



ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION

APPENDIX F

GROUNDWATER REVIEW

TRONOX LIMITED

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION

GROUNDWATER REVIEW

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1 INTRODUCTION

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Tronox Mining Australia Limited (Tronox). Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* in 2014.

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW and 270 km south-east of Broken Hill, NSW (Figure 1). The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km to the south-west of the township of Ivanhoe (Figure 1).

Product (mineral concentrates) generated as a result of operations at the Atlas-Campaspe Mine will be trucked to the Ivanhoe Rail Facility for transfer to train wagons, which will then be railed to the existing Broken Hill Mineral Separation Plant (the MSP) (Figure 1).

The Project will integrate with currently existing/approved Tronox operations in western NSW, including (Figure 1):

- The MSP – located in Broken Hill approximately 270 km north-west of the Atlas-Campaspe Mine
- Snapper Mine – located approximately 105 km to the west of the Atlas-Campaspe Mine
- Ginkgo Mine – located approximately 100 km to the west of the Atlas-Campaspe Mine.

This Groundwater Review has been prepared to support the application to modify Development Consent (SSD_5012) for the Project.

1.1 OVERVIEW OF THE MODIFICATION

Tronox proposes to modify Development Consent (SSD_5012) for the Project to allow for changes to optimise the Project (herein referred to the Optimisation Modification or Modification). The Modification would include:

- Increased mineral concentrate production from 546,000 tonnes per annum (tpa) to 665,000 tpa;
- Increased mineral concentrate transport from 450,000 tpa to 665,000 tpa;
- Increased mineral concentrate transport truck trips from 24 per day to 35 per day;

- Increased mineral concentrate transport train length (from 600 metres [m] to 920 m) and frequency (from six to eight train movements per week [i.e. four arrivals, four departures]);
- Increased MSP process waste disposal from 50,000 tonnes per annum (tpa) to 65,000 tpa;
- The option to use an overland conveyor to transfer overburden in addition to haul trucks;
- The relocation of the Atlas-Campaspe Mine accommodation camp;
- The option to develop on-site solar power generation infrastructure at the Atlas-Campaspe Mine to supplement diesel generator sets;
- Development of an emergency airstrip at the Atlas-Campaspe Mine;
- Construction and operation of a telecommunications tower at the Atlas-Campaspe Mine;
- Extension to the Ivanhoe Rail Facility hardstand area;
- Extension of the Ivanhoe Rail Facility rail siding and addition of a passing siding;
- A revised alignment of the Ivanhoe Rail Facility access road and access road intersection;
- A groundwater supply bore for the Ivanhoe Rail Facility; and
- The use of local roads other than the road haulage route by Project-related light vehicles to access site.

There would be no change to the following key components of the approved Project due to the Modification:

- Mine path or mine life;
- Mining method;
- Mineral concentration methods;
- Overburden and ore extraction rate;
- Sand residue, coarse reject and process waste placement management;
- Annual maximum water supply/demand;
- Rehabilitation works;
- Biodiversity offset area; or
- Workforce.

