and subsequent simulations was calculated to quantify the model's sensitivity to various parameters. The RPDs were then used to determine the sensitivity grade of the model to each parameter. Table 7 presents the RPD ranges and their interpreted sensitivity type.

Table 7: Sensitivity Type and Interpretation.

Relative Per Cent Difference of Flow Rate	Interpretation
RPD < 10%	Not sensitive
10% < RPD < 25%	Low sensitivity
25% < RPD < 50%	Moderate sensitivity
50% < RPD < 100%	High sensitivity
RPD > 100%	Very high sensitivity

4.8.2 Parameter Changes

The following parameter changes were applied during the sensitivity analysis:

Hydraulic Conductivity

The hydraulic conductivity (K) was changed globally (increased and decreased by a factor of two) and specifically for the Sherwin Ironstone Formation (increased and decreased by a factor of ten). Both the horizontal and vertical K values were changed as part of the sensitivity analysis.

Recharge

Recharge rates were doubled and halved throughout the model domain.

Evapo-transpiration (ET) Extinction Depth

The extinction depth of ET was increased to 15m and decreased to 2.0m.

Storage

Specific yield was doubled and halved for all formations.

Boundaries

As the model boundaries were located sufficiently far from the mine site, these were not changed during the sensitivity analysis.

4.8.3 Sensitivity Analysis Results

Table 8 shows the predicted groundwater inflow by changing various parameters as part of the sensitivity analysis. Figure 31 shows the impact of parameter changes on pre-mining model calibration. The predicted drawdown contours are presented in Appendix 2 of the RPS modelling report. The model-predicted sensitivity analysis of flow as part of the sensitivity analysis is presented in Table 8.

As shown in Figure 32 and Table 8, the model-predicted inflow rates to the proposed mine pits are most sensitive to the change in specific yield value. The model-predicted flow rate increases by a maximum of 67% compared to the base case when the specific yield value is doubled. However, the extent of the drawdown contours reduces by 33% (5.0m drawdown contours reduce to about 0.6km from the base case value of about 0.9km) over the seven year period. A reduction in specific yield value reduces the groundwater inflow rate, but increases the extent of drawdown. Decreasing the specific yield value by a

factor of two decreases the predicted flow rate by up to 38% but the extent of the 5.0m drawdown contour increases to about 1.2km.

An increase in the K value by a factor of two increases the predicted flow rate to the proposed mine pits by up to 37%. Also the extent of the 5.0m drawdown contour increases to about 1.2km from the base case value of 0.9km. As expected, the decrease in K value by a factor of two decreases the predicted mine inflow rate by up to 24%. Similarly, the extent of 5.0m drawdown reduces to about 0.6km which is a decline of up to 33% from the bases case value of 0.9km.

A ten-fold increase and decrease in the K values of the Sherwin Ironstone Formation predicted the groundwater inflow to the pit to increase and decrease by up to 65% and 44% respectively. However, the decrease in the K value of the Sherwin Ironstone Formation by a factor of 10 did not change the extent of the predicted drawdown value substantially, the increase in the K value by a factor of 10 increased the extent of the 5.0m drawdown contour to 2.0km. This is the largest extent of drawdown out of all the sensitivity analysis runs undertaken.

The model-predicted groundwater inflow rate and the extent of drawdown did not change while increasing and decreasing the recharge value by a factor of two. Hence, this parameter is not sensitive to the model outcome. This is due to the very low recharge values and the low K material inhibiting inflow of recharge water into the pit. This also indicates minimal change in seasonal groundwater inflow.

Similarly, increasing and decreasing the ET extinction depth to 15m and 2.0m did not change the pit inflow or drawdown rate significantly. There was a reduction of pit inflow by up to 4% when the ET extinction depth was increased to 15m and there was an increase in pit inflow by only about 1% when the ET extinction depth was made 2.0m. Hence, this parameter is not sensitive to the model outcome, provided the ET rate remains the constant.

The parameter sensitivity (in relation to the RMS Error) and sensitivity ranking are presented in Tables 9 and 10 respectively.

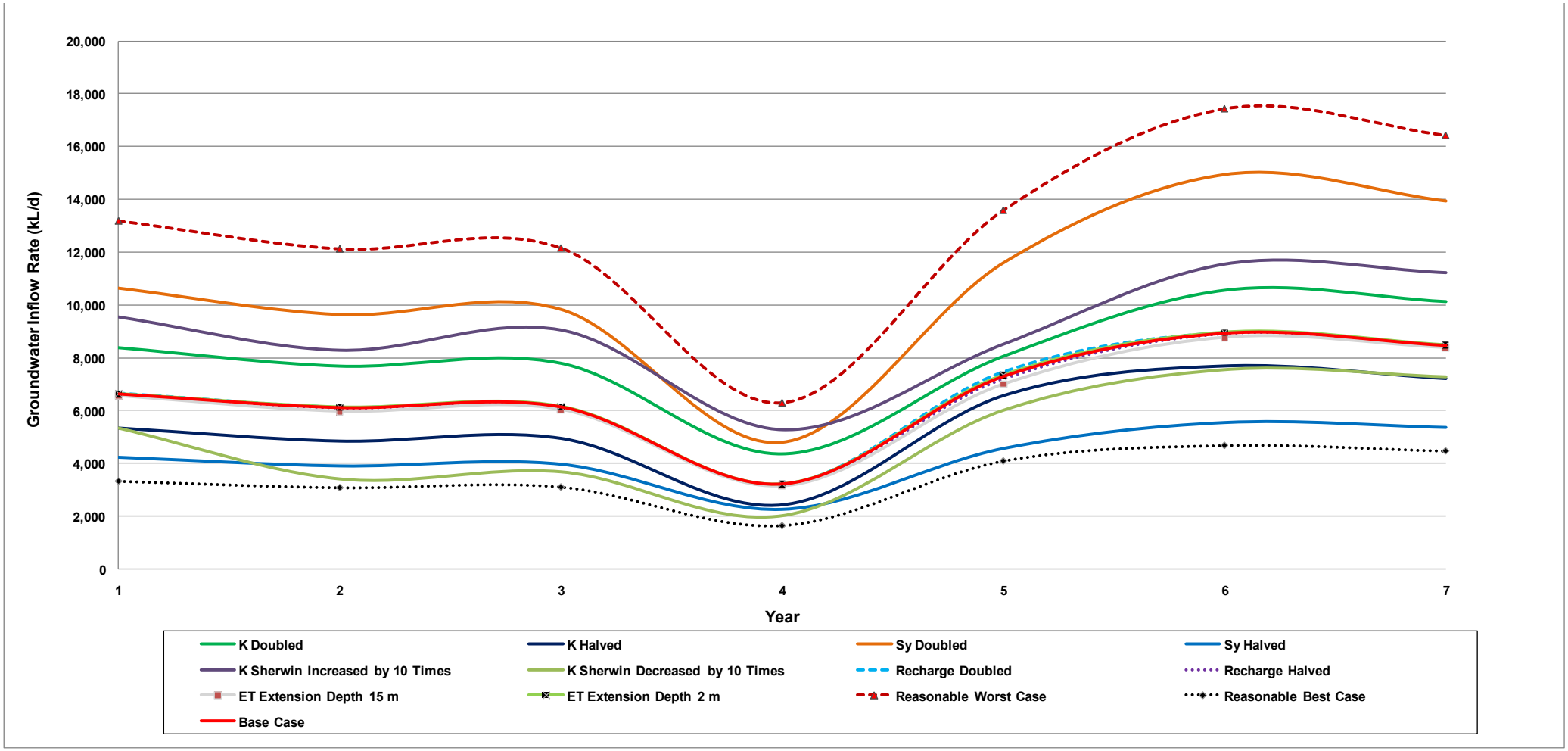


Figure 31: Sensitivity Analysis of Predicted Total Groundwater Inflow Rate.

Table 8: Sensitivity Analysis of Predicted Pit Inflow Rate and Drawdown.

Sensitivity Case	Year	Model Predicted Groundwater Inflow Rate (kL/d)			Extent of Drawdown from the Pit(km)		% Change from the Base Case	
		Zone 2 (F East)	Zone 3 (E East and E South)	Total for Zone 2 and 3 (F East, E East and E South)	5 m contour	1 m contour	Total Flow Rate	5 m Drawdown Contour
Base Case	1	6,614	4	6,618			N/A	
	2	5,616	482	6,098			N/A	
	3	5,551	575	6,125			N/A	
	4	2,549	650	3,199			N/A	
	5	2,110	5,172	7,282			N/A	
	6	1,857	7,063	8,921			N/A	
	7	1,685	6,773	8,458	0.9	1.2	N/A	N/A
K Doubled for all formations	1	8,381	6	8,387			27	
	2	7,042	649	7,691			26	
	3	7,011	787	7,798			27	
	4	3,469	905	4,374			37	
	5	2,886	5,176	8,062			11	
	6	2,541	8,015	10,557			18	
	7	2,320	7,808	10,129	1.2	1.5	20	33
K Halved for all formations	1	5,332	3	5,335			-19	
	2	4,473	369	4,841			-21	
	3	4,509	437	4,946			-19	
	4	1,944	486	2,430			-24	
	5	1,555	5,004	6,560			-10	
	6	1,359	6,323	7,683			-14	
	7	1,230	5,976	7,206	0.6	0.9	-15	-33
Sy Doubled for all formations	1	10,628	5	10,633			61	
	2	8,898	733	9,630			58	
	3	8,959	869	9,828			60	
	4	3,822	967	4,789			50	
	5	3,039	8,552	11,591			59	
	6	2,640	12,298	14,939			67	
	7	2,375	11,562	13,937	0.6	0.9	65	-33
Sy Halved for all formations	1	4,216	3	4,219			-36	
	2	3,566	326	3,892			-36	
	3	3,560	397	3,957			-35	
	4	1,796	457	2,253			-30	
	5	1,513	3,038	4,550			-38	
	6	1,346	4,182	5,528			-38	
	7	1,239	4,104	5,344	1.2	1.5	-37	33
K Increased by 10 times for Sherwin	1	9,526	23	9,549			44	
	2	7,376	909	8,284			36	
	3	7,969	1,085	9,054			48	
	4	4,011	1,256	5,267			65	
	5	3,441	5,073	8,514			17	

Sensitivity Case	Year	Model Predicted Groundwater Inflow Rate (kL/d)			Extent of Drawdown from the Pit(km)		% Change from the Base Case	
		Zone 2 (F East)	Zone 3 (E East and E South)	Total for Zone 2 and 3 (F East, E East and E South)	5 m contour	1 m contour	Total Flow Rate	5 m Drawdown Contour
	6	3,088	8,467	11,556			30	
	7	2,835	8,396	11,232	2	2.5	33	122
K Decreased by 10 times for Sherwin	1	5,347	1	5,349			-19	
	2	3,170	251	3,422			-44	
	3	3,388	302	3,690			-40	
	4	1,680	347	2,028			-37	
	5	1,458	4,564	6,022			-17	
	6	1,325	6,235	7,559			-15	
	7	1,234	6,053	7,287	0.5	1	-14	-44
Recharge Rate Doubled Everywhere	1	6,658	4	6,662			1	
	2	5,642	487	6,128			0	
	3	5,566	576	6,142			0	
	4	2,559	651	3,210			0	
	5	2,118	5,351	7,469			3	
	6	1,864	7,093	8,957			0	
	7	1,690	6,788	8,478	0.9	1.2	0	0
Recharge Rate Halved Everywhere	1	6,592	4	6,595			0	
	2	5,603	480	6,083			0	
	3	5,543	574	6,117			0	
	4	2,544	649	3,194			0	
	5	2,107	5,079	7,186			-1	
	6	1,854	7,048	8,902			0	
	7	1,682	6,765	8,447	0.9	1.2	0	0
ET Extinction Depth made 15 m	1	6,557	3	6,560			-1	
	2	5,523	446	5,969			-2	
	3	5,479	560	6,039			-1	
	4	2,497	639	3,136			-2	
	5	2,067	4,929	6,996			-4	
	6	1,820	6,952	8,772			-2	
	7	1,652	6,732	8,384	0.9	1.2	-1	0
ET Extinction Depth made 2 m	1	6,625	4	6,628			0	
	2	5,637	487	6,124			0	
	3	5,571	577	6,149			0	
	4	2,564	652	3,216			1	
	5	2,122	5,212	7,335			1	
	6	1,867	7,085	8,952			0	
	7	1,693	6,779	8,472	0.9	1.2	0	0
Reasonable Worst Case	1	13,181	7	13,189			99	
K Doubled and Sy Doubled	2	11,168	960	12,128			99	

Sensitivity Case	Year	Model Predicted Groundwater Inflow Rate (kL/d)			Extent of Drawdown from the Pit(km)		% Change from the Base Case	
		Zone 2 (F East)	Zone 3 (E East and E South)	Total for Zone 2 and 3 (F East, E East and E South)	5 m contour	1 m contour	Total Flow Rate	5 m Drawdown Contour
	3	11,020	1,144	12,164			99	
	4	5,011	1,294	6,305			97	
	5	4,122	9,469	13,591			87	
	6	3,605	13,828	17,433			95	
	7	3,251	13,175	16,426	0.9	1.2	94	0
Reasonable Best Case	1	3,327	2	3,329			-50	
K Halved and Sy Halved	2	2,840	244	3,084			-49	
	3	2,817	290	3,107			-49	
	4	1,319	328	1,648			-48	
	5	1,106	2,987	4,093			-44	
	6	985	3,696	4,681			-48	
	7	903	3,568	4,471	0.9	1.2	-47	0

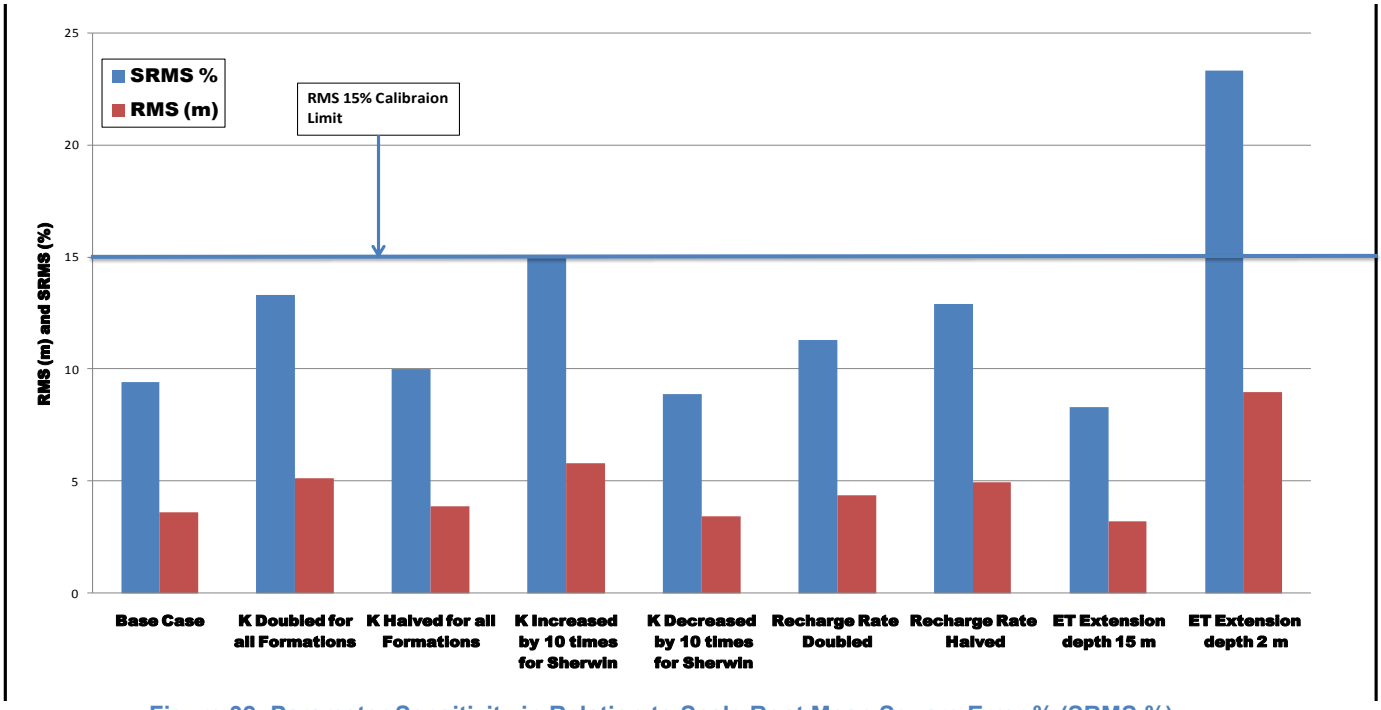


Figure 32: Parameter Sensitivity in Relation to Scale Root Mean Square Error % (SRMS %).

Table 9: Root Mean Square Error and Scaled RMS for Sensitivity Analysis Runs.

Run No	Case	RMS Error (m)	Scaled RMS %
WDR38	Base Case	3.62	9.4
WDR60	K Doubled for all Formations	5.13	13.3
WDR61	K Halved for all Formations	3.86	10
WDR62	K Increased by 10 times for Sherwin	5.79	15
WDR63	K Decreased by 10 times for Sherwin	3.44	8.9
WDR64	Recharge Rate Doubled	4.37	11.3

Run No	Case	RMS Error (m)	Scaled RMS %
WDR65	Recharge Rate Halved	4.97	12.9
WDR66	ET Extension Depth 15 m	3.19	8.3
WDR67	ET Extension Depth 2 m	8.99	23.3

Table 10: Sensitivity Ranking, Classification and Type.

Case	Overall Sensitivity Ranking	Sensitivity Classification	Overall Sensitivity Type
Base Case	N/A	N/A	N/A
Specific Yield	1	Highly Sensitive	N/A
Hydraulic Conductivity	2	Moderately Sensitive	Type 4
ET Extension Depth	3	Not Sensitive	Type 1 and 2
Recharge Rate	4	Not Sensitive	Type 1

The sensitivity analysis indicates that the model is insensitive (Type 1 Sensitivity) to the recharge rate and increase in ET extinction depth. This Type 1 sensitivity is of no concern, because the modelling conclusion is the same with variations in these parameter inputs. Type 2 sensitivity was applicable for the decrease in ET extinction depth. This is also of no concern, because the model predicted inflow rate and drawdown value did not change with the change in this parameter.

An increase and decrease of K values produced Type 4 sensitivity. This requires more attention as model uncertainty in modelling is high with Type 4 sensitivity. Although the Type 4 sensitivity is evident, the model results are considered defensible. This is because the parameters used in the prediction are higher than the aquifer test results especially when increasing the Sherwin Ironstone Formation by a factor of 10 (the upper value of tested K was 0.05 m/d, VDM 2011). The highest K value of 0.2 m/d used for the Sherwin Ironstone Formation increased the 5.0 m drawdown contours to 2 km and the inflow rate increased 65%.

Sensitivity type, as part of the sensitivity analysis, is not applicable for the specific yield value because the model was calibrated in steady state. However, the pit inflow rates are highly sensitive to changes in this value.

4.8.4 Uncertainty Analysis

Uncertainty Analysis Method

A level of uncertainty exists with all environmental data collection and modelling. An uncertainty analysis was performed by running a suite of simulations using a combination of parameters to determine the effect these have on the predicted outcomes.

The uncertainty analysis was undertaken in conjunction with the sensitivity analysis to quantify the possible total errors associated with the model predictions. The uncertainty analysis involved the comparison of flow rates predicted using the following generic simulations:

Simulation 1: The applied model which incorporates conservative parameters which are considered to reflect the "worst reasonable case"

Simulation 2: Using a combination of all the least conservative "best reasonable case" parameters.

The "worst and best reasonable cases" scenarios are within the calibrated range (i.e., <15% SRMS). A "worst reasonable case" scenario is considered to refer to parameter values that would typically result in a high flow rate (such as high K values), while a "best reasonable case" scenario is considered to refer to parameter values that would result in a low flow rate (such as low K values).

For this uncertainty analysis, the most sensitive model parameters were incorporated such that the "worst reasonable casse" consisted of doubling the K and Sy values, while the "best reasonable case" included halving the K and Sy values.

To quantify the model uncertainty, the relative groundwater flow rate was determined between:

- Simulation 1 and base case.
- Simulation 2 and base case.

Uncertainty Analysis Results

The relative percentage difference (RPD) of flow rates for the worst reasonable case increased by ~100% (doubled) compared to the base case. The RPD of flow rates for the best reasonable case decreased by ~50% (halved) compared to the base case.

Doubling and halving the K and Sy values did not extend increase the drawdown extent significantly because they cancel each other out in relation to drawdown extent. Hence, for drawdown extent, increasing the K value of the Sherwin Ironstone by 10 times (which was part of the sensitivity analysis) can be considered as the worst reasonable case for drawdown. For the case of increasing the Sherwin Ironstone K value by ten-fold, the extent of drawdown increased by 122%.

Even for this reasonable worst case, the extent of the 5.0m drawdown contours is not predicted to extend beyond 2.0km from the edge of the pit, hence the impact can be considered as localised. In terms of flow rate, while doubling the K and specific yield values can increase the flow rate by up to 100%, most of the increase is due to the removal of water from storage, hence the impact on pit dewatering can be considered minimal after the aquifer storage of the mined rock is depleted.

5 Water Quality

Groundwaters in the study area are characterised by circum-neutral pH, with an average of 6.5 ranging from 4.6 to 7.6 (Table 11). The highest electrical conductivity (EC) of 30.95mS/cm pertains to bore RBGW11 and the lowest of 0.83mS/cm to bore RBGW04. Total Dissolved Solids (TDS) concentrations average 3.1g/L ranging from 0.05g/L to 17.0g/L.

Major cations including calcium, magnesium, potassium and sodium have averages ranging from 34.6mg/L (potassium) to 724.1mg/L (sodium) (Table 10). High concentrations of sodium, particularly in bores RBGW02 (2,440mg/L) and RBGW11 (4,330mg/L), indicate that localised water bodies, particularly those found near the Towns River catchment system, are relatively saline waters. Magnesium concentrations in these waters are also relatively high concentrations of 688mg/L and 1430mg/L at bores RBGW02 and RBGW11, respectively.

Sulfate and chloride concentrations are also very high for bore RBGW02 and RBGW11. Whilst chloride in bore RBGW02 is about 5,680mg/L, in bore RBGW11 the concentration is 2,030mg/L. Salinity concentrations in both bores are 9.4 and 15.8ppt respectively.

Table 11: Water Quality Measured During Slug and Pump Tests.

Site	pH	Temp	EC	TDS	Ca	Mg	Na	K	SO_4^{2-}	Cl
	pH units	°C	µS/cm	mg/L						
RBGW1	7.1	33.3	7,550	4,230	94	239	888	43	2	2,010
RBGW2	6.1	33.2	18,800	10,560	71	688	2,440	120	549	5,680
RBGW3	7.6	33.7	1,580	879	31	37	206	14	62	318
RBGW4	4.6	33.5	83	46	<1	2	7	<1	<1	15
RBGW5	6.2	34.6	262	144	2	17	5	5	3	10
RBGW6	5.8	34.3	273	151	6	6	15	12	9	24
RBGW7	6.4	34.3	289	160	4	16	10	6	16	13
RBGW8	5.9	34	220	122	1	6	14	8	1	18
RBGW9	7.1	34.4	276	152	9	16	10	7	<1	20
RBGW10	7.5	34.4	446	246	7	15	40	11	2	45
RBGW11	6.7	34.6	30,950	17,010	355	1430	4,330	120	2,030	8,790
Average	**6.5**	**34.0**	**5,521**	**3,064**	**58**	**2,245**	**724**	**35**	**297**	**1,540**
Maximum	**7.6**	**34.6**	**30,950**	**17,010**	**355**	**1,430**	**4,330**	**120**	**2,030**	**8,790**
Minimum	**4.6**	**33.2**	**83**	**46**	**1**	**2**	**5**	**5**	**1**	**10**

Filtered trace metals including beryllium, cadmium, chromium, cobalt, lead and vanadium were all below their respective limits of reporting (LoRs). Arsenic, barium, copper, manganese, nickel and zinc are mostly above of their LoRs but below of their NEPM-Health investigation levels (HIL) (NHMRC, NRMMC 2011). However, barium at bore RBGW1 exceeds its HIL (2.0mg/L) with a high concentration of 9.09 mg/L and this appears to naturally originate within the sandstone rocks. Several investigators (e.g. Gilkenson et al. 1983) have indicated that the highest barium concentrations are also typical of confined aquifers at which dissolved sulfate concentrations are depleted by anaerobic microbial reactions. Sulfate concentration in borehole RBGW1 is 2.0mg/L. Owing to its natural background, iron concentrations also substantially exceeds their NEPM-Aesthetic investigation levels (0.3mg/L) with an average 4.1mg/L ranging from <0.05mg/L at bores RBGW10 and RBGW03 to 10.1 in bore RBGW08.

To achieve a hydrogeochemical data assessment, boreholes according to their location were distributed in three groups, these being:

- Group 1: bores RBGW01, RBGW02 and RBGW11 (all bores within the Towns River catchment).

- Group 2: bores RBGW03, RBGW04 and RBGW05 (covers southern portion of E-East and North portion of E-South project areas).
- Group 3: bores RBGW06, RBGW07, RBGW08, RBGW09 and RBGW10 (covers southern portion of E-South and northern portion of D-North project areas).

Groundwater, on the basis of their calcium and magnesium concentrations, can be classified as ranging from very soft to very hard waters (Table 12). Whilst Group 1 waters are classified as very hard Group 2 and 3 waters are very soft to moderately soft waters. However, waters from RBGW02 are identified as hard waters and appear to be geochemically correlated with waters from Group 1.

Table 12: Groundwater Classification on Relation to Calcium and Magnesium Concentrations.

Bore ID	Group	Hardness (mg/L $CaCO_3$)	Classification
RBGW01	1	1218.64	Very Hard
RBGW02	1	3009.66	Very Hard
RBGW03	2	229.73	Hard
RGBW04	2	8.23	Very Soft
RBGW05	2	74.98	Moderately Soft
RBGW06	3	39.68	Very Soft
RBGW07	3	75.86	Moderately Soft
RBGW08	3	27.20	Very Soft
RBGW09	3	88.34	Moderately Soft
RBGW10	3	79.23	Moderately Soft
RBGW11	1	5974.45	Very Hard

Hydrogeochemical processes, as expressed by Piper diagram (Figure 33), were also evaluated and indicate that:

- All groundwater samples are waters of Cl + SO_4 type.
- Three water samples, one from Group 2 (RBGW03) and two from Group 3 (RBGW07 and RBGW09), are reverse ion-exchange $CaCl_2$ water types with no particular cation dominant. Alkaline earths exceed alkali metals and strong acidic anions exceed weak acidic anions. These waters can also remain with permanent hardness, but this would be dependant of their interaction with lithological characteristics of the areas through which they circulate.
- Eight water samples (all from Group 1 and 7 between 2 and 3) are end point waters, with NaCl water type dominant. Alkali metals exceed alkaline earths and strong acidic anions exceed weak acidic anions in these waters. These waters generally create salinity problems.

During pump testing, pH at RBGW08 increased slightly from 8.07 to a maximum of 8.98 after about 13 hours of continuous pumping, whilst ECs decreased slightly (Figure 34). At RBGW07, pH decreased slightly from 7.26 to approximately 6.90, whilst the ECs increased slightly from 0.52 mS/cm to about 0.60 mS/cm. Short term groundwater quality behaviour suggests that with time, pH in groundwater within the quartz sandstone and siltstone and mudstone domains may increase to become slightly alkaline. Groundwater in deeper lithological domains, particularly those hosted by the HIO body; may with time remain circumneutral or

decrease to slightly acidic waters. These observations are to be verified during monitoring of groundwater during mining activities.

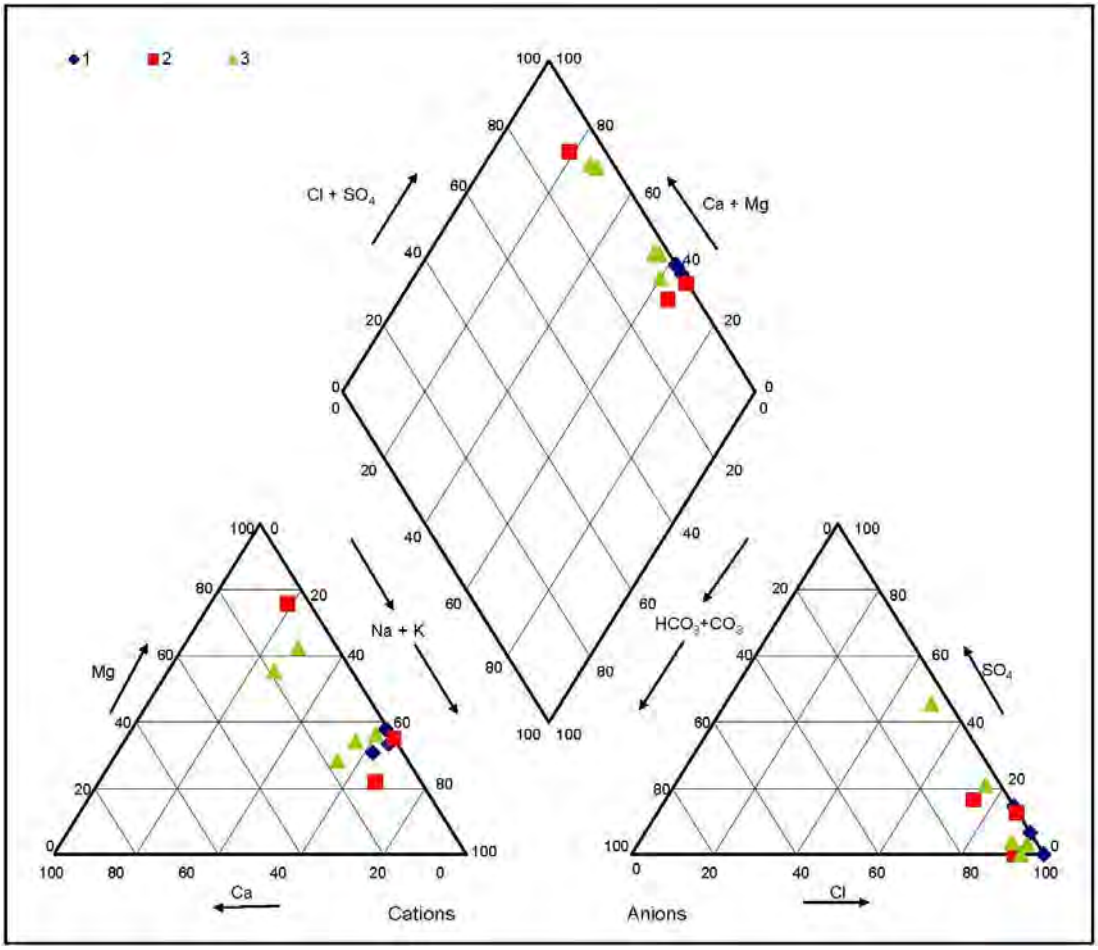


Figure 33: Piper Diagram for Groundwaters within WDRL.

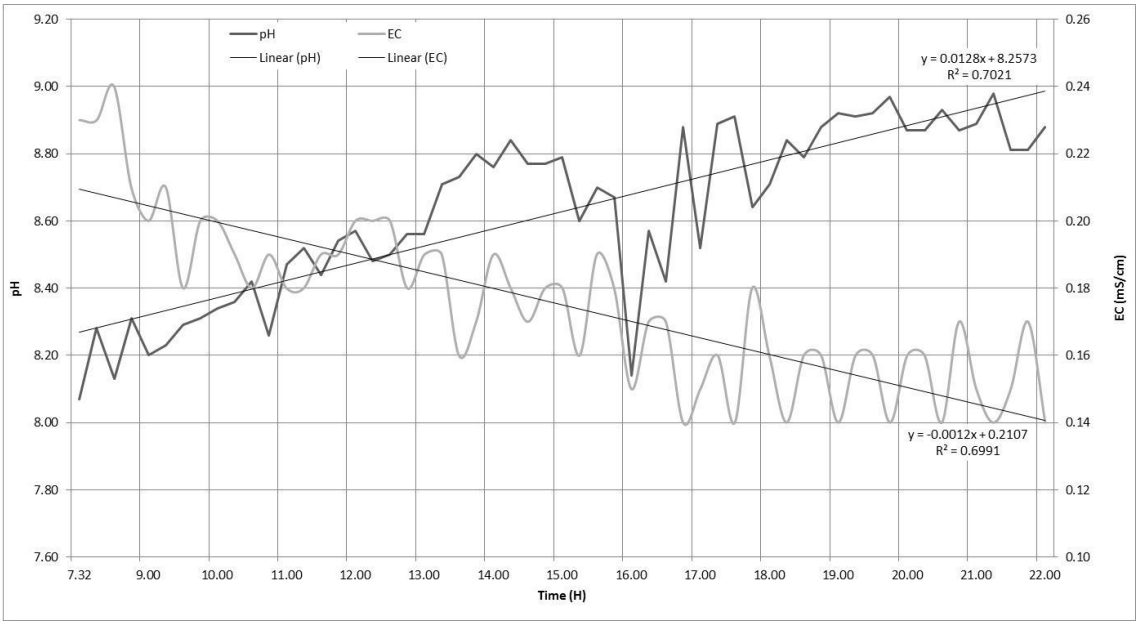


Figure 34: pH and EC (mS/cm) during the RBGW08 Pump Test.

6 Operational Groundwater Monitoring Program

Groundwater levels and field water quality are to be surveyed monthly whilst samples for laboratory analysis of water quality are to be obtained at quarterly intervals from all monitoring bores located both upstream and downstream of the mine site. The data and information gathered during these monitoring programs will be used to assess potential impacts of mining operations on downstream water qualities using comparisons against ambient water qualities and relevant standards and guidelines, trend diagrams, etc. A groundwater monitoring program is presented below, including baseline monitoring locations (Figure 9). The monitoring program are to be finalised prior to commencement of mining activities, in consultation with relevant regulatory agencies (i.e. DoR, NRETAS) including locations for shallow and deep groundwater monitoring bores at specific infrastructure locations i.e. WRDs, plant, ore stockpiles, etc,

It is proposed that site specific trigger values be developed using ambient water qualities from baseline monitoring and reference sites.

Table 13: Proposed Groundwater Monitoring program.

Monitoring Sites/Action	Frequency	Analytes
RBGW01 to RBGW11 Additional shallow and deep bores up- and downstream of specific infrastructure i.e. WRDs, plant, ore stockpiles, etc,	Monthly	Groundwater level. Field water quality: in-situ pH and electrical conductivity (EC).
RBGW01 to RBGW11 Additional shallow and deep bores up- and downstream of specific infrastructure i.e. WRDs, plant, ore stockpiles, etc,	Quarterly	Groundwater level. Field water quality: in-situ pH and electrical conductivity (EC). Laboratory: Total acidity and total alkalinity. Major anions (Cl, SO_4, CO_3/HCO_3, NO_3) and cations (Ca, Mg, Na and K) and fluoride. Sulphide S. Dissolved metals: As, Cd, Cr, Cu, Mn, Ni, Pb, Zn, Fe.
Reporting	Monthly and quarterly	Tabulations and trend diagrams. Mass transport model.
Response	Monthly and quarterly	Variations by more than 10% trigger further assessment, re-sampling and site investigations to ascertain cause, impact, remediation, preventative action and contingency measures.

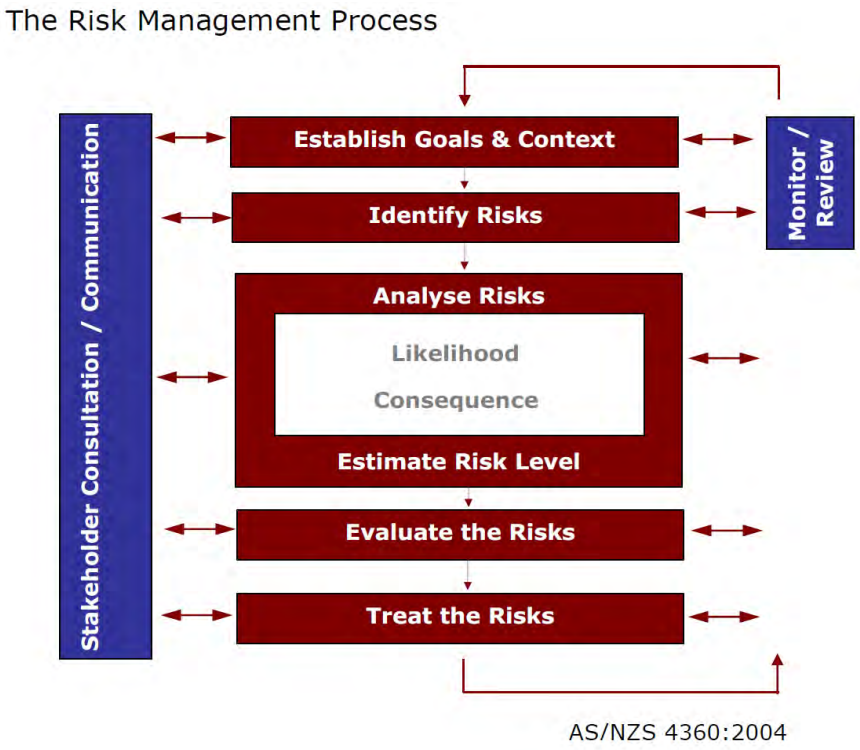
7 Groundwater Risk Assessment

7.1 Risk Assessment Framework

7.1.1 Definitions

Risk: The possibility of mining impacting upon the ground water regime measured in terms of their likelihood and consequences.

Risk Management:



Risk Manager/s: Person/s responsible for the Groundwater Risk Management System.

7.1.2 Establish Risk Context

The risk of mining impacts on groundwater need to be properly understood and assessed based on its relevance in the context of the development of the mine and its operating environment. Manmade, technical and natural processes should be taken into consideration for this process. Manmade processes refer to external and/or internal social processes and relationships with the wider community:

- External/internal stakeholders.
- Legal, regulatory and financial consequences.
- Susceptibility to Mine Economic Forecasts and/or Project Sustainability and/or to external influences.
- AMD risk manager.
- Team roles and responsibilities.
- Technical expertise.
- Objectives, goals and strategies of the overall project.

Natural processes refer to natural and environmental processes in relation to the wider mine development:

- Baseline environmental and geological conditions.
- Presence of any valued landforms, cultural and heritage items of significance, valued amenities and endemic or rare flora and fauna.
- Physical and chemical properties of waste/ore rock materials.
- Potential reactivity of sulphur and alkaline mineral materials.
- Water-solid interaction processes.

Technical processes refer to:

- Design and construction of open pits, processing plant and other operational infrastructure.
- Design and construction of solid and liquid waste infrastructure and disposal methodologies such as waste rock dumps (WRD).
- Contamination that could potentially be generated and released into the wider environment.
- Environmental pathways through which contaminants can move or be transported within and outside of lease areas (e.g. groundwater, surface waters, etc.).

7.1.3 Risk Criteria

Groundwater risk criteria may be expressed in terms of:

- Environmental implications.
- Social perception implications.
- Iron ore resource recovery implications.
- Financial implications.

7.1.4 Risk Management Context (RMC)

The risk management context is identified in terms of the ability required to manage groundwater risks.

7.2 Risk Identification

Groundwater risk identification needs to be comprehensive and systematic, with all potential risks being considered, whether manmade or natural. Each risk needs to be identified in terms of the risk criteria as follows:

- Environmental risks, including but not limited to:
  - Environmental and sensitive receptors and pathways to receiving environments such as GDEs.
  - Ground-surface water interactions.
  - Dewatering to facilitate mining: drawdown of groundwater levels, yields and quality.
  - Release and transport of contaminants from mine infrastructure such as WRDs, ore stockpiles, surface impoundments for water management.
- Project specific risk:
  - Achievement of main objectives.
  - Achievement of key milestones.
  - Available resources such as technical/non-technical people, equipment, money.
  - Available materials to be used for remediation processes and measures.
- Social risks:
  - Internal and external stakeholders.

- Wider community.

- Financial risks:
  - Financial capabilities.
  - Financial back up by shareholders.

Risk identification shall be an ongoing process with regular bi-monthly workshops held with relevant team members. A manager shall be responsible for the risk management process.

7.2.1 Existing Risk Data

Existing data and information are to be used to commence the risk identification process. Sources should include but not limited to:

- Geological investigations.
- Surface/groundwater investigations.
- Acid Mine Drainage (AMD) investigations.
- Generic examples from similar projects/activities.
- Typical risks identified by external authorities.
- Risk workshops.

7.3 Analyse Risks

The risk analysis includes assessments and identified risks and consequences, and provides input to decisions about prevention, management and treatment of impacts and risks to ground water. The risk analysis considers the source of a risk, its consequences, the likelihood of its occurrence and combine all three as a risk level rating. Risks are analysed to determine the chance of the risk occurrence (likelihood) and impact (consequences) from the risk should it occur. The following quantitative factors are assessed and addressed:

- ***Adequacy of existing control measures***: This shall be a quantitative measure of existing management systems and controls to determine if they are adequate to minimise the likelihood of residual risk occurrence.

Table 14: Adequacy of Existing Risk Controls.

Adequacy of Existing Controls		
High	4	Our existing controls are adequate and will prevent or provide adequate warming of, and impending event.
Moderate	3	Our existing controls are reasonable and should provide some warming of an impending event.
Low	2	Our existing controls are not sufficient to provide adequate warning.
Nil	1	We have no controls in place in respect of this risk event.

- ***Likelihood of occurrence:*** This shall be a quantitative measure of the likelihood or probability of inherent risk occurrence as indicated below.

Table 15: Likelihood of Occurrence.

Likelihood	Rating	Criteria
Improbable	1	Most unlikely to occur
Unlikely	2	Low frequency of occurrence is likely
Possible	3	Occurrence is possible
Likely	4	Occurrence is likely
Almost Certain	5	Occurrence is almost certain

- ***Uncertainty Description:*** This shall be a quantitative measure of whether the likelihood or probability of factors and materials with risk occurrence has been analysed and predicted.

Table 16: Uncertainty Description.

Uncertainty Description		
High	4	My prediction is a guess.
Moderate	3	My prediction feels right, but I'm unsure.
Low	2	My prediction is based on experience, and is reasonable.
Nil	1	I have little or no doubt about the prediction

- ***Consequence:*** This shall be a quantitative measure of the consequence or impact should the risk event occur. For example this should measure:

Table 17: Public Outrage Factor.

Public Outrage Factor		
High	4	Public pressure sufficient to halt the project, attract local and non-local opponents, cause lengthy delays and increase environmental investigations.
Moderate	3	Public pressure sufficient to attract only local persons, cause delays and increase environmental investigations.
Low	2	Public pressure from local people which can be resolved without delays.
Nil	1	None, if very little public reaction expected.

- ***Level of Risk:*** The likelihood and consequence of the risk shall be combined to give an overall level of risk, based on the table below.

7.3.1 Risk Likelihood

The quantitative factors above shall be used to determine the likelihood ratings and ultimately the level associated with the risk.

7.3.2 Consequence Rating

The impact or consequence rating shows the impact on the project of the risk occurring. Each risk shall be individually rated as:

Table 18: Consequence Rating.

Consequence	Rating	Description					
		Mortality	Health	Environment	Cost	Production	Community Concern
Catastrophic	5	Many	Lethal	Very extensive	Very high	Several months	Very high
Major	4	A few	Toxic	Extensive	High	Several weeks	High
Moderate	3	One	Temporary illness	Localised	Moderate	A week	Moderately high
Minor	2	Severe injury	Irritation	Low	Low	A few days	Low
Insignificant	1	Injury	Mild irritation	Insignificant	Insignificant	One day	Insignificant

7.3.3 Hazard Rating and Uncertainty Factor

The risk level rating shall be determined from the following table, using the risk likelihood and risk consequence ratings allocated to a risk:

Table 19: Hazard Rating / Risk Consequence.

Risk Likelihood		Risk Consequence				
		Insignificant	Minor	Moderate	Major	Catastrophic
		1	2	3	4	5
Improbable	1	Low (1)	Low (2)	Low (3)	Low (4)	Significant (5)
Unlikely	2	Low (2)	Low (4)	Low (6)	Significant (8)	High (10)
Possible	3	Low (3)	Low (6)	Significant (9)	High (12)	High (15)
Likely	4	Low (4)	Low (8)	Significant (12)	High (16)	High (20)
Almost Certain	5	Low (5)	Significant (10)	High (15)	High (20)	High (25)

Risk Level	
Low	Low risk, monitor to ensure it does not change to significant or high
Moderate	Moderate risk, mitigation plan may be considered.
Significant	Significant risk, mitigation plan may be required.
High	High risk, mitigation planning is required.

The uncertainty factor shall be determined from the following table, using the uncertainty with likelihood and uncertainty with consequence:

Table 20: Uncertainty Factor.

Uncertainty with likelihood		Uncertainty with Consequence			
		High, H	Moderate, M	Low, L	Nil, N
		4	3	2	1
High, H	4	16	12	8	4
Moderate, M	3	12	9	6	3
Low, L	2	8	6	4	2
Nil, N	1	4	3	2	1

Low	High Uncertainty
Moderate	Moderate Uncertainty
Significant	Low Uncertainty
High	No Uncertainty

7.3.4 Hazard/Risk Rating

The hazard/risk rating shall be determined from the following table, using the public outrage factor and hazard rating:

Table 21: Hazard/Risk Rating.

Public outrage Factor		Hazard Rating			
		High, H	Significant, S	Moderate, M	Low, L
		13-25	7-12	5-6	1-4
High, H	4	52-100	28-48	20-14	4-16
Significant, S	3	39-75	21-36	15-18	3-12
Moderate, M	2	26-50	14-24	10-12	2-8
Low, L	1	13-25	7-12	5-6	1-4

Low	High Risk
Moderate	Significant Risk
Significant	Moderate Risk
High	Low Risk

7.4 Evaluate Risks

The risk manager shall be responsible for evaluating risks and determining what risk treatment is to be applied.

7.4.1 Risk Treatment Priority (RTP)

Assign each risk a RTP according to:

Table 22: Risk Treatment Priority.

Treatment Priority	Rating	Definition
Low	1	Monitoring and reviewing
Medium	2	All Significant level risks. Treatment completion date has been specified, but execution as resources are available.
High	3	High level risks whose consequences are rated as Major or Moderate. Treatment shall be scheduled for completion before the risk event is likely to occur.
Critical	4	High level risks whose consequences are rated as Catastrophic. Risk Treatment activity shall be scheduled on the project Critical Path, with completion before the event is likely to occur (if possible).
Closed	5	Risk Closed.

7.5 Treat Risks

Risk treatment involves identifying the range of options for treating risks, assessing the options, and preparing and implementing risk treatment plans.

7.5.1 Risk Treatment Options

The risk manager in consultation with relevant internal stakeholders shall decide on one or more of the following treatments for each quantified risk:

- ***Accept the risk:*** No action shall be required to reduce the likelihood or the consequence of the risk occurring. This option shall only be adopted for risks having low impact consequences and low likelihood of occurrence.
- ***Monitor the risk:*** The risk manager shall not proactively mitigate the risk, but monitor it to see whether it is more or less likely to occur as time goes on. This option may be adopted for serious risks that are not likely to occur.
- ***Mitigate the risk:*** In most cases, this shall be the approach taken. Proactive steps shall be taken if a risk has been identified to ensure that the likelihood or consequence (impact) of the risk is minimised in the event it does occur. When required, a system or procedure shall be put in place (or improved) to mitigate the risk.

7.6 Risk Mitigation

The risk manager in consultation with senior managers shall be responsible for approving the risk mitigation activities. The risk mitigation shall include existing procedure or developing new procedures which:

- Reduce the likelihood of occurrence and/or
- Reduce the consequences

Risk mitigation shall take into account the costs associated with proposed actions, effectiveness of proposed mitigation methodologies and the time required implementing them. All mitigation activities shall be reviewed regularly to determine their impact on the risk and their effectiveness.

- ***High Level Risks***: shall have a risk mitigation strategy for each high level risk that is identified, to ensure the risk is managed successfully.
- ***Significant Level Risks:*** shall be evaluated to determine if the impact is severe enough to warrant the creation of an AMD risk mitigation strategy, or if existing systems are sufficient.

- ***Low Level Risks:*** shall be evaluated to determine if they should be listed as assumptions or recognised as a potential for problems. Low level risks do not normally require a risk mitigation strategy.

For every high and significant risk, the strategy shall include a contingency for options available to the project in the event the risk eventuates.

7.7 Monitor and Review

The risk manager shall be responsible for monitoring and reviewing all risks to the groundwater regime. Changes in risk likelihood or consequence may result in change to a risk's level rating. Any risk whose level changes shall be re-evaluated.

Risk ratings shall be frequently updated to reflect the effect of control or mitigation strategies. The risk manager shall conduct reviews to ensure that mitigation strategies are effective.

Communication and consultation is essential to effective risk management. The risk manager shall ensure that all stakeholders involved in the risk management process have effective means of communication in place, and that appropriate consultation forums are established to ensure that risks are identified, assessed, and treated and reported up to the next level of management as efficiently as is practicable.

7.8 Groundwater Risk Assessment

A risk assessment for the management of impacts to groundwater is presented below in Table 23. The key risks pertain to:

- Impacts to groundwater quality from mining activities causing contamination of groundwater or release of contaminated groundwater to surface water.
- Groundwater drawdown associated with dewatering impacting the local and regional aquifers, flows in the Towns River and any other groundwater dependant ecosystems.

The environmental objective is to:

- Ensure that groundwater quality and quantity is protected both now and in the future, such that ecological health and the health, welfare and amenity of people and land uses are maintained.

with the view to:

- Maintain the quality of groundwater so that it complies with relevant standards and guidelines and beneficial use declarations.
- Groundwater monitoring, based on the known availability and extent of the groundwater resource, is sufficient to ensure that regional drawdowns do not occur and that regional groundwater quality is not impacted.
- Prevent contaminated water migrating off-site.

Brief comments with regard to the above pertain to:

- It is unlikely that possible ground water contamination will migrate off site during mining as infrastructure such as most ore stockpiles and WRDs are located upstream of the open pits. Modelling has demonstrated that groundwater flow will be towards the open pits which will intercept pre- and post-mining contamination, if any.
- Mine infrastructure such as the waste rock dump and ore stockpiles are to be constructed in accordance with best practice to inhibit infiltration and release of potentially contaminated waters. The geological profile is relatively impermeable, as evidenced by surface ponding whilst the ground water level is well below the surface, which provides ample opportunity to collect and treat contaminated waters from these facilities. There is no direct hydraulic connection between surface and ground waters and surface waters may slowly leak into underlying aquifers.
- Monitoring of groundwater level behaviour (i.e. rising levels may indicate seepage) coupled with deteriorating water qualities in strategically located shallow and deep bores will be used (trend diagrams, detailed tabulations with statistical parameters and mass transport modelling) to assess

whether contamination is taking place. The cause of such potential contamination is to be ascertained to determine the most appropriate remediation and preventative action. Where current measures are inadequate, additional and/or new measures are to be implemented to prevent further and possible future contamination.

- Contingency measures will include ascertaining of cause of contamination by detailed assessment and site specific investigations to determine the most appropriate remediation and preventative action. Where current measures and treatment trains are inadequate, provide and implement additional and/or new measures and treatment trains to remediate and prevent further and possible future contamination.
- Groundwater impacts relating to aquifer yield and ground water level drawdowns will be restricted to within 1.2km from the edges of the open pits as a result of the relative impermeability of the geological formations, limited fracturing and low yields that will not be sustained over the long term coupled with groundwater levels deeper than 9m below surface.
- Following rehabilitation and closure ground water levels are expected to return to their pre-mining levels and the open pits are expected to behave as sinks since evaporation exceeds influx including rainfall, with possible slow migration of ground water towards the north and east along pre-mining flow directions.

Table 23: Groundwater Risk Assessment.

Impacts during Mining and Operations	Potential Risk			Comment/Proposed Controls	Residual Risk		
	Consequence	Likelihood	Risk Rank		Consequence	Likelihood	Risk Rank
Surface Water and GDEs							
Deterioration of water quality in Towns River	4	1	Low	No discharge without WDL, water balance deficit; sufficient storage capacity; containment of dirty runoff	Low		
Reduction in volume of surface water in Towns River	4	1	Low	There is no hydraulic connection between river and underlying aquifer; modelling indicated minor leakages from river	Low		
Impact on base flow, increase/decrease flow to/from GDEs, impact on biota	4	1	Low	Ground water levels deeper than 9m below surface; no hydraulic connection with surface waters	Low		
Ground Water							
Impact on aquifer yields	2	1	Low	Impermeable, low yields, ground water levels deeper than 9m, extent of dewatering less than 1.2km from open pits, localised	Low		
Impact on ground water level drawdown	2	1	Low		Low		
Mine Infrastructure							
Seepage from WRDs, stockpiles, surface impoundments	3	4	Significant	Impermeable soils/formations, encapsulate and contain by engineering	3	1	Low
Impact following Rehabilitation and Closure							
Ground Water							
Impact on ground water level drawdown	1	4	Low	Ground water levels will return to pre-mining levels; open pits acting as sinks where evaporation will exceed influx with possible slow migration along shallow gradients to the north and east following pre-mining flow directions	Low		

8 Conclusions and Recommendations

8.1 Conclusions

The salient findings of the hydrogeological investigations and assessments are:

- The geology of the area is characterised by a sequence of laterised soils overlying thick sequences of weathered interlayered siltstones and sandstones, siltstones and mudstones with minor bands of sandstones. Underlying these is a thin layer of extremely weathered whitish siderite, which in turn overlies the hematitic iron ore body. The iron ore layer is normally interlayered with fine to medium grained sandstones, grey to dark grey siltstones with thin layers of mudstones.
- Whilst groundwater levels imitate the local and regional topography and are deeper than 9m below surface, groundwater level behaviour indicates that the shallow groundwater levels are not hydraulically interconnected with surface waters. Any existing interaction including potential groundwater dependent ecosystems are limited to a spring west of the Mangaranyi River where rain recharges surficial fracture systems.
- In general, the time-drawdown/falling head curves display decreases in groundwater flows over the short term. Recovery of the groundwater level after discharge was incomplete, indicating that systems are dewatered during abstraction with no or little replenishment indicative of minor fractures in a low yielding environment. It is thus likely that bores will not maintain yields and that water influx into open pits will decrease with time.
- The hydraulic testing indicates a range in permeability of about two orders of magnitude. This is typical of fractured rock aquifers, where the permeability is controlled by a combination of primary porosity from the pore space matrix and secondary porosity resulting from fractures and bedding plains.
- Aquifer hydraulic parameters in the sandstones and siltstones and the hematite iron ore are low, with transmissivities in the order of 0.1m^2/day to 4.0m^2/day. The lower transmissivity pertains to the dominantly ferruginous sandstone materials and the highest to the quartzite sandstone interbedded with ferruginous sandstones. The hematite iron ore interbedded with sandstones, mudstones and siltstones have an average transmissivity of 0.4m^2/d.
- Based on the field observations and slug/drawdown curves, the investigated area can be defined as having two well defined near surface systems:

Table 24: Groundwater Systems.

Depth (m)	System	Description
to 30	Aquitard	A shallow unconfined aquitard system located at between 25 to 30m depth among a highly weathered sequence of sandstone interbedded with siltstones.
50 - 60	Semi-confined to confined aquifer	A shallow semi-confined to confined aquifer system among the Sherwin Ironstone Formation (SIF) located between 50 to 60m below ground level, particularly where the shallow dipping reserves were observed to exist. Deeper systems seem to be a continuity of this aquifer system and water appears to move downwards throughout primary conduits within the coarser Sherwin Iron Formation.

- Groundwater influxes are relatively small: for the F East mine pit, the predicted side inflow rate increases from 4,000kL/d in year one, to about 4,500kL/d in year three and then decreases to less than 2,000kL/d in year seven. For the E East and E South mine pits, the predicted side inflow rate increases from about 1,500kL/d in year five to about 3,000kL/d in year seven.
- The extent of the 5.0m and 1.0m drawdown contours are likely to be within 0.9km and 1.2km from the edges of the pits respectively. The localised impact is due to low hydraulic conductivities i.e. relatively impermeable formations at the mine site.
- The impact on surface watercourses from dewatering is considered to be insignificant as the regional

groundwater level is well below the levels of the streambeds.

- Groundwater has a near circum-neutral pH, with an average of 6.5 ranging from 4.6 to 7.6.
- Among major cations, sodium concentrations are relatively high indicating localised water bodies are relatively saline waters. Sulfate and chloride concentrations are also very high in these waters.
- The majority of filtered trace metals are below of their limits of reporting (LoRs). Arsenic, barium, copper, manganese, nickel and zinc are mostly above of their LoRs but below of their NEPM-Health Investigation Levels.
- On the basis of calcium and magnesium concentrations, groundwaters can be classified as ranging from very soft to very hard waters. Whilst Group 1 waters are classified as very hard, Groups 2 and 3 are ranging from very soft to moderately soft waters.
- All groundwater samples are waters of the Cl + SO_4 type.
- Short term groundwater quality behaviour suggests that with time, pH in shallow groundwater particularly those hosted within the quartz sandstone and siltstone and mudstone sequences may increase to become slightly alkaline. However, groundwater in deeper lithological domains, particularly those hosted by the hematite iron ore body may remain circum-neutral or decrease with time to become slightly acidic waters.
- Risks pertaining to groundwater and surface-groundwater interactions are considered low due to the prevailing hydrological-hydrogeological environment.

8.2 Recommendations

To direct and ensure appropriate long term mitigation and management of potential impacts on the groundwater regime as a result of mining activities, the following are relevant:

- Groundwater monitoring and sampling in accordance with this document.
- Further drilling and testing to assess continuity of the aquifer system hosted by the Sherwin Iron Ore or whether an independent deeper aquifer system exists. Bores should be designed to attain average 120 m depths below natural ground level.
- Additional environmental monitoring bores around and within the vicinity of planned mine infrastructure to gather site wide baseline data and facilitate monitoring of potential impacts during mining operations.
- Frequent updating of the groundwater flow model using the results of ongoing monitoring including further modelling on predicting post-mining water levels, pit water qualities and possible migration of any contamination off site.

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Appendix E1 – Bore Logs & Construction Details

Please refer to Appendix 1 of EIS Appendix E4 – RPS Groundwater Flow Monitoring Report

Appendix C: Summary of Drilling and Borehole Test Data

Investigative and Monitoring Boreholes November 2011

Roper Bar Iron Ore

Borehole Number	Coordinates Easting	Coordinates Northing	Ground Elevation (mAHD)	Top of Casing (ToC) (magl/mAHD)	Bore Depth (m)	Bottom of Bore (from TOC) mAHD	Depth of Water Strikes (mbgl)	Depth of Water Strikes (mAHD)	Screen Interval (mAHD)	Airlift Yield (L/s)	Lithology/ Aquifer Type	Ground Water Level (below ToC) After Drilling (mbtoc)	Ground Water Level (below ToC) Before Bore Test (mbtoc)	Ground Water Level (below ToC) 30-Nov-11 (mAHD)	Available Drawdown (m)		Test Details: Pump Tes Step Number	Pump Tes Discharge Rate (L/s)	Pump Tes Time Discharge (min)	Slug Test Slug rate (L/s)	Slug Test Duration of slug water injection (min)	Maximum Drawdown (m)	Drawdown Utilised (%)	Duration of slug dissipation / recovery (min)	Recovery (%)	Q/st (L/s/m)	Preliminary Estimates T=kD (m^2/day)	General Comments
Western Desert Resources																												
RBGW01	508,851	8,325,252	24.3	0.708	79.0	-54.0	33.5	-9.2	-24.7 to -54.7	<0.05	Weathered sandstone interbedded with siltstone	10.00	10.14	**14.87**	68.86		ST			3.5	1.6			207.5	97%		8.86.E-01	Rapid change in drawdown at early times till about 30min and more gradual at later times
				25.01			62.0	-37.7		<0.1	Weathered sandstone interbedded with siltstone	Ground water level well above depth of water strike indicative of semi-confined to confined ground water flow conditions																
							70.0	-45.7		<0.5	Weathered siltstone interbedded with coarse sandstone																	
RGGW02	510,617	8,325,804	23.1	0.696	102.0	-78.2	33.0	-9.9	-48.9 to -78.9	Moist	Contact weathered mudstone/sandstone	12.50	13.00	**10.80**	89.00		ST			3.7	1.7			1055	88%		9.28.E-02	Relatively rapid change in drawdown at early times and more gradual at later times
				23.80								Ground water level well above depth of water strike indicative of semi-confined to confined ground water flow conditions																
RBGW03	510,617	8,325,804	25.2	0.696	79.0	-53.1	70.0	-44.8	-23.8 to -53.8	<0.1	Siltstone interbedded with mudstone/shale	15.50	16.18	**9.72**	62.82		ST			2.8	2.4			880.75	98%		4.94.E-01	Very rapid change in drawdown at early times to about 30min and more gradual at later times
				25.90																								
RBGW04	513,832	8,322,687	52.5	0.754	71.0	-17.7	9.5	43.0	5.0 to -18.5	Slightly moist	Laterite/Extremely weathered siltstone and sandstones	17.50	18.51	**34.74**	52.49		ST			2.6	2.9			893	96%		4.27.E-01	Very rapid change in drawdown at early times to about 60min and more gradual at later times
				53.25																								
RBGW05	512,772	8,323,863	30.04	0.707	87.0	-56.3	61.0	-31.0	-32.96 to -56.96	Slightly moist	Red ferruginous sandstone	9.30	9.37	**21.38**	77.63		ST			1.3	5.9			1090	95%		5.06.E-02	Slow change in drawdown at early times to about 20min and more gradual at later times
				30.75								Ground water level well above depth of water strike indicative of semi-confined to confined ground water flow conditions																
RBGW06	511,029	8,322,996	55.8	0.822	56.0	0.6	23.2	32.6	11.8 to -0.2	0.3	Quartz sandstone	8.90	9.39	**47.23**	46.61		ST			1.5	2.9			1177	89%		3.30.E-01	After a very rapid change in drawdown at early times more gradual change at later times indicating a confined aquifer system.
				56.622								Ground water level well above depth of water strike indicative of semi-confined to confined ground water flow conditions																
RBGW07	509,942	8,323,656	26.8	0.736	123.0	-95.5	56.0	-29.2	-72.2 to -96.2	0.2	Laminated mudstone	12.30	12.32	**15.22**	110.68		CFT	0.5	127.5			82.48	75%	740	75%	0.01	(<100min, 1.18); (>100min, 2.30)	
				27.54			107.0	-80.2			Hematite Iron Ore Body	Ground water level well above depth of water strike indicative of semi-confined to confined ground water flow conditions																
RBGW08	509,981	8,321,938	38.96	0.624	56.0	-17.0	18.0	20.96	16.96 to-17.04	Moist	Quartzite sandstone	5.67	6.07	**33.51**	50.55													
				39.584			21.0	17.96		1.0	Quartzite sandstone	Ground water level well above depth of water strike indicative of semi-confined to confined ground water flow conditions				Stepped Test	1	0.5	120			7.30	14%			0.07	4.94.E-01	Confined aquifer (Test Analysis Method: Papadopulus and Cooper). On log-log plot leaky confined aquifer system.
																	2	0.8	120			13.24	26%			0.06		
																	3	1.0	33			19.52	39%	136	87%	0.05		
																	CFT	0.6	870.5			35.24	70%	119	83.1%	0.02	(<100min, 9.19)	Confined aquifer (Test Analysis Method: Papadopulus and Cooper)
RBGW09	508,527	8,321,313	31.8	0.470	71.0	-38.7	30.0	1.80	-21. 7 to -39.7	Slightly moist	Laminated siltstone	12.00	12.12	**20.15**	58.88		ST			1.4	3.6			1511	88%		5.35.E-02	
				32.27			57.0	-25.20		Moist	Siltstone interbedded with mudstone/shale	Ground water level well above depth of water strike indicative of semi-confined to confined ground water flow conditions																
							62.0	-30.20		0.3	Hematite Iron Ore Body interbedded with silicified sandstones/mudstones																	
RBGW10	508,433	8,322,638	26.8	0.464	72.0	-44.7	30.0	-3.20	-33.2 to -45.2	Slightly moist	Siltstone/Mudstone	9.30	9.34	**17.92**	62.66		ST			1.5	2.2			557.25	87%		3.48.E-01	
				27.26			58.0	-31.20		Moist	Hematite Iron Ore Body	Ground water level well above depth of water strike indicative of semi-confined to confined ground water flow conditions																
							60.0	-33.20		0.2	Hematite Iron Ore Body																	
RBGW11	504,539	8,325,139	27.3	0.658	71.5	-43.5	30.0	-2.70	-14.2 to -44.2	Moist	Siltstone	13.40	13.46	**14.50**	58.04		ST			3.7	1.4			1265.5	98%		1.29.E-01	
				27.96								Ground water level well above depth of water strike indicative of semi-confined to confined ground water flow conditions																

Notes:

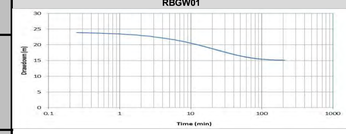
All bores were initially drilled with an internal diameter of 203.2 and then with 165.1mm with the top 6m cased with solid steel with PVC casing below.

Survey elevations are within ±0.2m accuracy.

Whilst ST stands for Slug Test, CFT stands for constant flow test

Time-Drawdown Curves

RBGW01



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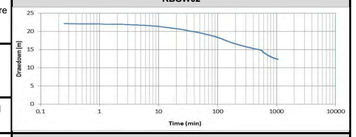

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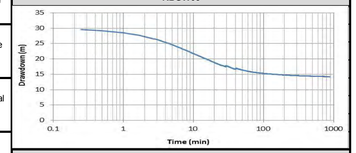

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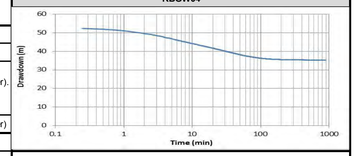

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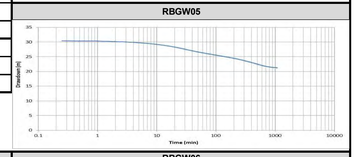

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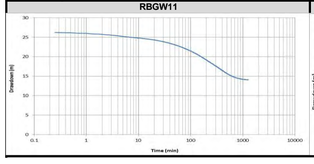

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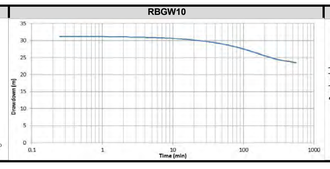

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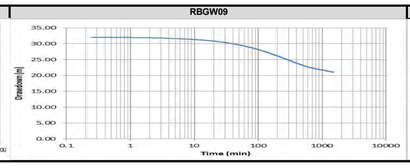

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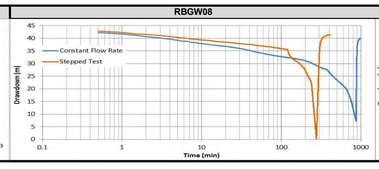

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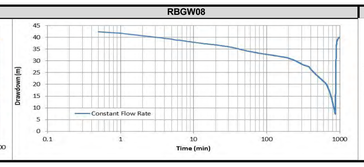

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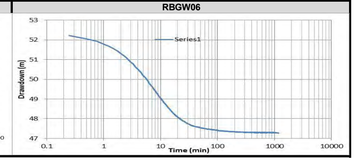
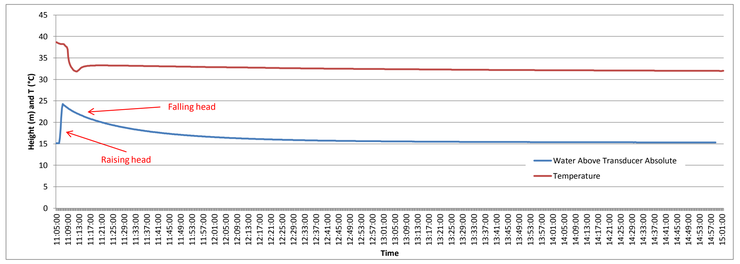
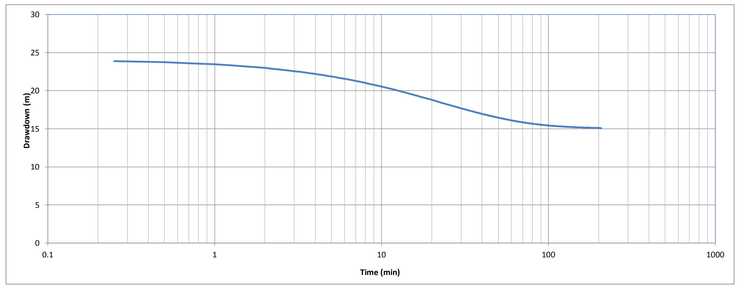
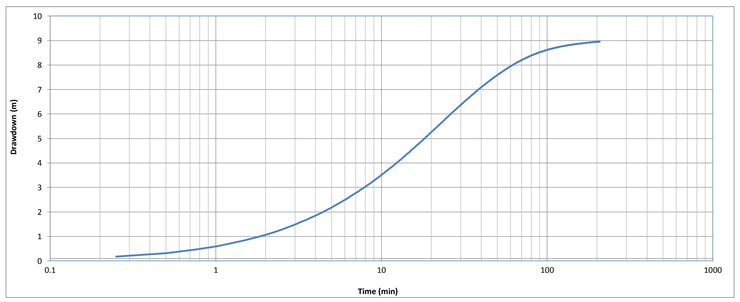


B A Pump Testing Job Details

Bore ID	RBGW01	Date	2-Nov-11	Comments
Test Type	Slug, 3.48 l/s			Water quality sample 0.50 EC, 0.25 TDS, 7.68 PH, 33.4 deg. Transducer removed 2/11/2011 @ SWL 9.832m, 97% recovered.
SWL	10.044m	TOC Height	0.714m	
Transducer Depth (Meters)	15.0m	Depth (Meters)	N/A	
Fill Volume (litres)	218L	Fill Time	1min 33sec	







Date	Pressure (m)	T (°C)	Date	Pressure (m)	T (°C)	Date	Pressure (m)	T (°C)	Date	Pressure (m)	T (°C)	Date	Pressure (m)	T (°C)	Date	Pressure (m)	T (°C)	Date	Pressure (m)	T (°C)	Date	Pressure (m)	T (°C)	Date	Pressure (m)	T (°C)	Date	Pressure (m)	T (°C)	Date	Pressure (m)	T (°C)
11:01:00	10.252	38.65	11:25:00	19.277	33.2	11:50:00	17.03	32.92	12:15:00	16.138	32.69	12:40:00	15.744	32.49	13:04:00	15.556	32.36	13:29:00	15.455	32.24	13:54:00	15.393	32.15	14:19:00	15.358	32.07	14:43:00	15.324	32	15:08:00	10.224	31.39
11:01:00	10.252	38.57	11:26:00	19.24	33.19	11:50:00	17.016	32.92	12:15:00	16.132	32.69	12:40:00	15.741	32.49	13:05:00	15.553	32.36	13:29:00	15.455	32.24	13:54:00	15.393	32.15	14:19:00	15.358	32.07	14:44:00	15.324	32	15:08:00	10.227	31.4
11:01:00	10.254	38.49	11:26:00	19.202	33.19	11:51:00	17.004	32.91	12:15:00	16.127	32.69	12:40:00	15.738	32.49	13:05:00	15.553	32.36	13:30:00	15.455	32.24	13:54:00	15.393	32.15	14:19:00	15.353	32.07	14:44:00	15.324	32	15:09:00	10.224	31.55
11:01:00	10.251	38.44	11:26:00	19.167	33.19	11:51:00	16.989	32.91	12:16:00	16.123	32.69	12:40:00	15.735	32.49	13:05:00	15.553	32.35	13:30:00	15.454	32.23	13:55:00	15.393	32.15	14:19:00	15.353	32.07	14:44:00	15.324	32	15:09:00	10.233	31.85
11:02:00	10.252	38.37	11:26:00	19.13	33.18	11:51:00	16.977	32.91	12:16:00	16.117	32.69	12:41:00	15.732	32.49	13:05:00	15.55	32.35	13:30:00	15.451	32.23	13:55:00	15.393	32.15	14:20:00	15.356	32.07	14:44:00	15.324	32	15:09:00	10.224	32.12
11:02:00	10.252	38.3	11:27:00	19.095	33.18	11:51:00	16.964	32.91	12:16:00	16.112	32.68	12:41:00	15.732	32.49	13:06:00	15.547	32.35	13:30:00	15.451	32.23	13:55:00	15.391	32.15	14:20:00	15.356	32.07	14:45:00	15.324	32	15:09:00	10.23	32.39
11:02:00	10.251	38.24	11:27:00	19.063	33.18	11:52:00	16.952	32.91	12:16:00	16.109	32.68	12:41:00	15.727	32.49	13:06:00	15.547	32.35	13:31:00	15.451	32.23	13:55:00	15.393	32.15	14:20:00	15.356	32.07	14:45:00	15.324	32	15:10:00	10.227	32.65
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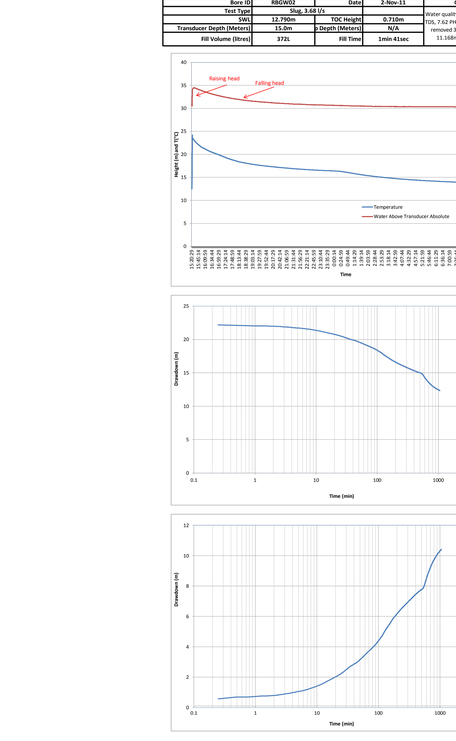
11:13:00	21.798	33.21	11:38:00	17.861	33.05	12:03:00	16.491	32.8	12:27:00	15.903	32.57	12:52:00	15.633	32.42	13:17:00	15.498	32.3	13:42:00	15.423	32.18	14:06:00	15.373	32.11	14:31:00	15.338	32.04	14:56:00	15.313	31.97			
11:13:00	21.727	33.22	11:38:00	17.841	33.05	12:03:00	16.479	32.8	12:28:00	15.897	32.57	12:52:00	15.631	32.42	13:17:00	15.495	32.29	13:42:00	15.423	32.18	14:07:00	15.37	32.1	14:31:00	15.338	32.04	14:56:00	15.315	31.97			
11:14:00	21.654	33.23	11:38:00	17.816	33.05	12:03:00	16.473	32.8	12:28:00	15.895	32.57	12:53:00	15.628	32.42	13:17:00	15.495	32.29	13:42:00	15.42	32.18	14:07:00	15.373	32.11	14:32:00	15.336	32.04	14:56:00	15.313	31.97			
11:14:00	21.583	33.24	11:39:00	17.796	33.05	12:03:00	16.465	32.79	12:28:00	15.892	32.57	12:53:00	15.628	32.41	13:18:00	15.495	32.29	13:42:00	15.42	32.18	14:07:00	15.373	32.1	14:32:00	15.338	32.04	14:57:00	15.315	31.97			
11:14:00	21.516	33.24	11:39:00	17.776	33.05	12:04:00	16.457	32.79	12:28:00	15.888	32.57	12:53:00	15.625	32.41	13:18:00	15.495	32.29	13:43:00	15.42	32.19	14:07:00	15.37	32.1	14:32:00	15.338	32.04	14:57:00	15.313	31.98			
11:14:00	21.45	33.24	11:39:00	17.756	33.05	12:04:00	16.447	32.79	12:29:00	15.883	32.57	12:53:00	15.625	32.41	13:18:00	15.495	32.29	13:43:00	15.416	32.19	14:08:00	15.37	32.11	14:32:00	15.338	32.04	14:57:00	15.313	31.98			
11:15:00	21.381	33.25	11:39:00	17.735	33.05	12:04:00	16.439	32.79	12:29:00	15.88	32.56	12:54:00	15.622	32.41	13:18:00	15.489	32.29	13:43:00	15.42	32.19	14:08:00	15.37	32.11	14:33:00	15.338	32.04	14:57:00	15.315	31.97			
11:15:00	21.32	33.25	11:40:00	17.716	33.04	12:04:00	16.433	32.79	12:29:00	15.875	32.56	12:54:00	15.62	32.41	13:19:00	15.489	32.29	13:43:00	15.416	32.18	14:08:00	15.368	32.11	14:33:00	15.338	32.03	14:58:00	15.313	31.97			
11:15:00	21.254	33.25	11:40:00	17.699	33.04	12:05:00	16.422	32.78	12:29:00	15.872	32.56	12:54:00	15.62	32.41	13:19:00	15.489	32.29	13:44:00	15.416	32.18	14:08:00	15.368	32.1	14:33:00	15.336	32.03	14:58:00	15.313	31.97			
11:15:00	21.19	33.25	11:40:00	17.679	33.04	12:05:00	16.416	32.78	12:30:00	15.868	32.55	12:54:00	15.616	32.41	13:19:00	15.489	32.29	13:44:00	15.416	32.18	14:09:00	15.37	32.1	14:33:00	15.338	32.03	14:58:00	15.313	31.97			
11:16:00	21.13	33.25	11:40:00	17.658	33.03	12:05:00	16.404	32.77	12:30:00	15.865	32.55	12:55:00	15.616	32.41	13:19:00	15.489	32.29	13:44:00	15.416	32.18	14:09:00	15.37	32.1	14:34:00	15.338	32.03	14:58:00	15.313	31.97			
11:16:00	21.067	33.26	11:41:00	17.641	33.03	12:05:00	16.402	32.77	12:30:00	15.863	32.55	12:55:00	15.613	32.41	13:20:00	15.486	32.29	13:44:00	15.416	32.18	14:09:00	15.37	32.1	14:34:00	15.338	32.03	14:59:00	15.289	31.96			
11:16:00	21.01	33.26	11:41:00	17.621	33.02	12:06:00	16.39	32.77	12:30:00	15.857	32.55	12:55:00	15.611	32.41	13:20:00	15.486	32.28	13:45:00	15.416	32.18	14:09:00	15.368	32.1	14:34:00	15.336	32.03	14:59:00	10.231	31.97			
11:16:00	20.949	33.26	11:41:00	17.601	33.02	12:06:00	16.383	32.76	12:31:00	15.854	32.55	12:55:00	15.611	32.4	13:20:00	15.489	32.28	13:45:00	15.413	32.18	14:10:00	15.368	32.1	14:34:00	15.336	32.03	14:59:00	10.221	31.96			
11:17:00	20.888	33.27	11:41:00	17.58	33.02	12:06:00	16.375	32.76	12:31:00	15.851	32.55	12:56:00	15.608	32.4	13:20:00	15.486	32.28	13:45:00	15.413	32.18	14:10:00	15.368	32.1	14:35:00	15.336	32.03	14:59:00	10.224	31.87			
11:17:00	20.834	33.27	11:42:00	17.563	33.02	12:06:00	16.366	32.76	12:31:00	15.845	32.54	12:56:00	15.605	32.41	13:21:00	15.483	32.28	13:45:00	15.413	32.18	14:10:00	15.368	32.1	14:35:00	15.336	32.03	15:00:00	10.219	31.73			
11:17:00	20.776	33.26	11:42:00	17.546	33.01	12:07:00	16.358	32.76	12:31:00	15.845	32.54	12:56:00	15.608	32.4	13:21:00	15.483	32.27	13:46:00	15.413	32.18	14:10:00	15.368	32.1	14:35:00	15.336	32.03	15:00:00	10.224	31.7			
11:17:00	20.721	33.26	11:42:00	17.528	33.01	12:07:00	16.352	32.76	12:32:00	15.842	32.54	12:56:00	15.605	32.4	13:21:00	15.483	32.27	13:46:00	15.411	32.18	14:11:00	15.368	32.1	14:35:00	15.336	32.03	15:00:00	10.224	31.71			
11:18:00	20.664	33.26	11:42:00	17.508	33.01	12:07:00	16.344	32.76	12:32:00	15.84	32.54	12:57:00	15.602	32.4	13:21:00	15.483	32.27	13:46:00	15.413	32.18	14:11:00	15.368	32.1	14:36:00	15.333	32.03	15:00:00	10.221	31.75			
11:18:00	20.612	33.25	11:43:00	17.491	33.01	12:07:00	16.337	32.76	12:32:00	15.833	32.54	12:57:00	15.6	32.4	13:22:00	15.48	32.27	13:46:00	15.411	32.18	14:11:00	15.368	32.1	14:36:00	15.333	32.03	15:01:00	10.219	31.81			
11:18:00	20.56	33.25	11:43:00	17.473	33	12:08:00	16.329	32.76	12:32:00	15.831	32.54	12:57:00	15.6	32.39	13:22:00	15.478	32.27	13:47:00	15.411	32.17	14:11:00	15.365	32.09	14:36:00	15.333	32.03	15:01:00	10.219	31.84			
11:18:00	20.508	33.25	11:43:00	17.454	32.99	12:08:00	16.323	32.76	12:33:00	15.828	32.54	12:57:00	15.596	32.39	13:22:00	15.478	32.27	13:47:00	15.411	32.18	14:12:00	15.365	32.09	14:36:00	15.333	32.03	15:01:00	10.219	31.85			
11:19:00	20.456	33.25	11:43:00	17.44	32.99	12:08:00	16.315	32.76	12:33:00	15.825	32.54	12:58:00	15.596	32.39	13:22:00	15.475	32.27	13:47:00	15.411	32.17	14:12:00	15.365	32.09	14:37:00	15.333	32.03	15:01:00	10.216	31.85			
11:19:00	20.404	33.25	11:44:00	17.421	32.99	12:08:00

B A Pump Testing Job Details

Bore ID	RBGW002	Date	2-Nov-11	Comments
Test Type	Slug_3.66 l/s			Water quality sample 0.50 FC, 0.25 TDS, 7.62 PH, 35.7 deg. Transducer removed 3/11/2011 at 5WL of 11.168m, 87% recovered.
SWL	12.790m	TOC Height	0.710m	
Transducer Depth (Meters)	15.0m	p Depth (Meters)	N/A	
Fill Volume (litres)	372L	Fill Time	1min 41sec	



Date & Time	Pressure (m)	T(°C)
15:14:59	10.225	34.81
15:15:14	10.225	34.93
15:15:29	10.225	35.09
15:15:44	10.221	35.28
15:15:59	10.225	35.44
15:16:14	10.228	35.66
15:16:29	10.225	35.9
15:16:44	10.221	36.09
15:16:59	10.231	36.15
15:17:14	10.231	36.02
15:17:29	10.236	36.02
15:17:44	11.565	35.56
15:17:59	12.401	34.03
15:18:14	12.404	33.05
15:18:29	12.404	32.47
15:18:44	12.408	32.09
15:18:59	12.408	31.74
15:19:14	12.447	31.56
15:19:29	12.443	31.37
15:19:44	12.443	31.22
15:19:59	12.447	31.11
15:20:14	12.447	31.04
15:20:29	12.447	30.93
15:20:44	12.447	30.86
15:20:59	12.443	30.8
15:21:14	12.447	30.74
15:21:29	12.447	30.69
15:21:44	12.447	30.64
15:21:59	12.447	30.61
15:22:14	12.447	30.57
15:22:29	12.45	30.54
15:22:44	12.45	30.51
15:22:59	12.447	30.49
15:23:14	12.996	31.11
15:23:29	13.945	32.13
15:23:44	21.076	32.93
15:24:14	24.684	33.64
15:24:14	24.2	33.75
15:24:29	23.619	33.95
15:24:44	23.515	34.07
15:24:59	23.503	34.14
15:25:14	23.471	34.2
15:25:29	23.445	34.25
15:25:44	23.435	34.26
15:25:59	23.422	34.29
15:26:14	23.408	34.31
15:26:29	23.389	34.33
15:26:44	23.362	34.35
15:26:59	23.337	34.36
15:27:14	23.31	34.39
15:27:29	23.289	34.4
15:27:44	23.264	34.42
15:27:59	23.243	34.44
15:28:14	23.218	34.46
15:28:29	23.195	34.45
15:28:44	23.178	34.45
15:28:59	23.156	34.46
15:29:14	23.145	34.46
15:29:29	23.123	34.46
15:29:44	23.116	34.46
15:29:59	23.099	34.46
15:30:14	23.081	34.46
15:30:29	23.066	34.46
15:30:44	23.045	34.46
15:30:59	23.025	34.46
15:31:14	23.004	34.45
15:31:29	22.988	34.45
15:31:44	22.968	34.45
15:31:59	22.948	34.45
15:32:14	22.927	34.44
15:32:29	22.91	34.44
15:32:44	22.892	34.44
15:32:59	22.872	34.42
15:33:14	22.855	34.41
15:33:29	22.835	34.41
15:33:44	22.817	34.41
15:33:59	22.8	34.41
15:34:14	22.784	34.41
15:34:29	22.766	34.4
15:34:44	22.749	34.4
15:34:59	22.734	34.4
15:35:14	22.717	34.39
15:35:29	22.7	34.39
15:35:44	22.684	34.38
15:35:59	22.665	34.37
15:36:14	22.65	34.37
15:36:29	22.629	34.36
15:36:44	22.61	34.35
15:36:59	22.592	34.35
15:37:14	22.577	34.34
15:37:29	22.563	34.33
15:37:44	22.544	34.31
15:37:59	22.527	34.31
15:38:14	22.509	34.31
15:38:29	22.497	34.3
15:38:44	22.481	34.29
15:38:59	22.464	34.28
15:39:14	22.449	34.28
15:39:29	22.431	34.27
15:39:44	22.42	34.27
15:39:59	22.408	34.26
15:40:14	22.391	34.26
15:40:29	22.377	34.25
15:40:44	22.363	34.25
15:40:59	22.348	34.24
15:41:14	22.335	34.24
15:41:29	22.322	34.23
15:41:44	22.305	34.23
15:41:59	22.292	34.22
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15:42:44	22.254	34.21
15:42:59	22.244	34.21
15:43:14	22.23	34.21
15:43:29	22.219	34.21
15:43:44	22.206	34.21
15:43:59	22.193	34.16
15:44:14	22.186	34.16
15:44:29	22.176	34.14
15:44:44	22.163	34.13
15:44:59	22.15	34.12
15:45:14	22.141	34.12
15:45:29	22.129	34.12
15:45:44	22.116	34.11
15:45:59	22.103	34.11
15:46:14	22.094	34.09
15:46:29	22.082	34.09
15:46:44	22.066	34.09
15:46:59	22.057	34.09
15:47:14	22.046	34.09
15:47:29	22.035	34.07
15:47:44	22.02	34.07
15:47:59	22.009	34.07
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15:48:44	21.974	34.06
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15:49:14	21.954	34.05
15:49:29	21.939	34.04
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15:50:14	21.904	34.02
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15:50:59	21.865	34
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15:54:59	21.671	33.92
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15:55:44	21.631	33.89
15:55:59	21.619	33.89
15:56:14	21.608	33.89
15:56:29	21.598	33.88
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15:56:59	21.573	33.86
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15:57:44	21.538	33.84
15:57:59	21.524	33.84
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15:59:44	21.467	33.8
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16:00:44	21.441	33.77
16:00:59	21.432	33.76
16:01:14	21.427	33.76
16:01:29	21.421	33.74
16:01:44	21.415	33.74
16:01:59	21.407	33.74
16:02:14	21.401	33.74
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16:04:14	21.342	33.71
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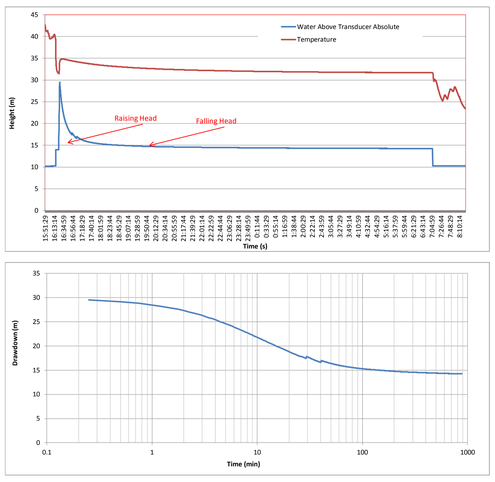
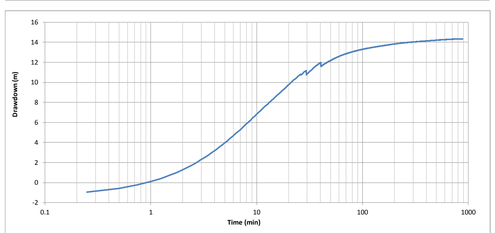
18:11:59	19.636	33.69
18:12:14	19.633	33.69
18

B A Pump Testing Job Details

Bore ID	RBGW03	Date	1-Nov-11	Comments
Test Type	Slug, 2.8l/s			Water quality 0.49 EC, 0.29 TDS, 7.23 PH, 32.4 deg. Removed on 2/11/2011 @ SWL of 16.002m, 98% recovered.
SWL	16.220m	TOC Height	0.700m	
Transducer Depth (Meters)	20.0m	Pump Depth (Meters)	N/A	
Fill Volume (litres)	404L	Fill Time	2min 23sec	





Date&Time	Pressure (m)	T (°C)	Date&Time	Pressure (m)	T (°C)	Date&Time	Pressure (m)	T (°C)	Date&Time	Pressure (m)	T (°C)	Date&Time	Pressure (m)	T (°C)	Date&Time	Pressure (m)	T (°C)	Date&Time	Pressure (m)	T (°C)	Date&Time	Pressure (m)	T (°C)	Date&Time	Pressure (m)	T (°C)	Date&Time	Pressure (m)	T (°C)	Date&Time	Pressure (m)	T (°C)	Date&Time	Pressure (m)	T (°C)	Date&Time	Pressure (m)	T (°C)
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15:51:44	10.182	42.49	17:06:29	16.995	34.19	18:21:14	15.159	33.24	19:35:59	14.789	32.75	20:50:44	14.614	32.42	22:05:29	14.514	32.21	23:20:14	14.447	32.07	0:34:59	14.391	31.96	1:49:44	14.343	31.87	3:04:29	14.307	31.8	4:19:14	14.28	31.75	5:33:59	14.266	31.7	6:48:44	14.251	31.67
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15:52:44	10.181	41.5	17:07:29	16.899	34.17	18:22:14	15.153	33.23	19:36:59	14.789	32.74	20:51:44	14.611	32.43	22:06:29	14.514	32.21	23:21:14	14.445	32.07	0:35:59	14.39	31.95	1:50:44	14.343	31.87	3:05:29	14.307	31.8	4:20:14	14.283	31.75	5:34:59	14.267	31.71	6:49:44	14.255	31.67
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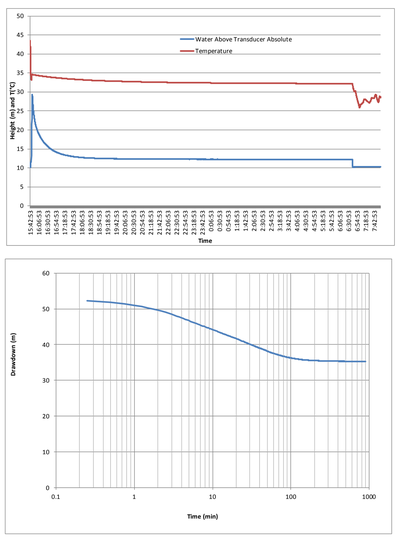
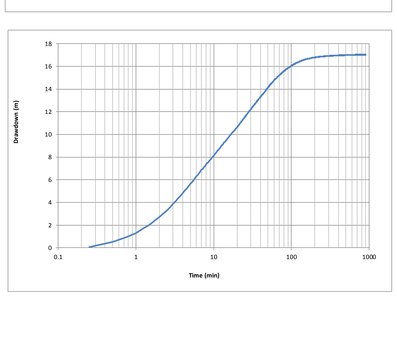
16:03:14	10.201	39.46	17:17:59	16.294	34.01	18:32:44	15.081	33.15	19:47:29	14.754	32.69	21:02:14	14.594	32.39	22:16:59	14.506	32.19	23:31:44	14.435	32.05	0:46:29	14.38	31.95	2:01:14	14.336	31.86	3:15:59	14.302	31.79	4:30:44	14.278	31.75	5:45:29	14.264	31.71	7:00:14	14.255	31.67
16:03:29	10.204	39.47	17:18:14	16.282	34	18:32:59	15.078	33.15	19:47:44	14.754	32.68	21:02:29	14.594	32.39	22:17:14	14.506	32.19	23:31:59	14.438	32.05	0:46:44	14.38	31.95	2:01:29	14.336	31.85	3:16:14	14.302	31.79	4:30:59	14.278	31.75	5:45:44	14.263	31.7	7:00:29	14.255	31.67
16:03:44	10.201	39.49	17:18:29	16.274	34	18:33:14	15.078	33.15	19:47:59	14.754	32.68	21:02:44	14.594	32.39	22:17:29	14.503	32.19	23:32:14	14.438	32.05	0:46:59	14.38	31.94	2:01:44	14.336	31.85	3:16:29	14.302	31.79	4:31:14	14.28	31.74	5:45:59	14.263	31.7	7:00:44	14.255	31.67
16:03:59	10.208	39.49	17:18:44	16.262	34	18:33:29	15.078	33.15	19:48:14	14.752	32.68	21:02:59	14.594	32.39	22:17:44	14.503	32.19	23:32:29	14.435	32.05	0:47:14	14.38	31.94	2:01:59	14.336	31.85	3:16:44	14.302	31.79	4:31:29	14.28	31.74	5:46:14	14.264	31.71	7:00:59	14.255	31.67
16:04:14	10.21	39.49	17:18:59	16.248	34	18:33:44	15.075	33.15	19:48:29	14.752	32.68	21:03:14	14.594	32.39	22:17:59	14.503	32.19	23:32:44	14.435	32.05	0:47:29	14.38	31.94	2:02:14	14.334	31.85	3:16:59	14.302	31.79	4:31:44	14.278	31.75	5:46:29	14.26	31.7	7:01:14	14.255	31.67
16:04:29	10.21	39.48	17:19:14	16.239	33.99	18:33:59	15.075	33.14	19:48:44	14.752	32.68	21:03:29	14.594	32.39	22:18:14	14.506	32.19	23:32:59	14.438	32.05	0:47:44	14.38	31.94	2:02:29	14.334	31.86	3:17:14	14.304	31.79	4:31:59	14.281	31.75	5:46:44	14.263	31.7	7:01:29	14.255	31.67
16:04:44	10.213	39.5	17:19:29	16.225	33.98	18:34:14	15.072	33.13	19:48:59	14.752	32.68	21:03:44	14.594	32.39	22:18:29	14.503	32.19	23:33:14	14.435	32.05	0:47:59	14.38	31.94	2:02:44	14.336	31.86	3:17:29	14.302	31.79	4:32:14	14.278	31.75	5:46:59	14.26	31.7	7:01:44	14.255	31.67
16:04:59	10.216	39.52	17:19:44	16.216	33.98	18:34:29	15.072	33.13	19:49:14	14.752	32.68	21:03:59	14.594	32.39	22:18:44	14.503	32.19	23:33:29	14.438	32.04	0:48:14	14.38	31.94	2:02:59	14.336	31.86	3:17:44	14.302	31.79	4:32:29	14.278	31.75	5:47:14	14.26	31.7	7:01:59	14.255	31.67
16:05:14	10.22	39.54	17:19:59	16.205	33.98	18:34:44	15.069	33.13	19:49:29	14.748	32.68	21:04:14	14.59	32.39	22:18:59	14.506	32.19	23:33:44	14.435	32.05	0:48:29	14.38	31.94	2:03:14	14.336	31.86	3:17:59	14.302	31.79	4:32:44	14.281	31.75	5:47:29	14.26	31.7	7:02:14	14.251	31.67
16:05:29	10.22	39.56	17:20:14	16.195	33.97	18:34:59	15.069	33.12	19:49:44	14.748	32.68	21:04:29	14.59	32.38	22:19:14	14.503	32.19	23:33:59	14.435	32.05	0:48:44	14.38	31.93	2:03:29	14.336	31.86	3:18:14	14.302	31.79	4:32:59	14.278	31.75	5:47:44	14.26	31.7	7:02:29	14.255	31.67
16:05:44	10.22	39.57	17:20:29	16.184	33.97	18:35:14	15.069	33.12	19:49:59	14.745	32.68	21:04:44	14.593	32.38	22:19:29	14.503	32.19	23:34:14	14.433	32.05	0:48:59	14.38	31.93	2:03:44	14.334	31.86	3:18:29	14.302

B A Pump Testing Job Details

Bore ID	RBGW04	Date	1-Nov-11	Comments	
Test Type	Slug, 2.57 l/s			Water quality 0.50 EC, 0.29 TDS, 7.23 PH, 32.3 deg. Removed 2/11/2011 @ SWL of 18.274m, 97% recovered.	
SWL	18.760m	TOC Height	0.760m		
Transducer Depth (Meters)	20.0m	Pump Depth (Meters)	N/A		
Fill Volume (litres)	480L	Fill Time	2min 53sec		





Date & Time	Pressure (m)	T (°C)
15:42:53	10.19	43.45
15:43:08	10.22	43.09
15:43:23	10.19	42.62
15:43:38	10.2	42.35
15:43:53	10.21	42.13
15:44:08	10.21	41.93
15:44:23	11.51	39.54
15:44:38	11.49	37.18
15:44:53	11.49	35.87
15:45:08	11.49	35.08
15:45:23	11.5	34.54
15:45:38	11.51	34.15
15:45:53	11.51	33.85
15:46:08	11.51	33.61
15:46:23	11.51	33.42
15:46:38	11.61	33.25
15:46:53	13.35	33.08
15:47:08	14.94	33.2
15:47:23	16.53	33.98
15:47:38	18.19	34.4
15:47:53	19.92	34.53
15:48:08	21.5	34.57
15:48:23	23.06	34.57
15:48:38	24.61	34.57
15:48:53	26.14	34.57
15:49:08	27.65	34.57
15:49:23	29.27	34.57
15:49:38	29.21	34.57
15:49:53	28.77	34.56
15:50:08	28.36	34.56
15:50:23	27.96	34.55
15:50:38	27.58	34.55
15:50:53	27.22	34.55
15:51:08	26.89	34.55
15:51:23	26.56	34.55
15:51:38	26.25	34.54
15:51:53	25.95	34.54
15:52:08	25.67	34.54
15:52:23	25.4	34.54
15:52:38	25.14	34.53
15:52:53	24.89	34.53
15:53:08	24.67	34.53
15:53:23	24.44	34.52
15:53:38	24.23	34.52
15:53:53	24.03	34.5
15:54:08	23.83	34.49
15:54:23	23.63	34.49
15:54:38	23.46	34.48
15:54:53	23.3	34.47
15:55:08	23.13	34.47
15:55:23	22.97	34.47
15:55:38	22.82	34.47
15:55:53	22.67	34.47
15:56:08	22.54	34.46
15:56:23	22.4	34.46
15:56:38	22.28	34.46
15:56:53	22.16	34.47
15:57:08	22.04	34.46
15:57:23	21.93	34.45
15:57:38	21.81	34.44
15:57:53	21.72	34.44
15:58:08	21.61	34.43
15:58:23	21.5	34.43
15:58:38	21.41	34.42
15:58:53	21.31	34.42
15:59:08	21.22	34.41
15:59:23	21.13	34.41
15:59:38	21.04	34.41
15:59:53	20.95	34.41
16:00:08	20.86	34.41
16:00:23	20.78	34.41
16:00:38	20.71	34.4
16:00:53	20.62	34.39
16:01:08	20.54	34.39
16:01:23	20.46	34.39
16:01:38	20.38	34.38
16:01:53	20.31	34.38
16:02:08	20.24	34.37
16:02:23	20.17	34.37
16:02:38	20.1	34.37
16:02:53	20.02	34.37
16:03:08	19.96	34.36
16:03:23	19.89	34.36
16:03:38	19.83	34.36
16:03:53	19.78	34.36
16:04:08	19.71	34.35
16:04:23	19.64	34.34
16:04:38	19.59	34.34
16:04:53	19.53	34.33
16:05:08	19.48	34.33
16:05:23	19.41	34.33
16:05:38	19.36	34.33
16:05:53	19.3	34.32
16:06:08	19.26	34.32
16:06:23	19.2	34.32
16:06:38	19.15	34.31
16:06:53	19.1	34.31
16:07:08	19.04	34.3
16:07:23	18.99	34.29
16:07:38	18.96	34.29
16:07:53	18.9	34.29
16:08:08	18.86	34.29
16:08:23	18.82	34.28
16:08:38	18.76	34.28
16:08:53	18.71	34.28
16:09:08	18.68	34.27
16:09:23	18.62	34.27
16:09:38	18.57	34.26
16:09:53	18.53	34.26
16:10:08	18.49	34.26
16:10:23	18.45	34.25
16:10:38	18.39	34.25
16:10:53	18.35	34.25
16:11:08	18.31	34.25
16:11:23	18.26	34.25
16:11:38	18.21	34.24
16:11:53	18.17	34.24
16:12:08	18.13	34.23
16:12:23	18.08	34.22
16:12:38	18.04	34.22
16:12:53	18	34.22
16:13:08	17.95	34.21
16:13:23	17.91	34.21
16:13:38	17.88	34.21
16:13:53	17.84	34.21
16:14:08	17.81	34.2
16:14:23	17.76	34.2
16:14:38	17.73	34.2
16:14:53	17.69	34.19
16:15:08	17.64	34.19
16:15:23	17.6	34.19
16:15:38	17.56	34.18
16:15:53	17.52	34.18
16:16:08	17.49	34.18
16:16:23	17.46	34.18
16:16:38	17.41	34.17
16:16:53	17.38	34.17
16:17:08	17.35	34.17
16:17:23	17.32	34.17
16:17:38	17.27	34.16
16:17:53	17.24	34.16
16:18:08	17.2	34.15
16:18:23	17.18	34.14
16:18:38	17.14	34.14
16:18:53	17.11	34.13
16:19:08	17.07	34.13
16:19:23	17.05	34.13
16:19:38	17.02	34.13
16:19:53	16.99	34.13
16:20:08	16.95	34.12
16:20:23	16.92	34.12
16:20:38	16.89	34.12
16:20:53	16.85	34.11
16:21:08	16.82	34.11
16:21:23	16.79	34.11
16:21:38	16.77	34.1
16:21:53	16.73	34.1
16:22:08	16.72	34.09
16:22:23	16.69	34.09
16:22:38	16.66	34.09
16:22:53	16.63	34.09
16:23:08	16.59	34.09
16:23:23	16.57	34.09