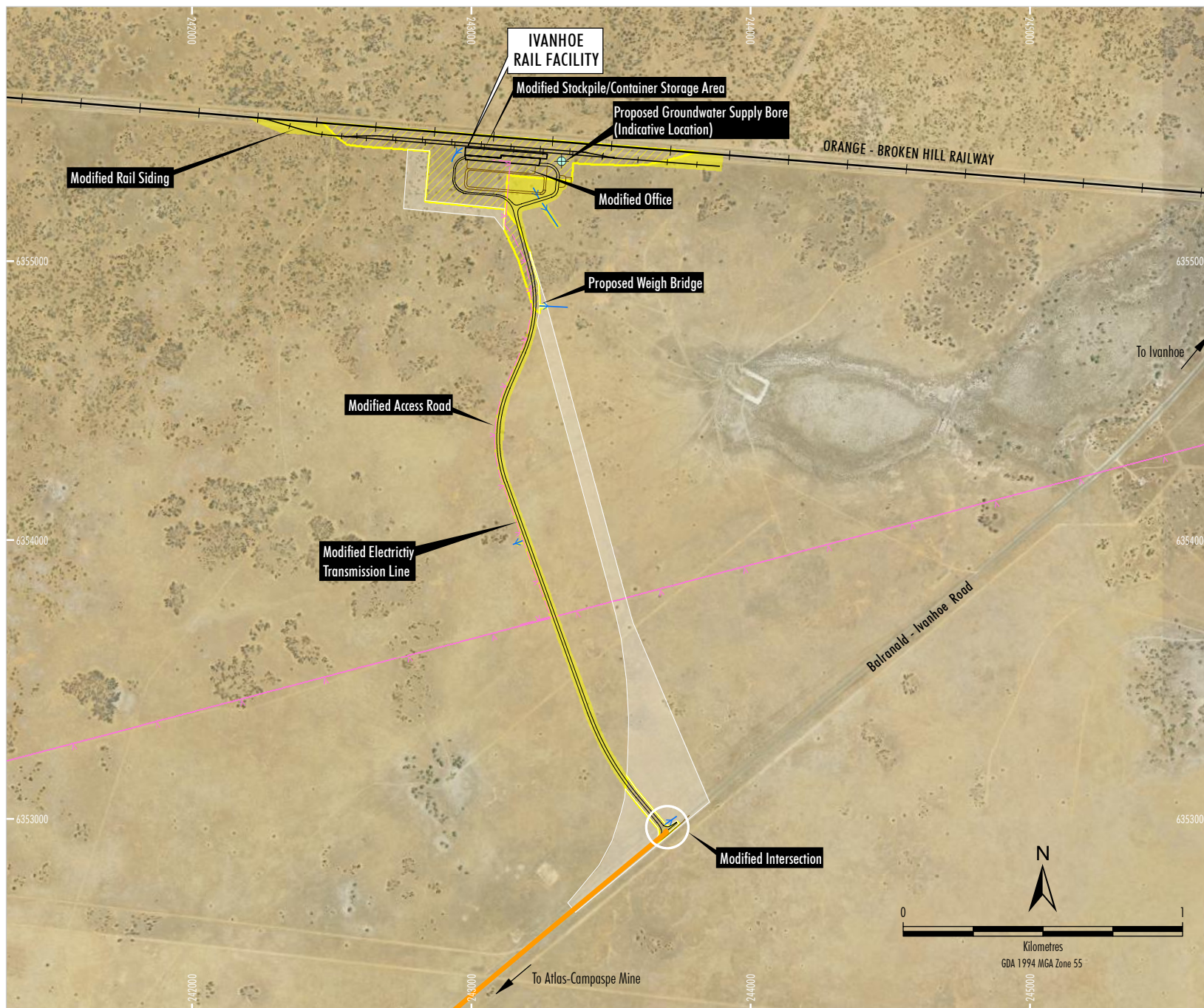
A detailed description of the Modification is provided in the main text of the Modification Report.

As the Modification would not have a significant change to the potential groundwater impacts at the Atlas-Campaspe Mine, this Groundwater Review focusses on the potential groundwater impacts associated with the proposed Ivanhoe Rail Facility groundwater supply bore.

1.2 IVANHOE RAIL FACILITY GROUNDWATER SUPPLY BORE

The Modification includes the installation of a groundwater supply bore at the Ivanhoe Rail Facility (Figure 2). The water would be utilised at the Ivanhoe Rail Facility for wash down purposes and dust suppression on the access road and mineral concentrate stockpiles.

The groundwater supply bore would provide up to approximately 60 million litres per year (ML/yr) (1.9 litres per second [L/s]) over the Project life. The bore would be designed to provide a peak demand of up to about 5 L/s.



- LEGEND**
- Approved Surface Development Area Required
 - Additional Surface Development Area
 - Approved Surface Development Area not Required
 - Approved Mineral Concentrate Transport Route*
 - Existing Electricity Transmission Line

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Tronox (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

TRONOX
OPTIMISATION MODIFICATION
Modified Ivanhoe Rail Facility
General Arrangement

Figure 2

2 HYDROGEOLOGICAL SETTING

A description of the hydrogeological setting at the Ivanhoe Rail Facility is provided in this section based on the following sources:

- Murray Basin Hydrogeological Map Series.¹
- Lachlan Fan/Ivanhoe Block Steady State Groundwater Model.²
- Lower Lachlan Groundwater Model.³
- NSW Government PINNEENA Groundwater Database.⁴
- Bureau of Meteorology (BOM) Australian Groundwater Explorer.⁵
- Bore census of local groundwater use (Attachment A).⁶
- Regional topographic data.
- Anecdotal information from local drilling contractor.

The Lower Lachlan Groundwater Model provides the most recent hydrogeological assessment of the area, and calibrated parameters from this model have been used as the primary source for the groundwater assessment.