Date & Time	Pressure (m)	T (°C)
16:23:38	16.54	34.08
16:23:53	16.52	34.08
16:24:08	16.49	34.08
16:24:23	16.46	34.08
16:24:38	16.43	34.07
16:24:53	16.4	34.06
16:25:08	16.37	34.06
16:25:23	16.34	34.05
16:25:38	16.31	34.05
16:25:53	16.3	34.05
16:26:08	16.27	34.05
16:26:23	16.24	34.05
16:26:38	16.22	34.05
16:26:53	16.19	34.05
16:27:08	16.17	34.04
16:27:23	16.14	34.04
16:27:38	16.12	34.04
16:27:53	16.1	34.04
16:28:08	16.06	34.03
16:28:23	16.04	34.03
16:28:38	16.02	34.03
16:28:53	16.01	34.02
16:29:08	15.98	34.02
16:29:23	15.95	34.02
16:29:38	15.93	34.02
16:29:53	15.91	34.01
16:30:08	15.88	34
16:30:23	15.86	34
16:30:38	15.84	34
16:30:53	15.81	34
16:31:08	15.8	34
16:31:23	15.78	33.99
16:31:38	15.76	33.99
16:31:53	15.74	33.99
16:32:08	15.72	33.99
16:32:23	15.7	33.99
16:32:38	15.67	33.98
16:32:53	15.66	33.98
16:33:08	15.63	33.98
16:33:23	15.61	33.97
16:33:38	15.6	33.97
16:33:53	15.57	33.97
16:34:08	15.55	33.97
16:34:23	15.54	33.96
16:34:38	15.52	33.96
16:34:53	15.5	33.95
16:35:08	15.47	33.95
16:35:23	15.45	33.94
16:35:38	15.44	33.94
16:35:53	15.42	33.94
16:36:08	15.39	33.94
16:36:23	15.36	33.94
16:36:38	15.35	33.94
16:36:53	15.34	33.93
16:37:08	15.3	33.93
16:37:23	15.28	33.93
16:37:38	15.26	33.92
16:37:53	15.25	33.92
16:38:08	15.22	33.92
16:38:23	15.19	33.92
16:38:38	15.17	33.91
16:38:53	15.16	33.91
16:39:08	15.14	33.91
16:39:23	15.12	33.91
16:39:38	15.1	33.91
16:39:53	15.08	33.91
16:40:08	15.06	33.91
16:40:23	15.04	33.91
16:40:38	15.02	33.9
16:40:53	15.01	33.89
16:41:08	14.99	33.89
16:41:23	14.97	33.88
16:41:38	14.95	33.88
16:41:53	14.94	33.87
16:42:08	14.92	33.87
16:42:23	14.9	33.87
16:42:38	14.88	33.87
16:42:53	14.86	33.86
16:43:08	14.85	33.86
16:43:23	14.82	33.85
16:43:38	14.81	33.85
16:43:53	14.79	33.85
16:44:08	14.77	33.84
16:44:23	14.76	33.84
16:44:38	14.75	33.84
16:44:53	14.74	33.84
16:45:08	14.73	33.84
16:45:23	14.7	33.84
16:45:38	14.69	33.84
16:45:53	14.68	33.83
16:46:08	14.67	33.83
16:46:23	14.66	33.83
16:46:38	14.64	33.82
16:46:53	14.63	33.81
16:47:08	14.61	33.81
16:47:23	14.6	33.81
16:47:38	14.59	33.81
16:47:53	14.57	33.81
16:48:08	14.56	33.81
16:48:23	14.55	33.81
16:48:38	14.53	33.81
16:48:53	14.51	33.8
16:49:08	14.5	33.8
16:49:23	14.48	33.8
16:49:38	14.47	33.79
16:49:53	14.47	33.79
16:50:08	14.45	33.79
16:50:23	14.43	33.78
16:50:38	14.42	33.78
16:50:53	14.41	33.78
16:51:08	14.41	33.78
16:51:23	14.38	33.78
16:51:38	14.38	33.78
16:51:53	14.37	33.78
16:52:08	14.36	33.77
16:52:23	14.35	33.76
16:52:38	14.33	33.76
16:52:53	14.32	33.76
16:53:08	14.31	33.76
16:53:23	14.3	33.76
16:53:38	14.29	33.76
16:53:53	14.28	33.76
16:54:08	14.27	33.75
16:54:23	14.26	33.75
16:54:38	14.25	33.75
16:54:53	14.23	33.75
16:55:08	14.21	33.75
16:55:23	14.2	33.74
16:55:38	14.2	33.73
16:55:53	14.19	33.73
16:56:08	14.17	33.73
16:56:23	14.17	33.73
16:56:38	14.14	33.72
16:56:53	14.14	33.72
16:57:08	14.14	33.71

Date & Time	Pressure (m)	T (°C)
16:26:23	12.44	32.87
16:26:38	12.44	32.87
16:26:53	12.44	32.87
16:27:08	12.44	32.87
16:27:23	12.44	32.87
16:27:38	12.44	32.87
16:27:53	12.44	32.87
16:28:08	12.44	32.87
16:28:23	12.44	32.87
16:28:38	12.44	32.87
16:28:53	12.44	32.87
16:29:08	12.44	32.86
16:29:23	12.44	32.86
16:29:38	12.44	32.86
16:29:53	12.44	32.86
16:30:08	12.44	32.86
16:30:23	12.44	32.86
16:30:38	12.44	32.86
16:30:53	12.44	32.86
16:31:08	12.44	32.86
16:31:23	12.44	32.86
16:31:38	12.44	32.86
16:31:53	12.44	32.86
16:32:08	12.44	32.86
16:32:23	12.44	32.86
16:32:38	12.44	32.86
16:32:53	12.44	32.85
16:33:08	12.44	32.85
16:33:23	12.44	32.85
16:33:38	12.44	32.85
16:33:53	12.44	32.85
16:34:08	12.44	32.85
16:34:23	12.44	32.85
16:34:38	12.44	32.85
16:34:53	12.43	32.85
16:35:08	12.43	32.85
16:35:23	12.43	32.85
16:35:38	12.43	32.85
16:35:53	12.43	32.85
16:36:08	12.43	32.85
16:36:23	12.43	32.85
16:36:38	12.43	32.85
16:36:53	12.43	32.85
16:37:08	12.43	32.85
16:37:23	12.43	32.85
16:37:38	12.43	32.85
16:37:53	12.43	32.85
16:38:08	12.43	32.85
16:38:23	12.43	32.85
16:38:38	12.43	32.85
16:38:53	12.43	32.85
16:39:08	12.43	32.85
16:39:23	12.43	32.85
16:39:38	12.43	32.85
16:39:53	12.43	32.85
16:40:08	12.43	32.85
16:40:23	12.43	32.85
16:40:38	12.43	32.85
16:40:53	12.43	32.85
16:41:08	12.43	32.85
16:41:23	12.43	32.85
16:41:38	12.43	32.85
16:41:53	12.43	32.85
16:42:08	12.43	32.85
16:42:23	12.43	32.85
16:42:38	12.43	32.85
16:42:53	12.43	32.85
16:43:08	12.43	32.85
16:43:23	12.43	32.85
16:43:38	12.43	32.85
16:43:53	12.43	32.85
16:44:08	12.43	32.85
16:44:23	12.43	32.85
16:44:38	12.43	32.85
16:44:53	12.43	32.85
16:45:08	12.43	32.85
16:45:23	12.43	32.85
16:45:38	12.43	32.85
16:45:53	12.43	32.85
16:46:08	12.43	32.85
16:46:23	12.43	32.85
16:46:38	12.43	32.85
16:46:53	12.43	32.85
16:47:08	12.43	32.85
16:47:23	12.43	32.85
16:47:38	12.43	32.85
16:47:53	12.43	32.85
16:48:08	12.43	32.85
16:48:23	12.43	32.85
16:48:38	12.43	32.85
16:48:53	12.43	32.85
16:49:08	12.43	32.85
16:49:23	12.43	32.85
16:49:38	12.43	32.85
16:49:53	12.43	32.85
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16:50:53	12.43	32.85
16:51:08	12.43	32.85
16:51:23	12.43	32.85
16:51:38	12.43	32.85
16:51:53	12.43	32.85
16:52:08	12.43	32.85
16:52:23	12.43	32.85
16:52:38	12.43	32.85
16:52:53	12.43	32.85
16:53:08	12.43	32.85
16:53:23	12.43	32.85
16:53:38	12.43	32.85
16:53:53	12.43	32.85
16:54:08	12.43	32.85
16:54:23	12.43	32.85
16:54:38	12.43	32.85
16:54:53	12.43	32.85
16:55:08	12.43	32.85
16:55:23	12.43	32.85
16:55:38	12.43	32.85
16:55:53	12.43	32.85
16:56:08	12.43	32.85
16:56:23	12.43	32.85
16:56:38	12.43	32.85
16:56:53	12.43	32.85
16:57:08	12.43	32.85

Date & Time	Pressure (m)	T (°C)
16:57:23	12.43	32.85
16:57:38	12.43	32.85
16:57:53	12.43	32.85
16:58:08	12.43	32.85
16:58:23	12.43	32.85
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16:58:53	12.43	32.85
16:59:08	12.43	32.85
16:59:23	12.43	32.85
16:59:38	12.43	32.85
16:59:53	12.43	32.85
17:00:08	12.43	32.85
17:00:23	12.43	32.85
17:00:38	12.43	32.85
17:00:53	12.43	32.85
17:01:08	12.43	32.85
17:01:23	12.43	32.85
17:01:38	12.43	32.85
17:01:53	12.43	32.85
17:02:08	12.43	32.85
17:02:23	12.43	32.85
17:02:38	12.43	32.85
17:02:53	12.43	32.85
17:03:08	12.43	32.85
17:03:23	12.43	32.85
17:03:38	12.43	32.85
17:03:53	12.43	32.85
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17:04:38	12.43	32.85
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17:05:38	12.43	32.85
17:05:53	12.43	32.85
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17:06:53	12.43	32.85
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17:21:53	12.43	32.85
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17:51:08	12.43	32.85
17:51:23	12.43	32.85
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17:52:08	12.43	32.85
17:52:23	12.43	32.85
17:52:38	12.43	32.85
17:52:53	12.43	32.85
17:53:08	12.43	32.85
17:53:23	12.43	32.85
17:53:38	12.43	32.85
17:53:53	12.43	32.85
17:54:08	12.43	32.85
17:54:23	12.43	32.85
17:54:38	12.43	32.85
17:54:53	12.43	32.85
17:55:08	12.43	32.85
17:55:23	12.43	32.85
17:55:38	12.43	32.85
17:55:53	12.43	32.85
17:56:08	12.43	32.85
17:56:23	12.43	32.85
17:56:38	12.43	32.85
17:56:53	12.43	32.85
17:57:08	12.43	32.85

Date & Time	Pressure (m)	T (°C)
17:57:23	12.43	32.85
17:57:38	12.43	32.85
17:57:53	12.43	32.85
17:58:08	12.43	32.85
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17:58:53	12.43	32.85
17:59:08	12.43	32.85
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17:59:53	12.43	32.85
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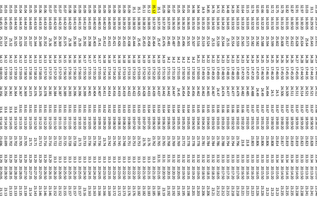
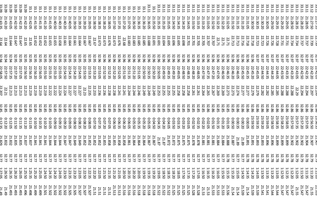
18:00:23	12.43	32.85
18:00:38	12.43	32.85
18:00:53	12.43	32.85
18:01:08	12.43	32.85
18:01:23	12.43	32.85
18:01:38	12.43	32.85
18:01:53	12.43	32.85
18:02:08	12.43	32.85
18:02:23	12.43	32.85
18:02:38	12.43	32.85
18:02:53	12.43	32.85
18:03:08	12.43	32.85
18:03:23	12.43	32.85
18:03:38	12.43	32.85
18:03:53	12.43	32.85
18:04:08	12.43	32.85
18:04:23	12.43	32.85
18:04:38	12.43	32.85
18:04:53	12.43	32.85
18:05:08	12.43	32.85
18:05:23	12.43	32.85
18:05:38	12.43	32.85
18:05:53	12.43

B.R Pump Testing Job Details

Test Information		Equipment	
Test Number:	1	Pump Model:	6" Flowtech
Test Date:	2/13/2024	Pump Serial:	6" Flowtech
Test Time:	10:00	Motor Model:	100 HP Flowtech
Test Operator:	Ryan Gaddis	Motor Serial:	100 HP Flowtech
Test Location:	Bridgeport, WV	Pump Type:	Flowtech
Test Type:	Pump Test	Pump Speed:	1800

Notes: Pump Test of Flowtech 100 HP Motor and 6" Flowtech Pump. Pump Speed set at 1800 RPM. Pump Test Performed at Flowtech Facility in Bridgeport, WV. Pump Test Performed by Ryan Gaddis.

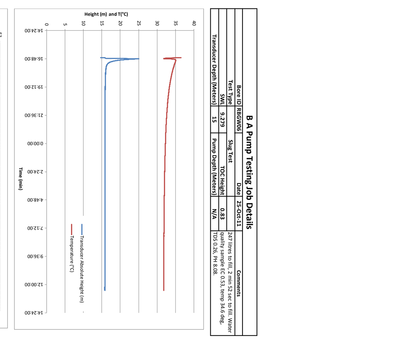


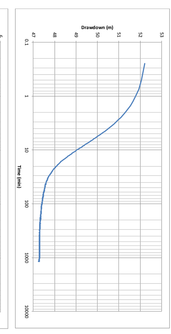


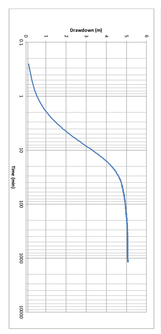
| Time | Hz | Amps | Volts | Watts | Pump Psi | Pump Flow | Pump Eff | Motor Psi | Motor Flow | Motor Eff

B & A Pump Testing Job Details

Customer:	Bonneville Power Administration
Job Number:	2020-0211
Test Type:	Hydraulic Performance Test
Test Date:	10/14/2020
Test Time:	10:00:00 AM - 10:44:45 AM
Temperature Range (deg F):	51 - 54
Barometer Range (inHg):	N/A
Test Operators:	Ryan Ellis, Tyler Ellis, Cole Ellis, Ty Ellis
Test Notes:	Test Pump: 1 Pump Type: Vertical Turbine Pump Test Type: Hydraulic Performance Test Test Date: 10/14/2020



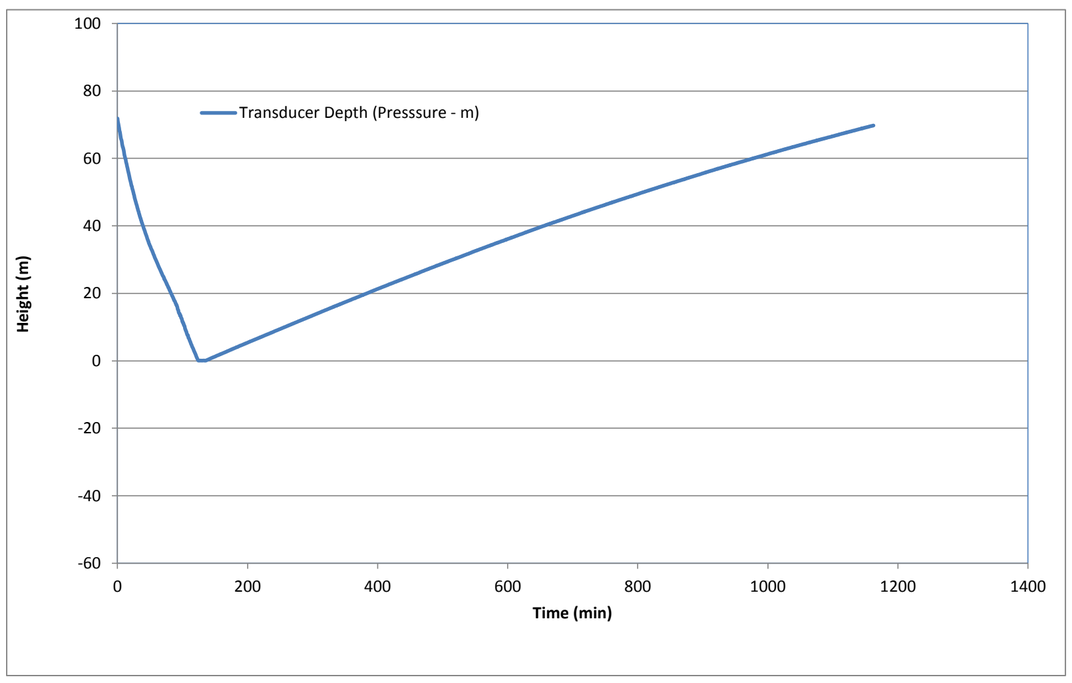


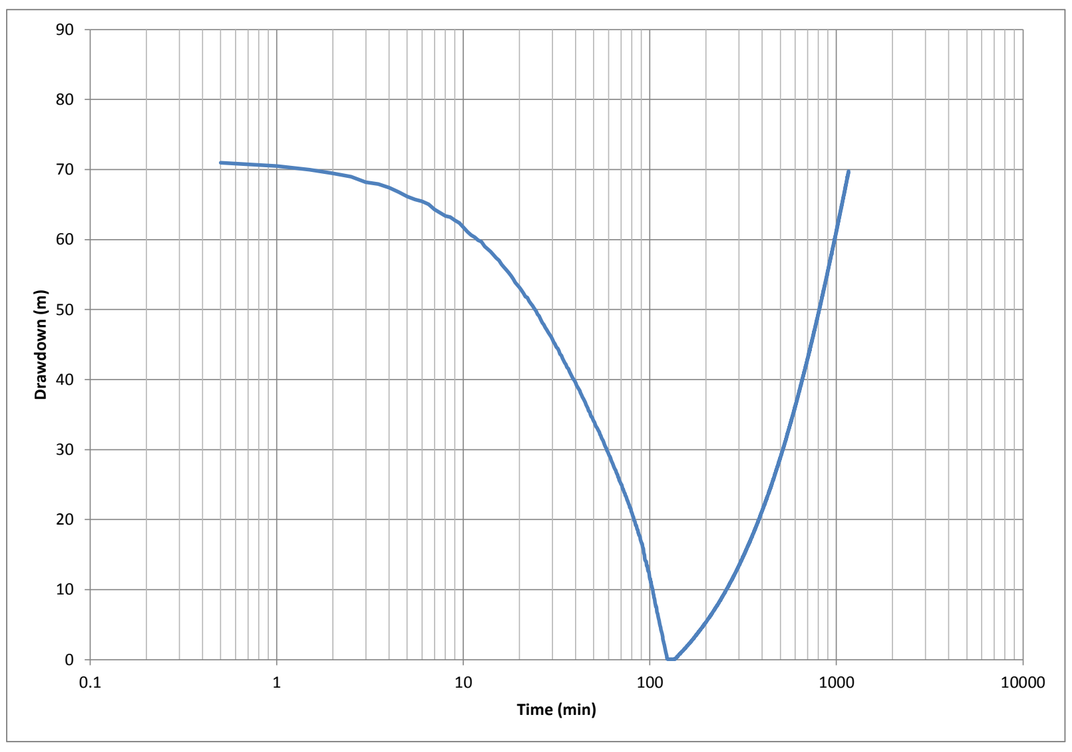


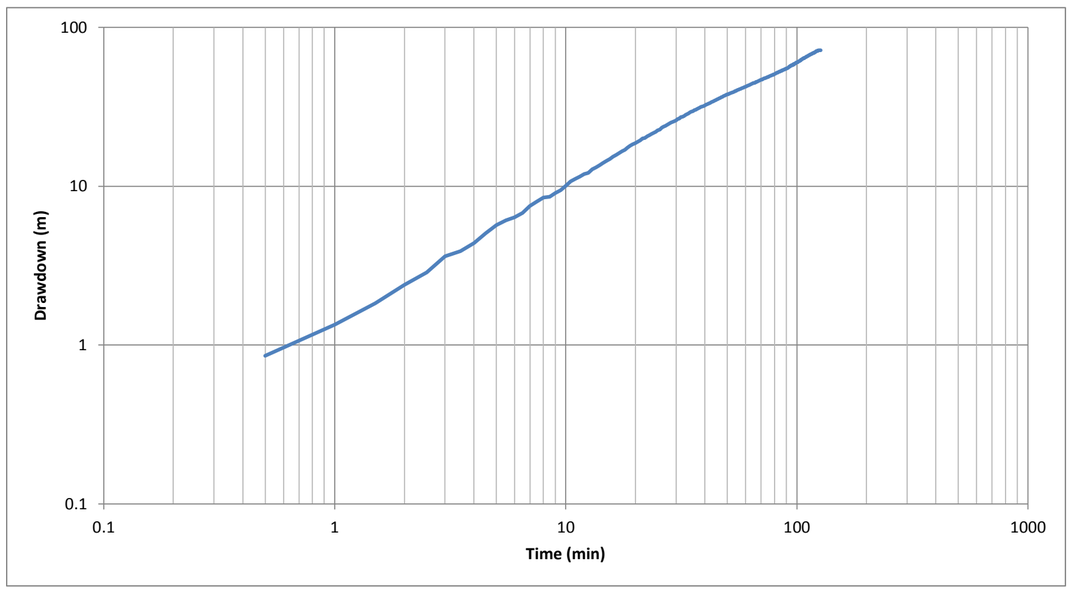
Date&Time	Power(w)	I(A)	Date&Time	Power(w)	I(A)	Date&Time	Power(w)	I(A)	Date&Time	Power(w)	I(A)	Date&Time	Power(w)	I(A)	Date&Time	Power(w)	I(A)
2020/10/14 10:00:00	37.7	0.7	2020/10/14 10:01:00	56.76	1.1	2020/10/14 10:02:00	0.0	0.0	2020/10/14 10:03:00	0.0	0.0	2020/10/14 10:04:00	0.0	0.0	2020/10/14 10:05:00	0.0	0.0
2020/10/14 10:00:01	37.7	0.7	2020/10/14 10:01:01	56.76	1.1	2020/10/14 10:02:01	0.0	0.0	2020/10/14 10:03:01	0.0	0.0	2020/10/14 10:04:01	0.0	0.0	2020/10/14 10:05:01	0.0	0.0
2020/10/14 10:00:02	37.7	0.7	2020/10/14 10:01:02	56.76	1.1	2020/10/14 10:02:02	0.0	0.0	2020/10/14 10:03:02	0.0	0.0	2020/10/14 10:04:02	0.0	0.0	2020/10/14 10:05:02	0.0	0.0
2020/10/14 10:00:03	37.7	0.7	2020/10/14 10:01:03	56.76	1.1	2020/10/14 10:02:03	0.0	0.0	2020/10/14 10:03:03	0.0	0.0	2020/10/14 10:04:03	0.0	0.0	2020/10/14 10:05:03	0.0	0.0
2020/10/14 10:00:04	37.7	0.7	2020/10/14 10:01:04	56.76	1.1	2020/10/14 10:02:04	0.0	0.0	2020/10/14 10:03:04	0.0	0.0	2020/10/14 10:04:04	0.0	0.0	2020/10/14 10:05:04	0.0	0.0
2020/10/14 10:00:05	37.7	0.7	2020/10/14 10:01:05	56.76	1.1	2020/10/14 10:02:05	0.0	0.0	2020/10/14 10:03:05	0.0	0.0	2020/10/14 10:04:05	0.0	0.0	2020/10/14 10:05:05	0.0	0.0
2020/10/14 10:00:06	37.7	0.7	2020/10/14 10:01:06	56.76	1.1	2020/10/14 10:02:06	0.0	0.0	2020/10/14 10:03:06	0.0	0.0	2020/10/14 10:04:06	0.0	0.0	2020/10/14 10:05:06	0.0	0.0
2020/10/14 10:00:07	37.7	0.7	2020/10/14 10:01:07	56.76	1.1	2020/10/14 10:02:07	0.0	0.0	2020/10/14 10:03:07	0.0	0.0	2020/10/14 10:04:07	0.0	0.0	2020/10/14 10:05:07	0.0	0.0
2020/10/14 10:00:08	37.7	0.7	2020/10/14 10:01:08	56.76	1.1	2020/10/14 10:02:08	0.0	0.0	2020/10/14 10:03:08	0.0	0.0	2020/10/14 10:04:08	0.0	0.0	2020/10/14 10:05:08	0.0	0.0
2020/10/14 10:00:09	37.7	0.7	2020/10/14 10:01:09	56.76	1.1	2020/10/14 10:02:09	0.0	0.0	2020/10/14 10:03:09	0.0	0.0	2020/10/14 10:04:09	0.0	0.0	2020/10/14 10:05:09	0.0	0.0
2020/10/14 10:00:10	37.7	0.7	2020/10/14 10:01:10	56.76	1.1	2020/10/14 10:02:10	0.0	0.0	2020/10/14 10:03:10	0.0	0.0	2020/10/14 10:04:10	0.0	0.0	2020/10/14 10:05:10	0.0	0.0
2020/10/14 10:00:11	37.7	0.7	2020/10/14 10:01:11	56.76	1.1	2020/10/14 10:02:11	0.0	0.0	2020/10/14 10:03:11	0.0	0.0	2020/10/14 10:04:11	0.0	0.0	2020/10/14 10:05:11	0.0	0.0
2020/10/14 10:00:12	37.7	0.7	2020/10/14 10:01:12	56.76	1.1	2020/10/14 10:02:12	0.0	0.0	2020/10/14 10:03:12	0.0	0.0	2020/10/14 10:04:12	0.0	0.0	2020/10/14 10:05:12	0.0	0.0
2020/10/14 10:00:13	37.7	0.7	2020/10/14 10:01:13	56.76	1.1	2020/10/14 10:02:13	0.0	0.0	2020/10/14 10:03:13	0.0	0.0	2020/10/14 10:04:13	0.0	0.0	2020/10/14 10:05:13	0.0	0.0
2020/10/14 10:00:14	37.7	0.7	2020/10/14 10:01:14	56.76	1.1	2020/10/14 10:02:14	0.0	0.0	2020/10/14 10:03:14	0.0	0.0	2020/10/14 10:04:14	0.0	0.0	2020/10/14 10:05:14	0.0	0.0
2020/10/14 10:00:15	37.7	0.7	2020/10/14 10:01:15	56.76	1.1	2020/10/14 10:02:15	0.0	0.0	2020/10/14 10:03:15	0.0	0.0	2020/10/14 10:04:15	0.0	0.0	2020/10/14 10:05:15	0.0	0.0
2020/10/14 10:00:16	37.7	0.7	2020/10/14 10:01:16	56.76	1.1	2020/10/14 10:02:16	0.0	0.0	2020/10/14 10:03:16	0.0	0.0	2020/10/14 10:04:16	0.0	0.0	2020/10/14 10:05:16	0.0	0.0
2020/10/14 10:00:17	37.7	0.7	2020/10/14 10:01:17	56.76	1.1	2020/10/14 10:02:17	0.0	0.0	2020/10/14 10:03:17	0.0	0.0	2020/10/14 10:04:17	0.0	0.0	2020/10/14 10:05:17	0.0	0.0
2020/10/14 10:00:18	37.7	0.7	2020/10/14 10:01:18	56.76	1.1	2020/10/14 10:02:18	0.0	0.0	2020/10/14 10:03:18	0.0	0.0	2020/10/14 10:04:18	0.0	0.0	2020/10/14 10:05:18	0.0	0.0
2020/10/14 10:00:19	37.7	0.7	2020/10/14 10:01:19	56.76	1.1	2020/10/14 10:02:19	0.0	0.0	2020/10/14 10:03:19	0.0	0.0	2020/10/14 10:04:19	0.0	0.0	2020/10/14 10:05:19	0.0	0.0
2020/10/14 10:00:20	37.7	0.7	2020/10/14 10:01:20	56.76	1.1	2020/10/14 10:02:20	0.0	0.0	2020/10/14 10:03:20	0.0	0.0	2020/10/14 10:04:20	0.0	0.0	2020/10/14 10:05:20	0.0	0.0
2020/10/14 10:00:21	37.7	0.7	2020/10/14 10:01:21	56.76	1.1	2020/10/14 10:02:21	0.0	0.0	2020/10/14 10:03:21	0.0	0.0	2020/10/14 10:04:21	0.0	0.0	2020/10/14 10:05:21	0.0	0.0
2020/10/14 10:00:22	37.7	0.7	2020/10/14 10:01:22	56.76	1.1	2020/10/14 10:02:22	0.0	0.0	2020/10/14 10:03:22	0.0	0.0	2020/10/14 10:04:22	0.0	0.0	2020/10/14 10:05:22	0.0	0.0
2020/10/14 10:00:23	37.7	0.7	2020/10/14 10:01:23	56.76	1.1	2020/10/14 10:02:23	0.0	0.0	2020/10/14 10:03:23	0.0	0.0	2020/10/14 10:04:23	0.0	0.0	2020/10/14 10:05:23	0.0	0.0
2020/10/14 10:00:24	37.7	0.7	2020/10/14 10:01:24	56.76	1.1	2020/10/14 10:02:24	0.0	0.0	2020/10/14 10:03:24	0.0	0.0	2020/10/14 10:04:24	0.0	0.0	2020/10/14 10:05:24	0.0	0.0
2020/10/14 10:00:25	37.7	0.7	2020/10/14 10:01:25	56.76	1.1	2020/10/14 10:02:25	0.0	0.0	2020/10/14 10:03:25	0.0	0.0	2020/10/14 10:04:25	0.0	0.0	2020/10/14 10:05:25	0.0	0.0
2020/10/14 10:00:26	37.7	0.7	2020/10/14 10:01:26	56.76	1.1	2020/10/14 10:02:26	0.0	0.0	2020/10/14 10:03:26	0.0	0.0	2020/10/14 10:04:26	0.0	0.0	2020/10/14 10:05:26	0.0	0.0
2020/10/14 10:00:27	37.7	0.7	2020/10/14 10:01:27	56.76	1.1	2020/10/14 10:02:27	0.0	0.0	2020/10/14 10:03:27	0.0	0.0	2020/10/14 10:04:27	0.0	0.0	2020/10/14 10:05:27	0.0	0.0
2020/10/14 10:00:28	37.7	0.7	2020/10/14 10:01:28	56.76	1.1	2020/10/14 10:02:28	0.0	0.0	2020/10/14 10:03:28	0.0	0.0	2020/10/14 10:04:28	0.0	0.0	2020/10/14 10:05:28	0.0	0.0
2020/10/14 10:00:29	37.7	0.7	2020/10/14 10:01:29	56.76	1.1	2020/10/14 10:02:29	0.0	0.0	2020/10/14 10:03:29	0.0	0.0	2020/10/14 10:04:29	0.0	0.0	2020/10/14 10:05:29	0.0	0.0
2020/10/14 10:00:30	37.7	0.7	2020/10/14 10:01:30	56.76	1.1	2020/10/14 10:02:30	0.0	0.0	2020/10/14 10:03:30	0.0	0.0	2020/10/14 10:04:30	0.0	0.0	2020/10/14 10:05:30	0.0	0.0
2020/10/14 10:00:31	37.7	0.7	2020/10/14 10:01:31	56.76	1.1	2020/10/14 10:02:31	0.0	0.0	2020/10/14 10:03:31	0.0	0.0	2020/10/14 10:04:31	0.0	0.0	2020/10/14 10:05:31	0.0	0.0
2020/10/14 10:00:32	37.7	0.7	2020/10/14 10:01:32	56.76	1.1	2020/10/14 10:02:32	0.0	0.0	2020/10/14 10:03:32	0.0	0.0	2020/10/14 10:04:32	0.0	0.0	2020/10/14 10:05:32	0.0	0.0
2020/10/14 10:00:33	37.7	0.7	2020/10/14 10:01:33	56.76	1.1	2020/10/14 10:02:33	0.0	0.0	2020/10/14 10:03:33	0.0	0.0	2020/10/14 10:04:33	0.0	0.0	2020/10/14 10:05:33	0.0	0.0
2020/10/14 10:00:34	37.7	0.7	2020/10/14 10:01:34	56.76	1.1	2020/10/14 10:02:34	0.0	0.0	2020/10/14 10:03:34	0.0	0.0	2020/10/14 10:04:34	0.0	0.0	2020/10/14 10:05:34	0.0	0.0
2020/10/14 10:00:35	37.7	0.7	2020/10/14 10:01:35	56.76	1.1	2020/10/14 10:02:35	0.0	0.0	2020/10/14 10:03:35	0.0	0.0	2020/10/14 10:04:35	0.0	0.0	2020/10/14 10:05:35	0.0	0.0
2020/10/14 10:00:36	37.7	0.7	2020/10/14 10:01:36	56.76	1.1	2020/10/14 10:02:36	0.0	0.0	2020/10/14 10:03:36	0.0	0.0	2020/10/14 10:04:36	0.0	0.0	2020/10/14 10:05:36	0.0	0.0
2020/10/14 10:00:37	37.7	0.7	2020/10/14 10:01:37	56.76	1.1	2020/10/14 10:02:37	0.0	0.0	2020/10/14 10:03:37	0.0	0.0	2020/10/14 10:04:37	0.0	0.0	2020/10/14 10:05:37	0.0	0.0
2020/10/14 10:00:38	37.7	0.7	2020/10/14 10:01:38	56.76	1.1	2020/10/14 10:02:38	0.0	0.0	2020/10/14 10:03:38	0.0	0.0	2020/10/14 10:04:38	0.0	0.0	2020/10/14 10:05:38	0.0	0.0
2020/10/14 10:00:39	37.7	0.7	2020/10/14 10:01:39	56.76	1.1	2020/10/14 10:02:39	0.0	0.0	2020/10/14 10:03:39	0.0	0.0	2020/10/14 10:04:39	0.0	0.0	2020/10/14 10:05:39	0.0	0.0
2020/10/14 10:00:40	37.7	0.7	2020/10/14 10:01:40	56.76	1.1	2020/10/14 10:02:40	0.0	0.0	2020/10/14 10:03:40	0.0	0.0	2020/10/14 10:04:40	0.0	0.0	2020/10/14 10:05:40	0.0	0.0
2020/10/14 10:00:41	37.7	0.7	2020/10/14 10:01:41	56.76	1.1	2020/10/14 10:02:41	0.0	0.0	2020/10/14 10:03:41	0.0	0.0	2020/10/14 10:04:41	0.0	0.0	2020/10/14 10:05:41	0.0	0.0
2020/10/14 10:00:42	37.7	0.7	2020/10/14 10:01:42	56.76	1.1	2020/10/14 10:02:42	0.0	0.0	2020/10/14 10:03:42	0.0	0.0	2020/10/14 10:04:42	0.0	0.0	2020/10/14 10:05:42	0.0	0.0
2020/10/14 10:00:43	37.7	0.7	2020/10/14 10:01:43	56.76	1.1	2020/10/14 10:02:43	0.0	0.0	2020/10/14 10:03:43	0.0	0.0	2020/10/14 10:04:43	0.0	0.0	2020/10/14 10:05:43	0.0	0.0
2020/10/14 10:00:44	37.7	0.7	2020/10/14 10:01:44	56.76	1.1	2020/10/14 10:02:44	0.0	0.0	2020/10/14 10:03:44	0.0	0.0	2020/10/14 10:04:44	0.0	0.0	2020/10/14 10:05:44	0.0	0.0
2020/10/14 10:00:45	37.7	0.7	2020/10/14 10:01:45	56.76	1.1	2020/10/14 10:02:45	0.0	0.0	2020/10/14 10:03:45	0.0	0.0	2020/10/14 10:04:45	0.0	0.0	2020/10/14 10:05:45	0.0	0.0
2020/10/14 10:00:46	37.7	0.7	2020/10/14 10:01:46	56.76	1.1	2020/10/14 10:02:46	0.0	0.0	2020/10/14 10:03:46	0.0	0.0	2020/10/14 10:04:46	0.0	0.0	2020/10/14 10:05:46	0.0	0.0
2020/10/14 10:00:47	37.7	0.7	2020/10/14 10:01:47	56.76	1.1	2020/10/14 10:02:47	0.0	0.0	2020/10/14 10:03:47	0.0	0.0	2020/10/14 10:04:47	0.0	0.0	2020/10/14 10:05:47	0.0	0.0
2020/10/14 10:00:48	37.7	0.7	2020/10/14 10:01:48	56.76	1.1	2020/10/14 10:02:48	0.0	0.0	2020/10/14 10:03:48	0.0	0.0	2020/10/14 10:04:48	0.0	0.0	2020/10/14 10:05:48	0.0	0.0
2020/10/14 10:00:49	37.7	0.7	2020/10/14 10:01:49	56.76	1.1	2020/10/14 10:02:49	0.0	0.0	2020/10/14 10:03:49	0.0	0.0	2020/10/14 10:04:49	0.0	0.0	2020/10/14 10:05:49	0.0	0.0
2020/10/14 10:00:50	37.7	0.7	2020/10/14 10:01:50	56.76	1.1	2020/10/14 10:02:50	0.0	0.0	2020/10/14 10:03:50	0.0	0.0	2020/10/14 10:04:50	0.0	0.0	2020/10/14 10:05:50	0.0	0.0
2020/10/14 10:00:51	37.7	0.7	2020/10/14 10:01:51	56.76	1.1	2020/10/14 10:02:51	0.0	0.0	2020/10/14 10:03:51	0.0	0.0	2020/10/14 10:04:51	0.0	0.0	2020/10/14 10:05:51	0.0	0.0
2020/10/14 10:00:52	37.7	0.7	2020/10/14 10:01:52	56.76	1.1	2020/10/14 10:02:52	0.0	0.0	2020/10/14 10:03:52	0.0	0.0	2020/10/14 10:04:52	0.0	0.0	2020/10/14 10:05:52	0.0	0.0
2020/10/14 10:00:53	37.7	0.7	2020/10/14 10:01:53	56.76	1.1	2020/10/14 10:02:53	0.0	0.0	2020/10/14 10:03:53	0.0	0.0	2020/10/14 10:04:53	0.0	0.0	2020/10/14 10:05:53	0.0	0.0
2020/10/14 10:00:54	37.7	0.7	2020/10/14 10:01:54	56.76	1.1	2020/10/14 10:02:54	0.0	0.0	2020/10/14 10:03:54	0.0	0.0	2020/10/14 10:04:54	0.0	0.0	2020/10/14 10:05:54	0.0	0.0
2020/10/14 10:00:55	37.7	0.7	2020/10/14 10:01:55	56.76	1.1	2020/10/14 10:02:55	0.0	0.0	2020/10/14 10:03:55	0.0	0.0	2020/10/14 10:04:55	0.0	0.0	2020/10/14 10:05:55	0.0	0.0
2020/10/14 10:00:56	37.7	0.7	2020/10/14 10:01:56	56.76	1.1	2020/10/14 10:02:56	0.0	0.0	2020/10/14 10:03:56	0.0	0.0	2020/10/14 10:04:56	0.0	0.0	2020/10/14 10:05:56	0.0	0.0
2020/10/14 10:00:57	37.7	0.7	2020/10/14 10:01:57	56.76	1.1	2020/10/14 10:02:57	0.0	0.0	2020/10/14 10:03:57	0.0	0.0	2020/10/14 10:04:57	0.0	0.0	2020/10/14 10:05:57	0.0	0.0
2020/10/14 10:00:58	37.7	0.7	2020/10/14 10:01:58	56.76	1.1	2020/10/14 10:02:58	0.0	0.0	2020/10/14 10:03:58	0.0	0.0	2020/10/14 10:04:58	0.0	0.0	2020/10/14 10:05:58	0.0	0.0
2020/10/14 10:00:59	37.7	0.7	2020/10/14 10:01:59	56.76	1.1	2020/10/14 10:02:59	0.0	0.0	2020/10/14 10:03:59	0.0	0.0	2020/10/14 10:04:59	0.0	0.0	2020/10/14 10:05:59	0.0	0.0
2020/10/14 10:01:00	37.7	0.7	2020/10/14 10:02:00	0.0	0.0	2020/10/14 10:03:00	0.0	0.0	2020/10/14 10:04:00	0.0	0.0	2020/10/14 10:05:00	0.0	0.0	2020/10/14 10:06:00	0.0	0.0
2020/10/14 10:01:01	37.7	0.7	2020/10/14 10:02:01	0.0	0.0	2020/10/14 10:03:01	0.0	0.0	2020/10/14 10:04:01	0.0	0.0	2020/10/14 10:05:01	0.0	0.0	2020/10/14 10:06:01	0.0	0.0
2020/10/14 10:01:02	37.7	0.7	2020/10/14 10:02:02	0.0	0.0	2020/10/14 10:03:02	0.0	0.0	2020/10/14 10:04:02	0.0	0.0	2020/10/14 10:05:02	0.0	0.0	2020/10/14 10:06:02	0.0	0.0
2020/10/14 10:01:03	37.7	0.7	2020/10/14 10:02:03	0.0	0.0	2020/10/14 10:03:03	0.0	0.0	2020/10/14 10:04:03	0.0	0.0	2020/10/14 10:05:03	0.0	0.0	2020/10/14 10:06:03	0.0	0.0
2020/10/14 10:01:04	37.7	0.7	2020/10/14 10:02:04	0.0	0.0	2020/10/14 10:03:04	0.0	0.0	2020/10/14 10:04:04	0.0	0.0	2020/10/14 10:05:04	0.0	0.0	2020/10/14 10:06:04	0.0	0.0
2020/10/14 10:01:05	37.7	0.7	2020/10/14 10:02:05	0.0	0.0	2020/10/14 10:03:05	0.0	0.0	2020/10/14 10:04:05	0.0	0.0	2020/10/14 10:05:05	0.0	0.0	2020/10/14 10:06:05	0.0	0.0
2020/10/14 10:01:06	37.7	0.7	2020/10/14 10:02:06	0.0	0.0	2020/10/14 10:03:06	0.0	0.0	2020/10/14 10:04:06	0.0	0.0	2020/10/14 10:05:06	0.0	0.0	2020/10/14 10:06:06	0.0	0.0
2020/10/14 10:01:07	37.7	0.7	2020/10/14 10:02:07	0.0	0.0	2020/10/14 10:03:07	0.0	0.0	2020/10/14 10:04:07	0.0	0.0	2020/10/14 10:05:07	0.0	0.0	2020/10/14 10:06:07	0.0	0.0
2020/10/14 10:01:08	37.7	0.7	2020/10/14 10:02:08	0.0	0.0	2020/10/14 10:03:08	0.0	0.0	2020/10/14 10:04:08	0.0	0.0	2020/10/14 10:05:08	0.0	0.0	2020/10/14 10:06:08	0.0	0.0
2020/10/14 10:01:09	37.7	0.7	2020/10/14 10:02:09	0.0	0.0	2020/10/14 10:03:09	0.0	0.0	2020/10/14 10:04:09	0.0	0.0	2020/10/14 10:05:09	0.0	0.0	2020/10/14 10:06:09	0.0	0.0
2020/10/14 10:01:10	37.7	0.7	2020/10/14 10:02:10	0.0	0.0	2020/10/14 10:03:10	0.0	0.0	2020/10/14 10:04:10	0.0	0.0	2020/10/14 10:05:10	0.0	0.0	2020/10/14 10:06:10	0.0	0.0
2020/10/14 10:01:11	37.7	0.7	2020/10/14 10:02:11	0.0	0.0	2020/10/14 10:03:11	0.0	0.0	2020/10/14 10:04:11	0.0	0.0	2020/10/14 10:05:11	0.0	0.0	2020/10/14 10:06:11	0.0	0.0
2020/10/14 10:01:12	37.7	0.7	2020/10/14 10:02:12	0.0	0.0	2020/10/14 10:03:12	0.0	0.0	2020/10/14 10:04:12	0.0	0.0	2020/10/14 10:05:12	0.0	0.0	2020/10/14 10:06:12	0.0	0.0
2020/10/14 10:01:13	37.7	0.7	2020/10/14 10:02:13	0.0	0.0	2020/10/14 10:03:13	0.0	0.0	2020/10/14 10:04:13	0.0	0.0	2020/10/14 10:05:13	0.0	0.0	2020/10/14 10:06:13	0.0	0.0
2020/10/14 10:01:14	37.7	0.7	2020/10/14 10:02:14	0.0	0.0	2020/10/14 10:03:14	0.0	0.0	2020/10/14 10:04:14	0.0	0.0	2020/10/14 10:05:14	0.0	0.0	2020/10/14 10:06:14	0.0	0.0
2020/10/14 10:01:15	37.7	0.7	2020/10/14 10:02:15	0.0	0.0	2020/10/14 10:03:15	0.0	0.0	2020/10/14 10:04:15	0.0	0.0	2020/10/14 10:05:15	0.0	0.0	2020/10/14 10:06:15	0.0	0.0
2020/10/14 10:01:16	37.7	0.7	2020/10/14 10:02:16	0.0	0.0	2020/10/14 10:03:16	0.0	0.0	2020/10/14 10:04:16	0.0	0.0	2020/10/14 10:05:16	0.0	0.0	2020/10/14 10:06:16	0.0	0.0
2020/10/14 10:01:17	37.7	0.7	2020/10/14 10:02:17	0.0	0.0	2020/10/14 10:03:17	0.0	0.0	2020/10/14 10:04:17	0.0	0.0	2020/10/14 10:05:17	0.0	0.0	2020/10/14 10:06:17	0.0	0.0
2020/10/14 10:01:18	37.7	0.7	2020/10/14 10:02:18	0.0	0.0	2020/10/14 10:03:18	0.0	0.0	2020/10/14 10:04:18	0.0	0.0	2020/10/14 10:05:18	0.0	0.0	2020/10/14 10:06:18	0.0	0.0
2020/10/14 10:01:19	37.7	0.7	2020/10/14 10:02:19	0.0	0.0	2020/10/14 10:03:19	0.0	0.0	2020/10/14 10:04:19	0.0	0.0	2020/10/14 10:05:19	0.0	0.0	2020/10/14 10:06:19	0.0	0.0
2020/10/14 10:01:20	37.7	0.7	2020/10/14 10:02:20	0.0	0.0	2020/10/14 10:03:20	0.0	0.0	2020/10/14 10:04:20	0.0	0.0	2020/10/14 10:05:20	0.0	0.0	2020/10/14 10:06:20	0.0	0.0
2020/10/14 10:01:21	37.7	0.7	2020/10/14 10:02:21	0.0	0.0	2020/10/14 10:03:21	0.0	0.0	2020/10/14 10:04:21	0.0	0.0	2020/10/14 10:05:21	0.0	0.0	2020/10/14 10:06:21	0.0	0.0
2020/10/14 10:01:22	37.7	0.7	2020/10/14 10:02:22	0.0	0.0	2020/10/14 10:03:22	0.0	0.0	2020/10/14 10:04:22	0.0	0.0	2020/10/14 10:05:22	0.0	0.0	2020/10/14 10:06:22	0.0	0.0
2020/10/14 10:01:23	37.7	0.7	2020/10/14 10:02:23	0.0	0.0	2020/10/14 10:03:23	0.0	0.0	2020/10/14 10:04:23	0.0	0.0	2020/10/14 10:05:23	0.0	0.0	2020/10/14 10:06:23	0.0	0.0
2020/10/14 10:01:24	37.7	0.7	2020/10/14 10:02:24	0.0	0.0	2020/10/14 10:03:24	0.0	0.0	2020/10/14 10:04:24	0.0	0.0	2020/10/14 10:05:24	0.0	0.0	2020/10/14 10:06:24	0.0	0.0
2020/10/14 10:01:25	37.7	0.7	2020/10/14 10:02:25	0.0	0.0	2020/10/14 10:03:25	0.0	0.0	2020/10/14 10:04:25	0.0	0.0	2020/10/14 10:05:25	0.0	0.0	2020/10/14 10:06:25	0.0	0.0
2020/10/14 10:01:26	37.7	0.7	2020/10/14 10:02:26	0.0	0.0	2020/10/14 10:03:26	0.0	0.0	2020/10/14 10:04:26	0.0	0.0	2020/10/14 10:05:26	0.0	0.0	2020/10/14 10:06:26	0.0	0.0
2020/10/14 10:01:27	37.7	0.7	2020/10/14 10:02:27	0.0	0.0	2020/10/14 10:03:27	0.0	0.0	2020/10/14 10:04:27	0.0	0.0	2020/10/14 10:05:27	0.0	0.0	2020/10/14 10:06:27	0.0	0.0
2020/10/14 10:01:28	37.7	0.7	2020/10/14 10:02:28	0.0	0.0	2020/10/14 10:03:28	0.0	0.0	2020/10/14 10:04:28	0.0	0.0	2020/10/14 10:05:28	0.0	0.0	2020/10/14 10:06:28	0.0	0.0
2020/10/14 10:01:29	37.7	0.7	2020/10/14 10:02:29	0.0	0.0	2020/10/14 10:03:29	0.0	0.0	2020/10/14 10:04:29	0.0	0.0	2020/10/14 10:05:29	0.0	0.0	2020/10/14 10:06:29	0.0	0.0
2020/10/14 10:01:30	37.7	0.7	2020/10/14 10:02:30	0.0	0.0	2020/10/14 10:03:30	0.0	0.0	2020/10/14 10:04:30	0.0	0.0	2020/10/14 10:05:30	0.0	0.0	2020/10/14 10:06:30	0.0	0.0
2020/10/14 10:01:31	37.7	0.7	2020/10/14 10:02:31	0.0	0.0	2020/10/14 10:03:31	0.0	0.0	2020/10/14 10:04:31	0.0	0.0	2020/10/14 10:05:31	0.0	0.0	2020/10/14 10:06:31	0.0	0.0
2020/10/14 10:01:32	37.7	0.7	2020/10/14 10:02:32	0.0	0.0	2020/10/14 10:03:32	0.0	0.0	2020/10/14 10:04:32	0.0	0.0	2020/10/14 10:05:32	0.0	0.0	2020/10/14 10:06:32	0.0	0.0
2020/10/14 10:01:33	37.7	0.7	2020/10/14 10:02:33	0.0	0.0	2020/10

B A Pump Testing Job Details

Bore ID	RBGW07	Date	22-Oct-11	Comments
Test Type	Constant Flow, 0.5 L/S			Water quality samples (15 mins) in attached scanned file.
SWL	24.893	TOC Height		
Transducer Depth (Meters)	96.96	Pump Depth (Meters)	98.00	







Date&Time	Pressure (m)	Flowrate (L/s)	Date&Time	Pressure (m)	Flowrate (L/s)
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07:17:14 10-22-2011	70.96845245	0.579971075	08:21:14 10-22-2011	27.40312958	0.415134549
07:17:44 10-22-2011	70.47990417	0.555549681	08:21:44 10-22-2011	27.2077713	0.56165421
07:18:14 10-22-2011	69.99153137	0.494499505	08:22:14 10-22-2011	27.03675461	0.439555794
07:18:44 10-22-2011	69.42997742	0.506710052	08:22:44 10-22-2011	26.7925663	0.445659757
07:19:14 10-22-2011	68.96601868	0.512814641	08:23:14 10-22-2011	26.5484066	0.451765597
07:19:44 10-22-2011	68.20883942	0.512814641	08:23:44 10-22-2011	26.3774929	0.433450073
07:20:14 10-22-2011	67.91584778	0.512814641	08:24:14 10-22-2011	26.08447647	0.482290894
07:20:44 10-22-2011	67.42753601	0.500605404	08:24:44 10-22-2011	25.96228981	0.439555794
07:21:14 10-22-2011	66.76825714	0.500605404	08:25:14 10-22-2011	25.66926384	0.488395602
07:21:44 10-22-2011	66.13315582	0.500605404	08:25:44 10-22-2011	25.44952583	0.616600037
07:22:14 10-22-2011	65.71807861	0.506710052	08:26:14 10-22-2011	25.25416565	0.494499505
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07:25:14 10-22-2011	63.22732925	0.5189206	08:29:14 10-22-2011	24.03309822	0.506710052
07:25:44 10-22-2011	62.7633667	0.506710052	08:29:44 10-22-2011	23.86218452	0.488395602
07:26:14 10-22-2011	62.37249374	0.506710052	08:30:14 10-22-2011	23.74007416	0.463974327
07:26:44 10-22-2011	61.73762131	0.525024712	08:30:44 10-22-2011	23.47149849	0.488395602
07:27:14 10-22-2011	61.10274506	0.482290894	08:31:14 10-22-2011	23.2761364	0.421240449
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08:17:14 10-22-2011	29.18580246	0.653229654	09:21:14 10-22-2011	0.052693054	0.396820068
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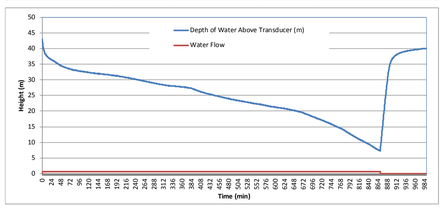
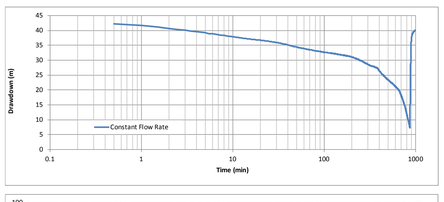
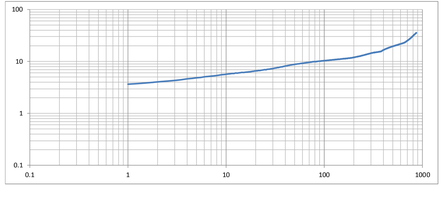
08:20:14 10-22-2011	27.7937851	0.586074889			

B A Pump Testing Job Details

Bore ID	RBGW08		Date	31-Oct-11	Comments
Test Type	Constant Flow 0.6 l/s				Water quality samples taken every 15min and attached in scaned file.
SWL	6.068m	TOC Height	0.624m		
Transducer Depth (Meters)	49.1m	Pump Depth (Meters)	50.0m		
Total Volume Pumped	31,780L				







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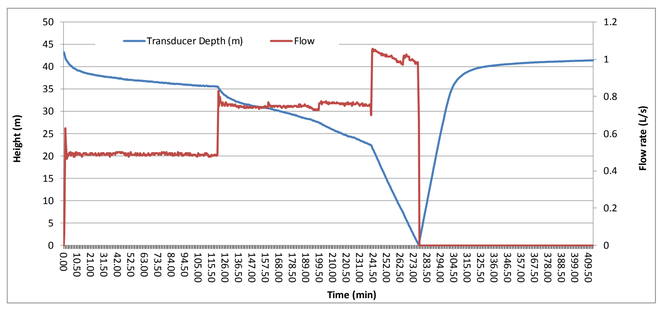
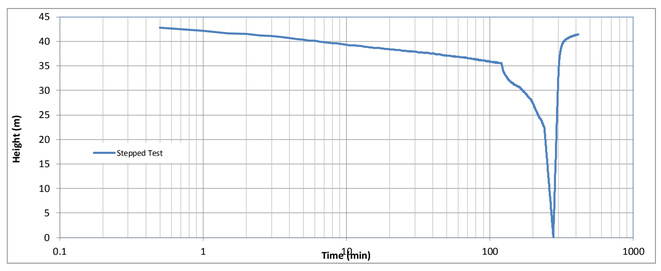
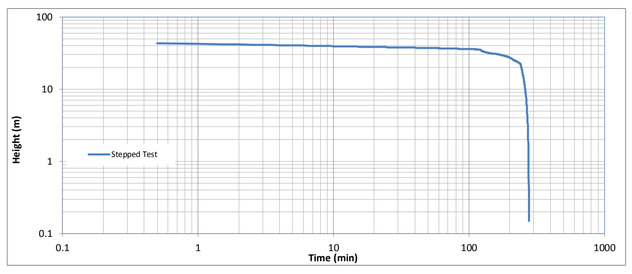
B A Pump Testing Job Details

Bore ID	RBGW08	Date	25-Oct-11	Comments
Test Type	Step, 0.5, 0.75, 1.0			
SWL	5.104	TOC Height	0.624	
Transducer Depth (Meters)	48.355	Pump Depth (Meters)	50.00	
Total Volume (Liters)	10,976			







Date & Time	Depth (m)	Flow Rate	Date & Time	Depth (m)	Flow Rate	Date & Time	Depth (m)	Flow Rate	Date & Time	Depth (m)	Flow Rate	Date & Time	Depth (m)	Flow Rate
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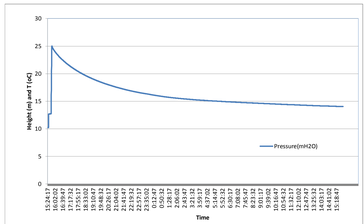
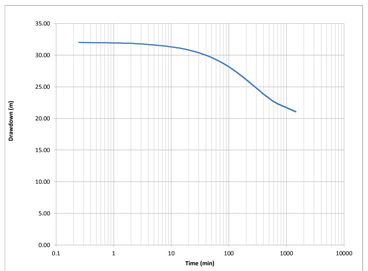
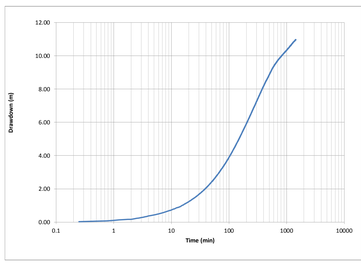
08:43:13 10-25-2011	36.902489	0.4883956	10:22:43 10-25-2011	30.797449	0.7448046	12:01:43 10-25-2011	12.042929	1.007319	13:40:43 10-25-2011	40.760868	0			
08:43:43 10-25-2011	36.878075	0.4822909	10:23:13 10-25-2011	30.773035	0.7387006	12:02:13 10-25-2011	11.749851	1.007319	13:41:13 10-25-2011	40.785286	0			
08:44:13 10-25-2011	36.902489	0.4944995	10:23:43 10-25-2011	30.724197	0.7448046	12:02:43 10-25-2011	11.481267	1.007319	13:41:43 10-25-2011	40.8097	0			
08:44:43 10-25-2011	36.85363	0.4883956	10:24:13 10-25-2011	30.724197	0.7387006	12:03:13 10-25-2011	11.139366	1.0012137	13:42:13 10-25

B A Pump Testing Job Details

Bore ID	RBGW09	Date	22-Oct-11	Comments
Test Type	Slug Test, Filling Flowrate @1.4L/S			Total 283 Litres into bore, 3 min
SWL(Meters)	12.504	TOC Height(Meters)	0.494	38 sec to fill, Water Quality
Transducer Depth (Meters)	15.00	Pump Depth (Meters)	N/A	reading = pH 7.75, TDS 0.29, EC







Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)
15:24:17	10.24	36.26	17:54:02	20.46	33.71	20:23:47	18.03	33.14	22:53:32	16.62	32.89	1:23:17	15.73	32.78	3:53:02	15.23	32.70	6:22:47	14.90	32.66	8:52:32	14.64	14.64	11:22:17	14.40	32.61	13:52:02	14.18	32.59
15:24:32	10.24	36.20	17:54:17	20.46	33.70	20:24:02	18.03	33.14	22:53:47	16.62	32.89	1:23:32	15.73	32.78	3:53:17	15.23	32.70	6:23:02	14.90	32.66	8:52:47	14.63	14.63	11:22:32	14.40	32.61	13:52:17	14.18	32.59
15:24:47	10.24	36.18	17:54:32	20.45	33.70	20:24:17	18.03	33.14	22:54:02	16.61	32.89	1:23:47	15.73	32.78	3:53:32	15.22	32.70	6:23:17	14.90	32.66	8:53:02	14.63	14.63	11:22:47	14.40	32.61	13:52:32	14.18	32.59
15:25:02	10.23	36.17	17:54:47	20.45	33.70	20:24:32	18.02	33.14	22:54:17	16.61	32.89	1:24:02	15.73	32.78	3:53:47	15.22	32.70	6:23:32	14.90	32.66	8:53:17	14.63	14.63	11:23:02	14.40	32.61	13:52:47	14.17	32.59
15:25:17	10.24	36.18	17:55:02	20.44	33.70	20:24:47	18.02	33.13	22:54:32	16.61	32.89	1:24:17	15.73	32.77	3:54:02	15.22	32.70	6:23:47	14.90	32.66	8:53:32	14.63	14.63	11:23:17	14.39	32.61	13:53:02	14.17	32.59
15:25:32	10.24	36.19	17:55:17	20.43	33.69	20:25:02	18.02	33.14	22:54:47	16.60	32.88	1:24:32	15.72	32.77	3:54:17	15.22	32.70	6:24:02	14.90	32.66	8:53:47	14.63	14.63	11:23:32	14.39	32.61	13:53:17	14.17	32.59
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15:26:17	10.24	36.41	17:56:02	20.42	33.69	20:25:47	18.01	33.13	22:55:32	16.60	32.89	1:25:17	15.72	32.77	3:55:02	15.22	32.70	6:24:47	14.90	32.66	8:54:32	14.63	14.63	11:24:17	14.39	32.61	13:54:02	14.17	32.59
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15:27:32	10.24	36.63	17:57:17	20.39	33.67	20:27:02	17.99	33.13	22:56:47	16.59	32.89	1:26:32	15.72	32.77	3:56:17	15.22	32.70	6:26:02	14.89	32.66	8:55:47	14.63	14.63	11:25:32	14.39	32.61	13:55:17	14.17	32.59
15:27:47	10.24	36.77	17:57:32	20.39	33.67	20:27:17	17.99	33.12	22:57:02	16.59	32.89	1:26:47	15.72	32.77	3:56:32	15.22	32.70	6:26:17	14.89	32.66	8:56:02	14.63	14.63	11:25:47	14.39	32.61	13:55:32	14.17	32.59
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15:30:47	12.69	34.17	18:00:32	20.32	33.66	20:30:17	17.96	33.12	23:00:02	16.57	32.88	1:29:47	15.70	32.77	3:59:32	15.21	32.70	6:29:17	14.89	32.66	8:59:02	14.63	14.63	11:28:47	14.39	32.60	13:58:32	14.17	32.59
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15:31:47	12.70	33.32	18:01:32	20.29	33.66	20:31:17	17.95	33.11	23:01:02	16.56	32.89	1:30:47	15.70	32.77	4:00:32	15.21	32.70	6:30:17	14.88	32.66	9:00:02	14.63	14.63	11:29:47	14.39	32.61	13:59:32	14.16	32.59
15:32:02	12.70	33.23	18:01:47	20.29	33.66	20:31:32	17.95	33.11	23:01:17	16.56	32.88	1:31:02	15.70	32.77	4:00:47	15.21	32.70	6:30:32	14.88	32.66	9:00:17	14.63	14.63	11:30:02	14.39	32.61	13:59:47	14.16	32.59
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15:33:02	12.70	33.00	18:02:47	20.27	33.65	20:32:32	17.93	33.11	23:02:17	16.55	32.88	1:32:02	15.70	32.77	4:01:47	15.20	32.70	6:31:32	14.88	32.66	9:01:17	14.62	14.62	11:31:02	14.39	32.61	14:00:47	14.16	32.59
15:33:17	12.70	32.96	18:03:02	20.26	33.65	20:32:47	17.93	33.11	23:02:32	16.55	32.88	1:32:17	15.70	32.77	4:02:02	15.20	32.70	6:31:47	14.88	32.66	9:01:32	14.62	14.62	11:31:17	14.39	32.61	14:01:02	14.16	32.59
15:33:32	12.70	32.92	18:03:17	20.26	33.64	20:33:02	17.93	33.11	23:02:47	16.55	32.88	1:32:32	15.69	32.77	4:02:17	15.20	32.70	6:32:02	14.88	32.66	9:01:47	14.62	14.62	11:31:32	14.39	32.61	14:01:17	14.16	32.59
15:33:47	12.70	32.88	18:03:32	20.25	33.64	20:33:17	17.93	33.11	23:03:02	16.55	32.88	1:32:47	15.69	32.77	4:02:32	15.20	32.70	6:32:17	14.88	32.66	9:02:02	14.62	14.62	11:31:47	14.39	32.61	14:01:32	14.16	32.59
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15:34:47	12.70	32.77	18:04:32	20.23	33.64	20:34:17	17.91	33.11	23:04:02	16.54	32.88	1:33:47	15.69	32.77	4:03:32	15.20	32.70	6:33:17	14.88	32.66	9:03:02	14.62	14.62	11:32:47	14.38	32.61	14:02:32	14.16	32.59
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15:35:17	12.71	32.73	18:05:02	20.22	33.64	20:34:47	17.91	33.10	23:04:32	16.54	32.88	1:34:17	15.69	32.77	4:04:02	15.20	32.70	6:33:47	14.88	32.66	9:03:32	14.62	14.62	11:33:17	14.38	32.61	14:03:02	14.16	32.59
15:35:32	12.71	32.71	18:05:17	20.22	33.64	20:35:02	17.90	33.10	23:04:47	16.54	32.88	1:34:32	15.69	32.77	4:04:17	15.20	32.70	6:34:02	14.88	32.65	9:03:47	14.62	14.62	11:33:32	14.39	32.61	14:03:17	14.16	32.59
15:35:47	12.71	32.69	18:05:32	20.21	33.63	20:35:17	17.90	33.11	23:05:02	16.53	32.88	1:34:47	15.68	32.77	4:04:32	15.20	32.70	6:34:17	14.88	32.66	9:04:02	14.62	14.62	11:33:47	14.39	32.61	14:03:32	14.16	32.59
15:36:02	12.71	32.68	18:05:47	20.20	33.63	20:35:32	17.90	33.11	23:05:17	16.53	32.88	1:35:02	15.68	32.77	4:04:47	15.19	32.70	6:34:32	14.88	32.66	9:04:17	14.62	14.62	11:34:02	14.39	32.60	14:03:47	14.16	32.59
15:36:17	12.71	32.66	18:06:02	20.20	33.63	20:35:47	17.89	33.11	23:05:32	16.53	32.88	1:35:17	15.68	32.77	4:05:02	15.19	32.70	6:34:47	14.88	32.66	9:04:32	14.62	14.62	11:34:17	14.39	32.61	14:04:02	14.16	32.59
15:36:32	12.71	32.65	18:06:17	20.20	33.63	20:36:02	17.89	33.11	23:05:47	16.53	32.88	1:35:32	15.68	32.77	4:05:17	15.19	32.70	6:35:02	14.88	32.66	9:04:47	14.62	14.62	11:34:32	14.38	32.60	14:04:17	14.16	32.59
15:36:47	12.71	32.64	18:06:32	20.19	33.62	20:36:17	17.88	33.11	23:06:02	16.53	32.88	1:35:47	15.68	32.77	4:05:32	15.19	32.70	6:35:17	14.87	32.66	9:05:02	14.62	14.62	11:34:47	14.38	32.61	14:04:32	14.16	32.59
15:37:02	12.71	32.63	18:06:47	20.19	33.62	20:36:32	17.88	33.11	23:06:17	16.52	32.88	1:36:02	15.68	32.77	4:05:47	15.19	32.70	6:35:32	14.88	32.66	9:05:17	14.62	14.62	11:35:02	14.39	32.61	14:04:47	14.16	32.59
15:37:17	12.71	32.62	18:07:02	20.18	33.62	20:36:47	17.88	33.11	23:06:32	16.52	32.88	1:36:17	15.68	32.77	4:06:02	15.19	32.70	6:35:47	14.87	32.65	9:05:32	14.61	14.61	11:35:17	14.38	32.61	14:05:02	14.16	32.59
15:37:32	12.71	32.61	18:07:17	20.17	33.61	20:37:02	17.88	33.11	23:06:47	16.52	32.88	1:36:32	15.68	32.77	4:06:17	15.19	32.70	6:36:02	14.87	32.66	9:05:47	14.61	14.61	11:35:32	14.38	32.61	14:05:17	14.16	32.59
15:37:47	12.71	32.60	18:07:32	20.17	33.61	20:37:17	17.87	33.11	23:07:02	16.52	32.88	1:36:47	15.67	32.77	4:06:32	15.19	32.70	6:36:17	14.87	32.65	9:06:02	14.61	14.61	11:35:47	14.38	32.61	14:05:32	14.16	32.59
15:38:02	12.71	32.60	18:07:47	20.16	33.61	20:37:32	17.87	33.11	23:07:17	16.52	32.88	1:37:02	15.68	32.77	4:06:47	15.19	32.70	6:36:32	14.87	32.66	9:06:17	14.61	14.61	11:36:02	14.38	32.61	14:05:47	14.16	32.59
15:38:17	12.71	32.59	18:08:02	20.16	33.61	20:37:47	17.87	33.11	23:07:32	16.52	32.88	1:37:17	15.67	32.77	4:07:02	15.19	32.70	6:36:47	14.87	32.65	9:06:32	14.61	14.61	11:36:17	14.38	32.61	14:06:02	14.16	32.59
15:38:32	12.71	32.59	18:08:17	20.15	33.61	20:38:02	17.86	33.10	23:07:47	16.52	32.88	1:37:32	15.67	32.77	4:07:17	15.19	32.70	6:37:02	14.87	32.66	9:06:47	14.61	14.61	11:36:32	14.38	32.60	14:06:17	14.16	32.59
15:38:47	12.71	32.58	18:08:32	20.15	33.61	20:38:17	17.86	33.10	23:08:02	16.51	32.88	1:37:47	15.67	32.77	4:07:32	15.19	32.70	6:37:17	14.87	32.66	9:07:02	14.61	14.61	11:36:47	14.38	32.61	14:06:32	14.16	32.59
15:39:02	12.71	32.58	18:08:47	20.14	33.61	20:38:32	17.86	33.10	23:08:17	16.51	32.88	1:38:02	15.67	32.77	4:07:47	15.19	32.70	6:37:32	14.87	32.66	9:07:17	14.61	14.61	11:37:02	14.38	32.60	14:06:47	14.16	32.59
15:39:17	12.71	32.57	18:09:02	20.14	33.61	20:38:47	17.86	33.10	23:08:32	16.51	32.88	1:38:17	15.67	32.77	4:08:02	15.19	32.70	6:37:47	14.87	32.65	9:07:32	14.61	14.61	11:37:17	14.38	32.61	14:07:02	14.16	32.59
15:39:32	12.71	32.57	18:09:17	20.13	33.61	20:39:02	17.85	33.10	23:08:47	16.51	32.88	1:38:32	15.67	32.77	4:08:17	15.19	32.70	6:38:02	14.87	32.65	9:07:47	14.61	14.61	11:37:32	14.38	32.60	14:07:17	14.16	32.59
15:39:47	12.71	32.57	18:09:32	20.13	33.61	20:39:17	17.85	33.10	23:09:02	16.51	32.88	1:38:47	15.67	32.77	4:08:32	15.19	32.70	6:38:17	14.87	32.65	9:08:02	14.61	14.61	11:37:47	14.38	32.60	14:07:32	14.16	32.59
15:40:02	12.71	32.56	18:09:47	20.12	33.61	20:39:32	17.85	33.10	23:09:17	16.51	32.88	1:39:02	15.67	32.77	4:08:47	15.19	32.70	6:38:32	14.87	32.65	9:08:17	14.61	14.61	11:38:02	14.38	32.60	14:07:47	14.16	32.59
15:40:17	12.71	32.55	18:10:02	20.12	33.61	20:39:47	17.85	33.10	23:09:32	16.51	32.88	1:39:17	15.67	32.77	4:09:02	15.19	32.70	6:38:47	14.87	32.65	9:08:32	14.61	14.61	11:38:17	14.38	32.60	14:08:02	14.16	32.59
15:40:32	12.71	32.55	18:10:17	20.11	33.61	20:40:02	17.84	33.09	23:09:47	16.51	32.88	1:39:32	15.67	32.77	4:09:17	15.19	32.70	6:39:02	14.87	32.65	9:08:47	14.61	14.61	11:38:32	14.38	32.60	14:08:17	14.16	32.59
15:40:47	12.71	32.55	18:10:32	20.11	33.61	20:40:17	17.84	33.10	23:10:02	16.50	32.88	1:39:47	15.66	32.77	4:09:32	15.19	32.70	6:39:17	14.87	32.65	9:09:02	14.61	14.61	11:38:47	14.38	32.60	14:08:32	14.16	32.59
15:41:02	12.71	32.55	18:10:47	20.10	33.60	20:40:32	17.84	33.09	23:10:17	16.50	32.88	1:40:02	15.66	32.77	4:09:47	15.19	32.70	6:39:32	14.87	32.65	9:09:17	14.61	14.61	11:39:02	14.38	32.60	14:08:47	14.16	32.59
15:41:17	12.72	32.54	18:11:02	20.10	33.60	20:40:47	17.84	33.09	23:10:32	16.50	32.88	1:40:17	15.66	32.76	4:10:02	15.18	32.70	6:39:47	14.87	32.65	9:09:32	14.61	14.61	11:39:17	14.38	32.60	14:09:02	14.15	32.59
15:41:32	12.72	32.54	18:11:17	20.09	33.60	20:41:02	17.83	33.09	23:10:47	16.49	32.87	1:40:32	15.66	32.76	4:10:17	15.18	32.70	6:40:02	14.87	32.65	9:09:47	14.61	14.61	11:39:32	14.38	32.60	14:09:17	14.16	32.59
15:41:47	12.72	32.54	18:11:32	20.09	33.60	20:41:17	17.83	33.09	23:11:02	16.49	32.88	1:40:47	15.66	32.77	4:10:32	15.18	32.70	6:40:17	14.87	32.65	9:10:02	14.61	14.61	11:39:47	14.38	32.60	14:09:32	14.16	32.59
15:42:02	12.71	32.54	18:11:47	20.08	33.60	20:41:32	17.83	33.08	23:11:17	16.49	32.88	1:41:02	15.66	32.77	4:10:47	15.18	32.70	6:40:32	14.87	32.65	9:10:17	14.61	14.61	11:40:02	14.37	32.60	14:09:47	14.15	32.59
15:42:17	12.71	32.54	18:12:02	20.08	33.60	20:41:47	17.82	33.08	23:11:32	16.49	32.88	1:41:17	15.66	32.77	4:11:02	15.18	32.70	6:40:47	14.87	32.65	9:10:32	14.61	14.61	11:40:17	14.37	32.60	14:10:02	14.15	32.59
15:42:32	13.27	32.54	18:12:17	20.07	33.60	20:42:02	17.82	33.08	23:11:47	16.49	32.88	1:41:32	15.66	32.77	4:11:17	15.18	32.70	6:41:02	14.87	32.65	9:10:47	14.61	14.61	11:40:32	14.37	32.60	14:10:17	14.15	32.59
15:42:47	14.26	32.54	18:12:32	20.07	33.60	20:42:17	17.82	33.08	23:12:02	16.49	32.88	1:41:47	15.66	32.77	4:11:32	15.18	32.70	6:41:17	14.86	32.65	9:11:02	14.61	14.61	11:40:47	14.37	32.60	14:10:32	14.15	32.59
15:43:02	15.19	32.53	18:12:47	20.06	33.60	20:42:32	17.82	33.08	23:12:17	16.49	32.88	1:

B A Pump Testing Job Details

Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)
16:05:32	23.81	34.61	18:35:17	19.63	33.51	21:05:02	17.56	33.05	23:34:47	16.35	32.85	2:04:32	15.56	32.76	4:34:17	15.13	32.69	7:04:02	14.82	32.65	9:33:47	14.57	14.57	12:03:32	14.33	32.60	14:33:17	14.13	32.59
16:05:47	23.80	34.60	18:35:32	19.62	33.51	21:05:17	17.56	33.05	23:35:02	16.35	32.85	2:04:47	15.57	32.75	4:34:32	15.13	32.69	7:04:17	14.82	32.65	9:34:02	14.57	14.57	12:03:47	14.33	32.60	14:33:32	14.13	32.59
16:06:02	23.79	34.60	18:35:47	19.62	33.51	21:05:32	17.56	33.05	23:35:17	16.35	32.85	2:05:02	15.57	32.76	4:34:47	15.13	32.69	7:04:32	14.82	32.65	9:34:17	14.57	14.57	12:04:02	14.33	32.60	14:33:47	14.13	32.59
16:06:17	23.77	34.60	18:36:02	19.61	33.51	21:05:47	17.56	33.05	23:35:32	16.35	32.85	2:05:17	15.56	32.76	4:35:02	15.13	32.69	7:04:47	14.82	32.65	9:34:32	14.57	14.57	12:04:17	14.33	32.60	14:34:02	14.13	32.59
16:06:32	23.76	34.61	18:36:17	19.61	33.51	21:06:02	17.56	33.05	23:35:47	16.35	32.85	2:05:32	15.56	32.75	4:35:17	15.13	32.69	7:05:02	14.82	32.65	9:34:47	14.57	14.57	12:04:32	14.33	32.60	14:34:17	14.13	32.59
16:06:47	23.75	34.61	18:36:32	19.60	33.51	21:06:17	17.55	33.05	23:36:02	16.34	32.85	2:05:47	15.56	32.75	4:35:32	15.13	32.69	7:05:17	14.82	32.65	9:35:02	14.57	14.57	12:04:47	14.33	32.60	14:34:32	14.13	32.59
16:07:02	23.74	34.61	18:36:47	19.60	33.51	21:06:32	17.55	33.04	23:36:17	16.34	32.85	2:06:02	15.56	32.75	4:35:47	15.13	32.69	7:05:32	14.82	32.65	9:35:17	14.57	14.57	12:05:02	14.33	32.60	14:34:47	14.13	32.59
16:07:17	23.73	34.62	18:37:02	19.59	33.51	21:06:47	17.55	33.04	23:36:32	16.34	32.85	2:06:17	15.56	32.76	4:36:02	15.12	32.69	7:05:47	14.82	32.65	9:35:32	14.56	14.56	12:05:17	14.33	32.60	14:35:02	14.13	32.59
16:07:32	23.72	34.62	18:37:17	19.59	33.50	21:07:02	17.55	33.04	23:36:47	16.34	32.85	2:06:32	15.56	32.76	4:36:17	15.12	32.69	7:06:02	14.82	32.65	9:35:47	14.56	14.56	12:05:32	14.33	32.60	14:35:17	14.13	32.59
16:07:47	23.71	34.63	18:37:32	19.59	33.50	21:07:17	17.55	33.04	23:37:02	16.34	32.85	2:06:47	15.56	32.76	4:36:32	15.12	32.69	7:06:17	14.82	32.65	9:36:02	14.56	14.56	12:05:47	14.33	32.60	14:35:32	14.13	32.59
16:08:02	23.69	34.64	18:37:47	19.58	33.50	21:07:32	17.54	33.04	23:37:17	16.34	32.85	2:07:02	15.56	32.76	4:36:47	15.12	32.69	7:06:32	14.82	32.65	9:36:17	14.56	14.56	12:06:02	14.33	32.60	14:35:47	14.13	32.59
16:08:17	23.68	34.64	18:38:02	19.58	33.50	21:07:47	17.54	33.04	23:37:32	16.34	32.85	2:07:17	15.56	32.76	4:37:02	15.12	32.69	7:06:47	14.82	32.65	9:36:32	14.56	14.56	12:06:17	14.33	32.60	14:36:02	14.12	32.59
16:08:32	23.67	34.64	18:38:17	19.57	33.50	21:08:02	17.54	33.04	23:37:47	16.34	32.85	2:07:32	15.55	32.76	4:37:17	15.12	32.69	7:07:02	14.82	32.65	9:36:47	14.57	14.57	12:06:32	14.33	32.60	14:36:17	14.13	32.59
16:08:47	23.66	34.64	18:38:32	19.57	33.50	21:08:17	17.53	33.04	23:38:02	16.33	32.85	2:07:47	15.55	32.76	4:37:32	15.12	32.69	7:07:17	14.82	32.65	9:37:02	14.56	14.56	12:06:47	14.32	32.60	14:36:32	14.13	32.59
16:09:02	23.65	34.64	18:38:47	19.56	33.50	21:08:32	17.53	33.04	23:38:17	16.33	32.85	2:08:02	15.55	32.76	4:37:47	15.12	32.69	7:07:32	14.82	32.65	9:37:17	14.56	14.56	12:07:02	14.32	32.60	14:36:47	14.13	32.59
16:09:17	23.64	34.64	18:39:02	19.56	33.50	21:08:47	17.53	33.04	23:38:32	16.33	32.85	2:08:17	15.55	32.75	4:38:02	15.12	32.69	7:07:47	14.82	32.65	9:37:32	14.56	14.56	12:07:17	14.32	32.60	14:37:02	14.12	32.59
16:09:32	23.63	34.63	18:39:17	19.56	33.50	21:09:02	17.53	33.04	23:38:47	16.33	32.85	2:08:32	15.55	32.75	4:38:17	15.12	32.69	7:08:02	14.82	32.65	9:37:47	14.56	14.56	12:07:32	14.33	32.60	14:37:17	14.13	32.59
16:09:47	23.62	34.62	18:39:32	19.55	33.50	21:09:17	17.53	33.04	23:39:02	16.33	32.85	2:08:47	15.55	32.76	4:38:32	15.12	32.69	7:08:17	14.82	32.65	9:38:02	14.57	14.57	12:07:47	14.32	32.60	14:37:32	14.12	32.59
16:10:02	23.61	34.61	18:39:47	19.55	33.49	21:09:32	17.52	33.04	23:39:17	16.33	32.85	2:09:02	15.55	32.75	4:38:47	15.12	32.69	7:08:32	14.81	32.65	9:38:17	14.56	14.56	12:08:02	14.32	32.60	14:37:47	14.12	32.59
16:10:17	23.59	34.61	18:40:02	19.54	33.49	21:09:47	17.52	33.04	23:39:32	16.33	32.85	2:09:17	15.55	32.75	4:39:02	15.12	32.69	7:08:47	14.81	32.65	9:38:32	14.56	14.56	12:08:17	14.32	32.60	14:38:02	14.13	32.59
16:10:32	23.59	34.59	18:40:17	19.54	33.49	21:10:02	17.52	33.03	23:39:47	16.32	32.85	2:09:32	15.55	32.75	4:39:17	15.12	32.69	7:09:02	14.81	32.65	9:38:47	14.56	14.56	12:08:32	14.32	32.60	14:38:17	14.12	32.59
16:10:47	23.57	34.58	18:40:32	19.53	33.49	21:10:17	17.51	33.03	23:40:02	16.32	32.85	2:09:47	15.54	32.75	4:39:32	15.12	32.69	7:09:17	14.81	32.65	9:39:02	14.56	14.56	12:08:47	14.32	32.60	14:38:32	14.12	32.59
16:11:02	23.56	34.57	18:40:47	19.53	33.49	21:10:32	17.51	33.04	23:40:17	16.32	32.85	2:10:02	15.54	32.75	4:39:47	15.12	32.69	7:09:32	14.81	32.65	9:39:17	14.56	14.56	12:09:02	14.32	32.60	14:38:47	14.12	32.59
16:11:17	23.55	34.56	18:41:02	19.52	33.49	21:10:47	17.51	33.04	23:40:32	16.32	32.85	2:10:17	15.54	32.75	4:40:02	15.11	32.69	7:09:47	14.81	32.65	9:39:32	14.56	14.56	12:09:17	14.32	32.60	14:39:02	14.12	32.59
16:11:32	23.54	34.54	18:41:17	19.52	33.49	21:11:02	17.51	33.04	23:40:47	16.32	32.85	2:10:32	15.54	32.75	4:40:17	15.11	32.68	7:10:02	14.81	32.65	9:39:47	14.56	14.56	12:09:32	14.32	32.60	14:39:17	14.12	32.59
16:11:47	23.53	34.54	18:41:32	19.52	33.49	21:11:17	17.50	33.04	23:41:02	16.32	32.85	2:10:47	15.54	32.75	4:40:32	15.11	32.69	7:10:17	14.81	32.65	9:40:02	14.56	14.56	12:09:47	14.32	32.60	14:39:32	14.12	32.59
16:12:02	23.52	34.54	18:41:47	19.51	33.49	21:11:32	17.50	33.04	23:41:17	16.32	32.85	2:11:02	15.54	32.75	4:40:47	15.11	32.69	7:10:32	14.81	32.65	9:40:17	14.56	14.56	12:10:02	14.32	32.60	14:39:47	14.12	32.59
16:12:17	23.51	34.53	18:42:02	19.50	33.49	21:11:47	17.50	33.04	23:41:32	16.32	32.85	2:11:17	15.54	32.75	4:41:02	15.11	32.68	7:10:47	14.81	32.65	9:40:32	14.56	14.56	12:10:17	14.32	32.60	14:40:02	14.12	32.59
16:12:32	23.50	34.53	18:42:17	19.50	33.49	21:12:02	17.50	33.04	23:41:47	16.31	32.85	2:11:32	15.54	32.75	4:41:17	15.11	32.68	7:11:02	14.81	32.65	9:40:47	14.56	14.56	12:10:32	14.32	32.60	14:40:17	14.12	32.59
16:12:47	23.49	34.53	18:42:32	19.49	33.48	21:12:17	17.49	33.04	23:42:02	16.31	32.85	2:11:47	15.54	32.75	4:41:32	15.11	32.68	7:11:17	14.81	32.65	9:41:02	14.56	14.56	12:10:47	14.32	32.60	14:40:32	14.12	32.59
16:13:02	23.48	34.53	18:42:47	19.49	33.48	21:12:32	17.49	33.04	23:42:17	16.31	32.85	2:12:02	15.54	32.75	4:41:47	15.11	32.68	7:11:32	14.81	32.65	9:41:17	14.56	14.56	12:11:02	14.32	32.60	14:40:47	14.12	32.59
16:13:17	23.47	34.53	18:43:02	19.49	33.48	21:12:47	17.49	33.04	23:42:32	16.31	32.85	2:12:17	15.54	32.75	4:42:02	15.11	32.68	7:11:47	14.81	32.65	9:41:32	14.56	14.56	12:11:17	14.32	32.60	14:41:02	14.12	32.59
16:13:32	23.45	34.52	18:43:17	19.48	33.48	21:13:02	17.49	33.04	23:42:47	16.31	32.85	2:12:32	15.54	32.75	4:42:17	15.11	32.68	7:12:02	14.81	32.65	9:41:47	14.56	14.56	12:11:32	14.32	32.60	14:41:17	14.12	32.59
16:13:47	23.45	34.51	18:43:32	19.48	33.48	21:13:17	17.48	33.04	23:43:02	16.31	32.85	2:12:47	15.53	32.75	4:42:32	15.11	32.68	7:12:17	14.81	32.65	9:42:02	14.56	14.56	12:11:47	14.32	32.60	14:41:32	14.12	32.59
16:14:02	23.44	34.51	18:43:47	19.47	33.47	21:13:32	17.48	33.04	23:43:17	16.30	32.85	2:13:02	15.53	32.75	4:42:47	15.10	32.68	7:12:32	14.80	32.65	9:42:17	14.56	14.56	12:12:02	14.32	32.60	14:41:47	14.12	32.59
16:14:17	23.42	34.51	18:44:02	19.47	33.47	21:13:47	17.48	33.03	23:43:32	16.30	32.85	2:13:17	15.53	32.75	4:43:02	15.10	32.68	7:12:47	14.81	32.65	9:42:32	14.55	14.55	12:12:17	14.32	32.60	14:42:02	14.12	32.59
16:14:32	23.42	34.50	18:44:17	19.46	33.47	21:14:02	17.48	33.03	23:43:47	16.30	32.85	2:13:32	15.53	32.75	4:43:17	15.11	32.68	7:13:02	14.80	32.65	9:42:47	14.56	14.56	12:12:32	14.32	32.60	14:42:17	14.12	32.59
16:14:47	23.40	34.50	18:44:32	19.46	33.47	21:14:17	17.47	33.03	23:44:02	16.30	32.84	2:13:47	15.53	32.75	4:43:32	15.10	32.68	7:13:17	14.80	32.65	9:43:02	14.55	14.55	12:12:47	14.32	32.60	14:42:32	14.12	32.59
16:15:02	23.40	34.50	18:44:47	19.46	33.47	21:14:32	17.47	33.03	23:44:17	16.30	32.84	2:14:02	15.53	32.75	4:43:47	15.10	32.68	7:13:32	14.80	32.65	9:43:17	14.56	14.56	12:13:02	14.32	32.60	14:42:47	14.12	32.59
16:15:17	23.38	34.49	18:45:02	19.45	33.47	21:14:47	17.47	33.03	23:44:32	16.29	32.84	2:14:17	15.53	32.75	4:44:02	15.10	32.68	7:13:47	14.81	32.65	9:43:32	14.55	14.55	12:13:17	14.32	32.60	14:43:02	14.12	32.59
16:15:32	23.37	34.48	18:45:17	19.45	33.47	21:15:02	17.46	33.03	23:44:47	16.29	32.84	2:14:32	15.53	32.75	4:44:17	15.10	32.68	7:14:02	14.80	32.65	9:43:47	14.55	14.55	12:13:32	14.32	32.60	14:43:17	14.12	32.59
16:15:47	23.36	34.48	18:45:32	19.45	33.47	21:15:17	17.46	33.03	23:45:02	16.29	32.85	2:14:47	15.53	32.75	4:44:32	15.10	32.68	7:14:17	14.80	32.65	9:44:02	14.55	14.55	12:13:47	14.31	32.60	14:43:32	14.12	32.59
16:16:02	23.35	34.48	18:45:47	19.44	33.47	21:15:32	17.46	33.03	23:45:17	16.29	32.85	2:15:02	15.53	32.75	4:44:47	15.10	32.68	7:14:32	14.80	32.65	9:44:17	14.55	14.55	12:14:02	14.31	32.60	14:43:47	14.12	32.59
16:16:17	23.34	34.48	18:46:02	19.43	33.47	21:15:47	17.46	33.03	23:45:32	16.29	32.85	2:15:17	15.52	32.75	4:45:02	15.10	32.68	7:14:47	14.80	32.65	9:44:32	14.55	14.55	12:14:17	14.31	32.60	14:44:02	14.12	32.59
16:16:32	23.33	34.48	18:46:17	19.43	33.47	21:16:02	17.45	33.03	23:45:47	16.29	32.84	2:15:32	15.52	32.75	4:45:17	15.10	32.68	7:15:02	14.80	32.65	9:44:47	14.55	14.55	12:14:32	14.31	32.60	14:44:17	14.12	32.59
16:16:47	23.32	34.47	18:46:32	19.43	33.47	21:16:17	17.45	33.03	23:46:02	16.29	32.85	2:15:47	15.52	32.75	4:45:32	15.10	32.68	7:15:17	14.80	32.65	9:45:02	14.55	14.55	12:14:47	14.31	32.60	14:44:32	14.12	32.59
16:17:02	23.31	34.47	18:46:47	19.42	33.47	21:16:32	17.45	33.03	23:46:17	16.29	32.84	2:16:02	15.52	32.75	4:45:47	15.10	32.68	7:15:32	14.80	32.65	9:45:17	14.55	14.55	12:15:02	14.31	32.60	14:44:47	14.12	32.59
16:17:17	23.30	34.47	18:47:02	19.42	33.46	21:16:47	17.45	33.03	23:46:32	16.28	32.85	2:16:17	15.52	32.75	4:46:02	15.10	32.68	7:15:47	14.80	32.65	9:45:32	14.55	14.55	12:15:17	14.31	32.60	14:45:02	14.12	32.59
16:17:32	23.29	34.47	18:47:17	19.41	33.47	21:17:02	17.45	33.03	23:46:47	16.28	32.85	2:16:32	15.52	32.75	4:46:17	15.10	32.68	7:16:02	14.80	32.65	9:45:47	14.55	14.55	12:15:32	14.31	32.60	14:45:17	14.12	32.59
16:17:47	23.28	34.47	18:47:32	19.41	33.47	21:17:17	17.44	33.03	23:47:02	16.28	32.85	2:16:47	15.52	32.75	4:46:32	15.10	32.68	7:16:17	14.80	32.65	9:46:02	14.55	14.55	12:15:47	14.31	32.60	14:45:32	14.12	32.59
16:18:02	23.27	34.46	18:47:47	19.41	33.47	21:17:32	17.44	33.03	23:47:17	16.28	32.85	2:17:02	15.52	32.74	4:46:47	15.10	32.68	7:16:32	14.80	32.65	9:46:17	14.55	14.55	12:16:02	14.31	32.60	14:45:47	14.11	32.59
16:18:17	23.26	34.46	18:48:02	19.40	33.47	21:17:47	17.44	33.03	23:47:32	16.27	32.85	2:17:17	15.52	32.75	4:47:02	15.10	32.68	7:16:47	14.80	32.65	9:46:32	14.55	14.55	12:16:17	14.31	32.60	14:46:02	14.11	32.59
16:18:32	23.25	34.45	18:48:17	19.39	33.47	21:18:02	17.44	33.03	23:47:47	16.27	32.84	2:17:32	15.52	32.75	4:47:17	15.10	32.69	7:17:02	14.80	32.65	9:46:47	14.55	14.55	12:16:32	14.31	32.60	14:46:17	14.11	32.59
16:18:47	23.24	34.45	18:48:32	19.39	33.47	21:18:17	17.44	33.02	23:48:02	16.27	32.85	2:17:47	15.52	32.75	4:47:32	15.10	32.69	7:17:17	14.80	32.65	9:47:02	14.55	14.55	12:16:47	14.31	32.60	14:46:32	14.12	32.59
16:19:02	23.23	34.45	18:48:47	19.39	33.46	21:18:32	17.43	33.02	23:48:17	16.27	32.85	2:18:02	15.52	32.74	4:47:47	15.10	32.68	7:17:32	14.80	32.65	9:47:17	14.55	14.55	12:17:02	14.31	32.60	14:46:47	14.11	32.59
16:19:17	23.22	34.45	18:49:02	19.38	33.46	21:18:47	17.43	33.02	23:48:32	16.27	32.85	2:18:17	15.52	32.74	4:48:02	15.10	32.69	7:17:47	14.80	32.65	9:47:32	14.55	14.55	12:17:17	14.31	32.60	14:47:02	14.11	32.59
16:19:32	23.21	34.44	18:49:17	19.38	33.46	21:19:02	17.43	33.02	23:48:47	16.27	32.85	2:18:32	15.51	32.74	4:48:17	15.10	32.69	7:18:02	14.80	32.65	9:47:47	14.55	14.55	12:17:32	14.31	32.60	14:47:17	14.11	32.59
16:19:47	23.20	34.44	18:49:32	19.38	33.46	21:19:17	17.42	33.02	23:49:02	16.26	32.85	2:18:47	15.51	32.74	4:48:32	15.09	32.69	7:18:17	14.80	32.65	9:48:02	14.54	14.54	12:17:47	14.31	32.60	14:47:32	14.11	32.59
16:20:02	23.19	34.44	18:49:47	19.37	33.46	21:19:32	17.42	33.02	23:49:17	16.26	32.84	2:19:02	15.51	32.74	4:48:47	15.09	32.69	7:18:32	14.80	32.65	9:48:17	14.54	14.54	12:18:02	14.31	32.60	14:47:47	14.11	32.59
16:20:17	23.18	34.43	18:50:02	19.37	33.46	21:19:47	17.42	33.02	23:49:32	16.26	32.85	2:19:17	15.51	32.74	4:49:02	15.09	32.69	7:18:47	14.80	32.65	9:48:32	14.54	14.54	12:18:17	14.31	32.60	14:48:02	14.11	32.59
16:20:32	23.17	34.43	18:50:17	19.36	33.46	21:20:02	17.42	33.02	23:49:47	16.26	32.85	2:19:32	15.51	32.74	4:49:17	15.09	32.69	7:19:02	14.80	32.65	9:48:47	14.54	14.54	12:18:32	14.31	32.60	14:48:17	14.11	32.59
16:20:47	23.16	34.43	18:50:32	19.36	33.46	21:20:17	17.42	33.02	23:50:02	16.26	32.84	2:19:47	15.51	32.74	4:49:32	15.09	32.68	7:19:17	14.79	32.65	9:49:02	14.54	14.54	12:18:47	14.31	32.60	14:48:32	14.11	32.59
16:21:02	23.15	34.42	18:50:47	19.36	33.46	21:20:32	17.41	33.02	23:50:17	16.25	32.84	2:20:02	15.51	32.74	4:49:47	15.09	32.69	7:19:32	14.80	32.65	9:49:17	14.54	14.54	12:19:02	14.31	32.60	14:48:47	14.11	32.59
16:21:17	23.14	34.42	18:51:02	19.35	33.45	21:20:47	17.41	33.02	23:50:32	16.25	32.84	2:20:17	15.51	32.74	4:50:02	15.09	32.68	7:19:47	14.79	32.65	9:49:32	14.54	14.54	12:19:17	14.31	32.60	14:49:02	14.11	32.59
16:21:32	23.13	34.42	18:51:17	19.35	33.45	21:21:02	17.41	33.02	23:50:47	16.25	32.84	2:20:32	15.51	32.74	4:50:17	15.09	32.69	7:20:02	14.79	32.65	9:49:47	14.54	14.54	12:19:32	14.31	32.60	14:49:17	14.11	32.59
16:21:47	23.12	34.42	18:51:32	19.34	33.44	21:21:17	17.40	33.02	23:51:02	16.25	32.84	2:20:47	15.51	32.74	4:50:32	15.09	32.69	7:20:17	14.79	32.65	9:50:02	14.54	14.54	12:19:47	14.30	32.60	14:49:32	14.11	32.59
16:22:02	23.11	34.42	18:51:47	19.34	33.44	21:21:32	17.40	33.02	23:51:17	16.25	32.84	2:21:02	15.51	32.74	4:50:47	15.09	32.69	7:20:32	14.79	32.65	9:50:17	14.54	14.54	12:20:02	14.30	32.60	14:49:47	14.11	32.59
16:22:17	23.11	34.42	18:52:02	19.34	33.44	21:21:47	17.40	33.02	23:51:32	16.25	32.84	2:21:17	15.51	32.74	4:51:02	15.09	32.69	7:20:47	14.79	32.65	9:50:32	14.54	14.54	12:20:17	14.30	32.60	14:50:02	14.11	32.59
16:22:32	23.09	34.42	18:52:17	19.33	33.44	21:22:02	17.40	33.02	23:51:47	16.25	32.84	2:21:32	15.51	32.74	4:51:17	15.09	32.69	7:21:02	14.79	32.65	9:50:47	14.54	14.54	12:20:32	14.31	32.60	14:50:17	14.11	32.59
16:22:47	23.09	34.42	18:52:32	19.32	33.44	21:22:17	17.39	33.02	23:52:02	16.24	32.84	2:21:47	15.50	32.74	4:51:32	15.09	32.69	7:21:17	14.79	32.65	9:51:02	14.54	14.54	12:20:47	14.30	32.60	14:50:32	14.11	32.59
16:23:02	23.07	34.41	18:52:47	19.32	33.44	21:22:32	17.39	33.02	23:52:17	16.24	32.84	2:22:02	15.50	32.74	4:51:47	15.09	32.68	7:21:32	14.79	32.65	9:51:17	14.54	14.54	12:21:02	14.30	32.60	14:50:47	14.11	32.59
16:23:17	23.07	34.40	18:53:02	19.32	33.44	21:22:47	17.39	33.02	23:52:32	16.24	32.84	2:22:17	15.50	32.74	4:52:02	15.09	32.69	7:21:47	14.79	32.65	9:51:32	14.54	14.54	12:21:17	14.30	32.60	14:51:02	14.11	32.59
16:23:32	23.06	34.40	18:53:17	19.31	33.44	21:23:02	17.39	33.02	23:52:47	16.24	32.84	2:22:32	15.50	32.74	4:52:17	15.09	32.68	7:22:02	14.79	32.65	9:51:47	14.54	14.54	12:21:32	14.30	32.60	14:51:17	14.11	32.59
16:23:47	23.05	34.40	18:53:32	19.31	33.44	21:23:17	17.39	33.02	23:53:02	16.24	32.84	2:22:47	15.50	32.74	4:52:32	15.09	32.68	7:22:17	14.79	32.65	9:52:02	14.54	14.54	12:21:47	14.30	32.60	14:51:32	14.11	32.59
16:24:02	23.04	34.40	18:53:47	19.30	33.44	21:23:32	17.38	33.02	23:53:17	16.23	32.84	2:23:02	15.50	32.74	4:52:47	15.09	32.69	7:22:32	14.79	32.65	9:52:17	14.54	14.54	12:22:02	14.30	32.60	14:51:47	14.11	32.59
16:24:17	23.03	34.40	18:54:02	19.30	33.44	21:23:47	17.38	33.02	23:53:32	16.23	32.84	2:23:17	15.50	32.74	4:53:02	15.09	32.68	7:22:47	14.79	32.65	9:52:32	14.54	14.54	12:22:17	14.30	32.60	14:52:02	14.11	32.59
16:24:32	23.02	34.40	18:54:17	19.30	33.43	21:24:02	17.38	33.02	23:53:47	16.23	32.84	2:23:32	15.50	32.74	4:53:17	15.09	32.68	7:23:02	14.79	32.65	9:52:47	14.54	14.54	12:22:32	14.30	32.60	14:52:17	14.11	32.59
16:24:47	23.01	34.40	18:54:32	19.30	33.43	21:24:17	17.37	33.02	23:54:02	16.23	32.84	2:23:47	15.50	32.74	4:53:32	15.08	32.68	7:23:17	14.79	32.64	9:53:02	14.54	14.

B A Pump Testing Job Details

Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)
16:46:17	22.26	34.18	19:16:02	18.95	33.36	21:45:47	17.17	32.98	0:15:32	16.09	32.82	2:45:17	15.43	32.73	5:15:02	15.04	32.68	7:44:47	14.75	32.64	10:14:32	14.50	14.50	12:44:17	14.27	32.60	15:14:02	14.08	32.59
16:46:32	22.25	34.17	19:16:17	18.95	33.35	21:46:02	17.16	32.98	0:15:47	16.09	32.82	2:45:32	15.43	32.73	5:15:17	15.03	32.68	7:45:02	14.75	32.64	10:14:47	14.50	14.50	12:44:32	14.27	32.60	15:14:17	14.08	32.59
16:46:47	22.24	34.17	19:16:32	18.94	33.35	21:46:17	17.16	32.98	0:16:02	16.09	32.82	2:45:47	15.42	32.73	5:15:32	15.03	32.68	7:45:17	14.75	32.64	10:15:02	14.50	14.50	12:44:47	14.27	32.60	15:14:32	14.08	32.59
16:47:02	22.23	34.17	19:16:47	18.94	33.35	21:46:32	17.16	32.98	0:16:17	16.09	32.82	2:46:02	15.43	32.73	5:15:47	15.03	32.68	7:45:32	14.75	32.64	10:15:17	14.50	14.50	12:45:02	14.27	32.60	15:14:47	14.08	32.59
16:47:17	22.23	34.16	19:17:02	18.94	33.35	21:46:47	17.16	32.98	0:16:32	16.09	32.82	2:46:17	15.42	32.73	5:16:02	15.04	32.68	7:45:47	14.75	32.64	10:15:32	14.50	14.50	12:45:17	14.27	32.60	15:15:02	14.08	32.59
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16:48:32	22.19	34.14	19:18:17	18.92	33.35	21:48:02	17.15	32.98	0:17:47	16.08	32.82	2:47:32	15.42	32.73	5:17:17	15.03	32.68	7:47:02	14.75	32.64	10:16:47	14.49	14.49	12:46:32	14.27	32.60	15:16:17	14.08	32.59
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16:50:17	22.13	34.12	19:20:02	18.89	33.34	21:49:47	17.13	32.97	0:19:32	16.07	32.82	2:49:17	15.41	32.73	5:19:02	15.03	32.68	7:48:47	14.74	32.64	10:18:32	14.49	14.49	12:48:17	14.26	32.60	15:18:02	14.07	32.58
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16:52:02	22.08	34.11	19:21:47	18.86	33.34	21:51:32	17.11	32.97	0:21:17	16.06	32.82	2:51:02	15.41	32.73	5:20:47	15.02	32.68	7:50:32	14.74	32.64	10:20:17	14.49	14.49	12:50:02	14.26	32.60	15:19:47	14.07	32.58
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16:52:32	22.06	34.11	19:22:17	18.86	33.34	21:52:02	17.11	32.97	0:21:47	16.06	32.82	2:51:32	15.41	32.73	5:21:17	15.02	32.67	7:51:02	14.74	32.64	10:20:47	14.49	14.49	12:50:32	14.26	32.60	15:20:17	14.07	32.59
16:52:47	22.05	34.10	19:22:32	18.85	33.34	21:52:17	17.11	32.97	0:22:02	16.05	32.82	2:51:47	15.41	32.73	5:21:32	15.02	32.68	7:51:17	14.74	32.64	10:21:02	14.49	14.49	12:50:47	14.26	32.60	15:20:32	14.07	32.59
16:53:02	22.05	34.09	19:22:47	18.84	33.33	21:52:32	17.11	32.97	0:22:17	16.05	32.82	2:52:02	15.41	32.73	5:21:47	15.02	32.68	7:51:32	14.74	32.64	10:21:17	14.49	14.49	12:51:02	14.26	32.60	15:20:47	14.07	32.59
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16:54:02	22.01	34.09	19:23:47	18.83	33.33	21:53:32	17.10	32.97	0:23:17	16.05	32.82	2:53:02	15.40	32.73	5:22:47	15.02	32.68	7:52:32	14.74	32.64	10:22:17	14.49	14.49	12:52:02	14.26	32.60	15:21:47	14.07	32.59
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16:55:47	21.96	34.07	19:25:32	18.80	33.33	21:55:17	17.08	32.97	0:25:02	16.04	32.82	2:54:47	15.39	32.73	5:24:32	15.02	32.67	7:54:17	14.73	32.63	10:24:02	14.48	14.48	12:53:47	14.26	32.60	15:23:32	14.07	32.59
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16:58:47	21.87	34.05	19:28:32	18.76	33.32	21:58:17	17.05	32.96	0:28:02	16.02	32.81	2:57:47	15.39	32.73	5:27:32	15.01	32.67	7:57:17	14.73	32.64	10:27:02	14.48	14.48	12:56:47	14.25	32.60	15:26:32	14.07	32.59
16:59:02	21.86	34.05	19:28:47	18.76	33.32	21:58:32	17.05	32.96	0:28:17	16.02	32.81	2:58:02	15.39	32.73	5:27:47	15.01	32.67	7:57:32	14.73	32.64	10:27:17	14.48	14.48	12:57:02	14.25	32.60	15:26:47	14.06	32.59
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17:01:02	21.80	34.03	19:30:47	18.73	33.30	22:00:32	17.04	32.96	0:30:17	16.01	32.81	3:00:02	15.38	32.73	5:29:47	15.01	32.68	7:59:32	14.73	32.64	10:29:17	14.48	14.48	12:59:02	14.25	32.60	15:28:47	14.06	32.59
17:01:17	21.80	34.03	19:31:02	18.72	33.30	22:00:47	17.03	32.96	0:30:32	16.01	32.81	3:00:17	15.38	32.72	5:30:02	15.01	32.68	7:59:47	14.73	32.64	10:29:32	14.48	14.48	12:59:17	14.25	32.60	15:29:02	14.06	32.59
17:01:32	21.80	34.03	19:31:17	18.72	33.30	22:01:02	17.03	32.96	0:30:47	16.00	32.81	3:00:32	15.38	32.73	5:30:17	15.01	32.68	8:00:02	14.73	32.64	10:29:47	14.48	14.48	12:59:32	14.25	32.60	15:29:17	14.06	32.59
17:01:47	21.79	34.03	19:31:32	18.72	33.30	22:01:17	17.03	32.96	0:31:02	16.00	32.81	3:00:47	15.37	32.73	5:30:32	15.01	32.68	8:00:17	14.73	32.63	10:30:02	14.48	14.48	12:59:47	14.25	32.60	15:29:32	14.06	32.59
17:02:02	21.78	34.03	19:31:47	18.72	33.30	22:01:32	17.02	32.96	0:31:17	16.00	32.81	3:01:02	15.37	32.73	5:30:47	15.01	32.68	8:00:32	14.73	32.64	10:30:17	14.48	14.48	13:00:02	14.25	32.60	15:29:47	14.06	32.59
17:02:17	21.77	34.03	19:32:02	18.71	33.30	22:01:47	17.02	32.96	0:31:32	16.00	32.81	3:01:17	15.37	32.73	5:31:02	15.01	32.68	8:00:47	14.72	32.64	10:30:32	14.48	14.48	13:00:17	14.25	32.60	15:30:02	14.06	32.59
17:02:32	21.76	34.03	19:32:17	18.71	33.30	22:02:02	17.02	32.96	0:31:47	16.00	32.81	3:01:32	15.37	32.73	5:31:17	15.00	32.68	8:01:02	14.72	32.64	10:30:47	14.48	14.48	13:00:32	14.25	32.60	15:30:17	14.06	32.59
17:02:47	21.76	34.03	19:32:32	18.70	33.30	22:02:17	17.02	32.96	0:32:02	16.00	32.81	3:01:47	15.37	32.73	5:31:32	15.00	32.67	8:01:17	14.73	32.64	10:31:02	14.48	14.48	13:00:47	14.25	32.60	15:30:32	14.06	32.59
17:03:02	21.75	34.02	19:32:47	18.70	33.30	22:02:32	17.02	32.96	0:32:17	16.00	32.81	3:02:02	15.37	32.73	5:31:47	15.00	32.68	8:01:32	14.73	32.64	10:31:17	14.47	14.47	13:01:02	14.25	32.60	15:30:47	14.06	32.59
17:03:17	21.74	34.02	19:33:02	18.70	33.30	22:02:47	17.01	32.96	0:32:32	16.00	32.81	3:02:17	15.37	32.73	5:32:02	15.00	32.68	8:01:47	14.72	32.64	10:31:32	14.47	14.47	13:01:17	14.24	32.60	15:31:02	14.06	32.59
17:03:32	21.74	34.02	19:33:17	18.69	33.30	22:03:02	17.01	32.96	0:32:47	15.99	32.81	3:02:32	15.37	32.73	5:32:17	15.00	32.68	8:02:02	14.72	32.64	10:31:47	14.47	14.47	13:01:32	14.25	32.60	15:31:17	14.06	32.59
17:03:47	21.73	34.02	19:33:32	18.69	33.30	22:03:17	17.01	32.96	0:33:02	15.99	32.81	3:02:47	15.37	32.73	5:32:32	15.00	32.68	8:02:17	14.72	32.64	10:32:02	14.47	14.47	13:01:47	14.25	32.60	15:31:32	14.06	32.59
17:04:02	21.72	34.02	19:33:47	18.69	33.30	22:03:32	17.01	32.96	0:33:17	15.99	32.81	3:03:02	15.37	32.72	5:32:47	15.00	32.68	8:02:32	14.72	32.64	10:32:17	14.47	14.47	13:02:02	14.24	32.60	15:31:47	14.06	32.58
17:04:17	21.72	34.02	19:34:02	18.68	33.30	22:03:47	17.00	32.96	0:33:32	15.99	32.81	3:03:17	15.37	32.72	5:33:02	15.00	32.68	8:02:47	14.72	32.64	10:32:32	14.47	14.47	13:02:17	14.24	32.60	15:32:02	14.06	32.59
17:04:32	21.71	34.01	19:34:17	18.68	33.30	22:04:02	17.00	32.96	0:33:47	15.99	32.81	3:03:32	15.37	32.72	5:33:17	15.00	32.68	8:03:02	14.72	32.63	10:32:47	14.47	14.47	13:02:32	14.25	32.60	15:32:17	14.06	32.59
17:04:47	21.70	34.01	19:34:32	18.68	33.30	22:04:17	17.00	32.96	0:34:02	15.99	32.81	3:03:47	15.37	32.72	5:33:32	15.00	32.68	8:03:17	14.72	32.64	10:33:02	14.47	14.47	13:02:47	14.24	32.60	15:32:32	14.06	32.59
17:05:02	21.69	34.00	19:34:47	18.67	33.30	22:04:32	17.00	32.96	0:34:17	15.99	32.81	3:04:02	15.37	32.72	5:33:47	15.00	32.68	8:03:32	14.72	32.64	10:33:17	14.47	14.47	13:03:02	14.24	32.60	15:32:47	14.06	32.59
17:05:17	21.68	34.00	19:35:02	18.67	33.30	22:04:47	17.00	32.96	0:34:32	15.99	32.81	3:04:17	15.37	32.72	5:34:02	15.00	32.68	8:03:47	14.72	32.64	10:33:32	14.47	14.47	13:03:17	14.24	32.60	15:33:02	14.06	32.59
17:05:32	21.68	34.00	19:35:17	18.66	33.30	22:05:02	16.99	32.96	0:34:47	15.98	32.81	3:04:32	15.37	32.72	5:34:17	15.00	32.68	8:04:02	14.72	32.64	10:33:47	14.47	14.

B A Pump Testing Job Details

Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)
17:27:02	21.10	33.85	19:56:47	18.37	33.21	22:26:32	16.82	32.93	0:56:17	15.87	32.80	3:26:02	15.30	32.72	5:55:47	14.95	32.66	8:25:32	14.68	32.63	10:55:17	14.43	14.43	13:25:02	14.21	32.59						
17:27:17	21.10	33.85	19:57:02	18.37	33.20	22:26:47	16.82	32.93	0:56:32	15.86	32.80	3:26:17	15.30	32.71	5:56:02	14.96	32.66	8:25:47	14.68	32.63	10:55:32	14.43	14.43	13:25:17	14.21	32.59						
17:27:32	21.09	33.85	19:57:17	18.36	33.20	22:27:02	16.82	32.93	0:56:47	15.86	32.80	3:26:32	15.30	32.72	5:56:17	14.95	32.66	8:26:02	14.68	32.63	10:55:47	14.43	14.43	13:25:32	14.21	32.59						
17:27:47	21.08	33.85	19:57:32	18.36	33.20	22:27:17	16.81	32.93	0:57:02	15.86	32.80	3:26:47	15.30	32.71	5:56:32	14.95	32.66	8:26:17	14.68	32.63	10:56:02	14.43	14.43	13:25:47	14.21	32.59						
17:28:02	21.08	33.85	19:57:47	18.36	33.20	22:27:32	16.81	32.93	0:57:17	15.86	32.80	3:27:02	15.30	32.71	5:56:47	14.95	32.66	8:26:32	14.68	32.63	10:56:17	14.43	14.43	13:26:02	14.21	32.59						
17:28:17	21.07	33.85	19:58:02	18.35	33.20	22:27:47	16.81	32.93	0:57:32	15.86	32.79	3:27:17	15.30	32.71	5:57:02	14.95	32.66	8:26:47	14.68	32.63	10:56:32	14.43	14.43	13:26:17	14.21	32.59						
17:28:32	21.06	33.85	19:58:17	18.35	33.19	22:28:02	16.81	32.93	0:57:47	15.86	32.79	3:27:32	15.30	32.71	5:57:17	14.95	32.66	8:27:02	14.68	32.63	10:56:47	14.43	14.43	13:26:32	14.21	32.59						
17:28:47	21.06	33.85	19:58:32	18.35	33.20	22:28:17	16.80	32.93	0:58:02	15.85	32.79	3:27:47	15.30	32.71	5:57:32	14.95	32.66	8:27:17	14.68	32.63	10:57:02	14.43	14.43	13:26:47	14.21	32.59						
17:29:02	21.05	33.85	19:58:47	18.34	33.20	22:28:32	16.80	32.93	0:58:17	15.85	32.80	3:28:02	15.30	32.71	5:57:47	14.95	32.66	8:27:32	14.68	32.63	10:57:17	14.43	14.43	13:27:02	14.21	32.59						
17:29:17	21.04	33.85	19:59:02	18.34	33.20	22:28:47	16.80	32.93	0:58:32	15.85	32.79	3:28:17	15.30	32.71	5:58:02	14.95	32.66	8:27:47	14.68	32.63	10:57:32	14.43	14.43	13:27:17	14.21	32.59						
17:29:32	21.04	33.84	19:59:17	18.33	33.19	22:29:02	16.80	32.93	0:58:47	15.85	32.79	3:28:32	15.29	32.71	5:58:17	14.95	32.66	8:28:02	14.68	32.63	10:57:47	14.43	14.43	13:27:32	14.21	32.59						
17:29:47	21.03	33.84	19:59:32	18.33	33.20	22:29:17	16.80	32.93	0:59:02	15.85	32.79	3:28:47	15.29	32.71	5:58:32	14.95	32.66	8:28:17	14.68	32.63	10:58:02	14.43	14.43	13:27:47	14.21	32.59						
17:30:02	21.03	33.84	19:59:47	18.33	33.19	22:29:32	16.80	32.93	0:59:17	15.85	32.79	3:29:02	15.29	32.71	5:58:47	14.95	32.66	8:28:32	14.68	32.63	10:58:17	14.43	14.43	13:28:02	14.21	32.59						
17:30:17	21.02	33.84	20:00:02	18.33	33.19	22:29:47	16.80	32.93	0:59:32	15.85	32.79	3:29:17	15.29	32.71	5:59:02	14.95	32.66	8:28:47	14.68	32.63	10:58:32	14.43	14.43	13:28:17	14.21	32.59						
17:30:32	21.02	33.84	20:00:17	18.32	33.19	22:30:02	16.79	32.93	0:59:47	15.85	32.79	3:29:32	15.29	32.71	5:59:17	14.95	32.66	8:29:02	14.68	32.63	10:58:47	14.43	14.43	13:28:32	14.21	32.59						
17:30:47	21.01	33.84	20:00:32	18.32	33.19	22:30:17	16.79	32.93	1:00:02	15.85	32.79	3:29:47	15.29	32.71	5:59:32	14.95	32.66	8:29:17	14.68	32.63	10:59:02	14.43	14.43	13:28:47	14.21	32.59						
17:31:02	21.00	33.84	20:00:47	18.31	33.19	22:30:32	16.79	32.93	1:00:17	15.85	32.79	3:30:02	15.29	32.71	5:59:47	14.94	32.66	8:29:32	14.68	32.63	10:59:17	14.43	14.43	13:29:02	14.21	32.59						
17:31:17	21.00	33.84	20:01:02	18.31	33.19	22:30:47	16.79	32.93	1:00:32	15.84	32.79	3:30:17	15.29	32.71	6:00:02	14.95	32.66	8:29:47	14.68	32.63	10:59:32	14.42	14.42	13:29:17	14.21	32.59						
17:31:32	20.99	33.83	20:01:17	18.31	33.19	22:31:02	16.78	32.93	1:00:47	15.84	32.79	3:30:32	15.29	32.71	6:00:17	14.94	32.66	8:30:02	14.68	32.63	10:59:47	14.42	14.42	13:29:32	14.21	32.59						
17:31:47	20.98	33.83	20:01:32	18.31	33.19	22:31:17	16.78	32.93	1:01:02	15.84	32.79	3:30:47	15.28	32.71	6:00:32	14.94	32.66	8:30:17	14.68	32.63	11:00:02	14.42	14.42	13:29:47	14.21	32.59						
17:32:02	20.98	33.83	20:01:47	18.30	33.19	22:31:32	16.78	32.92	1:01:17	15.84	32.79	3:31:02	15.29	32.71	6:00:47	14.94	32.66	8:30:32	14.68	32.63	11:00:17	14.42	14.42	13:30:02	14.21	32.59						
17:32:17	20.97	33.83	20:02:02	18.30	33.18	22:31:47	16.78	32.93	1:01:32	15.84	32.79	3:31:17	15.29	32.71	6:01:02	14.94	32.66	8:30:47	14.68	32.63	11:00:32	14.42	14.42	13:30:17	14.21	32.59						
17:32:32	20.96	33.83	20:02:17	18.29	33.18	22:32:02	16.78	32.92	1:01:47	15.84	32.79	3:31:32	15.28	32.71	6:01:17	14.94	32.66	8:31:02	14.68	32.63	11:00:47	14.42	14.42	13:30:32	14.20	32.59						
17:32:47	20.96	33.83	20:02:32	18.29	33.18	22:32:17	16.78	32.92	1:02:02	15.83	32.79	3:31:47	15.28	32.71	6:01:32	14.94	32.66	8:31:17	14.68	32.63	11:01:02	14.43	14.43	13:30:47	14.21	32.59						
17:33:02	20.95	33.83	20:02:47	18.29	33.18	22:32:32	16.77	32.92	1:02:17	15.83	32.79	3:32:02	15.28	32.71	6:01:47	14.94	32.66	8:31:32	14.67	32.63	11:01:17	14.42	14.42	13:31:02	14.21	32.59						
17:33:17	20.95	33.83	20:03:02	18.28	33.18	22:32:47	16.77	32.92	1:02:32	15.83	32.79	3:32:17	15.28	32.71	6:02:02	14.94	32.66	8:31:47	14.67	32.63	11:01:32	14.42	14.42	13:31:17	14.21	32.59						
17:33:32	20.94	33.82	20:03:17	18.28	33.18	22:33:02	16.77	32.92	1:02:47	15.83	32.79	3:32:32	15.28	32.71	6:02:17	14.94	32.66	8:32:02	14.67	32.63	11:01:47	14.42	14.42	13:31:32	14.20	32.59						
17:33:47	20.93	33.82	20:03:32	18.28	33.19	22:33:17	16.77	32.92	1:03:02	15.83	32.79	3:32:47	15.28	32.71	6:02:32	14.94	32.66	8:32:17	14.67	32.63	11:02:02	14.42	14.42	13:31:47	14.20	32.59						
17:34:02	20.93	33.81	20:03:47	18.28	33.19	22:33:32	16.76	32.92	1:03:17	15.83	32.79	3:33:02	15.28	32.71	6:02:47	14.94	32.66	8:32:32	14.67	32.63	11:02:17	14.42	14.42	13:32:02	14.20	32.59						
17:34:17	20.92	33.81	20:04:02	18.27	33.18	22:33:47	16.77	32.92	1:03:32	15.83	32.79	3:33:17	15.28	32.71	6:03:02	14.94	32.66	8:32:47	14.67	32.63	11:02:32	14.42	14.42	13:32:17	14.20	32.59						
17:34:32	20.91	33.81	20:04:17	18.27	33.18	22:34:02	16.76	32.92	1:03:47	15.83	32.79	3:33:32	15.28	32.71	6:03:17	14.94	32.66	8:33:02	14.67	32.63	11:02:47	14.42	14.42	13:32:32	14.20	32.59						
17:34:47	20.91	33.81	20:04:32	18.27	33.18	22:34:17	16.76	32.92	1:04:02	15.83	32.79	3:33:47	15.28	32.71	6:03:32	14.94	32.66	8:33:17	14.67	32.63	11:03:02	14.42	14.42	13:32:47	14.20	32.59						
17:35:02	20.90	33.81	20:04:47	18.26	33.18	22:34:32	16.76	32.91	1:04:17	15.83	32.79	3:34:02	15.28	32.71	6:03:47	14.94	32.66	8:33:32	14.67	32.63	11:03:17	14.42	14.42	13:33:02	14.20	32.59						
17:35:17	20.90	33.81	20:05:02	18.26	33.18	22:34:47	16.76	32.91	1:04:32	15.82	32.79	3:34:17	15.28	32.71	6:04:02	14.94	32.66	8:33:47	14.67	32.63	11:03:32	14.42	14.42	13:33:17	14.20	32.59						
17:35:32	20.89	33.81	20:05:17	18.26	33.18	22:35:02	16.75	32.91	1:04:47	15.82	32.79	3:34:32	15.28	32.71	6:04:17	14.94	32.66	8:34:02	14.67	32.63	11:03:47	14.42	14.42	13:33:32	14.20	32.59						
17:35:47	20.88	33.81	20:05:32	18.25	33.18	22:35:17	16.75	32.91	1:05:02	15.82	32.79	3:34:47	15.28	32.71	6:04:32	14.93	32.66	8:34:17	14.67	32.63	11:04:02	14.42	14.42	13:33:47	14.20	32.59						
17:36:02	20.88	33.81	20:05:47	18.25	33.18	22:35:32	16.75	32.91	1:05:17	15.82	32.79	3:35:02	15.27	32.71	6:04:47	14.93	32.66	8:34:32	14.67	32.63	11:04:17	14.42	14.42	13:34:02	14.20	32.59						
17:36:17	20.87	33.81	20:06:02	18.24	33.18	22:35:47	16.75	32.91	1:05:32	15.82	32.79	3:35:17	15.27	32.71	6:05:02	14.93	32.66	8:34:47	14.67	32.63	11:04:32	14.42	14.42	13:34:17	14.20	32.59						
17:36:32	20.87	33.81	20:06:17	18.24	33.18	22:36:02	16.75	32.91	1:05:47	15.81	32.79	3:35:32	15.27	32.71	6:05:17	14.93	32.66	8:35:02	14.67	32.63	11:04:47	14.42	14.42	13:34:32	14.20	32.59						
17:36:47	20.86	33.81	20:06:32	18.24	33.18	22:36:17	16.74	32.91	1:06:02	15.81	32.79	3:35:47	15.27	32.71	6:05:32	14.93	32.66	8:35:17	14.67	32.63	11:05:02	14.42	14.42	13:34:47	14.20	32.59						
17:37:02	20.85	33.81	20:06:47	18.24	33.18	22:36:32	16.74	32.91	1:06:17	15.81	32.79	3:36:02	15.27	32.71	6:05:47	14.93	32.66	8:35:32	14.66	32.63	11:05:17	14.42	14.42	13:35:02	14.20	32.59						
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17:37:47	20.84	33.80	20:07:32	18.23	33.18	22:37:17	16.73	32.91	1:07:02	15.81	32.79	3:36:47	15.27	32.71	6:06:32	14.93	32.66	8:36:17	14.66	32.63	11:06:02	14.42	14.42	13:35:47	14.20	32.59						
17:38:02	20.83	33.80	20:07:47	18.22	33.17	22:37:32	16.73	32.91	1:07:17	15.81	32.79	3:37:02	15.27	32.71	6:06:47	14.93	32.66	8:36:32	14.66	32.63	11:06:17	14.42	14.42	13:36:02	14.20	32.59						
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17:38:47	20.81	33.80	20:08:32	18.22	33.17	22:38:17	16.73	32.91	1:08:02	15.80	32.79	3:37:47	15.27	32.71	6:07:32	14.93	32.66	8:37:17	14.67	32.63	11:07:02	14.42	14.42	13:36:47	14.20	32.59						
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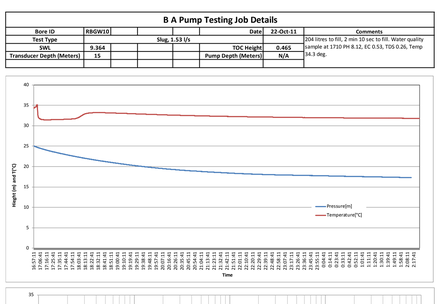
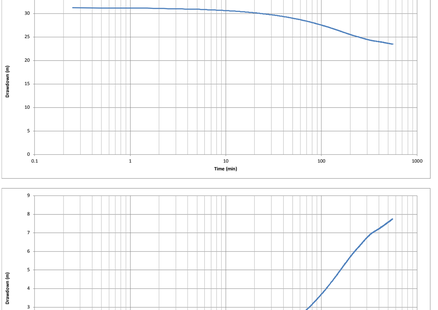
17:47:47	20.60	33.75	20:17:32	18.11	33.16	22:47:17	16.66	32.90	1:17:02	15.76	32.78

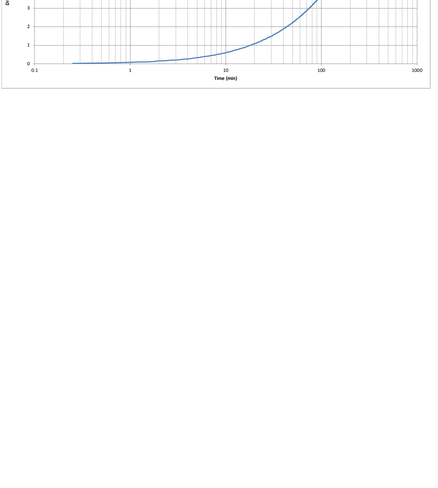
B A Pump Testing Job Details

Bore ID	RBGW10			Date	22-Oct-11
Test Type			Slug, 1.53 l/s		
SWL	9.364			TOC Height	0.465
Transducer Depth (Meters)	15			Pump Depth (Meters)	N/A

Comments
204 litres to fill, 2 min 10 sec to fill. Water quality sample at 1730 PH 8.12, EC 0.53, TDS 0.26, Temp 14.3 deg.







Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)	Date & Time	Pressure (m)	Temp (°)
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16:57:41	10.27	34.31	18:49:41	21.35	33.14	20:41:41	19.19	32.51	22:33:41	18.14	32.13	0:25:41	17.70	31.92	2:17:41	17.32	31.81	4:09:41	17.01	31.73	6:01:41	16.78	31.67	7:53:41	16.59	31.63	9:45:41	16.44	31.61	11:37:41	16.31	31.59	13:29:41	16.19	31.57	15:21:41	16.12	31.56	17:13:41	16.08	31.55
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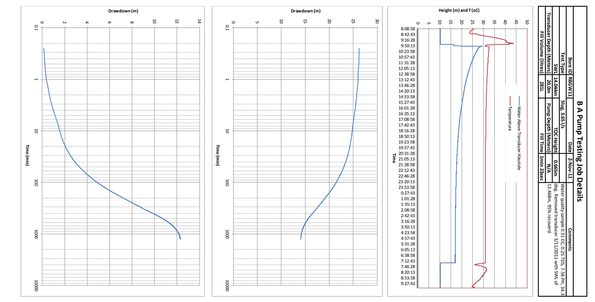
17:09:26	25.03	31.50	19:01:26	21.06	33.07	20:53:26	19.03	32.46	22:45:26	18.07	32.1	0:37:26	17.66	31.91	2:29:26	17.29	31.79	4:21:26	16.97	31.72	6:13:26	16.75	31.67	8:05:26	16.58	31.63	9:57:26	16.42	31.61	11:49:26	16.30	31.59	13:41:26	16.19	31.57	15:33:26	16.11	31.57			
17:09:41	24.94	31.49	19:01:41	21.05	33.07	20:53:41	19.03	32.46	22:45:41	18.07	32.11	0:37:41	17.66	31.91	2:29:41	17.29	31.79	4:21:41	16.97	31.72	6:13:41	16.75	31.67	8:05:41	16.58	31.63	9:57:41	16.42	31.61	11:49:41	16.30	31.59	13:41:41	16.19	31.57	15:33:41	16.11	31.57			
17:09:56	24.99	31.49	19:01:56	21.04	33.07	20:53:56	19.03	32.46	22:45:56	18.07	32.1	0:37:56	17.66	31.91	2:29:56	17.29	31.79	4:21:56	16.98	31.72	6:13:56	16.75	31.67	8:05:56	16.57	31.63	9:57:56	16.43	31.61	11:49:56	16.30	31.59	13:41:56	16.19	31.57	15:33:56	16.10	31.57			
17:10:11	24.97	31.48	19:02:11	21.04	33.07	20:54:11	19.03	32.46	22:46:11	18.06	32.1	0:38:11	17.66	31.91	2:30:11	17.29	31.79	4:22:11	16.98	31.72	6:14:11	16.75	31.67	8:06:11	16.57	31.63	9:58:11	16.43	31.61	11:50:11	16.30	31.59	13:42:11	16.19	31.57	15:34:11	16.10	31.57			
17:10:26	24.95	31.48	19:02:26	21.02	33.07	20:54:26	19.02	32.46	22:46:26	18.07	32.1	0:38:26	17.66	31.90	2:30:26	17.29	31.79	4:22:26	16.98	31.72	6:14:26	16.75	31.67	8:06:26	16.57	31.63	9:58:26	16.42	31.61	11:50:26	16.29	31.59	13:42:26	16.19	31.57	15:34:26	16.11	31.57			
17:10:41	24.94	31.47	19:02:41	21.02	33.07	20:54:41	19.02	32.46	22:46:41	18.06	32.1	0:38:41	17.66	31.90	2:30:41	17.29	31.79	4:22:41	16.98	31.72	6:14:41	16.75	31.67	8:06:41	16.57	31.63	9:58:41	16.42	31.61	11:50:41	16.29	31.59	13:42:41	16.19	31.57	15:34:41	16.11	31.57			
17:10:56	24.92	31.47	19:02:56	21.01	33.07	20:54:56	19.01	32.46	22:46:56	18.06	32.



8 Km Array Data SN005

Site:	Offshore Kwanyeong
Lat:	34° 0.000' N
Long:	126° 0.000' E
Water Depth:	0 m
Deployed by:	Ocean Tech
Recovered by:	Ocean Tech
Deployment date:	2011-Jan-01 00:00
Recovery date:	2011-Jan-01 00:00
Deployment comments:	
Recovery comments:	

Instrument type: Nortek Aquadopp Profiler
Serial number: 5900
Firmware version: 1.34
Configuration date: 2011-Jan-01
Instrument depth: 0.5 m
Number of cells: 20
Cell size: 0.50 m
Blanking distance: 0.50 m
Average interval: 1 min
Burst interval: 1 min
Pressure sensor: Yes
Compass: Yes
Tilt sensor: Yes
Temperature sensor: Yes
Velocity range: 1.0 m/s
Coordinate system: ENU
Speed of sound: Auto
Salinity: 35.0 PSU
Analog input 1: Yes
Analog input 2: Yes
Battery type: Alkaline
Battery voltage: 18.0 V
Battery capacity: 18000 Ah
Memory: 4 GB
Recorder: Yes
Recorder size: 4 GB
Recorder free space: 3.8 GB
Recorder comments: OK
Instrument comments: Deployed in 8 km array, SN005
Data quality: Good

Date	Time	Speed (knots)	Direction (deg)	Date	Time	Speed (knots)	Direction (deg)	Date	Time	Speed (knots)	Direction (deg)	Date	Time	Speed (knots)	Direction (deg)	Date	Time	Speed (knots)	Direction (deg)	Date	Time	Speed (knots)	Direction (deg)	Date	Time	Speed (knots)	Direction (deg)	Date	Time	Speed (knots)	Direction (deg)
2011-Jan-01	00:00	0.0	000	2011-Jan-01	00:00	0.0	000	2011-Jan-01	00:00	0.0	000	2011-Jan-01	00:00	0.0	000	2011-Jan-01	00:00	0.0	000	2011-Jan-01	00:00	0.0	000	2011-Jan-01	00:00	0.0	000	2011-Jan-01	00:00	0.0	000

Report Note:

Several pages in Appendix 2 of this document are intentionally not printed to appropriate scale. Please refer to electronic version of the report to view these pages at appropriate scale.

All pages have been scaled to A4 page size.

RPS

GROUNDWATER FLOW MODELLING REPORT

Western Desert Resources

GROUNDWATER FLOW MODELLING REPORT

Western Desert Resources

Prepared for:

VDM CONSULTING (NT) PTY LTD
GPO Box 381
DARWIN NT 0801

Version/Date: Rev 1, March 2012

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1.0 INTRODUCTION

Western Desert Resources Limited (WDR) is planning to develop an iron ore mine located at Roper Bar, in the Northern Territory. The proposed mine site is located about 40 km west of the Gulf of Carpentaria (Figures 1 and 2). The project involves mining of moderate-grade haematitic ironstone. Initial work is expected to commence with open pit mining.

As the proposed mining operation is expected to extend below the regional groundwater table, lowering of the water table will be required to develop the mine. Lowering of the water table requires an assessment of groundwater inflow into the proposed pits and the impact associated with it. A numerical groundwater flow model is required to assess such an impact and to predict the inflow into the proposed pit.

RPS was commissioned by VDM Consulting Pty Ltd in order to develop a numerical groundwater flow model of the area.

1.1 Objectives of the Numerical Modelling

The objectives of the numerical groundwater flow modelling are to:

- estimate the groundwater inflow into the proposed pit
- estimate the impact of dewatering on surrounding aquifers
- assess the impact of dewatering on the nearby surface drainage (rivers).

1.2 Scope of the Work

The scope of work comprised of:

- data collection and the creation of a conceptual hydrogeological model
- numerical groundwater model set up and calibration in steady-state to available groundwater measurements
- prediction of groundwater inflow and drawdown due to mine dewatering
- sensitivity analysis on predictions by varying aquifer parameters
- completion of report that provides the results and uncertainty.

Figure 1: Location Map (Regional)

Figure 2: Location Map (near Mine Site)

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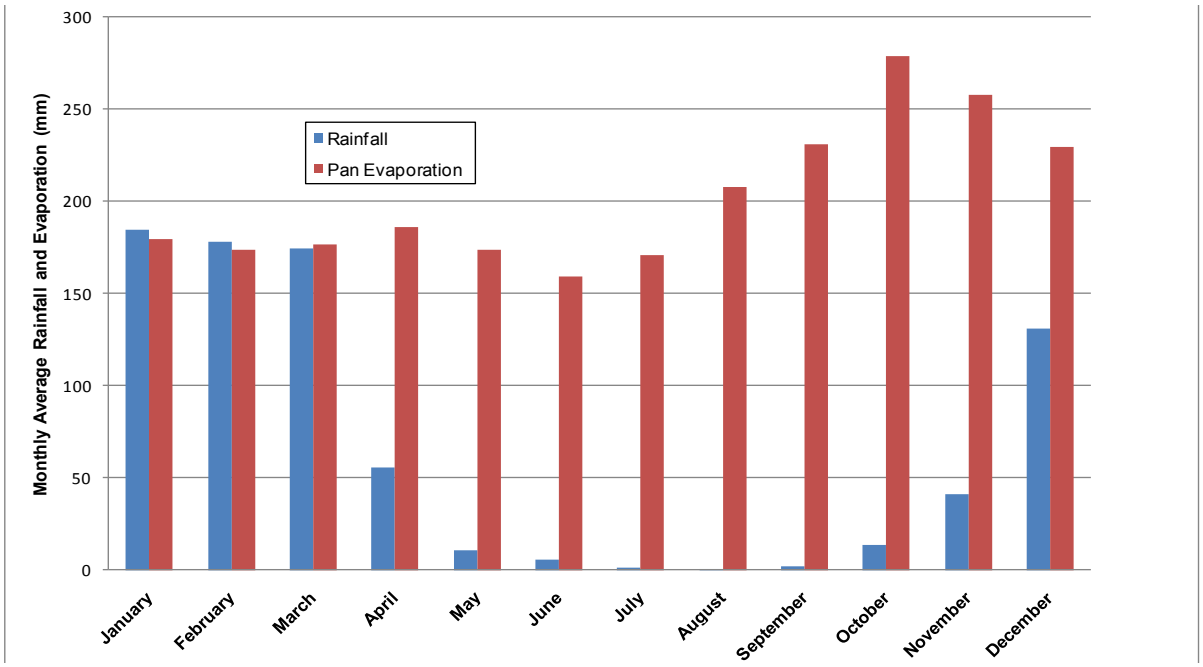
2.0 CONCEPTUALISATION

2.1 Data Collection and Review

Environmental data was collected from regional geological maps (1:250 000) of the area available on the internet (http://www.geoscience.gov.au); topographic data and cartography; rainfall and evaporation data from a nearby meteorological station (http://www.bom.gov.au); bore hole logs from VDM Group; water levels from VDM Group; and a site geology map and cross-section provided by VDM Group. The potential recharge range in the area was analysed by using the GeoScience Australia MapConnect data base (http://mapconnect.ga.gov.au/MapConnect).

2.1.1 Rainfall, Pan Evaporation and Potential Recharge and Discharge

The project site is located within the Roper Region and has a tropical savannah climate with a marked wet season from November to April and dry season from May to October (Graph 1). The average annual rainfall for Ngukurr (Station No. 014609, located 60 km to the north-west of the site), from 1910 to 2011 was 814 mm (Bureau of Meteorology (BoM). The average annual pan evaporation from 1964 to 2011 was 2409 mm for the same station. On average, annual pan evaporation exceeds annual rainfall by three times.



Graph 1: Average Monthly Rainfall and Pan Evaporation- Ngukurr (Station No. 014609)

As shown on Graph 1, average monthly rainfall and pan evaporation values are similar for the months of January, February and March. For all other months, pan evaporation exceeds the rainfall.

Potential recharge estimation for the project area was undertaken by selecting nine points (Figure 3) spread throughout the region using MapConnect data base (http://map connect.ga.gov.au/MapConnect). This database takes into account the rainfall, temperature, vegetation and geology of an area to estimate the recharge rate on a regional scale. The Method of Last Resort approach provided the potential groundwater recharge range from 0.2 mm/year to 64 mm/year with the mean recharge value being 3.5 mm/year. These values were used as guide for recharge values for the groundwater modelling.

Figure 3: Recharge Estimation Location Map from Map Connect

Groundwater recharging to the aquifer is also expected through the river bed, when the rivers flow briefly after heavy rainfall events.

Groundwater discharge is expected to occur as diffuse discharge via evapo-transpiration processes, through the river bed and through springs (if any). In a semi-arid area like this, where evaporation exceeds rainfall by three times, evaporation from the groundwater table may occur due to the matrix potential (dry air and soil near the ground surface causing groundwater to evaporate from within the soil profile) at a relatively low rate.

2.1.2 Topography and Hydrology

The project area lies within the Towns River catchment. The other major river catchments of the area are the Roper River catchment (to the north) and the Limmen Bight River catchment (to the south) of the Towns River catchment. Towns River is an ephemeral river, which flows briefly after significant rainfall (pers. comm. VDM December 2012). These rivers drain north-east towards the Gulf of Carpentaria (SKM 2010).

The topography within the proposed mine area (ML28264 application) ranges from 5 to 60 mAHD. Higher elevations of up to about 100 mAHD exist to the south of the site proposed for mining. Higher elevations correspond to the outcrops of the weathering resistant Sherwin Ironstone Formation and Moroak Sandstone Formations.

2.1.3 Geology and Hydrogeology

2.1.3.1 Regional Geology

The geology of the project area is dominated by the Roper Group of the McArthur Basin. The stratigraphy of the Project Area is described in Table 1 below (WDR 2008; as cited in SKM 2010).

Table 1: Roper Bar Stratigraphy

Geological Group	Formation	Description	
		Local	Regional
Roper Group	Kyalla Member	Thinly interbedded mudstone. Siltstone, very fine grained silty sandstone and fine-grained sandstone	Fine-grained, thin-bedded to flaggy sandstone with mudstone interbeds
	Sherwin Ironstone Formation	Haematic oolite with intervals of thinly interbedded siltstone and fine-grained sandstone. Oolitic sandstone with variable siderite cement towards base of unit	Sandstone, sandy ironstone and haematic shale interbedded with sandstone and mudstone and beds of silicified and ferruginous ooids
	Moroak Sandstone Member		Mainly fine-grained sandstone. Thin bedded to flaggy with some interbedded coarse-grained sandstone
	Velkerri Formation		Flaggy, fine-grained sandstone and siltstone

The Sherwin Ironstone Formation contains sedimentary oolitic beds which contain iron mineralisation and hence is the mining target. In the project area, the thickness of mineralisation ranges from 0.5 m to 10 m (SKM 2010). A geological note sent to RPS by VDM also describes this member being on average 10 m thick (Haines et al. 1993). A brief description of the Moroak Sandstone

(underlying the Sherwin Ironstone), the Sherwin Ironstone and the Kyalla Member (overlying the Sherwin Ironstone) is provided below:

Moroak Sandstone Member

The Moroak Sandstone Member consists mainly of fine grained sandstone, although minor conglomerate is present. Most of the member is thin-bedded and flaggy, although some medium to thick-bedded horizons are also present. Minor sedimentary ironstone, similar to that seen in the overlying Sherwin Ironstone Member is also present near the top. It is estimated to be approximately 60 m thick (Haines et al. 1993).

Sherwin Ironstone Member

The Sherwin Ironstone Member is a sequence of ferruginous sandstone, sandy ironstone, and haematitic shale, inter-bedded with fine grained micaceous sandstone and mudstone. The unit is about 10 m thick in the Mount Young geological sheet (Haines et al. 1993).

Kyalla Member

The Kyalla Member is composed of purple, thin-bedded and flaggy, fine-grained, micaceous sandstone with mudstone interbeds. Some beds are ferruginous and contain minor sedimentary ironstone. Its complete thickness is uncertain as the top is generally not exposed. However, about 100 m of the member is present when it outcrops (Haines et al. 1993).

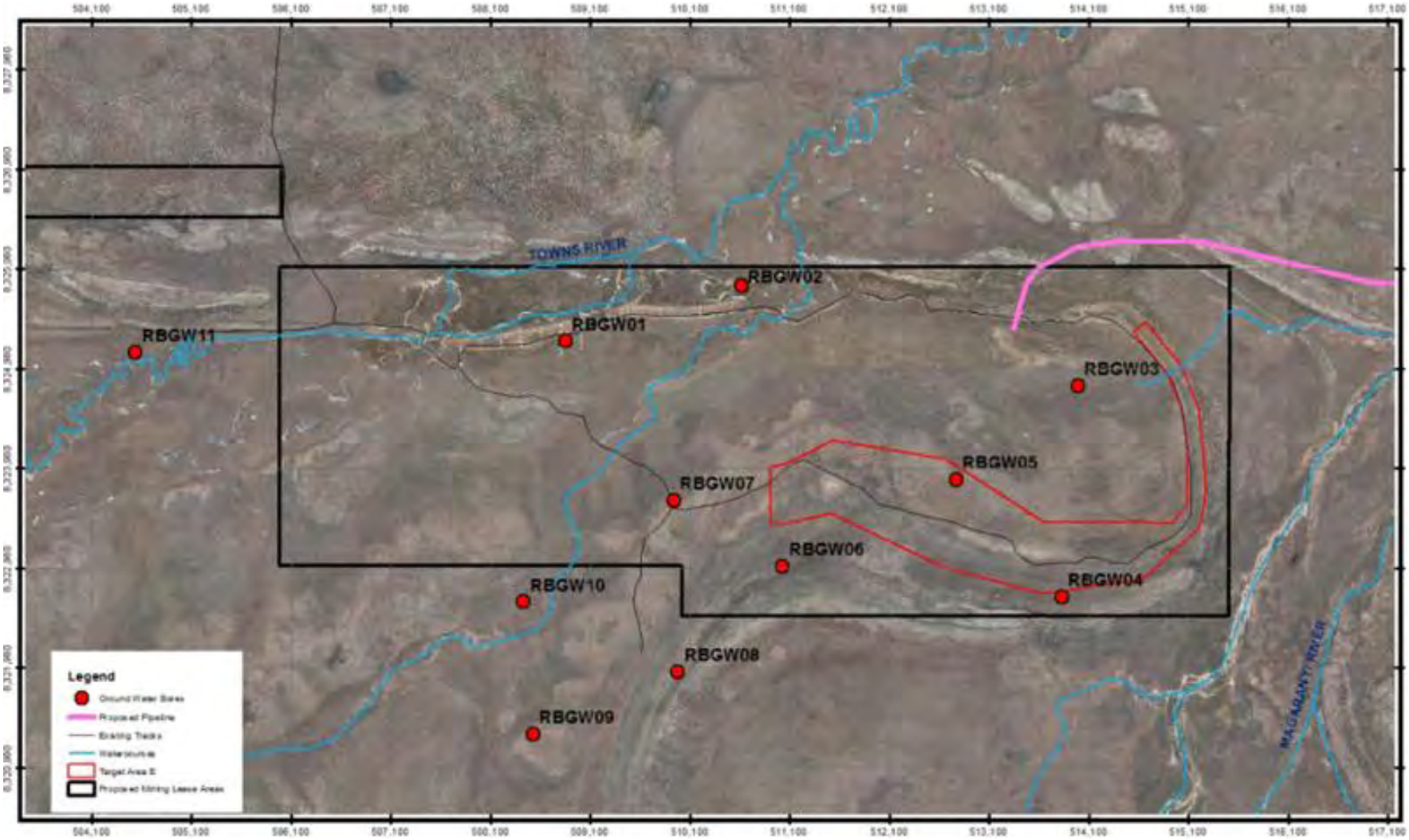
2.1.3.2 Regional Hydrogeology

The Roper River Catchment that lies to the north of the Towns River Catchment contains regional limestone aquifers. However, the Towns River Catchment where the proposed mining activity is proposed has limited water resource potential (SKM 2010).

The regional groundwater flow direction is expected to be from the south-west to north-east following the river catchment. However, at the local scale, groundwater is expected to flow from the top of the ridge in all directions into the lower topographic area. Localised fractured zones within the sandstone and siltstone may have some water resource potential. Otherwise the whole Roper Group can be considered as an aquitard as assumed by (Knapton 2009). Mineralised portions of the Sherwin Ironstone and weathered zones can also have limited water supply potential.

2.1.4 Site Scale Groundwater Investigation

VDM Consulting have undertaken groundwater site investigations including the installation of monitoring, test pumping and slug testing bores in 2011. The locations of these bores are shown in Figure 4. A summary of the tested range of hydraulic conductivity (K) values and water level data (supplied by VDM) is provided in Tables 2 and 3. Bore logs are provided in Appendix 1.



(Source VDM)

Figure 4: Location of Groundwater Bores

Table 2: Bore Location and Measured Water Level

Hole ID	Coordinates (GDA 94 Zone 53)		Ground Elevation	Top of Casing	Groundwater Level (mAHD)			
	Easting	Northing	mAHD	mAHD	mBTOC (nov 2011)	mBTOC (Jan 2012)	mAHD (nov 2011)	mAHD (Jan 2012)
RBGW01	508851	8325252	24.3	25.01	10.14	9.57	14.87	15.44
RBGW02	510617	8325804	23.1	23.8	13	12.42	10.8	11.38
RBGW03	513995	8324801	25.2	25.9	16.18	15.98	9.71	9.92
RBGW04	513832	8322687	52.5	53.25	18.51	16.49	34.74	36.76
RBGW05	512772	8323863	30.04	30.75	9.37	8.67	21.38	22.08
RBGW06	511029	8322996	55.8	56.62	9.39	8.39	47.24	48.23
RBGW07	509942	8323656	26.8	27.54	12.32	11.66	15.22	15.88
RBGW08	509981	8321938	38.96	39.58	6.07	3.8	33.52	35.78
RBGW09	508527	8321313	31.8	32.27	12.12	11.87	20.15	20.4
RBGW10	508433	8322638	26.8	27.26	9.34	9.17	17.93	18.09
RBGW11	504539	8325139	27.3	27.96	13.46	13.64	14.5	14.32

(Source VDM)

Note: mBTOC is metres below top of the casing

Table 3: Results of Slug Test and Pump Test Analysis

Slug Test Analysis										Aquifer Thickness
Bore ID	Bouwer and Rice		Hvorslev		Cooper-Bredehoeft-Papadopoulos			Average		
	K (m/d)	T (m2/d)	K (m/d)	T (m2/d)	K (m/d)	T (m2/d)	S [-]	K (m/d)	T (m2/d)	m
GW01	1.07E-02	7.81E-01	1.33E-02	9.71E-01	1.24E-02	9.05E-01		1.21E-02	8.86E-01	73.00
GW02	1.18E-03	1.13E-01	1.47E-03	1.41E-01	2.50E-04	2.40E-02		9.67E-04	9.28E-02	96.00
GW03	7.32E-03	5.38E-01	9.12E-03	6.70E-01	1.66E-02	2.73E-01		1.10E-02	4.94E-01	73.50
GW04	5.89E-03	3.86E-01	7.42E-03	4.86E-01	6.26E-03	4.10E-01		6.52E-03	4.27E-01	65.50
GW05	3.51E-04	2.84E-02	4.42E-04	3.58E-02	8.77E-03	8.77E-02		3.19E-03	5.06E-02	81.00
GW06	1.85E-03	9.34E-02	2.38E-03	1.20E-01	1.53E-02	7.75E-01		6.51E-03	3.30E-01	50.50
GW09	1.31E-03	6.22E-02	1.66E-03	7.89E-02	4.08E-04	1.94E-02		1.13E-03	5.35E-02	47.50
GW10	4.37E-03	2.08E-01	5.63E-03	2.67E-01	4.26E-03	5.70E-01		4.75E-03	3.48E-01	47.50
GW11	1.59E-03	1.03E-01	2.68E-03	1.73E-01	1.73E-03	1.11E-01		2.00E-03	1.29E-01	64.50
Average	3.84E-03	2.57E-01	4.90E-03	3.27E-01	7.33E-03	3.53E-01		5.36E-03	3.12E-01	66.56
Maximun	1.07E-02	7.81E-01	1.33E-02	9.71E-01	1.66E-02	9.05E-01		1.21E-02	8.86E-01	96.00
Minimum	3.51E-04	2.84E-02	4.42E-04	3.58E-02	2.50E-04	1.94E-02		9.67E-04	5.06E-02	47.50
	Pump Test Analysis									
	Boulton			Theis			Average			
	K (m/d)	T (m2/d)	S [-]	K (m/d)	T (m2/d)	S [-]	K (m/d)	T (m2/d)	S [-]	
GW07	1.31E-03	9.05E-02		1.96E-03	1.35E-01		1.64E-03	1.13E-01		69.00
GW08	5.86E-02	4.04E+00		5.37E-02	3.70E+00		5.62E-02	3.87E+00		49.50
GW08A	3.46E-02	1.71E+00		3.46E-02	1.71E+00		3.46E-02	1.71E+00		49.50
Average	3.15E-02	1.95E+00		3.01E-02	1.85E+00		3.08E-02	1.90E+00		56.00
Maximun	5.86E-02	4.04E+00		5.37E-02	3.70E+00		5.62E-02	3.87E+00		69.00
Minimum	1.31E-03	9.05E-02		1.96E-03	1.35E-01		1.64E-03	1.13E-01		49.50

(Source VDM)

Note: K represents horizontal hydraulic conductivity and T represents transmissivity of the aquifer.

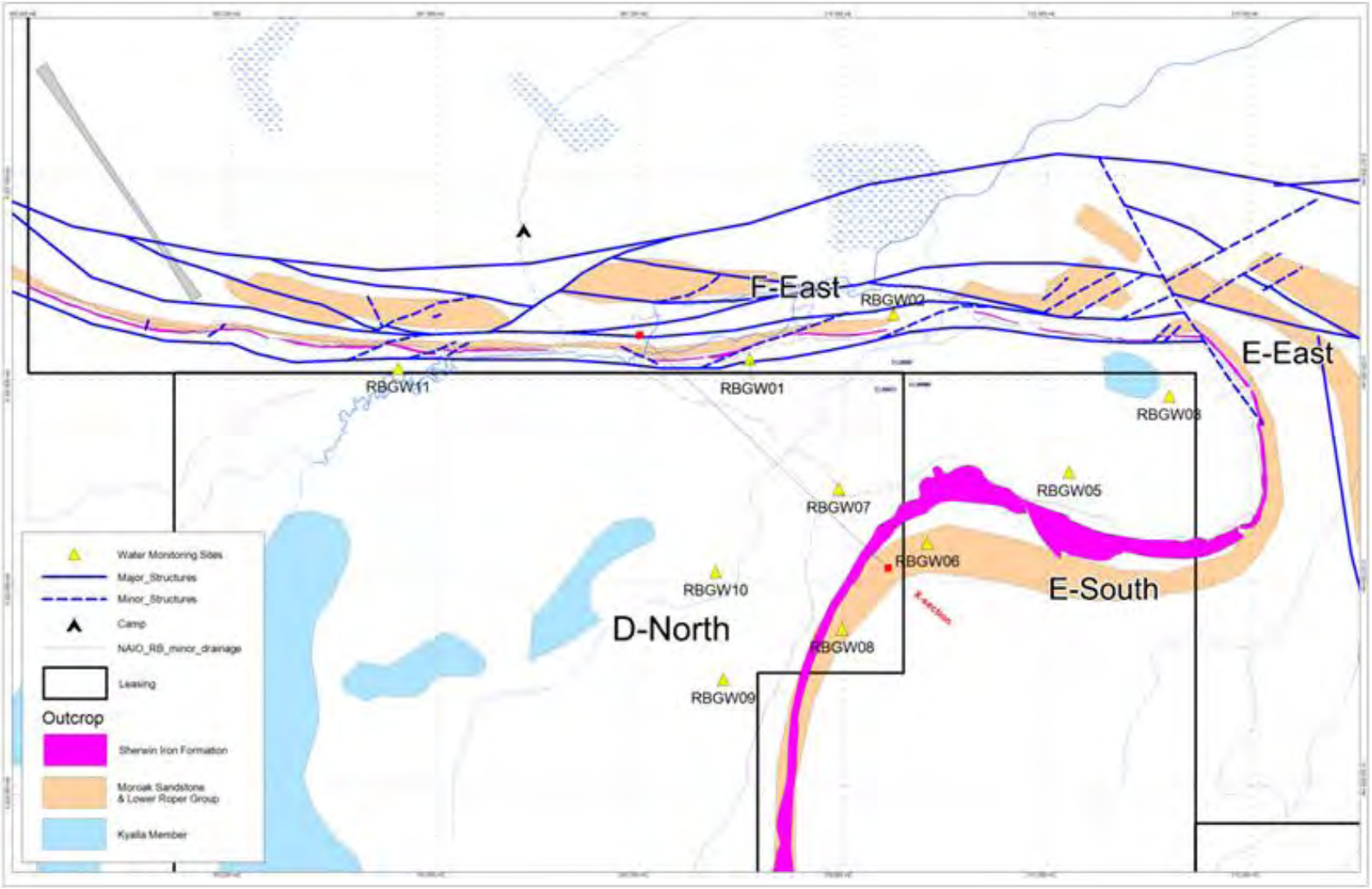
The review of bore logs showed the existence of four layers in the project site, with the first layer being the surface weathered zone (about 12 to 28 m thick), followed by the Kyalla Member (0 to more than 90 m thick), the Sherwin Ironstone (0 to 25 m thick) and the Moroak Sandstone (0 to 40 m thick). It should

be noted that in some cases the bases of the Kyalla Member and Moroak Sandstone were not fully penetrated by the bore holes. From the site scale geological map and cross-section provided by VDM (Figures 5 and 6 respectively), the maximum thickness of the Kyalla Member can be considered to be approximately 160 m (or extending up to an elevation of -150 mAHD) and for the Moroak Sandstone a maximum thickness of 60 m can be assumed based on the geological description in Section 2.1.3.

As presented in Table 3, aquifer testing indicates the members have a relatively low transmissivity. This is consistent with the description provided in the groundwater modelling report (Knapton 2009), which describes whole Roper Group as an aquitard. The tested K values ranged from 3 $x10^{-4}$ m/d to 5 x 10^{-2} m/d. Based on their on-site experience, VDM considers the Sherwin Ironstone to be more permeable than the Moroak Sandstone and the Kyalla Member.

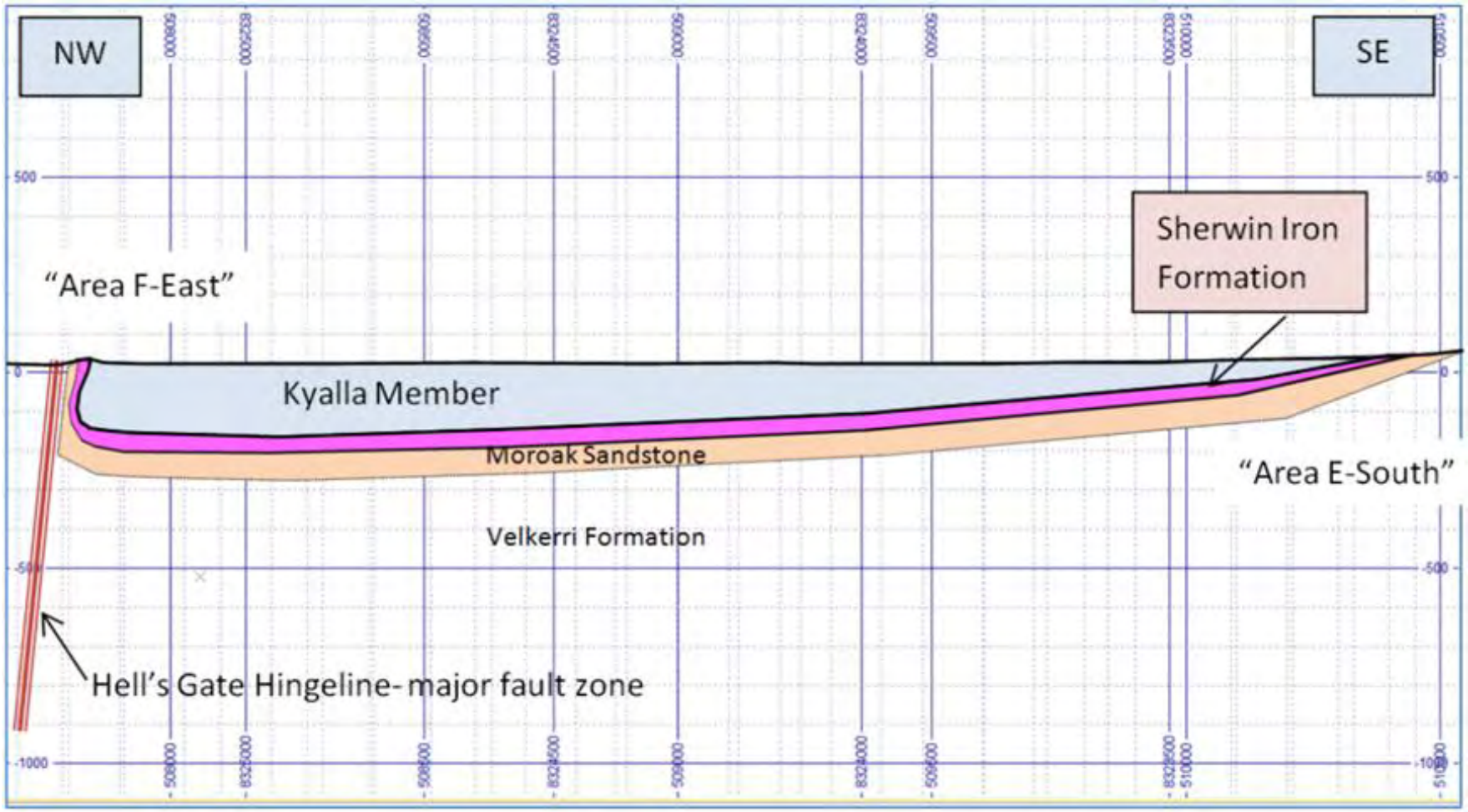
Consistent with the low K values of the strata, the bore yields were also very low ranging from less than 0.1 L/s up to 1 L/s. Overall, the whole Roper Group Formation around the mine site is of low conductivity with some isolated fractured zones likely to provide higher yielding zones.

The groundwater table lies between 4 to 18 m below the ground surface and closely follows the topography. Measured groundwater levels (November 2011 and January 2012) range from 9.7 mAHD (metres relative to Australian Height Datum) to 48.2 mAHD.



(source VDM)

Figure 5: Geology near Mine Site



(Source VDM)

Figure 6: Geological Cross-section near Mine Site

2.1.5 Conceptual Model

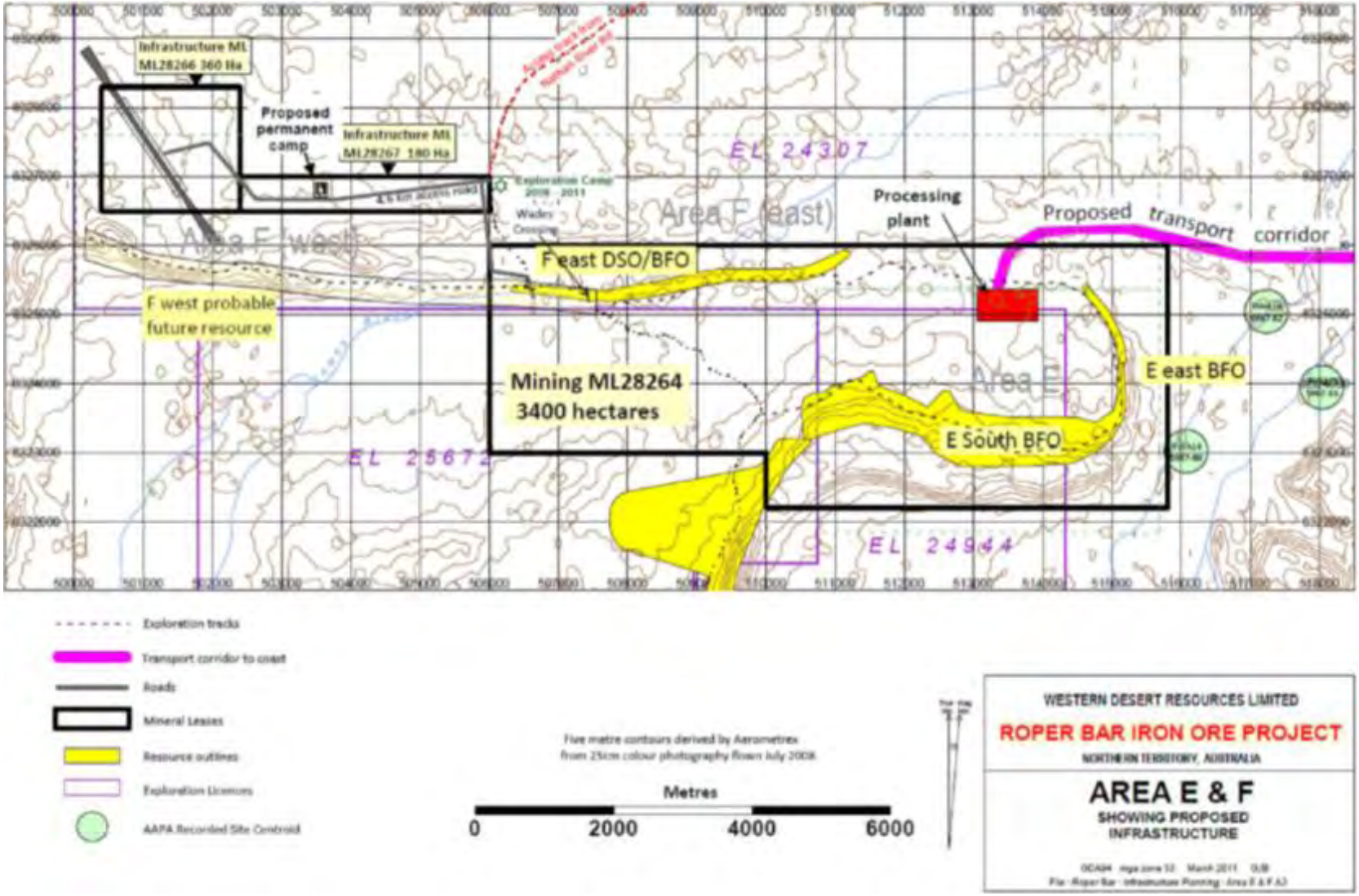
Consistent with the on-site groundwater investigation and information from the regional geological map, a conceptual model diagram representing the study area has been developed (Figure 7). In this model, the top layer primarily consists of the weathered zone (12 to 28 m thick), underlain by the Kyalla Member(0 to 160 m thick), the Sherwin Ironstone Member(0 to 25 m thick) and the Moroak Sandstone (about 60 m thick).

The Sherwin Ironstone outcrops near the mine site (Area E-South), it dips down towards west. Hell's Gate Hingeline (a major fault) has moved the Ironstone Formation near the surface in Area F-East. The mine footprint represented by Area E and Area F is presented in Figure 8.

Figure 9 presents the fence diagram of the various formations from the 11 groundwater bores provided by VDM to RPS.

Input of water in the model is considered to be from rainfall recharge, up-gradient groundwater inflow and from river leakage (where the groundwater table is below the river stage). Output from the model is considered to be via evapo-transpiration (ET), groundwater outflow down-gradient and groundwater discharge to the river (where the groundwater table is above the river stage). Across the study area groundwater is generally expected to be below the river stage, hence the rivers are likely to provide groundwater input rather than output.

Figure 7: Conceptual Model Design



(Source VDM)

Figure 8: Location of Proposed Mine Footprint

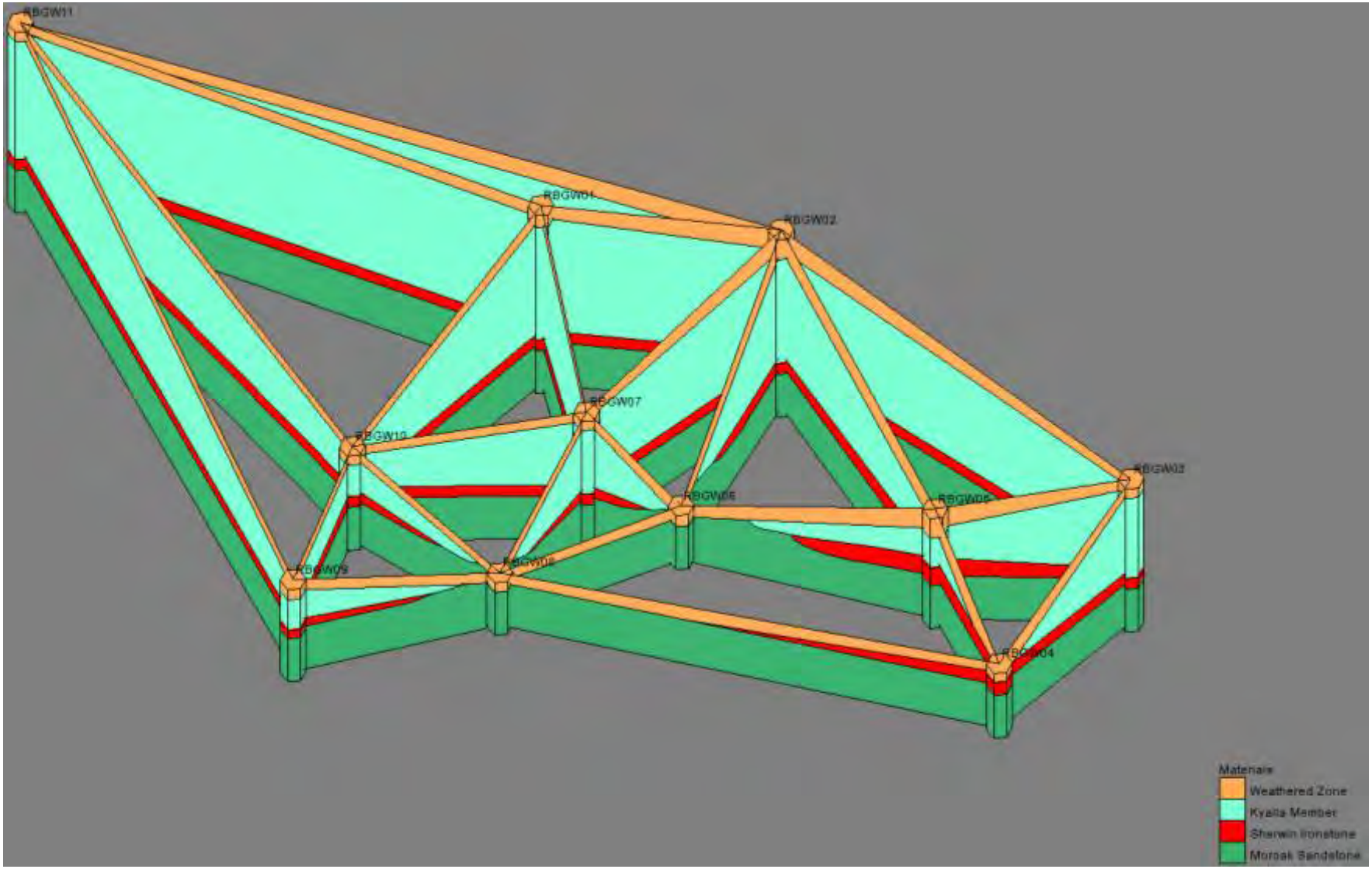


Figure 9: Fence Diagram from 11 Groundwater Bores

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3.0 NUMERICAL MODEL SET UP AND CALIBRATION

3.1 Selection of Modelling Code

The MODFLOW-SURFACT (Version 3) (developed by Hydrogeologic Inc.) modelling code was selected instead of the industry standard MODFLOW code for this study. This is because MODFLOW-SURFACT can better handle dry cell issues related to mine dewatering. Groundwater Vistas (Version 6.1) (developed by Rumbaugh, J. and Rumbaugh, D.) was used for pre- and post-processing of the data.

3.2 Grid Design

The numerical model has been set up with four layers, 370 rows and the 360 columns with total model nodes of 532,800. The grid size ranges from 50 m near mine site to 200 m towards boundaries. The grid spacing increases by a maximum factor of 1.2 which is less than the maximum factor of 1.5 suggested by Anderson and Woessner (2002) for numerical accuracy.

The model origin in GDA 94 Zone 53 is at (50,500 mE, 8,290,000 mN). The model extends 45,000 m in both row and column directions. The grid was rotated 35 degrees to align it with the major flow direction.

Figure 10 shows the model grid in section and plan views.

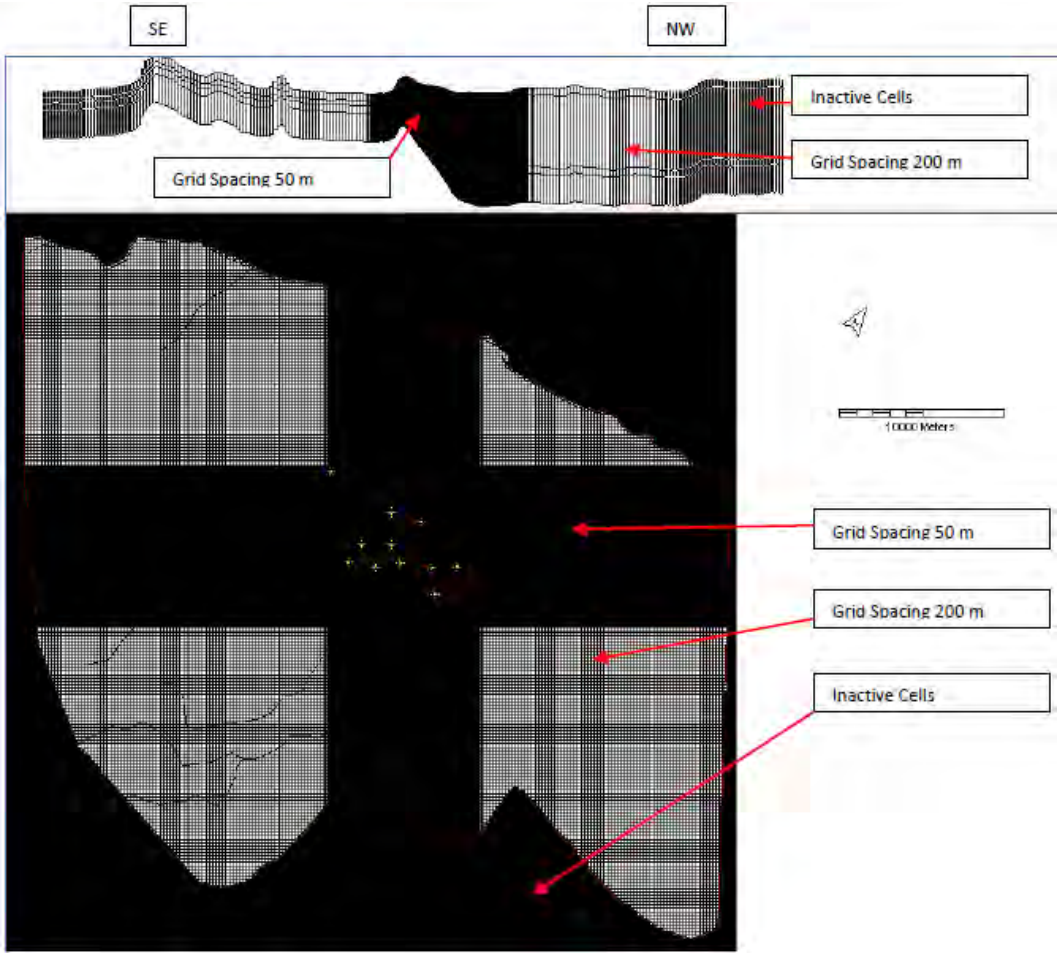


Figure 10: Model Grid Design (Top: Section View; Bottom: Plan View)

3.3 Boundary Conditions

The flow model was developed with the following boundary conditions:

- Magaranyi River, Towns River and Little Towns River have been assigned with river boundary conditions in layer1.
- Small creeks within the model domain have been modelled with drain boundary conditions.
- Eastern boundaries: constant hydraulic head in all layers with head values ranging from 4 m to 25 m (approximately 5 m below topography).
- The south-western corner of Magaranyi River flood plain has been assigned constant head boundaries in all four layers with the head value of 33 m (approximately 5 m below topography).
- Where no boundary conditions have been assigned, no-flow boundary conditions apply.

- No-flow boundary at the base of the model.
- Specified flow as rainfall recharge at the top of the model.

The model domain and boundary conditions are presented in Figure 11.

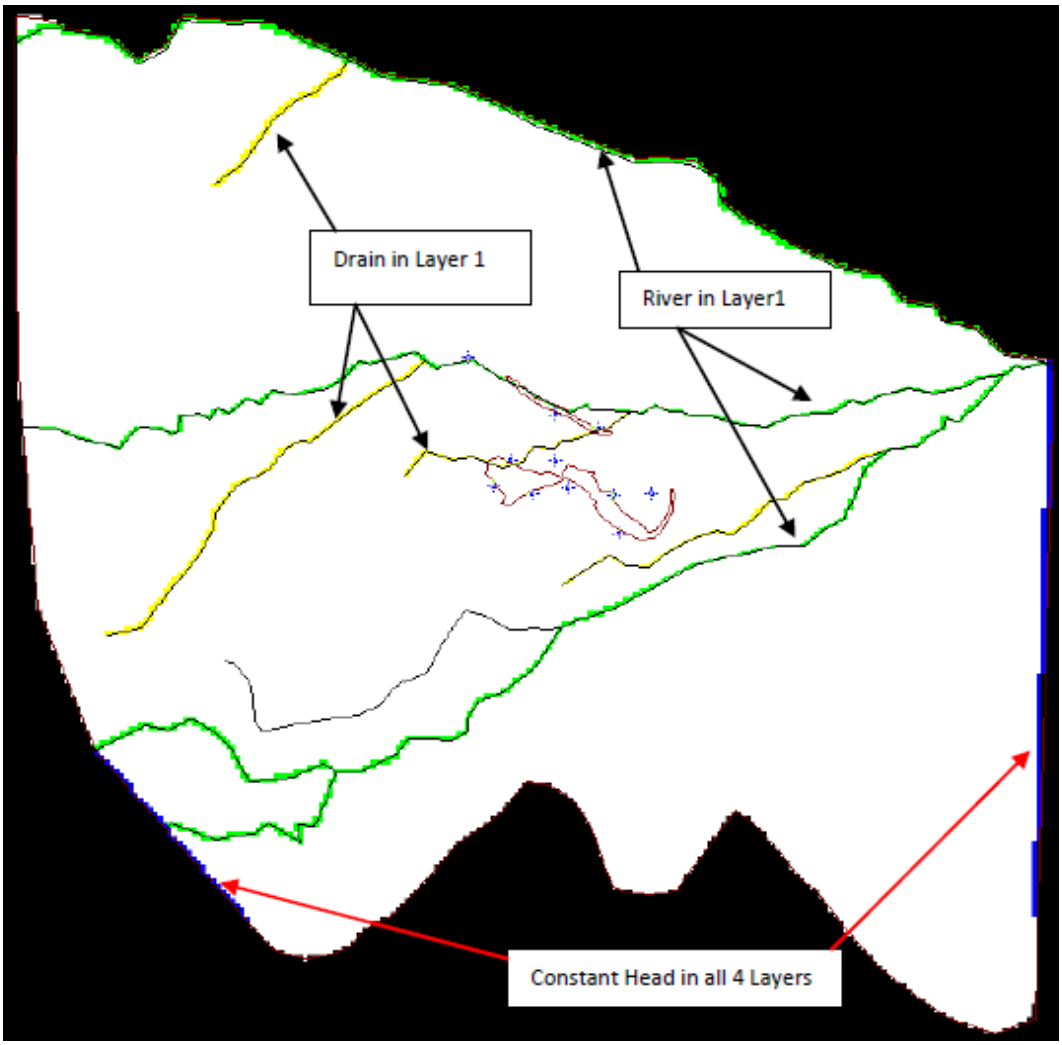


Figure 11: Model Boundary Conditions

3.4 Model Calibration

The groundwater flow model was calibrated by comparing computed groundwater heads with observed groundwater heads from the 11 observation wells within the model domain. These observation wells are shown in Figures 12 and 13. The calibration was conducted via trial and error.

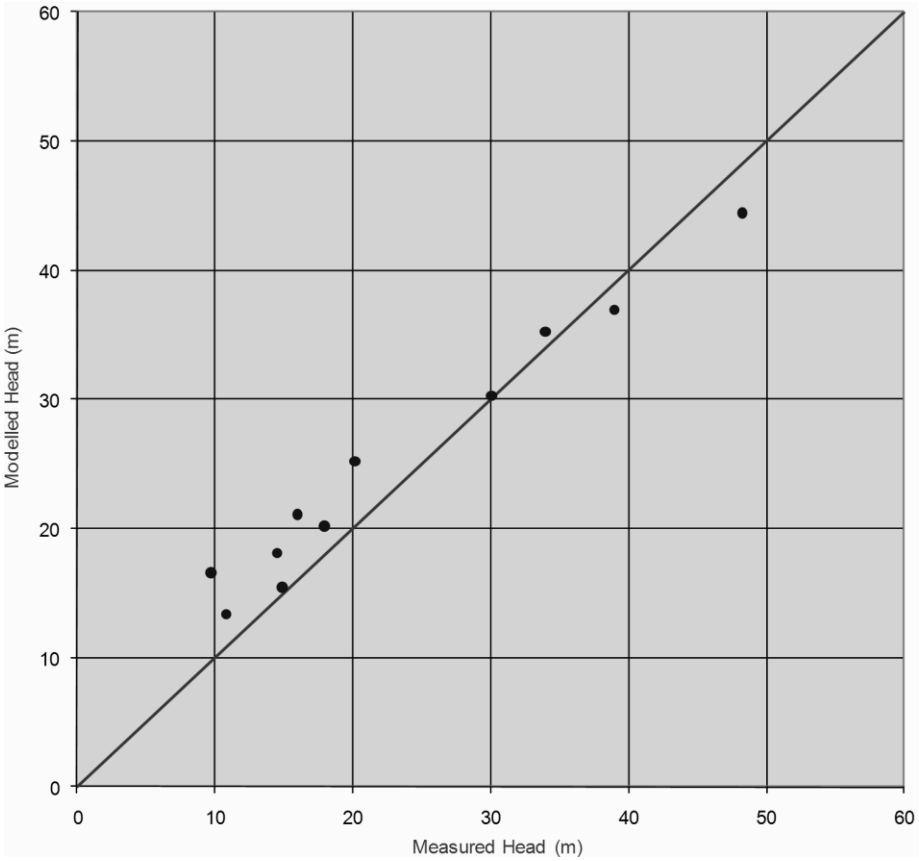
A measure of the calibration error is the mean absolute residual head (MARH), which is the mean absolute difference between measured and simulated groundwater levels across the site. Another measure is the root mean square residual head error (RMS) and scaled root mean square error (SRMS). The

calibration process provided a SRMS for the steady-state simulation of 9.4% (RMS error of 3.62 m) (for November 2011 measured head). The steady-state calibration graph (or scattergram) is presented in Graph 2.

The calibration process required assigning an evapo-traspiration (ET) extinction depth of 10 m, with a maximum evaporation rate of 0.0003 m/d (or 5% of Pan Evaporation). Initial trial and error modelling was conducted without ET, by varying recharge between 1 mm/yr to 60 mm/yr and varying the K values of the Formations within the measured ranges (0.001 m/d to 0.05 m/d). This resulted in a higher SRMS; hence, the introduction of ET was required in the model to calibrate it.

When the groundwater table closely follows the topography, as is the case at this site, ET is generally considered to be a major controlling factor on the groundwater flow system. The calibration results improved with increasing the ET extinction depth to 12 m or higher. However, a higher extinction depth is not supported by the literature. The height of capillary rise in fine silt material has been reported as 7.5 m by Fetter (1994). Even higher values of more than 7.5 m of capillary rise are possible for finer grain sizes than silt. Also, in a semi-arid area like our study area, dry soil near the ground surface has a high matrix potential which means it can lift water in the vapour phase from greater depths.

The modelled head distribution for the steady-state calibration is presented in Figures 12 and 13. As shown in these figures, the modelled head closely follows the topography.



Graph 2: Steady State Calibration Scattergram

Figure 12: Modelled Steady State Head Distribution

Figure 13: Modelled Steady Sate Head Distribution (near Mine Site)

3.5 Calibrated Model Parameters

3.5.1 Recharge

The calibrated model used recharge values as follows (also shown in Figure 14):

- 36.5 mm/year (or 4.5% of rainfall) at the ridge top where fractured/weathered Sherwin Ironstone and Moroak Sandstone outcrop
- 8.8 mm/ year (or 1.1% of rainfall) on areas of alluvium
- 2.9 mm/year (or 0.35% of rainfall) at the rest of the weathered zone.

These values are within the ranges provided by the Geo Science MapConnect data base.

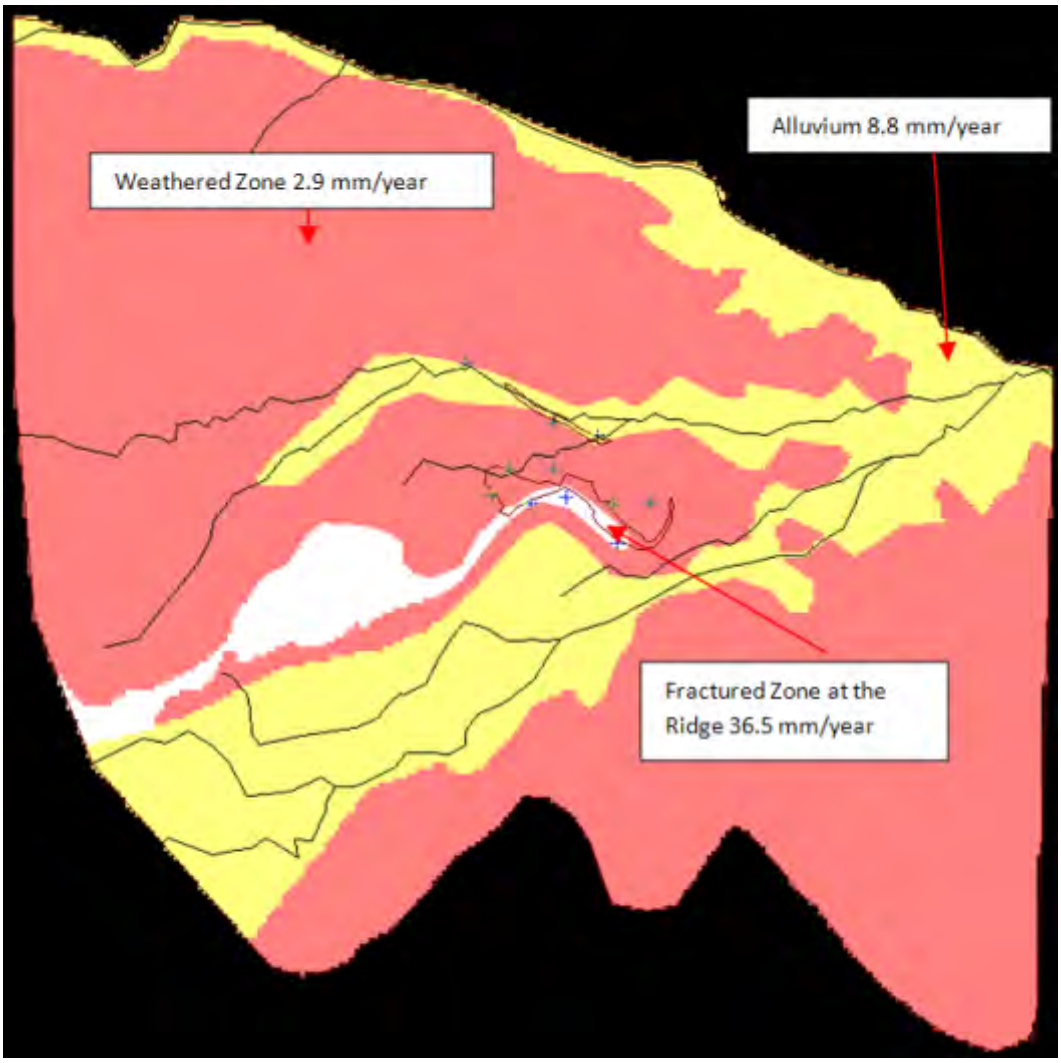


Figure 14: Modelled Recharge Distribution

3.5.2 Hydraulic Conductivity

The horizontal and vertical hydraulic conductivity (Kh) and (Kv) values from the steady-state model calibration are as follows (as shown in Figures 15 to 18):

- Alluvium along river channels (Kh - 1m/d) and (Kv) - 0.1 m/d)
- Weathered and Fractured Zone (Kh - 0.1 m/d) and (Kv - 0.01 m/d)
- Kyalla Member (Kh and Kv - 0.005 m/d).
- Sherwin Ironstone Formation (Kh and Kv - 0.02 m/d)
- Moroak Sandstone Member (Kh and Kv - 0.005 m/d)
- Chert/Brecia – (Kh and Kv - 0.005 m/d).

It should be noted that the Sherwin Ironstone Formation extent shown (Layer 3) in Figure 17 is as an extensive layer (coloured red). However, this model area represents a hydro-stratigraphic layer rather than the extent of ironstone mineralisation.

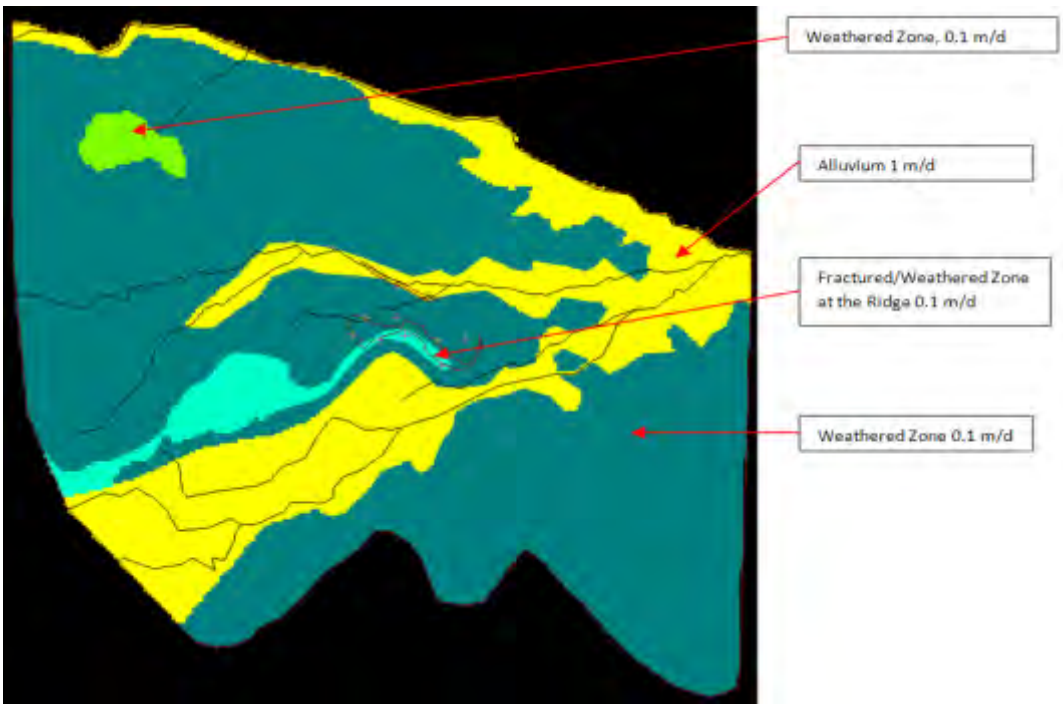


Figure 15: Modelled Horizontal Conductivity Distribution (Layer 1)

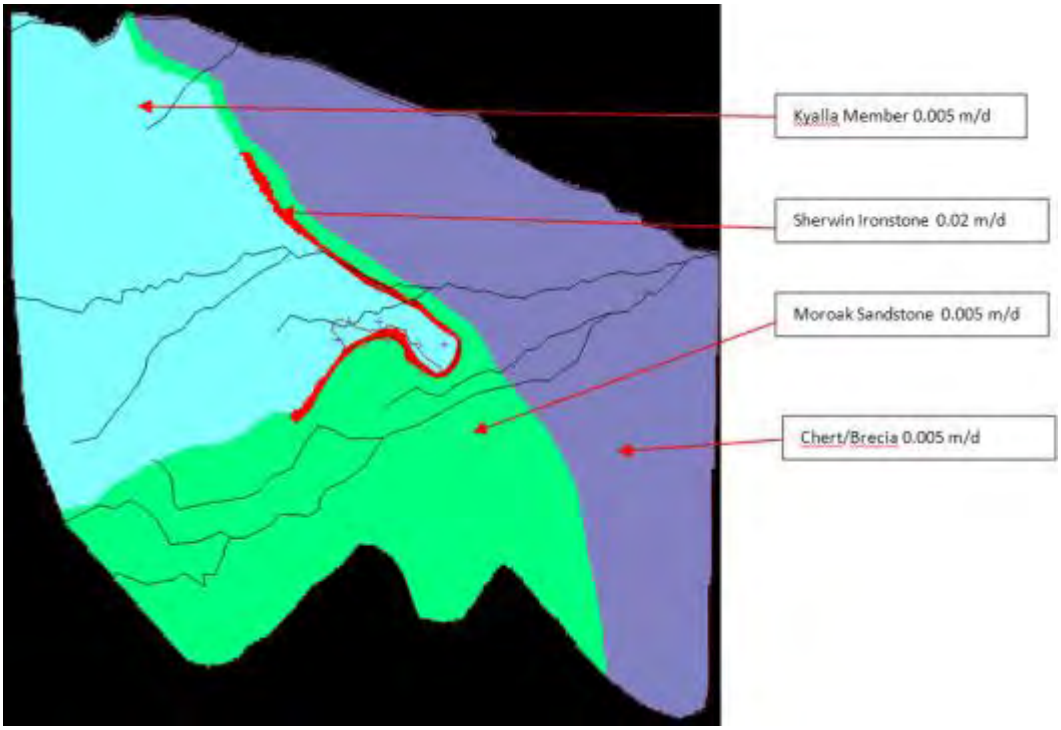


Figure 16: Modelled Horizontal Conductivity Distribution (Layer 2)

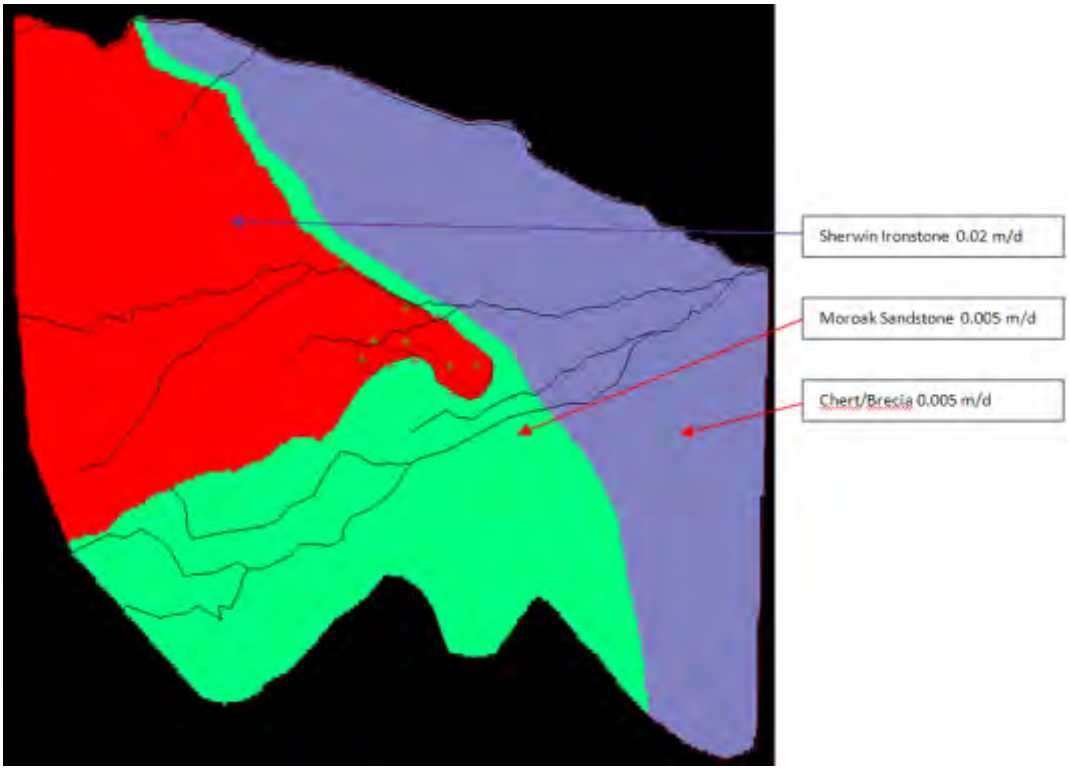


Figure 17: Modelled Horizontal Conductivity Distribution (Layer 3)

Figure 18: Modelled Horizontal Conductivity Distribution (Layer 4)

3.5.3 Proposed Storage Parameters

Storage parameters are not required for a steady-state calibration; however they are necessary for the transient prediction run. Based on the low K of the materials on site, the following storage parameters have been proposed:

- Storage Coefficient – 10^{-5} (for all layers and all formations)
- Specific Yield – Alluvium - 0.1
- Specific Yield –Weathered Zone - 0.05
- Specific Yield –Sherwin Ironstone Formation- 0.02
- Specific Yield –Kyalla member, Moroak Sandstone and Chert/Brecia - 0.01.

3.6 Water Balance

The water balance for the steady-state model is provided in Table 4. According to the model results, the water balance error for the entire model domain is less than 0.1%, the error specified by Konikow (1978) that is considered ideal.

Table 4: Water Balance from Steady-state Calibration

Flow Component	Flow In (m^3/d)	Flow Out (m^3/d)
Specified Head Boundaries	1,121	192
Recharge	19,173	0
ET	0	23,849
River Leakage	3,762	15
Drain	0	0
Total	**24,056**	**24,056**
Flow In – Flow Out	0	
Per Cent Discrepancy (%)	0.00	

As shown in Table 4, most of the water is input to the system via recharge (80%), and river leakage (15%). Most of the water exits the system via ET (99%).

3.7 Predictions

3.7.1 Overview

The steady-state model was used as the basis for the transient modelling predictions. The purpose of the modelling predictions is to estimate the groundwater inflow into the proposed pit and the drawdown extent during mining.

3.7.2 Predictive Model Assumptions

The predictive model used the same model parameters as the steady-state model, except for the following modifications:

- In order to simulate inflow of water into the proposed pit, drains were assigned to the relevant location with the drain elevation corresponding to the mining elevation. The preliminary mine plan is such that Area F will be mined from one to three years to a depth of 60 m (20 m depth per year); Area E East will be mined from one to seven years to a depth of 70 m (10 m depth per year) and Area E South will be mined from five to seven years to a depth of 45 m (approximately 15 m depth per year). The locations of Areas E and F are shown on Figure 8.

- The predictive model was run for seven years with yearly stress periods. Each stress period was divided into 12 time steps (monthly time steps).

- The initial heads for the transient predictions were based on the steady-state model outputs.

- Storage parameters as described in Section 3.5.3.
- The drain boundary conditions used in the steady-state conditions were removed for the transient predictions, as these were not removing any groundwater, hence were inactive.

- The small section of Towns River that crosses the mine site at Area F East was removed from the model, as this river would have to be diverted during mining.

3.7.3 Results

3.7.3.1 Predicted Mine Inflow Rate

The base case prediction shows that the total groundwater inflow rate changes from 6,600 kL/d for the first year of mining, decreasing to about 3,200 kL/d in year four and increasing to about 8,900 kL/d in year six (Graph 3). The reduction in groundwater flow rate in year four is because pumping of Pit F East has declined due to the water level already being dewatered to the base of this pit in year three. Also, E South pit dewatering does not commence until year five. The flow rates presented in Graph 3 include groundwater that is stored within the rock-mass of the orebody as well as groundwater entering from the sides and base of the pits. Groundwater inflow into the pits from the sides and floor for both pits is presented in Graph 4.

Given the size of the pit void and evaporation rate of the area, most of the water is expected to evaporate from the pit surface. Effective dewatering by using bore-hole is limited, unless fractured zones with higher hydraulic conductivity values are discovered during mining. The dewatering can be undertaken by pumping from the sumps that are generally located at the bottom of the pit.

3.7.3.2 Predicted Groundwater Drawdown

Figure 19 shows the 5 m drawdown contour interval and Figure 20 shows the 1 m drawdown contour interval (from 1 to 5 m drawdown only). As shown in these figures, the predicted drawdown values of 5 m and 1 m are located within 0.9 km and 1.2 km respectively from the edge of the mine pit at the end of the seven year period. Hence, the model predicts the impact of mining on lowering the regional water table is minimal and localised. The localised impact on lowering the water table is primarily due to the low K of the material surrounding the mine site.

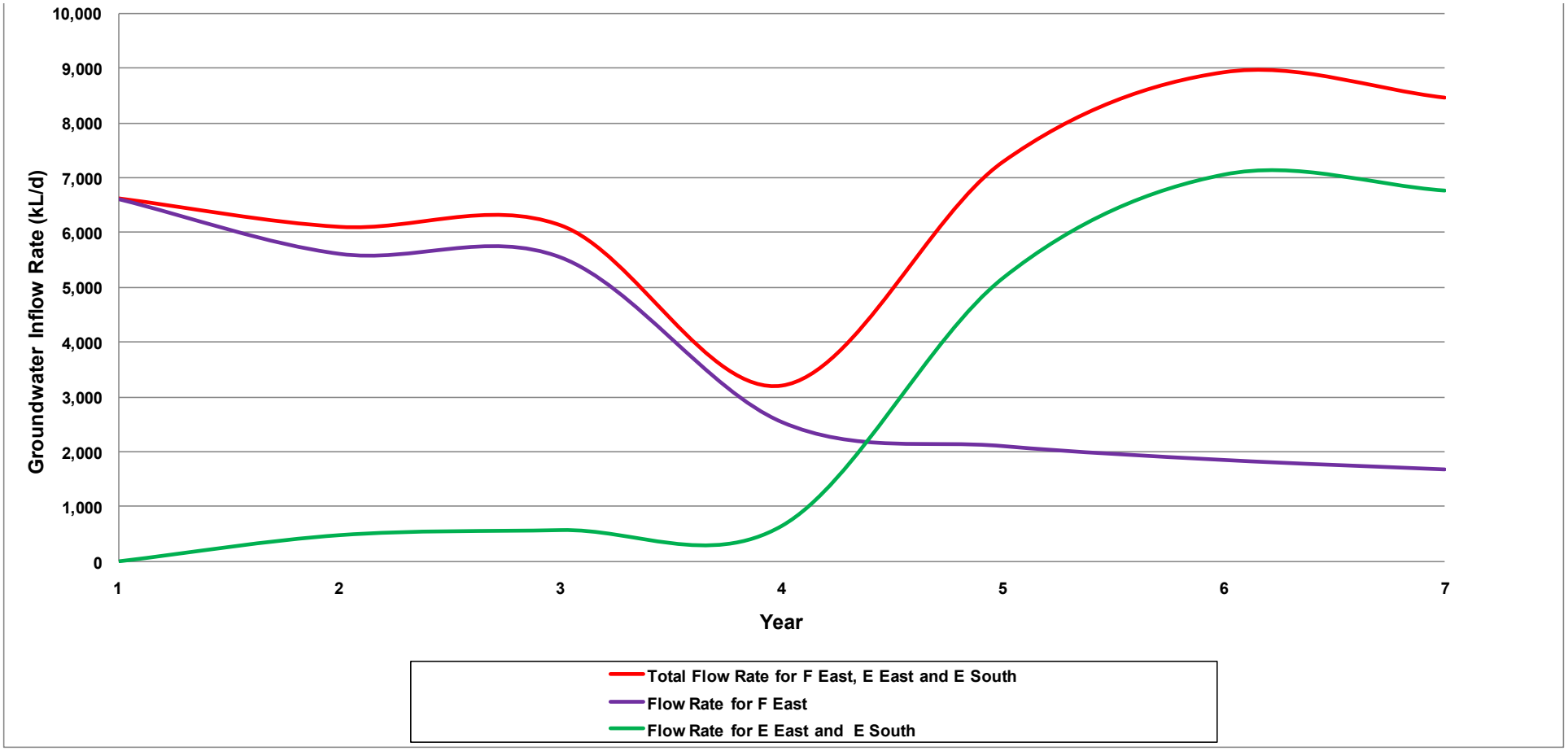
The time-drawdown graph at three selected locations (MW1, MW2 and MW3) (Figures 19 and 20) near Pit F East is presented in Graph 5.

3.7.3.3 Predicted Impact on Surface Water Courses

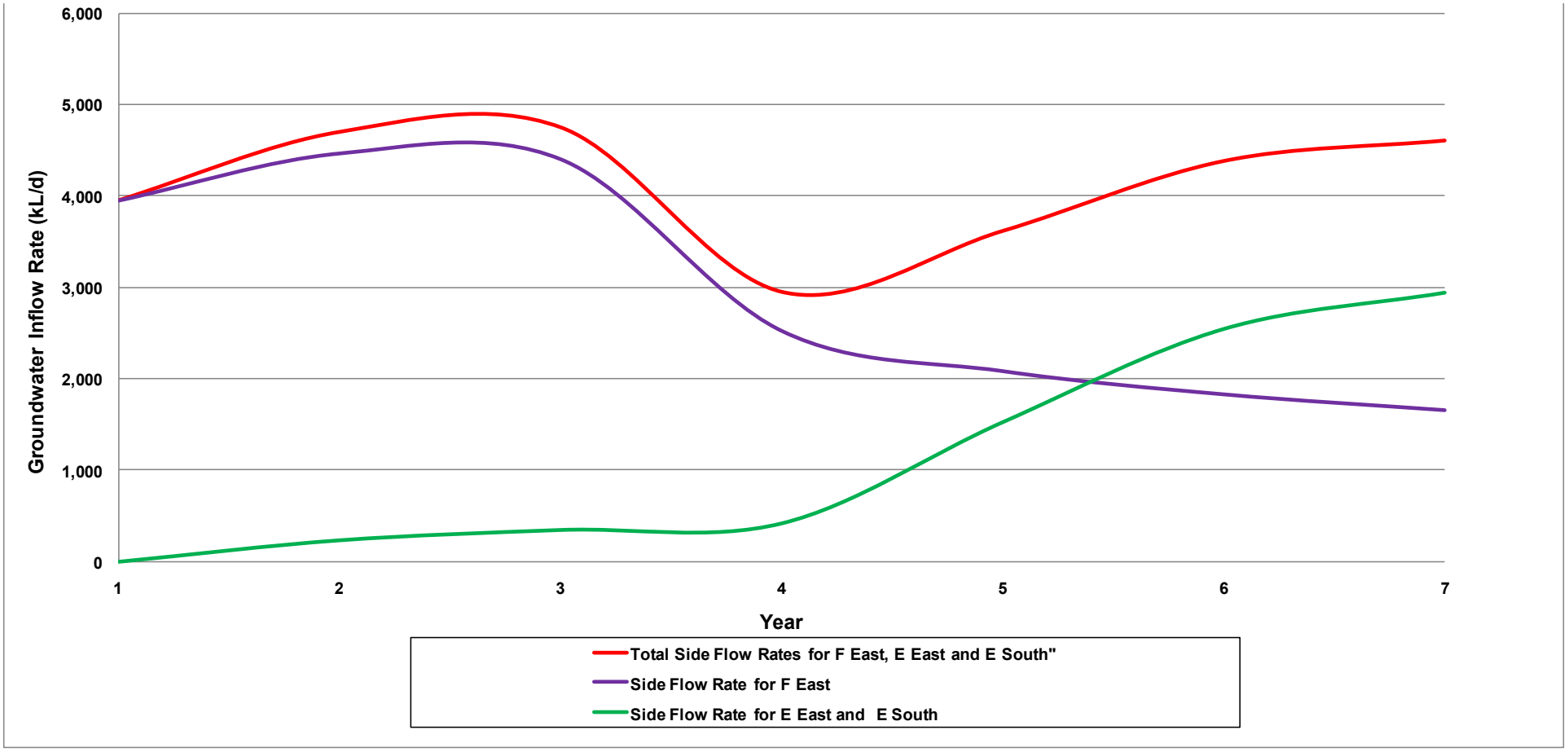
The impact on surface water bodies due to mining activity is also predicted to be limited.

The impact on rivers from mine dewatering has been assessed by comparing the net river leakage rate pre- and post-mining. The pre-mining steady-state net river leakage rate was 3,747 kL/d, which only reduces to 3,642 kL/d post-mining. This small reduction in river leakage is due to the fact that a small part of the Towns River Creek will be removed from the model during mine dewatering, as this section would have to be diverted during mining. The reduction in net river leakage of 2.8% is considered to be minor in terms of impact to the surface water course. This is consistent with the conceptual understanding of the site, where the regional water table is sitting below the river bottom elevation, which means further reduction in water table elevation does not induce more leakage from the river to the aquifer.

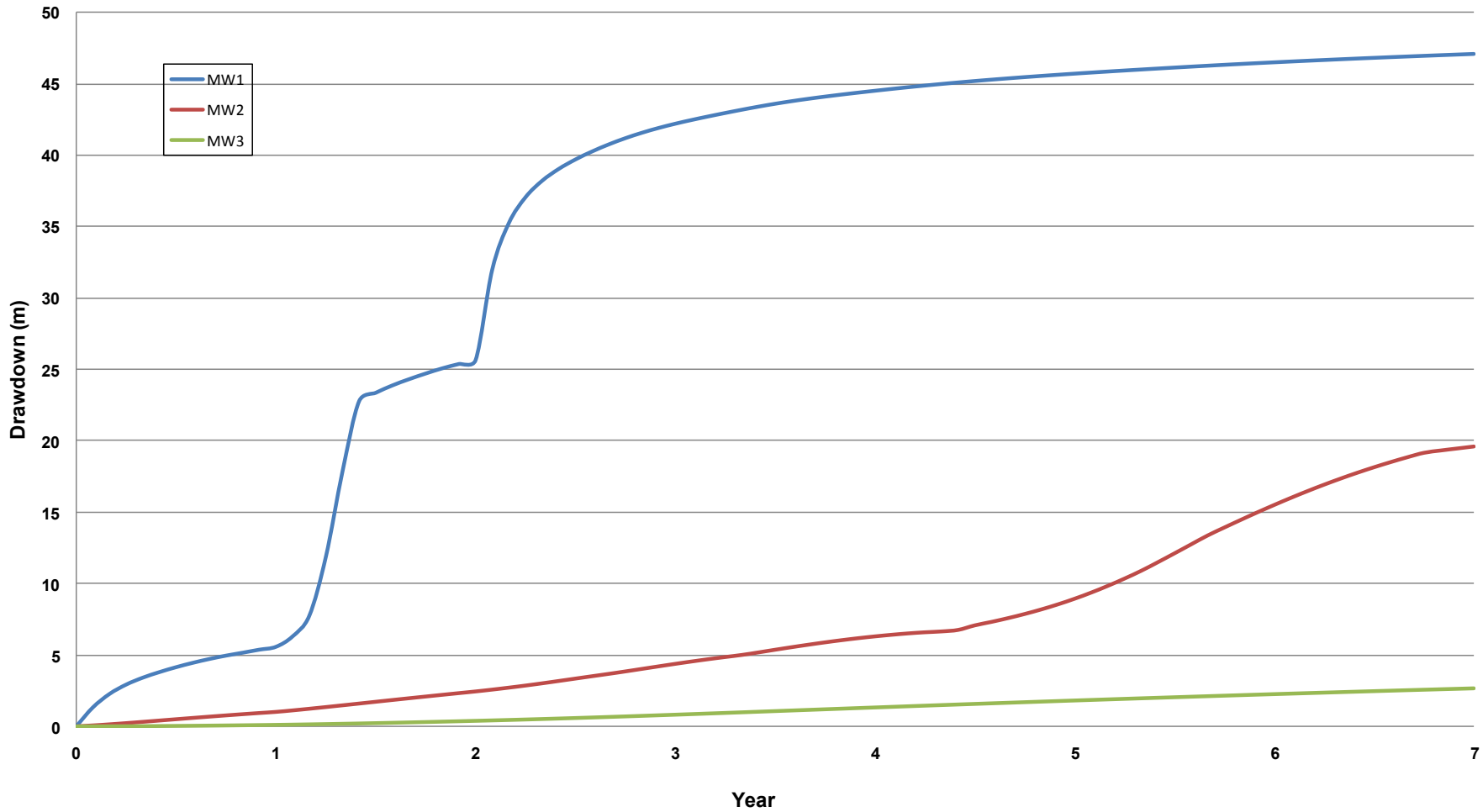
The model predicted base case flow rates are also provided in Table 6, together with the sensitivity analysis (Section 3.3.3). It should be noted that the groundwater flow rates presented in Table 6 and in Section 3.3.3 include initial storage as well as the groundwater coming from the sides (pit walls and floor) of the pits.



Graph 3: Base Case Model Predicted Groundwater Inflow (Side Inflow plus Initial Storage)



Graph 4: Base Case Model Predicted Groundwater Inflow (From the Sides and Floor of the Pit Only)



Graph 5: Base Case Model Predicted Time-Drawdown Plot at Three Selected Locations

Figure 19: Predicted Drawdown Contours (End of Seven Year Period) (5 m Interval)

Figure 20: Predicted Drawdown Contours (End of Seven Year Period) (1 m Interval, 1 to 5 m)

3.8 Sensitivity and Uncertainty Analyses

3.8.1 Sensitivity Analysis Method

A sensitivity analysis was undertaken to determine the effect of varying a range of parameter values on the predicted groundwater inflow rate and the extent of drawdown. The sensitivity analysis was conducted by varying one parameter globally at a time within its expected range, while maintaining all other parameters constant.

Using the Murray Darling Basin Commission (MDBC 2000) and the American Society for Testing and Materials (ASTM) D5611 (1994) methodology, the sensitivity grade of the model to each parameter can be classified as follows:

Type 1 sensitivity: Variation of parameter causes an insignificant change in the model calibration and conclusions. Type I sensitivity is of no concern because the modelling conclusion will remain the same regardless of the value of the parameter input.

Type 2 sensitivity: Variation of parameter causes a significant change in the model calibration but insignificant changes to model conclusions. Type II sensitivity is of no concern because the modelling conclusion will remain the same regardless of the value of the parameter input.

Type 3 sensitivity: Variation of parameter causes a significant change in both the model calibration and conclusions. Type III sensitivity is of no concern because, although the modelling conclusions change as a result of varying the parameter input, the parameter values result in the model being uncalibrated.

Type 4 sensitivity: Variation of a parameter causes a significant change in the model conclusions but produces an insignificant change to the calibration. Type IV sensitivity can invalidate model results as the modelling conclusions can change despite the model being considered to be calibrated.

The Relative Per cent Difference (RPD) of groundwater discharge rates between the base case simulation and subsequent simulations was calculated to quantify the model's sensitivity to various parameters. The RPDs were then used to determine the sensitivity grade of the model to each parameter. Table 5 presents the RPD ranges and their interpreted sensitivity type.

Table 5: Sensitivity Type and Interpretation

Relative Per Cent Difference of Flow Rate	Interpretation
RPD < 10%	Not sensitive
10% < RPD < 25%	Low sensitivity
25% < RPD < 50%	Moderate sensitivity
50% < RPD < 100%	High sensitivity
RPD > 100%	Very high sensitivity

3.8.2 Parameter Changes

The following parameter changes were applied during the sensitivity analysis:

3.8.2.1 Hydraulic Conductivity

The hydraulic conductivity (K) was changed globally (increased and decreased by a factor of two) and specifically for the Sherwin Ironstone Formation (increased and decreased by a factor of ten). Both the horizontal and vertical K values were changed as part of the sensitivity analysis.

3.8.2.2 Recharge

Recharge rates were doubled and halved throughout the model domain.

3.8.2.3 Evapo-transpiration (ET) Extinction Depth

The extinction depth of ET was increased to 15 m and decreased to 2 m.

3.8.2.4 Storage

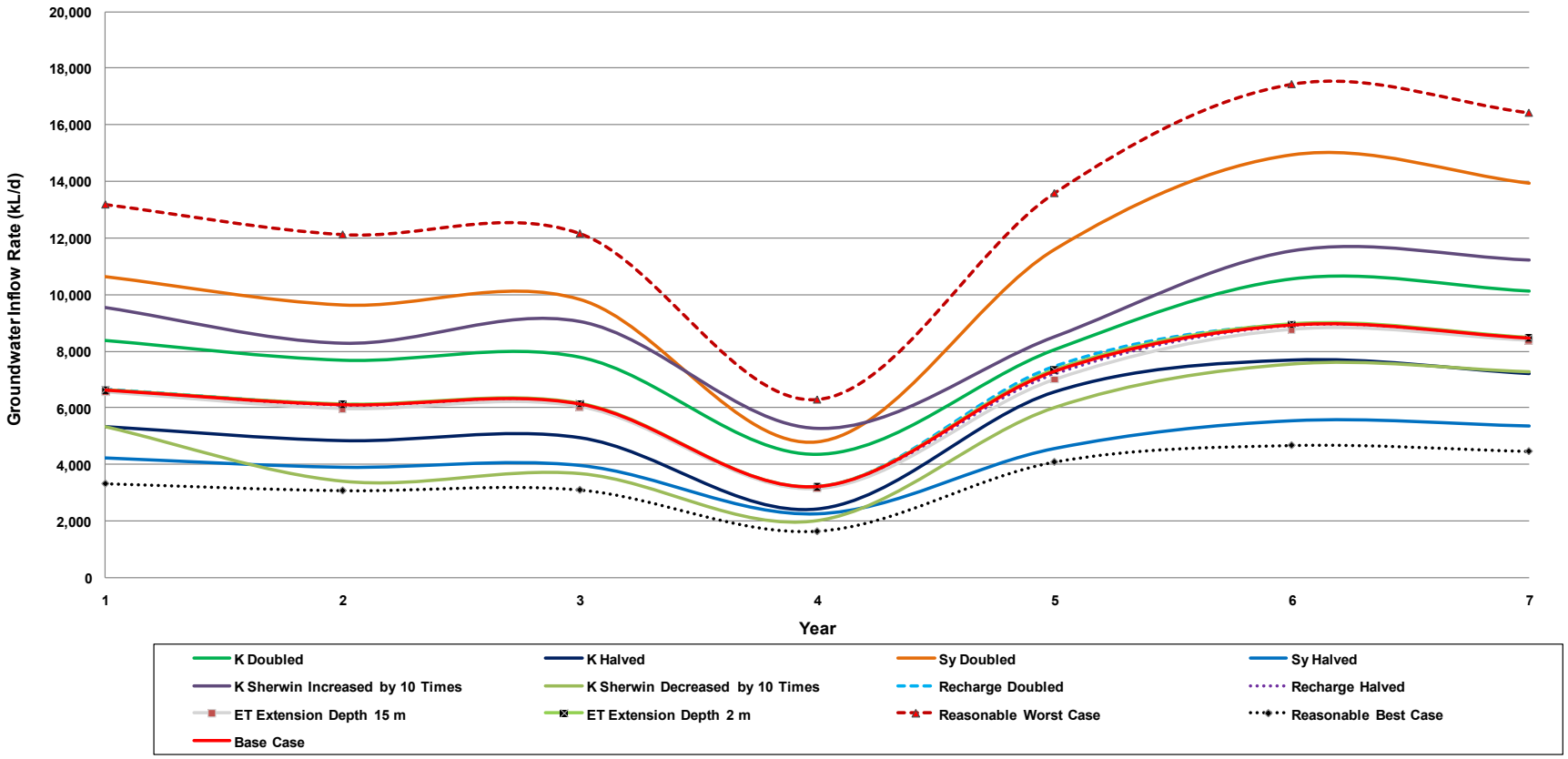
Specific yield was doubled and halved for all formations.

3.8.2.5 Boundaries

As the model boundaries were located sufficiently far from the mine site, these were not changed during the sensitivity analysis.

3.8.3 Sensitivity Analysis Results

Graph 6 shows the predicted groundwater inflow by changing various parameters as part of the sensitivity analysis. Graph 7 shows the impact of parameter changes on pre-mining model calibration. The predicted drawdown contours are presented in Appendix 2. The model predicted sensitivity analysis of flow as part of the sensitivity analysis is presented in Table 6.



Graph 6: Sensitivity Analysis of Predicted Total Groundwater Inflow Rate

Table 6: Sensitivity Analysis of Predicted Pit Inflow Rate and Drawdown

Sensitivity Case	Year	Model Predicted Groundwater Inflow Rate (kL/d)			Extent of Drawdown from the Pit(km)		% Change from the Base Case	
		Zone 2 (F East)	Zone 3 (E East and E South)	Total for Zone 2 and 3 (F East, E East and E South)	5 m contour	1 m contour	Total Flow Rate	5 m Drawdown Contour
Base Case	1	6,614	4	6,618			N/A	
	2	5,616	482	6,098			N/A	
	3	5,551	575	6,125			N/A	
	4	2,549	650	3,199			N/A	
	5	2,110	5,172	7,282			N/A	
	6	1,857	7,063	8,921			N/A	
	7	1,685	6,773	8,458	0.9	1.2	N/A	N/A
K Doubled for all formations	1	8,381	6	8,387			27	
	2	7,042	649	7,691			26	
	3	7,011	787	7,798			27	
	4	3,469	905	4,374			37	
	5	2,886	5,176	8,062			11	
	6	2,541	8,015	10,557			18	
	7	2,320	7,808	10,129	1.2	1.5	20	33
K Halved for all formations	1	5,332	3	5,335			-19	
	2	4,473	369	4,841			-21	
	3	4,509	437	4,946			-19	
	4	1,944	486	2,430			-24	
	5	1,555	5,004	6,560			-10	
	6	1,359	6,323	7,683			-14	
	7	1,230	5,976	7,206	0.6	0.9	-15	-33
Sy Doubled for all formations	1	10,628	5	10,633			61	
	2	8,898	733	9,630			58	
	3	8,959	869	9,828			60	
	4	3,822	967	4,789			50	
	5	3,039	8,552	11,591			59	
	6	2,640	12,298	14,939			67	
	7	2,375	11,562	13,937	0.6	0.9	65	-33
Sy Halved for all formations	1	4,216	3	4,219			-36	
	2	3,566	326	3,892			-36	
	3	3,560	397	3,957			-35	
	4	1,796	457	2,253			-30	
	5	1,513	3,038	4,550			-38	

Sensitivity Case	Year	Model Predicted Groundwater Inflow Rate (kL/d)			Extent of Drawdown from the Pit(km)		% Change from the Base Case	
		Zone 2 (F East)	Zone 3 (E East and E South)	Total for Zone 2 and 3 (F East, E East and E South)	5 m contour	1 m contour	Total Flow Rate	5 m Drawdown Contour
	6	1,346	4,182	5,528			-38	
	7	1,239	4,104	5,344	1.2	1.5	-37	33
K Increased by 10 times for Sherwin	1	9,526	23	9,549			44	
	2	7,376	909	8,284			36	
	3	7,969	1,085	9,054			48	
	4	4,011	1,256	5,267			65	
	5	3,441	5,073	8,514			17	
	6	3,088	8,467	11,556			30	
	7	2,835	8,396	11,232	2	2.5	33	122
K Decreased by 10 times for Sherwin	1	5,347	1	5,349			-19	
	2	3,170	251	3,422			-44	
	3	3,388	302	3,690			-40	
	4	1,680	347	2,028			-37	
	5	1,458	4,564	6,022			-17	
	6	1,325	6,235	7,559			-15	
	7	1,234	6,053	7,287	0.5	1	-14	-44
Recharge Rate Doubled Everywhere	1	6,658	4	6,662			1	
	2	5,642	487	6,128			0	
	3	5,566	576	6,142			0	
	4	2,559	651	3,210			0	
	5	2,118	5,351	7,469			3	
	6	1,864	7,093	8,957			0	
	7	1,690	6,788	8,478	0.9	1.2	0	0
Recharge Rate Halved Everywhere	1	6,592	4	6,595			0	
	2	5,603	480	6,083			0	
	3	5,543	574	6,117			0	
	4	2,544	649	3,194			0	
	5	2,107	5,079	7,186			-1	
	6	1,854	7,048	8,902			0	
	7	1,682	6,765	8,447	0.9	1.2	0	0
ET Extinction Depth made 15 m	1	6,557	3	6,560			-1	
	2	5,523	446	5,969			-2	
	3	5,479	560	6,039			-1	

Sensitivity Case	Year	Model Predicted Groundwater Inflow Rate (kL/d)			Extent of Drawdown from the Pit(km)		% Change from the Base Case	
		Zone 2 (F East)	Zone 3 (E East and E South)	Total for Zone 2 and 3 (F East, E East and E South)	5 m contour	1 m contour	Total Flow Rate	5 m Drawdown Contour
	4	2,497	639	3,136			-2	
	5	2,067	4,929	6,996			-4	
	6	1,820	6,952	8,772			-2	
	7	1,652	6,732	8,384	0.9	1.2	-1	0
ET Extinction Depth made 2 m	1	6,625	4	6,628			0	
	2	5,637	487	6,124			0	
	3	5,571	577	6,149			0	
	4	2,564	652	3,216			1	
	5	2,122	5,212	7,335			1	
	6	1,867	7,085	8,952			0	
	7	1,693	6,779	8,472	0.9	1.2	0	0
Reasonable Worst Case	1	13,181	7	13,189			99	
K Doubled and Sy Doubled	2	11,168	960	12,128			99	
	3	11,020	1,144	12,164			99	
	4	5,011	1,294	6,305			97	
	5	4,122	9,469	13,591			87	
	6	3,605	13,828	17,433			95	
	7	3,251	13,175	16,426	0.9	1.2	94	0
Reasonable Best Case	1	3,327	2	3,329			-50	
K Halved and Sy Halved	2	2,840	244	3,084			-49	
	3	2,817	290	3,107			-49	
	4	1,319	328	1,648			-48	
	5	1,106	2,987	4,093			-44	
	6	985	3,696	4,681			-48	
	7	903	3,568	4,471	0.9	1.2	-47	0

As shown in Graph 6 and Table 6, the model predicted inflow rates to the proposed mine pits are most sensitive to the change in specific yield value. The model predicted flow rate increases by a maximum of 67% compared to the base case when the specific yield value is doubled. However, the extent of the drawdown contours reduces by 33% (5 m drawdown contours reduce to about 0.6 km from the base case value of about 0.9 km) over the seven year period. A reduction in specific yield value reduces the groundwater inflow rate, but increases the extent of drawdown. Decreasing the specific yield value by a factor

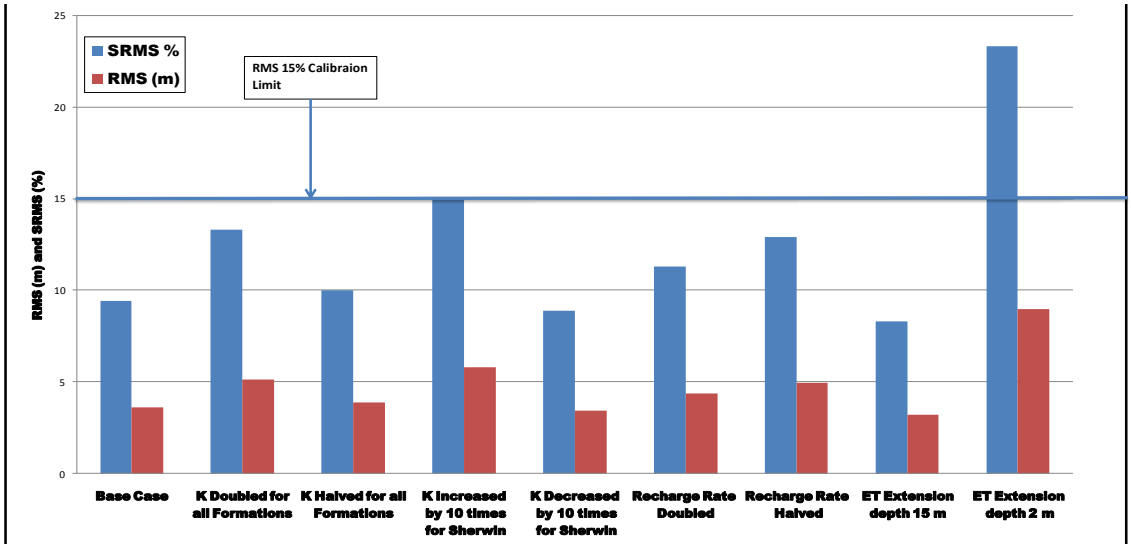
of two decreases the predicted flow rate by up to 38% but the extent of the 5 m drawdown contour increases to about 1.2 km.
An increase in the K value by a factor of two increases the predicted flow rate to the proposed mine pits by up to 37%. Also the extent of the 5 m drawdown contour increases to about 1.2 km from the base case value of 0.9 km. As expected, the decrease in K value by a factor of two decreases the predicted mine inflow rate by up to 24%. Similarly, the extent of 5 m drawdown reduces to about 0.6 km which is a decline of up to 33% from the bases case value of 0.9 km.

A ten-fold increase and decrease in the K values of the Sherwin Ironstone Formation predicted the groundwater inflow to the pit to increase and decrease by up to 65% and 44% respectively. Although, the decrease in the K value of the Sherwin Ironstone Formation by a factor of 10 did not change the extent of the predicted drawdown value substantially, the increase in the K value by a factor of 10 increased the extent of the 5 m drawdown contour to 2 km. This is the largest extent of drawdown out of all the sensitivity analysis runs undertaken.

The model predicted groundwater inflow rate and the extent of drawdown did not change while increasing and decreasing the recharge value by a factor of two. Hence, this parameter is not sensitive to the model outcome. This is due to the very low recharge values and the low K material inhibiting inflow of recharge water into the pit. This also indicates minimal change in seasonal groundwater inflow.

Similarly, increasing and decreasing the ET extinction depth to 15 m and 2 m did not change the pit inflow or drawdown rate significantly. There was a reduction of pit inflow by up to 4% when the ET extinction depth was increased to 15 m and there was an increase in pit inflow by only about 1% when the ET extinction depth was made 2 m. Hence, this parameter is not sensitive to the model outcome, provided the ET rate remains the constant.

The parameter sensitivity (in relation to the RMS Error) and sensitivity ranking are presented in Tables 7 and 8 respectively.



Graph 7: Parameters Sensitivity in relation to Scaled Root Mean Square Error % (or SRMS %)

Table 7: Root Mean Square Error and Scaled RMS for Sensitivity Analysis Runs

Run No	Case	RMS Error (m)	Scaled RMS %
WDR38	Base Case	3.62	9.4
WDR60	K Doubled for all Formations	5.13	13.3
WDR61	K Halved for all Formations	3.86	10
WDR62	K Increased by 10 times for Sherwin	5.79	15
WDR63	K Decreased by 10 times for Sherwin	3.44	8.9
WDR64	Recharge Rate Doubled	4.37	11.3
WDR65	Recharge Rate Halved	4.97	12.9
WDR66	ET Extension Depth 15 m	3.19	8.3
WDR67	ET Extension Depth 2 m	8.99	23.3

Table 8: Sensitivity Ranking, Classification and Type

Case	Overall Sensitivity Ranking	Sensitivity Classification	Overall Sensitivity Type
Base Case	N/A	N/A	N/A
Specific Yield	1	Highly Sensitive	N/A
Hydraulic Conductivity	2	Moderately Sensitive	Type 4
ET Extension Depth	3	Not Sensitive	Type 1 and 2
Recharge Rate	4	Not Sensitive	Type 1

The sensitivity analysis indicates that the model is insensitive (Type 1 Sensitivity) to the recharge rate and increase in ET extinction depth. This Type 1 sensitivity is of no concern because the modelling conclusion is the same with variations in these parameter inputs. Type 2 sensitivity was applicable for the decrease in ET

extinction depth. This is also of no concern because the model predicted inflow rate and drawdown value did not change with the change in this parameter.

An increase and decrease of K values produced Type 4 sensitivity. This requires more attention as model uncertainty in modelling is high with Type 4 sensitivity. Although the Type 4 sensitivity is evident, the model results are considered defensible. This is because the parameters used in the prediction are higher than the aquifer test results especially when increasing the Sherwin Ironstone Formation by a factor of 10 (the upper value of tested K was 0.05 m/d, VDM 2011). The highest K value of 0.2 m/d used for the Sherwin Ironstone Formation increased the 5 m drawdown contours to 2 km and the inflow rate increased 65%.

Sensitivity type, as part of the sensitivity analysis, is not applicable for the specific yield value because the model was calibrated in steady state. However, the pit inflow rates are highly sensitivity to changes in this value.

3.8.4 Uncertainty Analysis

3.8.4.1 Uncertainty Analysis Method

A level of uncertainty exists with all environmental data collection and modelling. An uncertainty analysis was performed by running a suite of simulations using a combination of parameters to determine the effect these have on the predicted outcomes.

The uncertainty analysis was undertaken in conjunction with the sensitivity analysis to quantify the possible total errors associated with the model predictions. The uncertainty analysis involved the comparison of flow rates predicted using the following generic simulations:

Simulation 1: The applied model which incorporates conservative parameters which are considered to reflect the “worst reasonable case”

Simulation 2: Using a combination of all the least conservative “best reasonable case” parameters.

The “worst and best reasonable cases” scenarios are within the calibrated range (i.e. <15% SRMS). A “worst reasonable case” scenario is considered to refer to parameter values that would typically result in a high flow rate (such as high K values), while a “best reasonable case” scenario is considered to refer to parameter values that would result in a low flow rate (such as low K values).

For this uncertainty analysis, the most sensitive model parameters were incorporated such that the “worst reasonable casse” consisted of doubling the K

and Sy values, while the "best reasonable case" included halving the K and Sy values.
To quantify the model uncertainty, the relative groundwater flow rate was determined between:

- simulation 1 and base case
- simulation 2 and base case.

3.8.4.2 Uncertainty Analysis Results

The relative percentage difference (RPD) of flow rates for the worst reasonable case increased by ~100% (doubled) compared to the base case. The RPD of flow rates for the best reasonable case decreased by ~50% (halved) compared to the base case.

Doubling and halving the K and Sy values did not extend increase the drawdown extent significantly because they "cancel each other out" in relation to drawdown extent. Hence, for drawdown extent, increasing the K value of the Sherwin Ironstone by 10 times (which was part of the sensitivity analysis) can be considered as the worst reasonable case for drawdown. The extent of drawdown increased by 122% for the case of increasing the Sherwin Ironstone K value ten-fold.
Even for this reasonable worst case, the extent of the 5 m drawdown contours is not predicted to extend beyond 2 km from the edge of the pit, hence the impact can be considered localised. In terms of flow rate, while doubling the K and specific yield values can increase the flow rate by up to 100%, most of the increase is due to the removal of water from storage, hence the impact on pit dewatering can be considered minimal after the aquifer storage of the mined rock is depleted.

3.9 Groundwater Flow Modelling Conclusions

Groundwater flow modelling was undertaken on the Western Desert Resources (Roper Bar Mine Site) to predict groundwater flow to the proposed pits, to predict the drawdown extent, as well as to assess the impact on surface water courses.

The model predicted maximum base case total pit flow rate was 8,900 kL/d in year six of the mining program. This rate includes water stored within the rock to be excavated as well as the water coming from the pit walls and floors.

For the F East mine pit, the predicted side inflow rate increases from 4,000 kL/d in year one, to about 4,500 kL/d in year three and then decreases to less than 2,000 kL/d in year seven. For the E East and E South mine pits, the predicted side inflow rate increases from about 1,500 kL/d in year five to about 3,000 kL/d in year seven.

The extent of the 5 m and 1 m drawdown contours are likely to be within 0.9 km and 1.2 km from the edge of the pit respectively. The localised impact is due to the fact that the K of the material near the mine site is low.

The impact on surface watercourses from dewatering is also considered to be minimal, as the regional water table is expected to be below the riverbed levels. The impact related to the diversion of the river has not been assessed in this groundwater modelling study.

It is recommended that monthly monitoring of groundwater levels be conducted and the groundwater flow model is periodically updated, based on the results of the ongoing monitoring. Further modelling work on predicting post-mining water levels, pit water quality and possible migration of the contamination off site is also recommended.

4.0 REFERENCES

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APPENDIX 1

Bore Logs (Source VDM)

VDM CONSULTING
EcOz
Third Floor, Winlow House
75 Woods St, Darwin
NT 0800
Tel No: (08) 8981-1100
Fax No: (08) 8981-1102

Date: 29/30 OCTOBER 2011

BORE ID: **RBGW01**

Project: ROPER BAR	Drilled By: TREVOR HUGHES DRILLING	Groundwater level (GL):	9.43 mbGL
Reference:	Method: ROTARY AIR	Elevation (TOC):	25.01 mAHD
Client: WDRL	Logged By: PAUL LIVSEY	Elevation (GL):	24.30 mAHD
Northing: 8325252	Easting: 508851	Elevation (Groundwater level from TOC):	14.87 mAHD
Datum: WGS84	Projection: UTM Zone: 53L		

Depth mbgl	Depth RL (m)	Well Construction	Water / MC	Depth (m)	Lithological Description	Remarks and Observations
0.0	24.30					
1.0	23.30			0 - 1m	Red laterised clayey top soil.	
2.0	22.30			1 - 3m	Light brown sandy clay.	
3.0	21.30					
4.0	20.30			3 - 4m	Red laterised clayey sand.	
5.0	19.30			4 - 6m	Brownish red to light grey clay overlying dark grey to black shale/mudstone.	
6.0	18.30					
7.0	17.30			6 - 9m	Dark grey siltstone interbedded with grey to orange brown clay.	
8.0	16.30					
9.0	15.30		<5%			Highly weathered siltstone are dominant.
10.0	14.30	▼		9 - 12m	Dark grey to grey siltstone.	
11.0	13.30				Reddish grey sandstone interbedded with brown to grey siltstone.	
12.0	12.30					
13.0	11.30			12 - 13m	Dark grey siltstone.	
14.0	10.30			13 - 15m	Dark grey siltstone with fine beds of brown siltstone.	
15.0	9.30					
16.0	8.30			15 - 16m	Dark grey siltstone.	
17.0	7.30			16 - 17m	Dark reddish grey siltstone.	
18.0	6.30					
19.0	5.30					
20.0	4.30					
21.0	3.30					
22.0	2.30		<5%			
23.0	1.30					
24.0	0.30					
25.0	-0.70					
26.0	-1.70					
27.0	-2.70		5-10%			
28.0	-3.70		10%			
29.0	-4.70					
30.0	-5.70		10-15%			
31.0	-6.70		15%			
32.0	-7.70		15-20%			
33.0	-8.70		20%			
34.0	-9.70	▽				Airlift yield: approx. <0.05 L/s.
35.0	-10.70					
36.0	-11.70					
37.0	-12.70					
38.0	-13.70					
39.0	-14.70		>30%			
40.0	-15.70					Some disseminated sulphide (pyrite?) observed. Sulphur odour felt.
41.0	-16.70					

42.0	-17.70			
43.0	-18.70		17 - 69m	Dark grey fine grain sandstone interbedded with fine layers of very dark grey siltstone.
44.0	-19.70			
45.0	-20.70			Driller using water & foam, can't estimate MC
46.0	-21.70			
47.0	-22.70			
48.0	-23.70			
49.0	-24.70			
50.0	-25.70			
51.0	-26.70			
52.0	-27.70			
53.0	-28.70			
54.0	-29.70			
55.0	-30.70			
56.0	-31.70			
57.0	-32.70			
58.0	-33.70			
59.0	-34.70			
60.0	-35.70			
61.0	-36.70			
62.0	-37.70	Saturated		
63.0	-38.70			Airlift yield: approx. <0.1 L/s
64.0	-39.70			
65.0	-40.70			
66.0	-41.70			
67.0	-42.70			
68.0	-43.70			
69.0	-44.70			
70.0	-45.70		69 - 70m	Dark grey siltstone interbedded with grey medium to coarse grain sandstone. Airlift yield: approx. <0.5 L/s
71.0	-46.70			
72.0	-47.70			
73.0	-48.70			
74.0	-49.70			
75.0	-50.70		70 - 79m	Dark grey fine grain sandstone interbedded with fine layers of very dark grey siltstone.
76.0	-51.70			
77.0	-52.70			
78.0	-53.70			
79.0	-54.70			

Bottom of borehole: 79m

LEGEND: W/L: Water logged

Finishing: Lockable Steel Riser

Notes: Airlift yield: approx. <0.5 L/s.
TOC (Height from NGL): 0.708m

Well Casing:
- Solid Class 12x150 PVC Casing
- Well Screen
- Groundwater strike
- Groundwater level

Well Construction:
- Cement grout and steel casing
- Bentonite
- Gravel

VDM CONSULTING
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Fax No: (08) 8981-1102

Date: 28 OCTOBER 2011

BORE ID:

RBGW02

Project: ROPER BAR	Drilled By: TREVOR HUGHES DRILLING	Groundwater level (GL):	12.30 mbGL
Reference:	Method: ROTARY AIR	Elevation (TOC):	23.80 mAHD
Client: WDRL	Logged By: PAUL LIVSEY	Elevation (GL):	23.10 mAHD
Northing: 8325804	Easting: 510617	Elevation (Groundwater level from TOC):	10.80 mAHD
Datum: WGS84	Projection: UTM Zone: 53L		

Depth mbgl	RL (m)	Well Construction	Water / MC	Depth (m)	Lithological Description	Remarks and Observations
0.0	23.10					
1.0	22.10		10%			
2.0	21.10			1 - 4m		
3.0	20.10					
4.0	19.10					
5.0	18.10			4 - 5m		
6.0	17.10			5 - 6m	Orange-ish brown to light grey laterite.	Degree of weathering increasing from moderate to extremely weathered.
7.0	16.10		<5%			
8.0	15.10					
9.0	14.10			6 - 12m		
10.0	13.10					
11.0	12.10					
12.0	11.10	▼				
13.0	10.10					
14.0	9.10		<5%	12 - 16m		
15.0	8.10					
16.0	7.10					
17.0	6.10			16 - 17m		
18.0	5.10			17 - 18m		
19.0	4.10			18 - 19m		
20.0	3.10		<5%	19 - 20m	Brownish red to grey, laterised siltstone.	Minor finely layered sand lenses content.
21.0	2.10			20 - 21m		
22.0	1.10			21 - 22m		
23.0	0.10			22 - 23m		
24.0	-0.90					
25.0	-1.90					
26.0	-2.90		<5%	23 - 28m		
27.0	-3.90					
28.0	-4.90					
29.0	-5.90					
30.0	-6.90		<5%	28 - 32m	Light grey clayey material, interbedded with dark grey siltstone.	
31.0	-7.90					
32.0	-8.90					

33.0	-9.90	▽	5-10%	32 - 33m	Dark grey, fine grained sandstone.	
34.0	-10.90		>30%	33 - 35m	Dark grey siltstone.	
35.0	-11.90					
36.0	-12.90			35 - 40m	Dark grey siltstone finely interbedded with grey sandstone.	
37.0	-13.90					
38.0	-14.90					
39.0	-15.90					
40.0	-16.90					
41.0	-17.90			40 - 42m	Dark grey siltstone.	
42.0	-18.90					
43.0	-19.90			42 - 43m	Brownish dark grey siltstone.	
44.0	-20.90			43 - 44m	Very dark grey siltstone.	Siltstone dominant with lenses of sandstones.
45.0	-21.90			44 - 55m	Dark grey sandy siltstone.	
46.0	-22.90					
47.0	-23.90					
48.0	-24.90					
49.0	-25.90					
50.0	-26.90					
51.0	-27.90					
52.0	-28.90					
53.0	-29.90					
54.0	-30.90					
55.0	-31.90					
56.0	-32.90			55 - 57m	Dark grey silty mudstone.	
57.0	-33.90					
58.0	-34.90			57 - 59m	Dark grey siltstone.	
59.0	-35.90					
60.0	-36.90			59 - 60m	Dark grey silty mudstone.	Some pyrite observed.
61.0	-37.90			60 - 63m	Dark grey siltstone.	
62.0	-38.90					
63.0	-39.90					
64.0	-40.90			63 - 70m	Very dark grey mudstone.	
65.0	-41.90					
66.0	-42.90					
67.0	-43.90					
68.0	-44.90					
69.0	-45.90					
70.0	-46.90					

ed by above water strike and drilling methodology

71.0	-47.90	Moist influenc	70 - 72m	Very dark grey mudstone interbedded with grey sandstone.	Some finely layered, slightly to weathered mudstones.
72.0	-48.90		72 - 73m	Dark grey mudstone thinly interbedded with grey fine grained sandstone.	
73.0	-49.90		73 - 74m	Dark grey to grey siltstone interbedded with sandstone.	
74.0	-50.90		74 - 82m	Dark grey mudstone thinly interbedded with grey fine grained sandstone.	
75.0	-51.90				
76.0	-52.90				
77.0	-53.90				
78.0	-54.90				
79.0	-55.90				
80.0	-56.90				
81.0	-57.90				
82.0	-58.90				
83.0	-59.90		82 - 102m	Dark grey siltstone.	
84.0	-60.90				
85.0	-61.90				
86.0	-62.90				Some pyrite observed.
87.0	-63.90				
88.0	-64.90				
89.0	-65.90				
90.0	-66.90				
91.0	-67.90				
92.0	-68.90				
93.0	-69.90				
94.0	-70.90				
95.0	-71.90				Lenses of fine grained sandstone.
96.0	-72.90				
97.0	-73.90				
98.0	-74.90				
99.0	-75.90				
100.0	-76.90				
101.0	-77.90				
102.0	-78.90				

Bottom of borehole: 86.9m

LEGEND: W/L: Water logged

Finishing: Lockable Steel Riser

Notes: Very low flow: approx. <0.01 L/s.
TOC (Height from NGL): 0.696m

Well Casing:
- Solid Class 12x150 PVC Casing
- Well Screen
- Groundwater strike
- Groundwater level

Well Construction:
- Cement grout and steel casing
- Bentonite
- Gravel

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Fax No: (08) 8981-1102

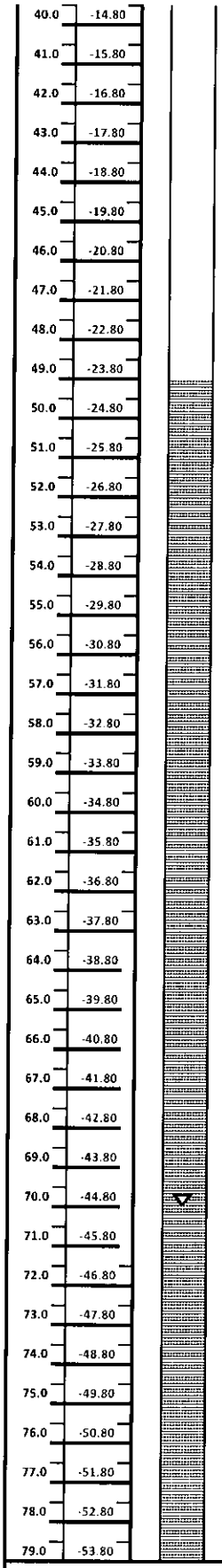
Date: 26/27 OCTOBER 2011

BORE ID:

RBGW03

Project: ROPER BAR	Drilled By: TREVOR HUGHES DRILLING	Groundwater level (GL):	15.49 mbGL
Reference:	Method: ROTARY AIR	Elevation (TOC):	25.90 mAHD
Client: WDRL	Logged By: PAUL LIVSEY	Elevation (GL):	25.20 mAHD
Northing: 8324801	Easting: 513995	Elevation (Groundwater level from TOC):	9.71 mAHD
Datum: WGS84	Projection: UTM Zone: 53L		

Depth mbgl	RL (m)	Water / MC	Depth (m)	Lithological Description	Remarks and Observations
0.0	25.20				
1.0	24.20	<5%	0 - 1m	Pale brownish grey lateritic soils.	Minor clay content.
2.0	23.20	<5%	1 - 2m	Brown to reddish grey lateritic soils.	
3.0	22.20	<5%	2 - 13m	Brown gravelly laterised silty clay	Increased reddish brown colour.
4.0	21.20				
5.0	20.20			Reddish to grey fine laterised silty clay.	
6.0	19.20				
7.0	18.20				
8.0	17.20				
9.0	16.20				
10.0	15.20				
11.0	14.20				
12.0	13.20				
13.0	12.20	<5%	13 - 23m	Dark grey to black laminated sandstone with minor siltstone.	
14.0	11.20				
15.0	10.20				
16.0	9.20				
17.0	8.20				
18.0	7.20				
19.0	6.20				
20.0	5.20				
21.0	4.20				
22.0	3.20				
23.0	2.20	<5%	23 - 30m	Dark grey to black mudstone/shales interbedded with dark grey siltstone	Band os hard, grey sandstone can be frequently found.
24.0	1.20				
25.0	0.20				
26.0	-0.80				
27.0	-1.80				
28.0	-2.80				
29.0	-3.80				
30.0	-4.80				
31.0	-5.80	<5%	30 - 34m		
32.0	-6.80				
33.0	-7.80				
34.0	-8.80				
35.0	-9.80		34 - 36m	Dark grey to black siltstone interbedded with minor dark grey mudstone	
36.0	-10.80				
37.0	-11.80		36 - 38m		
38.0	-12.80				
39.0	-13.80		38 - 39m		



<5%	39 - 53m	Dark grey mudstone/shale interbedded with very dark grey to black minor siltstone.	Disseminated sulphide (Pyrite?).
			Disseminated sulphide (Pyrite?).
	53 - 56m	Grey sandstone, hard.	
		Grey to dark grey fine grain sandstone interbedded with siltstone.	
	56 - 60m	Dark grey siltstone interbedded with black mudstone.	Disseminated sulphides (Pyrite?).
	60 - 72m	Dark grey to grey siltstone interbedded with mudstone/shale and minor sandstone.	Siltstone and mudstone are finely layered and frequently interbedded.
			Airlift yield: approx. <0.1L/s
>30%	72 - 73m		
	73 - 79.0m	Dark grey sandstone interbedded with siltstone.	Some pale red to grey sandstone. Siltstone and mudstone are finely layered and frequently interbedded.

Bottom of borehole: 79.0m

LEGEND: W/L: Water logged

Finishing: Lockable Steel Riser

Notes: Airlift yield: approx. <0.1L/s.
TOC (Height from NGL): 0.696m

Well Casing:
- Solid Class 12x150 PVC Casing
- Well Screen
- Groundwater strike
- Groundwater level

Well Construction:
- Cement grout and steel casing
- Bentonite
- Gravel

VDM CONSULTING
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75 Woods St, Darwin
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Tel No: (08) 8981-1100
Fax No: (08) 8981-1102

Date: 24/25 OCTOBER 2011

BORE ID:

RBGW04

Project: ROPER BAR	Drilled By: TREVOR HUGHES DRILLING	Groundwater level (GL):	18.51 mbGL
Reference:	Method: ROTARY AIR	Elevation (TOC):	53.25 mAHD
Client: WDRL	Logged By: PAUL LIVSEY	Elevation (GL):	52.5 mAHD
Northing: 8322687	Easting: 513832	Elevation (Groundwater level from TOC):	33.99 mAHD
Datum: WGS84	Projection: UTM Zone: 53L		

Depth mbgl	RL (m)	Water / MC	Depth (m)	Lithological Description	Remarks and Observations
0.0	52.50				
1.0	51.50				
2.0	50.50				
3.0	49.50				
4.0	48.50	<5%	0 - 7m		
5.0	47.50				
6.0	46.50			Brown to pale orangey lateritic soils.	Clay rich zone with abundant white/grey magnesite particulates. From 6 to 9.0m deep there is a band of haematitic ironstone.
7.0	45.50				
8.0	44.50				
9.0	43.50				
10.0	42.50		7 - 12m		
11.0	41.50				
12.0	40.50				
13.0	39.50		12 - 14m	Pale grey to whitish quartzite sandstone.	
14.0	38.50				
15.0	37.50				
16.0	36.50		14 - 17m		
17.0	35.50				
18.0	34.50	>30%		Reddish pale grey to grey quartzite sandstone interbedded with reddish brown siltstones.	
19.0	33.50		17 - 21m		
20.0	32.50				
21.0	31.50				
22.0	30.50				Finely grained siltstone layers are abundant. Some finely layered iron ore bands are frequent with depth.
23.0	29.50		21 - 25m		
24.0	28.50				
25.0	27.50				
26.0	26.50			Light grey fine grained quartzite sandstone with fine red iron ore veins.	
27.0	25.50				
28.0	24.50		25 - 30m		
29.0	23.50				
30.0	22.50	Water seemed to be in this zone			
31.0	21.50		30 - 31m	Grey sandstone, coarse grained.	
32.0	20.50		31 - 33m	grey fine grain sandstone interbedded with siltstone.	
33.0	19.50				
34.0	18.50				
35.0	17.50				
36.0	16.50				

33 - 40m	Dark grey to grey siltstone, some light grey sandstone from 33 - 34m.	Sandstones are finely layered. Clay bands can be observed among some fractured sections.	
40 - 41m	Grey fine grain sandstone interbedded with red medium grain sandstone.		
41 - 43m	Pale pinkish grey sandstone, fine to medium grey.		
43 - 44m	Very pale pinkish grey, fine grain sandstone. Some light yellowish orange material.		
44 - 45m	Pale pinkish grey fine grain sandstone overlying dark grey siltstone.	Airlift Yield approx. 0.2 L/s	
45 - 60m	Pale grey to white quartzite sandstone.	Bands of pale pinkish to grey fine banded siltstones.	Saturated
		Interbeds of reddish sandstones and ironstones.	
60 - 71.5m	Grey fine grained sandstone interbedded with dark grey siltstone.	Some pyrite observed within siltstone, but is most prevalent at siltstone/sandstone interface.	

37.0	15.50
38.0	14.50
39.0	13.50
40.0	12.50
41.0	11.50
42.0	10.50
43.0	9.50
44.0	8.50
45.0	7.50
46.0	6.50
47.0	5.50
48.0	4.50
49.0	3.50
50.0	2.50
51.0	1.50
52.0	0.50
53.0	-0.50
54.0	-1.50
55.0	-2.50
56.0	-3.50
57.0	-4.50
58.0	-5.50
59.0	-6.50
60.0	-7.50
61.0	-8.50
62.0	-9.50
63.0	-10.50
64.0	-11.50
65.0	-12.50
66.0	-13.50
67.0	-14.50
68.0	-15.50
69.0	-16.50
70.0	-17.50
71.0	-18.50

Bottom of borehole: 71.5m

LEGEND: W/L: Water logged

Finishing: Lockable Steel Riser

Notes: Airlift yield: approx. 0.3 L/s.
TOC (Height from NGL): 0.754m

Well Casing:
- Solid Class 12x150 PVC Casing
- Well Screen
- Groundwater strike
- Groundwater level

Well Construction:
- Cement grout and steel casing
- Bentonite
- Gravel

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Tel No: (08) 8981-1100
Fax No: (08) 8981-1102

Date: 22/23 OCTOBER 2011

BORE ID:

RBGW05

Project: ROPER BAR	**Drilled By:** TREVOR HUGHES DRILLING	**Groundwater level (GL):**	8.66 mbGL
Reference:	**Method:** ROTARY AIR	**Elevation (TOC):**	30.75 mAHD
Client: WDRL	**Logged By:** PAUL LIVSEY	**Elevation (GL):**	30.04 mAHD
Northing: 8323868	**Easting:** 512767	**Elevation (Groundwater level from TOC):**	21.38 mAHD
Datum: WGS84	**Projection:** UTM **Zone:** 53L		

Depth mbgl	RL (m)	Well Construction	Water / MC	Depth (m)	Lithological Description	Remarks and Observations
0.0						
1.0	29.04		<5%	0 - 3m	Red lateritic ironstone soil.	Finely grained, clayey.
2.0	28.04					
3.0	27.04		<5%		Pinkish red fine grained sandy laterites	
4.0	26.04			3 - 9m	Grey to pale grey, extremely weathered lateritic siltstone.	Some fine layers of extremely weathered sandstone can be found.
5.0	25.04					
6.0	24.04		<5%			
7.0	23.04					
8.0	22.04					
9.0	21.04	▼				
10.0	20.04			9 - 19m		Some fine greenish sandy layers with fine extremely weathered mudstones.
11.0	19.04					
12.0	18.04					
13.0	17.04		<5%		Dark grey to brownish, extremely weathered sandstone. Finely interlayered.	
14.0	16.04					
15.0	15.04					
16.0	14.04					
17.0	13.04					
18.0	12.04		<5%			Degree of weathering decreasing with depth.
19.0	11.04					
20.0	10.04		<5%	19 - 20m	Grey fine to medium grained siltstone, hard	
21.0	9.04					
22.0	8.04					
23.0	7.04					
24.0	6.04					
25.0	5.04					
26.0	4.04					
27.0	3.04					
28.0	2.04					

29.0	1.04				
30.0	0.04				
31.0	-0.96			20 - 42m	Grey fine to medium grained siltstone with minor mudstone/shales, hard. Top sequence contains fine layers hard siltstone to about 24.0 m deep and abundant greyish fine grain sandstone layers.
32.0	-1.96				
33.0	-2.96				
34.0	-3.96				
35.0	-4.96				
36.0	-5.96				
37.0	-6.96				
38.0	-7.96				
39.0	-8.96				
40.0	-9.96				Dark grey to blackish siltstones interbedded with mudstones/shales.
41.0	-10.96		<5%		
42.0	-11.96				
43.0	-12.96			42 - 56m	Grey to black mudstone/shales. Mudstone are predominant.
44.0	-13.96				
45.0	-14.96				
46.0	-15.96				
47.0	-16.96				
48.0	-17.96				
49.0	-18.96				
50.0	-19.96				
51.0	-20.96				
52.0	-21.96				
53.0	-22.96				
54.0	-23.96				
55.0	-24.96				
56.0	-25.96				
57.0	-26.96			56 - 60m	Black mudstone interbedded with dark grey siltstone and grey fine grained sandstone.
58.0	-27.96				
59.0	-28.96				
60.0	-29.96				
61.0	-30.96	▽		60 - 62m	Red ferruginous sandstone (silica ironstone?).
62.0	-31.96				

63.0	-32.96				
64.0	-33.96				
65.0	-34.96				
66.0	-35.96				
67.0	-36.96			62 - 71m	Black to dark grey mudstone/shales.
68.0	-37.96				
69.0	-38.96				
70.0	-39.96				
71.0	-40.96				
72.0	-41.96				
73.0	-42.96				
74.0	-43.96				
75.0	-44.96		>30%	71 - 82m	Red ferruginous sandstone (silica ironstone?).
76.0	-45.96				
77.0	-46.96				
78.0	-47.96				
79.0	-48.96				
80.0	-49.96				
81.0	-50.96				Red ferruginous sandstone (silica ironstone?) interbedded with siltstone.
82.0	-51.96				
83.0	-52.96			82 - 83m	Dark grey to black interbedded mudstone and siltstone.
84.0	-53.96			83 - 84m	Light yellowish grey sandstone interbedded with dark grey weathered siltstone/mudstones.
85.0	-54.96				
86.0	-55.96			84 - 87m	Dark grey to grey fine grain mudstones interbedded with siltstone.
87.0	-56.96				

Coarse, quartz-sandstone is dominant. Mudstone are interbedded with siltstones.

Dominant finely laeyerd and hard mudstone/shales

Bottom of borehole: 86.9m

LEGEND: W/L: Water logged

Finishing: Lockable Steel Riser

Notes: Very low flow: approx. <0.1 L/s.
TOC (Height from NGL): 0.707m

Well Casing:
- Solid Class 12x150 PVC Casing
- Well Screen
- Groundwater strike
- Groundwater level

Well Construction:
- Cement grout and steel casing
- Bentonite
- Gravel

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Date: 19/20 October 2011

BORE ID:

RBGW06

Project: WDRL	**Drilled By:** TREVOR HUGHES DRILLING	**Groundwater level (GL):**	8.57 mbGL
Reference:	**Method:** ROTARY AIR	**Elevation (TOC):**	56.62 mAHD
Client: WR	**Logged By:** Emma Murray	**Elevation (GL):**	55.8 mAHD
Northing: 8322996	**Easting:** 511029	**Elevation (Groundwater level from TOC):**	47.23 mAHD
Datum: WGS84	**Projection:** UTM **Zone:** S3L		

Depth mbgl	RL (m)	Water / MC	Depth (m)	Lithological Description	Remarks and Observations
0.0	55.80				
1.0	54.80		0 - 3m	Red-brown laterised siltstone	
2.0	53.80				
3.0	52.80				
4.0	51.80		3-4m	Pale brown extremely weathered siltstone	
5.0	50.80		4-6m	Yellow very weathered siltstone (limonite)	
6.0	49.80				
7.0	48.80		6-8m	Dark red-brown weathered siltstone	Weathering profile of medium grained siltstone - clay rich zone
8.0	47.80				
9.0	46.80		8-9m	Pale red weathered siltstone	
10.0	45.80	<5%	9-10m	Purple-red weathered siltstone	
11.0	44.80		10-11m	Pale red weathered siltstone	
12.0	43.80		11 - 14m	White to grey weathered siltstone	
13.0	42.80				
14.0	41.80				
15.0	40.80		14-15m	Brown weathered sandstone	
16.0	39.80		15-16m	White quartz sandstone	
17.0	38.80		16-19m	White to pale yellow quartz sandstone	Medium grained sandstone
18.0	37.80				
19.0	36.80				
20.0	35.80		19-23m	Orange-brown quartz sandstone	Medium grained sandstone, very moist, clay-rich
21.0	34.80				
22.0	33.80				
23.0	32.80				
24.0	31.80		23-26m	Quartzite sandstone - yellow-brown	
25.0	30.80				
26.0	29.80				
27.0	28.80		26-31m	Quartzite sandstone- pinkish with black flecks	
28.0	27.80				

29.0	26.80			26-31m	Quartzite sandstone, pinkish with black flecks	
30.0	25.80					
31.0	24.80					
32.0	23.80			31-39m	Grey quartz sandstone, very uniform, well, sorted	Fine to medium grained, saturated approx 0.3L/s water yield
33.0	22.80					
32.0	23.80					
33.0	22.80					
34.0	21.80					
35.0	20.80					
36.0	19.80					
37.0	18.80		>30%		Grey quartz sandstone, very uniform, sorted, interbedded with thin dark grey siltstone layers	
38.0	17.80					
39.0	16.80					
40.0	15.80			39-56.0m	Grey siltstone with some thin interbedded fine grained grey quartz sandstone	Saturated approx 0.3L/sec flow
41.0	14.80					
42.0	13.80					
43.0	12.80					
44.0	11.80					
45.0	10.80					
46.0	9.80					
47.0	8.80					
48.0	7.80					
49.0	6.80					
50.0	5.80					
51.0	4.80					
52.0	3.80					
53.0	2.80					
54.0	1.80					
55.0	0.80					
56.0	-0.20					

Bottom of borehole.

LEGEND: W/L: Water logged

Finishing: Lockable Steel Riser

Notes: Approximate water flow 0.3 L/s
TOC (Height from NGL): 0.822m

Well Casing:
- Solid Clas 12x150 PVC Casing
- Well Screen
- Groundwater strike
- Groundwater level

Well Construction:
- Cement grout and steel casing
- Bentonite
- Gravel

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Date: 10/11 October 2011

BORE ID:

RBGW07

Project: WDRL	Drilled By: TREVOR HUGHES DRILLING	Groundwater level (GL):	12.32 mbGL
Reference:	Method: ROTARY AIR	Elevation (TOC):	27.54 mAHD
Client: WR	Logged By: Emma Murray	Elevation (GL):	26.8 mAHD
Northing: 8323656	Easting: 509942	Elevation (Groundwater level from TOC):	14.48 mAHD
Datum: WGS84	Projection: UTM Zone: 53L		

Depth mbgl	RL (m)	Water / MC	Depth (m)	Lithological Description	Remarks and Observations
0.0	26.80				
1.0	25.80				
2.0	24.80		0 - 2m	Red-Brown laterised siltstone	
3.0	23.80				
4.0	22.80				
5.0	21.80				
6.0	20.80	<5%	2-10m	Pale grey to pinkish, extremely weathered siltstone with finely interbedded iron-sandstone	Finely grained with laminated finely grained ironstone.
7.0	19.80				
8.0	18.80				
9.0	17.80				
10.0	16.80				
11.0	15.80		10-11m	Quartz sandstone	
12.0	14.80	10%	11-12m	Mudstone with interbedded siltstone	
13.0	13.80				
14.0	12.80				
15.0	11.80	<5%	12-18m	Mudstone with interbedded Qtz sandstone	Slightly moist
16.0	10.80				
17.0	9.80				
18.0	8.80				
19.0	7.80	>15%	18-20m	Weathered mudstone with finely interbedded Qtz sandstone	Moist
20.0	6.80				
21.0	5.80				
22.0	4.80	<5%	20-24m	Mudstone	
23.0	3.80				
24.0	2.80				
25.0	1.80	10%	24-26m	Weathered Mudstone	
26.0	0.80				
27.0	-0.20				
28.0	-1.20	<5%	26-29m	Grey siltstone with some thin interbedded fine grained grey quartz sandstone	
29.0	-2.20				

30.0	-3.20	10%	29-31m	Weathered mudstone	Finely laminated and grained, slightly moist
31.0	-4.20				
32.0	-5.20				
33.0	-6.20				
32.0	-5.20				
33.0	-6.20	<5%	31-37m	Grey to dark grey, weathered mudstone	
34.0	-7.20				
35.0	-8.20				
36.0	-9.20				
37.0	-10.20				
38.0	-11.20	10%	37-39m	Weathered mudstone with finely interbedded Qtz sandstone	
39.0	-12.20				
40.0	-13.20				
41.0	-14.20	<5%	39-42m	Grey to pale grey, slightly weathered siltstone	Degrees of weathering decrease with depth.
42.0	-15.20				
43.0	-16.20	10%	42-44m	Grey Qtz sandstone	
44.0	-17.20				
45.0	-18.20				
46.0	-19.20				
47.0	-20.20				
48.0	-21.20				
49.0	-22.20	<5%	44-54m	Grey to dark grey, finely laminated mudstone	Degrees of weathering decrease with deep, slightly moist.
50.0	-23.20				
51.0	-24.20				
52.0	-25.20				
53.0	-26.20				
54.0	-27.20				
55.0	-28.20		54-56m		
56.0	-29.20				
57.0	-30.20		56-63m	Interbedded siltstones and mudstones and thin Qtz sandstone layers	Extremely weathered to weathered, finely layered, moist.
58.0	-31.20				
59.0	-32.20				
60.0	-33.20				
61.0	-34.20				
62.0	-35.20				
63.0	-36.20				

64.0	-37.20				
65.0	-38.20				
66.0	-39.20				
67.0	-40.20				
68.0	-41.20				
69.0	-42.20				
70.0	-43.20				
71.0	-44.20				
72.0	-45.20				
73.0	-46.20				
74.0	-47.20				
75.0	-48.20				
76.0	-49.20				
77.0	-50.20				
78.0	-51.20				
79.0	-52.20				
80.0	-53.20		>30%		
81.0	-54.20				
82.0	-55.20				
83.0	-56.20			63-102m	Grey to pale grey, slightly weathered siltstone	Massive with some fine layering of weathered mudstone layers.
84.0	-57.20				
85.0	-58.20				
86.0	-59.20				
87.0	-60.20				
88.0	-61.20				
89.0	-62.20				
90.0	-63.20				
91.0	-64.20				
92.0	-65.20				
93.0	-66.20				
94.0	-67.20				
95.0	-68.20				
96.0	-69.20				
97.0	-70.20				
98.0	-71.20				
99.0	-72.20				

100.0	-73.20			
101.0	-74.20			
102.0	-75.20			
103.0	-76.20			
104.0	-77.20		102-105m	Red haematitic iron ore body
105.0	-78.20			
106.0	-79.20		105-107m	
107.0	-80.20			
108.0	-81.20			
109.0	-82.20			
110.0	-83.20			Interbedding with sandstone and siltstones increases with depth.
111.0	-84.20			Red haematitic iron ore body interbedded with fine grained Qtz sandstone and siltstones.
112.0	-85.20		107-117m	
113.0	-86.20			
114.0	-87.20	Saturated		
115.0	-88.20			
116.0	-89.20			
117.0	-90.20			
118.0	-91.20			
119.0	-92.20			
120.0	-93.20		117-123m	Hard, whitish quartzite
121.0	-94.20			Very competent and massive rock mass.
122.0	-95.20			
123.0	-96.20			

Bottom of borehole.

LEGEND:

W/L: Water logged

Finishing: Lockable Steel Riser

Notes: Approximate water flow 0.15 L/s
TOC (Height from NGL): 0.736m

Well Casing:
- Solid Clas 12x150 PVC Casing
- Well Screen
- Groundwater strike
- Groundwater level

Well Construction:
- Cement grout and steel casing
- Bentonite
- Gravel

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Date: 21/22 OCTOBER 2011

BORE ID:

RBGW08

Project: ROPER BAR	**Drilled By:** TREVOR HUGHES DRILLING	**Groundwater level (GL):**	5.44 mbGL
Reference:	**Method:** ROTARY AIR	**Elevation (TOC):**	39.58 mAHD
Client: WDRL	**Logged By:** PAUL LIVSEY	**Elevation (GL):**	38.96 mAHD
Northing: 8321940	**Easting:** 509981	**Elevation (Groundwater level from TOC):**	33.52 mAHD
Datum: WGS84	**Projection:** UTM **Zone:** 53L		

Depth mbgl	RL (m)	Water / MC	Depth (m)	Lithological Description	Remarks and Observations
0.0	38.96				
1.0	37.96	<5%	0 - 2m	Red-Brown laterised iron-sandstone	
2.0	36.96				
3.0	35.96	<5%	3 - 5m	Brown to pale yellowish brown weathered laterised sandstone, fine to very fine grained.	Weathering profile of fine to medium grained sandstone increases with deep.
4.0	34.96				
5.0	33.96				
6.0	32.96	<5%	5 - 8m	Pale brown to light brown weathered laterised sandstone, fine grained. Some brown interbedded very fine grained siltstone.	
7.0	31.96				
8.0	30.96				
9.0	29.96		8-15m	Brown to yellowish brown sandstone with interbedded siltstone.	Clay rich zone, slightly moist
10.0	28.96				
11.0	27.96	5 - 10%			
12.0	26.96	<5%			
13.0	25.96				
14.0	24.96				
15.0	23.96				
16.0	22.96	5 - 10%	15 - 17m	White quartz sandstone. Some very fine pale yellow laminate at 16-17m.	
17.0	21.96	10%			
18.0	20.96		17 - 25m	Weathered yellowish brown to grey, quartzite sandstone with some fine red ferruginous layers present within the grey sandstone.	
19.0	19.96				
20.0	18.96				
21.0	17.96				
22.0	16.96				
23.0	15.96				
24.0	14.96				
25.0	13.96				
26.0	12.96			Light grey, poorly sorted sandstone interbedded with grey siltstone.	
27.0	11.96				
28.0	10.96				

29.0	9.96				
30.0	8.96			25 - 35m	Grey to light grey sandstone with interbedded siltstone.
31.0	7.96				
32.0	6.96				
33.0	5.96				Dark grey to pale grey sandstone with interbedded siltstone.
34.0	4.96				
35.0	3.96				
36.0	2.96		>30%	35 - 41m	Dark grey siltstone with sandstones/shales, very fine bedding.
37.0	1.96				
38.0	0.96				
39.0	-0.04				
40.0	-1.04				
41.0	-2.04				
42.0	-3.04			41 - 54.5m	Grey to dark grey sandstone interbedded with mudstone/shales and siltstone.
43.0	-4.04				
44.0	-5.04				
45.0	-6.04				
46.0	-7.04				
47.0	-8.04				
48.0	-9.04				
49.0	-10.04				
50.0	-11.04				
51.0	-12.04				
52.0	-13.04				
53.0	-14.04				
54.0	-15.04				
55.0	-16.04			54.5 - 56.0m	Grey to dark grey sandstone interbedded with siltstone.
56.0	-17.04				

Weathering increases with deep, flow rate after water strike: approx. 0.3 L/s. Occasional finely layered shales can be observed with deep, particularly between 46 to 56.

Bottom of borehole: 56m

LEGEND: W/L: Water logged

Finishing: Lockable Steel Riser

Notes: Estimated air-lift yield: 1.00 L/s. Water level above water strike indicates semi-confined to confined behaviour.
pH = 7.00, EC = 0.31mS/cm.
TOC (Height from NGL): 0.624m

Well Casing:
- Solid Class 12x150 PVC Casing
- Well Screen
- Groundwater strike
- Groundwater level

Well Construction:
- Cement grout and steel casing
- Bentonite
- Gravel

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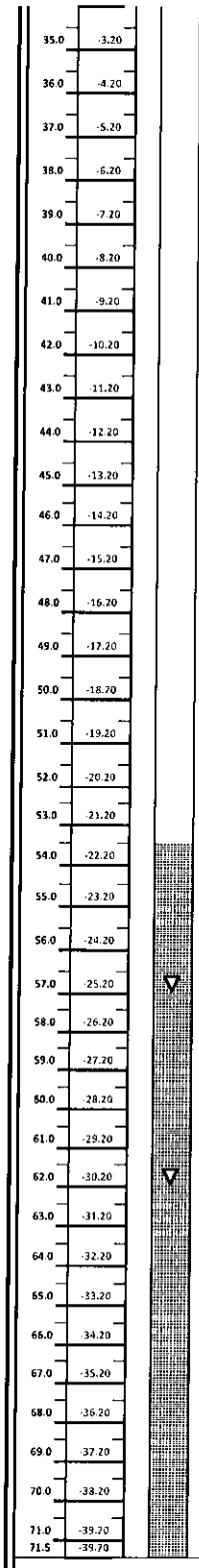
Date: 09 October 2011

BORE ID: **RBGW09**

Project: WDRL	Drilled By: TREVOR HUGHES DRILLING	Groundwater level (GL):	11.65 mbGL
Reference:	Method: ROTARY AIR	Elevation (TOC):	32.27 mAHD
Client: WR	Logged By: EAL	Elevation (GL):	31.8 mAHD
Northing: 8321313	Easting: 508527	Elevation (Groundwater level from TOC):	20.15 mAHD
Datum: WGS84	Projection: UTM Zone: 53L		

Depth mbgl	RL (m)	Water / MC	Depth (m)	Lithological Description	Remarks and Observations
0.0	31.80				
1.0	30.80	10%			
2.0	29.80		0 - 3m	Reddish to pale red, sandy, laterised ironstones.	Coarse grained size ironstones
3.0	28.80				
4.0	27.80	5 - 10%			
5.0	26.80			Pale gray, silty laterised siltstones.	
6.0	25.80				
7.0	24.80				
8.0	23.80				
9.0	22.80		3 - 15m	Pale gray to yellowish, extremely weathered siltstones	Lenses of alluvial fine to conglomeritic sand
10.0	21.80				
11.0	20.80	<5%			
12.0	19.80				
13.0	18.80			Pale gray to whitish, very fine extremely weathered siltstone	
14.0	17.80				
15.0	16.80				
16.0	15.80				
17.0	14.80				
18.0	13.80				
19.0	12.80				
20.0	11.80			Light gray to dark gray, finely laminated, sandstones with minor mudstone/shales	
21.0	10.80				
22.0	9.80				
23.0	8.80				Dominant silt and clay grain size with some lenses of hard and coarsely fractured mudstones. Some iron hydroxide stains in finely layered sandstones at about 25 to 30.0m deep.
24.0	7.80				
25.0	6.80				
26.0	5.80				
27.0	4.80				
28.0	3.80			Light gray to dark gray, weathered, finely laminated siltstone and shale with minor sandstones.	
29.0	2.80				
30.0	1.80	>30%			
31.0	0.80				
32.0	-0.20				
33.0	-1.20				
32.0	-0.20				
33.0	-1.20				
34.0	-2.20				



12 - 57m	Light gray to dark gray, finely laminated, hard siltstones and mudstone/shales.	At about 40 to 42.0m deep there is some iron hydroxide stains and some highly disseminated sulphides.
	Pale gray to dark gray intensely weathered, finely laminated siltstones and mudstone/shale.	Fine layers of pale gray, slightly weathered siltstones and hardened mudstones. Siltstone layers increase with depth, particularly between 54 to 55.0m deep. At about 50m extending to about 54m deep, a pale gray, fine interbedded layer of sandstone, siltstone and shales is evident.
57-59m	Pale gray to whitish, intensely weathered siderite.	Fine to silty grain size.
57-61m	Haematitic iron ore body.	Very fine to silt grain size. At depth (60.0 to 61.0m), interbedded with extremely weathered siltstone.
61 - 65m	Haematitic shale interbedded with silicified sandstones and mudstones.	Coarse grained in nature.
65-69m	Haematitic shale interbedded with silicified siltstones.	Fine to silt grain size. Layers of siltstone are more prominent with depth
69-71.5m	Interbedded gray to light gray sandstones, siltstones and hardened finely layered mudstones.	Layering between siltstone and mudstones are distinctive due to foliation of mudstones

Bottom of borehole

LEGEND: W/L: Water logged

Finishing: Lockable Steel Riser

Notes: Approximate water flow 0.3 L/s
TOC (Height from NGL): 0.47m

Well Casing:
- Solid Class 12x150 PVC Casing
- Well Screen
- Groundwater strike
- Groundwater level

Well Construction:
- Cement grout and steel casing
- Bentonite
- Gravel

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Date: 08 October 2011

BORE ID:

RBGW10

Project: WDRL	Drilled By: TREVOR HUGHES DRILLING	Groundwater level (GL):	8.87 mbGL
Reference:	Method: ROTARY AIR	Elevation (TOC):	31.44 mAHD
Client: WR	Logged By: EAL	Elevation (GL):	26.8 mAHD
Northing: 8322638	Easting: 508433	Elevation (Groundwater level from TOC):	17.93 mAHD
Datum: WGS84	Projection: UTM Zone: 53L		

Depth mbgl	RL (m)	Water / MC	Depth (m)	Lithological Description	Remarks and Observations
0.0	26.80				
1.0	25.80	10%	0 - 3m	Reddish to pale red, sandy, laterised ironstones.	Coarse grained size ironstones
2.0	24.80				
3.0	23.80				
4.0	22.80	5 - 10%	3 - 7m	Brownish to reddish, silty laterised siltstones.	
5.0	21.80				
6.0	20.80				
7.0	19.80				
8.0	18.80		7 - 11m	Pale gray to yellowish, silty laterised siltstones	Lenses of alluvial fine to conglomeritic sand
9.0	17.80				
10.0	16.80				
11.0	15.80				
12.0	14.80		11 - 12m	Reddish to dark brown, coarse to fine ironstone band.	
13.0	13.80		12 - 57m	Light gray to dark gray, finely laminated siltstones with minor mudstone/shales.	Dominant silt and clay grain size with some lenses of sand grain size particles. At depth, between 24 to approximately 28m, shales are mottled with an intense reddish coloration indicating seasonal water flux. At about 30m deep a moist layer (about 10% moist content) is observed.
14.0	12.80				
15.0	11.80				
16.0	10.80				
17.0	9.80				
18.0	8.80	<5%			
19.0	7.80				
20.0	6.80				
21.0	5.80				
22.0	4.80				
23.0	3.80				
24.0	2.80				
25.0	1.80			Gray to dark gray intensely weathered, ferruginous, finely laminated siltstones with shale.	
26.0	0.80				
27.0	-0.20				
28.0	-1.20				
29.0	-2.20				
30.0	-3.20	>30%			
31.0	-4.20				
32.0	-5.20				
33.0	-6.20				
32.0	-5.20				
33.0	-6.20				
34.0	-7.20				
35.0	-8.20				

36.0	-9.20			Light gray to dark gray, finely laminated siltstone with significant hard mudstones/shales.	Fine layers of pale gray, slightly weathered siltstones are evident and this increase with depth, particularly between 36.0 to 39.0m deep. At about 50.0m extending to about 56.0m deep, a fine interbedded layer of sandstone, siltstone and shales is evident
37.0	-10.20				
38.0	-11.20				
39.0	-12.20				
40.0	-13.20				
41.0	-14.20				
42.0	-15.20				
43.0	-16.20				
44.0	-17.20				
45.0	-18.20				
46.0	-19.20				
47.0	-20.20				
48.0	-21.20				
49.0	-22.20		Saturated	Pale gray to dark gray intensely weathered, finely laminated siltstones with mudstone/shale.	
50.0	-23.20				
51.0	-24.20				
52.0	-25.20				
53.0	-26.20				
54.0	-27.20				
55.0	-28.20				
56.0	-29.20				
57.0	-30.20				
58.0	-31.20	▽		57-59m Pale gray to whitish, intensely weathered siderite.	Fine to silty grain size.
59.0	-32.20				
60.0	-33.20	▽		59-61m Haematitic iron ore body.	Very fine to silt grain size. At depth (60.5 to 61.0m), interbedded with extremely weathered siltstone.
61.0	-34.20				
62.0	-35.20				
63.0	-36.20			61 - 65m Haematitic shale interbedded with silicified sandstones and mudstones.	Coarse grained in nature.
64.0	-37.20				
65.0	-38.20				
66.0	-39.20				
67.0	-40.20				
68.0	-41.20				
69.0	-42.20			65-68m Haematitic shale interbedded with silicified siltstones.	Fine to silt grain size. Layers of siltstone are more prominent with depth.
70.0	-43.20				
71.0	-44.20				
72.0	-45.20				

Bottom of borehole.

LEGEND: W/L: Water logged

Finishing: Lockable Steel Riser

Notes: Approximate water flow 0.2 L/s
TOC (Heightfrom NGL): 0.464m

Well Casing:
- Solid Clas 12x150 PVC Casing
- Well Screen
- Groundwater strike
- Groundwater level

Well Construction:
- Cement grout and steel casing
- Bentonite
- Gravel

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Date: 30 OCTOBER 2011

BORE ID:

RBGW11

Project: ROPER BAR	Drilled By: TREVOR HUGHES DRILLING	Groundwater level (GL):	12.80 mbGL
Reference:	Method: ROTARY AIR	Elevation (TOC):	27.96 mAHD
Client: WDRL	Logged By: PAUL LIVSEY	Elevation (GL):	27.30 mAHD
Northing: 8325139	Easting: 504539	Elevation (Groundwater level from TOC):	14.50 mAHD
Datum: WGS84	Projection: UTM Zone: 53L		

Depth mbgl	RL (m)	Water / MC	Depth (m)	Lithological Description	Remarks and Observations
0.0	27.30				
1.0	26.30				
2.0	25.30		0 - 4m	Brown to light brown clayey sand.	
3.0	24.30				
4.0	23.30	<5%			
5.0	22.30				
6.0	21.30				
7.0	20.30		4 - 9m	Light brown clayey sandstone.	Clay rich zone.
8.0	19.30	5-10%			
9.0	18.30				
10.0	17.30		9 - 10m	Brown to grey sandy clay.	
11.0	16.30				
12.0	15.30		10 - 13m	Dark brownish grey weathered siltstone.	
13.0	14.30	▼			
14.0	13.30		13 - 15m	Dark grey weathered siltstone.	
15.0	12.30				
16.0	11.30				
17.0	10.30				
18.0	9.30		15 - 20m	Dark grey siltstone.	
19.0	8.30	<5%			
20.0	7.30				
21.0	6.30		20 - 21m	Dark grey to grey fine grain sandstone interbedded with siltstone.	
22.0	5.30				
23.0	4.30		21 - 24m	Dark grey siltstone.	
24.0	3.30				
25.0	2.30		24 - 25m	Dark grey siltstone interbedded with fine grain sandstone.	
26.0	1.30				
27.0	0.30				
28.0	-0.70		25 - 30m	Dark grey siltstone.	
29.0	-1.70				
30.0	-2.70	▽			
31.0	-3.70				
32.0	-4.70				
33.0	-5.70				
34.0	-6.70		30 - 37m	Dark grey siltstone interbedded with fine grain sandstone.	
35.0	-7.70				
36.0	-8.70				

37.0	-9.70				
38.0	-10.70				
39.0	-11.70		>30%		
40.0	-12.70				
41.0	-13.70				
42.0	-14.70				Weathering increases with depth. Occasional very fine layers of mudstones/silty mudstones.
43.0	-15.70				
44.0	-16.70				
45.0	-17.70				
46.0	-18.70			37 - 54m	Grey to light grey fine grain sandstone interbedded with dark grey siltstone and thin layers of mudstones..
47.0	-19.70				
48.0	-20.70				
49.0	-21.70				
50.0	-22.70				
51.0	-23.70				
52.0	-24.70				
53.0	-25.70				
54.0	-26.70				
55.0	-27.70		Driller using water and foam, can't estimate relative water yield.		
56.0	-28.70				
57.0	-29.70				
58.0	-30.70				
59.0	-31.70				
60.0	-32.70				
61.0	-33.70				
62.0	-34.70				
63.0	-35.70			54 - 71.5m	Dark grey siltstone with increased fine layers of mudstones/silty mudstones.
64.0	-36.70				
65.0	-37.70				
66.0	-38.70				
67.0	-39.70				
68.0	-40.70				
69.0	-41.70				
70.0	-42.70				
71.0	-43.70				
71.5	-44.20				

Bottom of borehole: 71.5m

LEGEND: W/L: Water logged

Finishing: Lockable Steel Riser

Notes: Airlift yield: approx <0.01 L/s.
TOC (Height from NGL): 0.658m

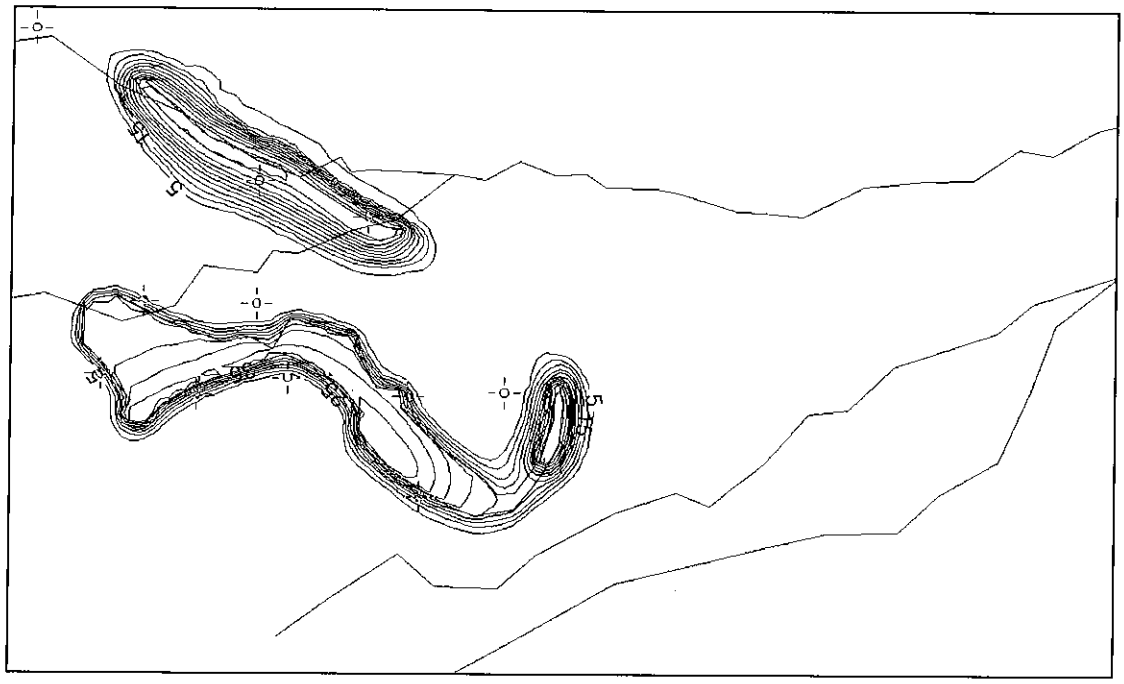
Well Casing:
- Solid Class 12x150 PVC Casing
- Well Screen
- Groundwater strike
- Groundwater level

Well Construction:
- Cement grout and steel casing
- Bentonite
- Gravel

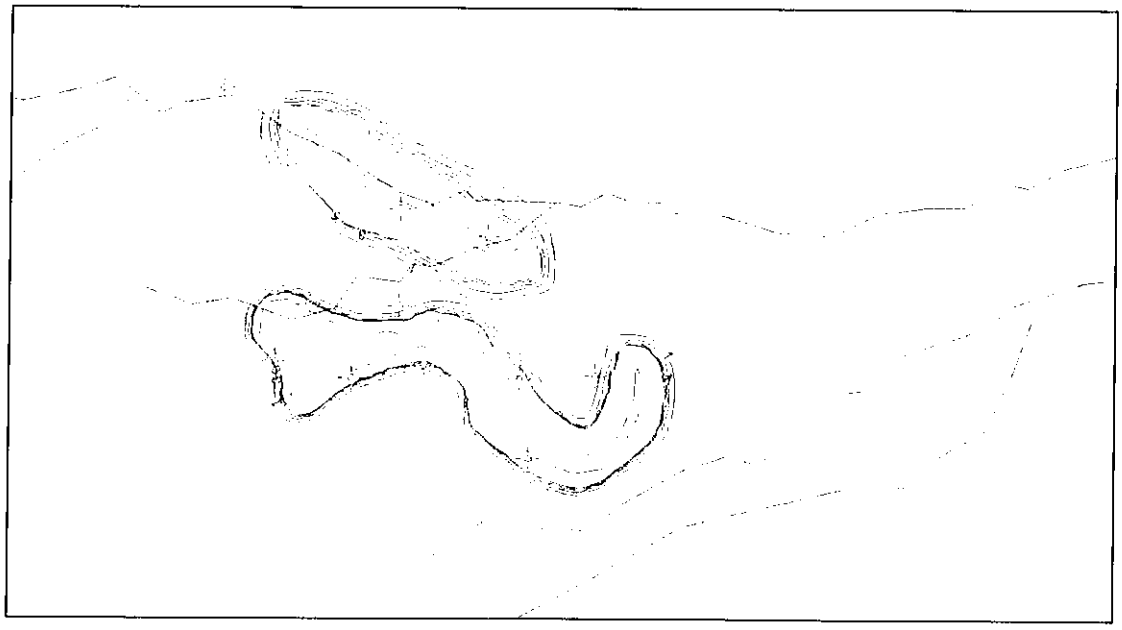
APPENDIX 2

Drawdown Contours for Various Sensitivity Runs (End of Seven Year Period)

APPENDIX 2: Drawdown Contours for Various Sensitivity Runs (End of Seven Year Period)



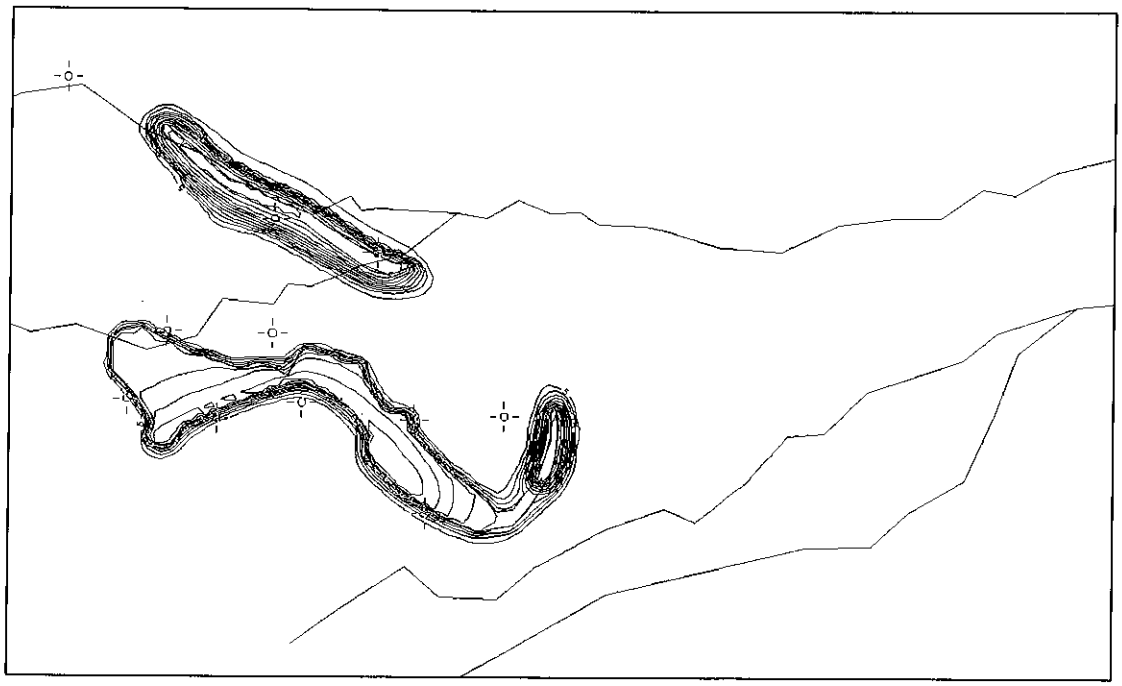
Run 46: **Base Case (Seven Year Drawdown Contours 5 m Interval)**



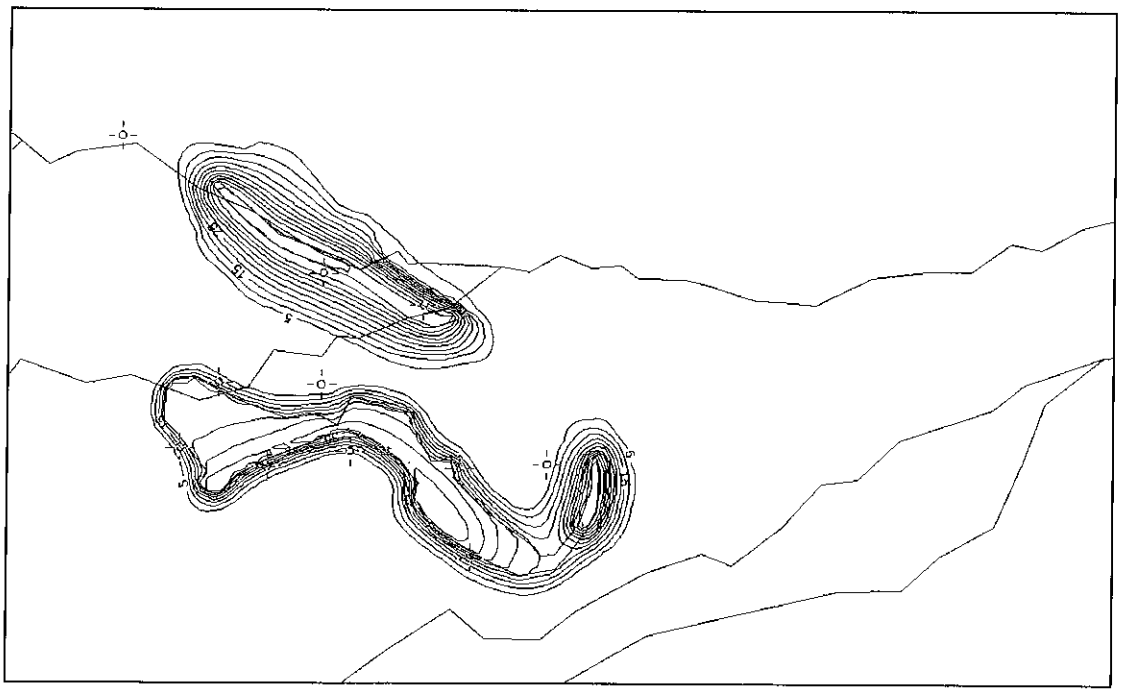
Run 46: **Base (Seven Year Drawdown Contours 1 m Interval (1 to 5 m)).**

Run 47: K doubled for all Formations (Seven Year Drawdown Contours 5 m Interval)

Run 48: K Halved for all Formations (Seven Year Drawdown Contours 5 m Interval)

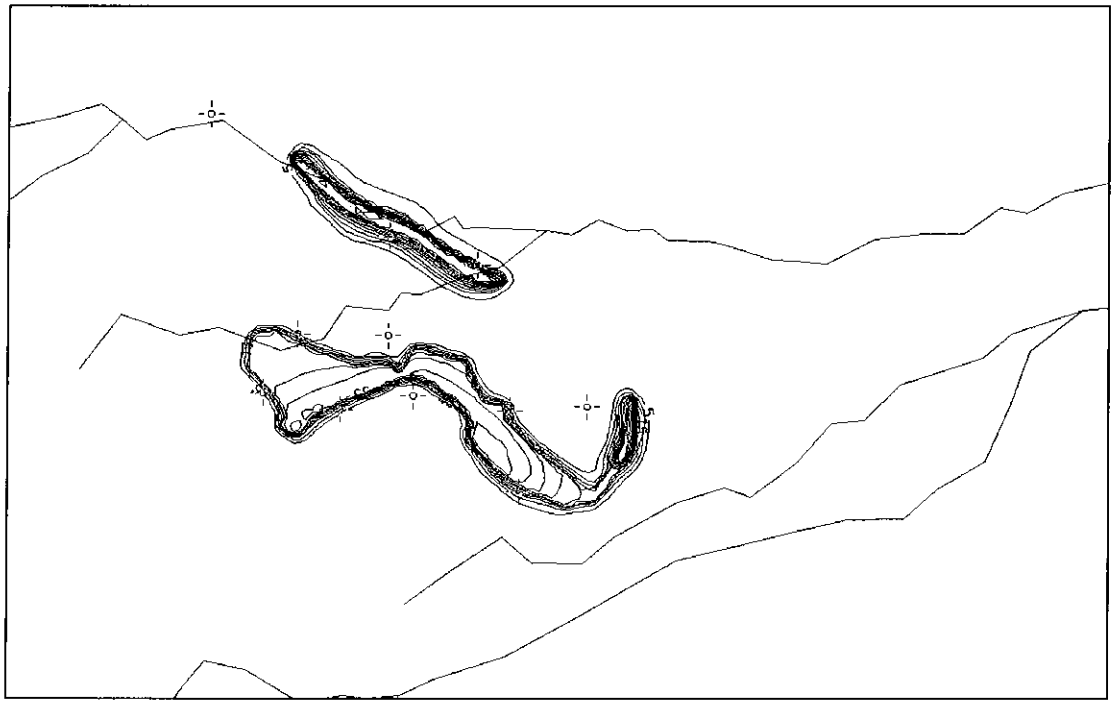


Run 49: Sy Doubled for all Formation (Seven Year Drawdown Contours 5 m Interval)

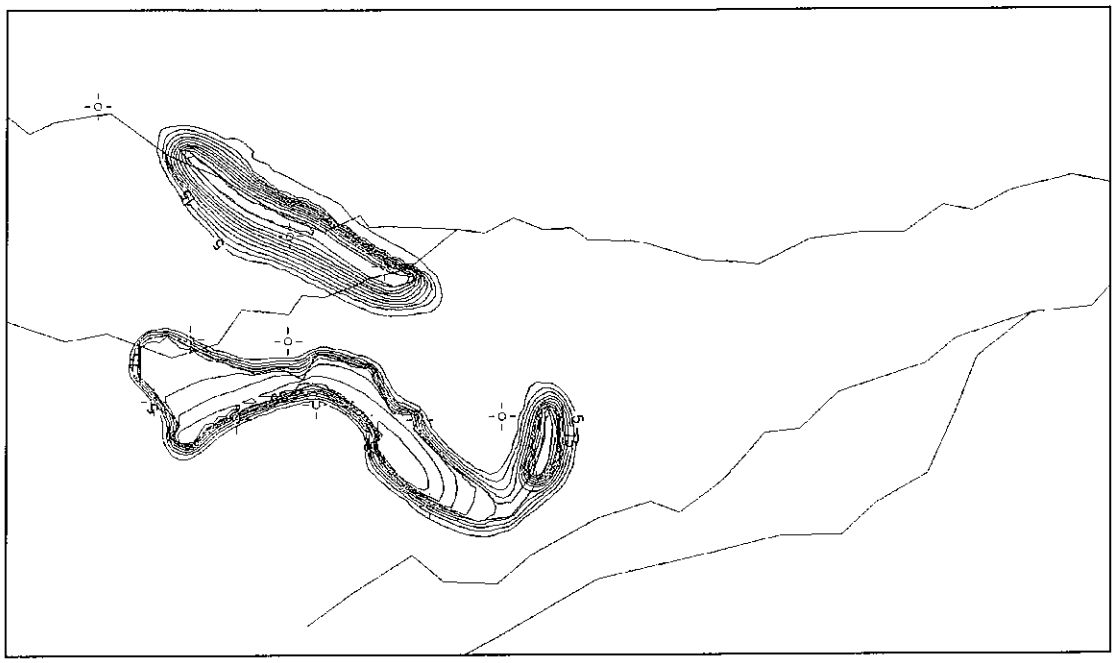


Run 50: Sy Halved for all Formation (Seven Year Drawdown Contours 5 m Interval)

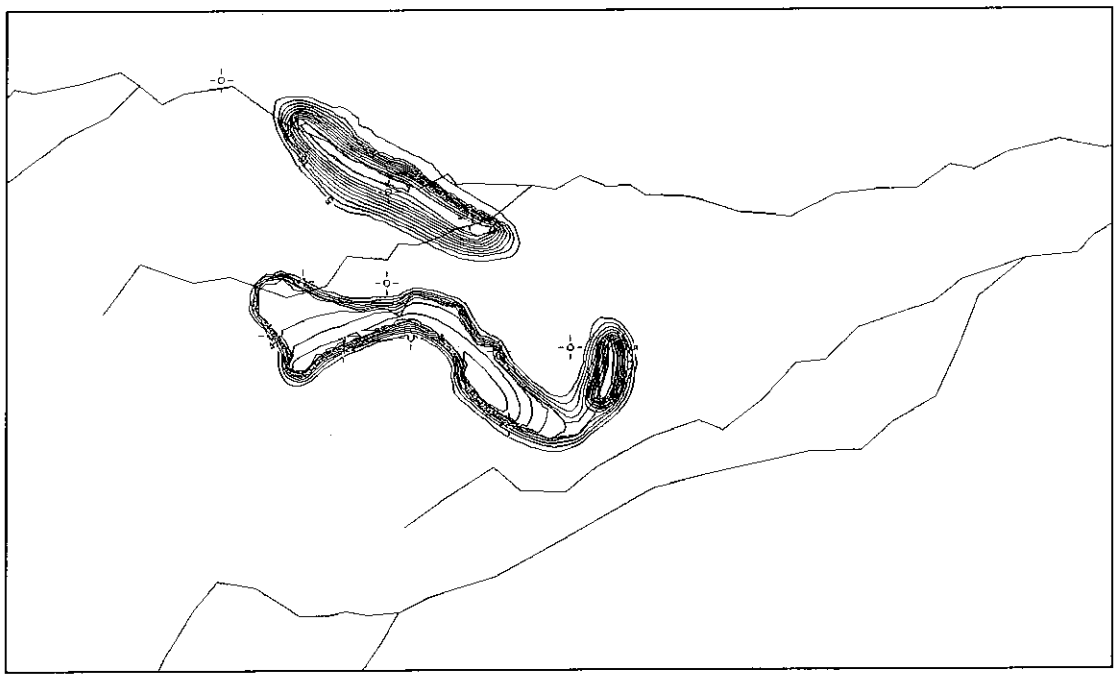
Run 51: K of Sherwin Increased By 10 Times (Seven Year Drawdown Contours 5 m Interval)



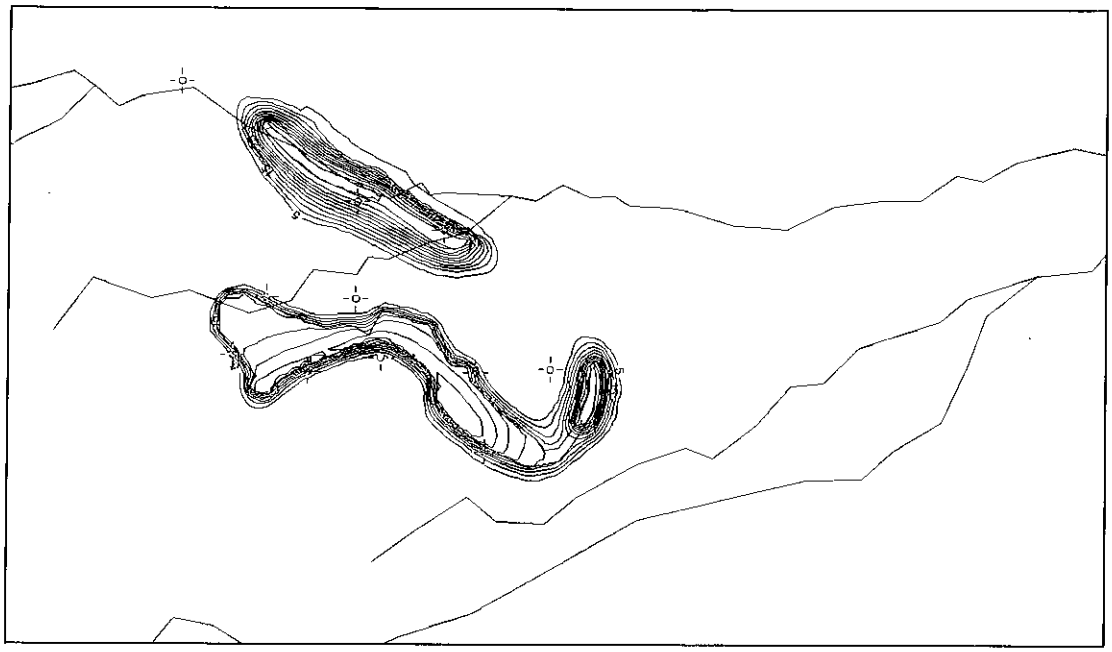
Run 52: K of Sherwin Decreased By 10 Times (Seven Year Drawdown Contours 5 m Interval)



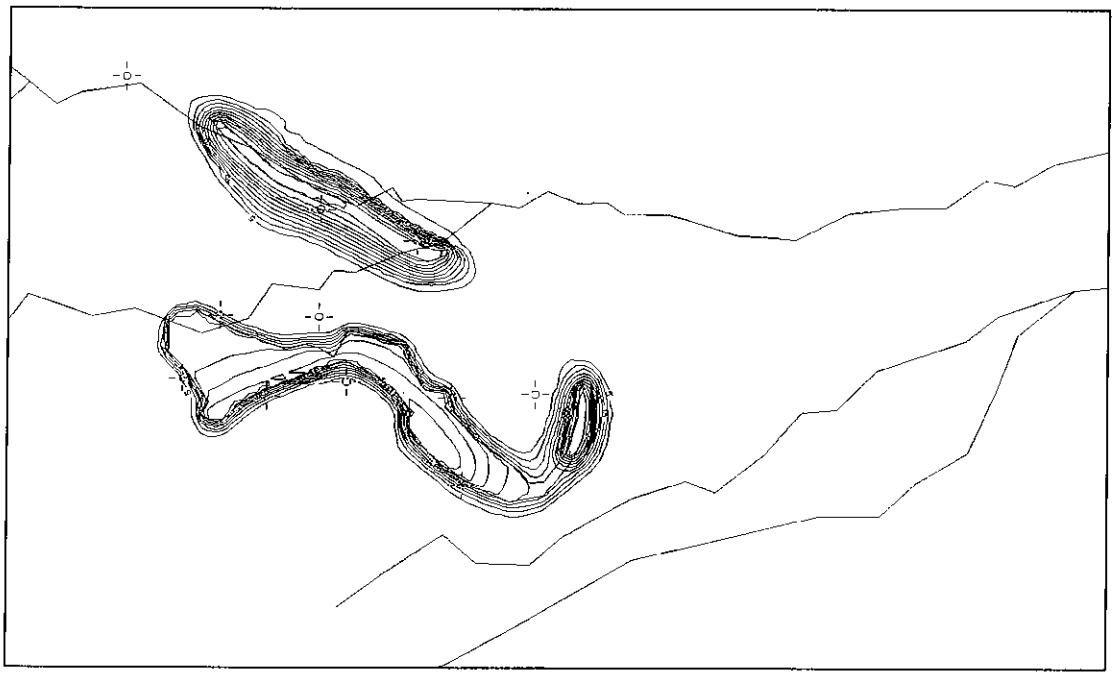
Run 53: **Recharge Rate Doubled Throughout (Seven Year Drawdown Contours 5 M Interval)**



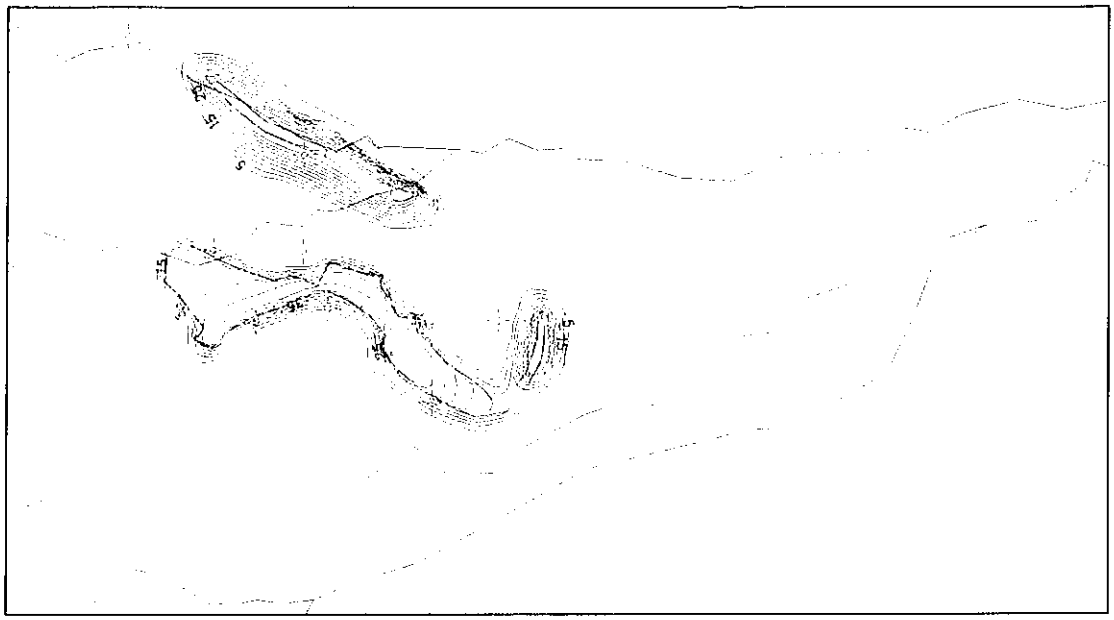
Run 54: **Recharge Rate Doubled Throughout (Seven Year Drawdown Contours 5 m Interval)**



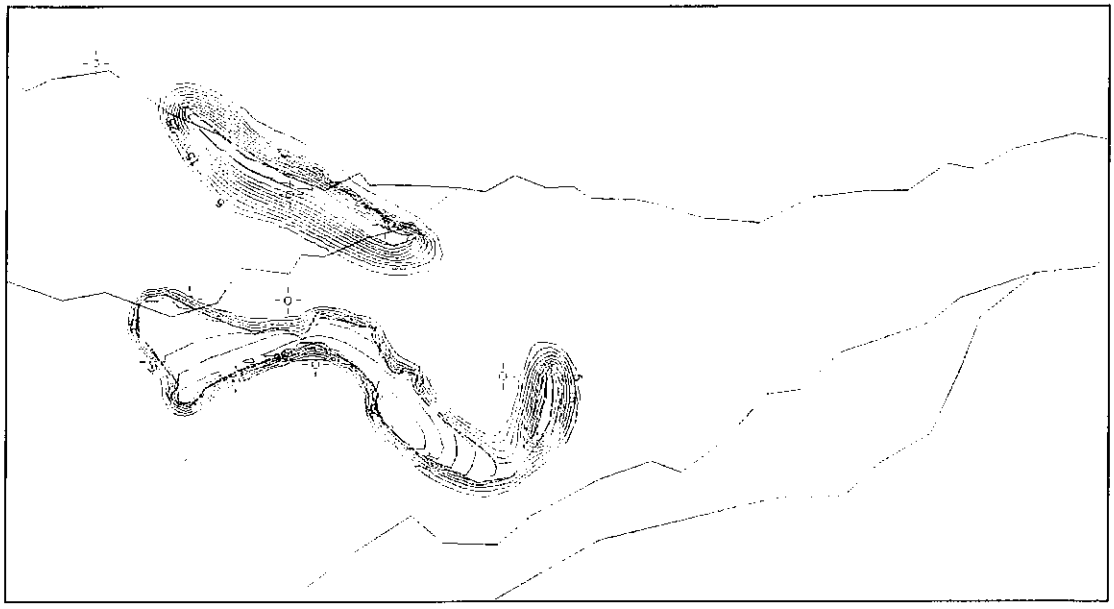
Run 55: ET Extension Depth Of 15 M (Seven Year Drawdown Contours 5 m Interval)



Run 56: ET Extension Depth of 2 m (Seven Year Drawdown Contours 5 m Interval)



Run 57: Reasonable Worst Case for Flow (K doubled, Sy doubled)



Run 58: Reasonable Worst Case for Flow (K Halved, Sy Halved)