2.1 TOPOGRAPHY AND DRAINAGE

The Ivanhoe Rail Facility is located within the Willandra Creek catchment in the Lachlan River basin. Willandra Creek is an effluent creek of the lower Lachlan River which terminates in a series of lignum swamps and intermittent lakes in the Benanee basin south-west of Ivanhoe⁷. Flows into Willandra Creek are primarily controlled by Willandra Weir on the Lachlan River, and like most unregulated streams in western NSW experience long periods of no flow interspersed with rare flows of varying magnitude.

There are no permanent surface water bodies in the Ivanhoe area.

-
1. Australian Geological Survey Organisation (AGSO) and Bureau of Mineral Resources, Geology and Geophysics (BMR) (1991-1994) Murray Basin Hydrogeological Map Series 1:250,000 *Map Sheets, Mildura, Balranald, Pooncarie, Manara, Hay and Booligal*
 2. Kellet, J. R. (1997) *Lachlan Fan / Ivanhoe Block Steady State Groundwater Model*. Australian Geological Survey Organization, Canberra.
 3. Mampitiya, D. (2010) *Lower Lachlan Groundwater Model*. NSW Office of Water, April 2010.
 4. NWS Department of Industry (2014) PINNEENA 10.1,
 5. <www.bom.gov.au/water/groundwater/explorer/>
 6. Tronox (2019) *Ivanhoe Rail Facility Bore Census*.
 7. Green, D., Petrovic, J., Moss, P., And Burrell, M. (2011) *Water resources and management overview – Lachlan catchment*. NSW Office of Water, Sydney.

The Ivanhoe Rail Facility area is relatively flat lying and sparsely vegetated, characterised by stabilised sand dunes and Native Grassland/Sparse Acacia/Chenopod Shrubs and Belah-Rosewood/Acacia Woodland vegetation communities (Australian Museum Business Services, 2013). The landform at the Ivanhoe Rail Facility is flat at approximately 100 metres Australian Height Datum (m AHD).

2.2 RAINFALL AND EVAPORATION

The climate in the Ivanhoe area is semi-arid with low and sporadic rainfall and high evaporation. Annual rainfall at Ivanhoe is both low (average 306 millimetres [mm]) as well as highly variable (minimum 69 mm and maximum 880 mm).⁸

Average areal actual evapotranspiration has been estimated by the BOM to be about 300 millimetres per year (mm/year) for data obtained from 1961 to 1990.⁹ The average areal potential evaporation is estimated by the BOM to be about 1,200 mm/yr, and the average point potential evapotranspiration is indicated to be about 2,100 mm/yr.

The thin surficial Quaternary sediments (Section 2.4) are quite variable in terms of infiltration potential including both clayey and sandy layers. The Shepparton Formation tends to be clayey, reducing the potential for infiltration, while the Calivil Sands include a mixture of sand and clay.

2.3 LAND USE

Contemporary land use in the vicinity of the Ivanhoe Rail Facility is dominated by agricultural activities (low intensity grazing) and the Orange – Broken Hill railway. The township of Ivanhoe is located approximately 4.5 km to the north-east of the Ivanhoe Rail Facility.

2.4 STRATIGRAPHY AND LITHOLOGY

The stratigraphy of the Ivanhoe area is described below in descending order.¹⁰

- Surficial Quaternary sediments (alluvial, evaporite, calcrete, aeolian).
- The Tertiary-Quaternary Shepparton Formation (TQs) is a thin fluvio-lacustrine deposit comprising clay, silty clay and sand with lenses of coarse sand and gravel, and minor aeolian reworked material.
- The Pliocene Calivil Formation (Tpc) is primarily a fluvio-lacustrine sand deposit and is expected to be the water table aquifer at the site.

8. BOM Climate Data Online. Ivanhoe Post Office Station 049019. 1884—2016. <
http://www.bom.gov.au/climate/averages/tables/cw_049019.shtml>

9. BOM *Average Annual and Monthly Evapotranspiration*.
Website: <http://www.bom.gov.au/jsp/ncc/climate_averages/evapotranspiration/index.jsp?maptype=1&period=an>

10. Brown, C.M. and Stephenson, A.E. (1991). *Geology of the Murray Basin, Southeastern Australia*. Bureau of Mineral Resources, Australia. Bulletin 235.

- The Tertiary Renmark Group (Ter) comprises sands and clays and is a significant aquifer in the region.
- The Cretaceous Monash Formation (Kl) includes sands, sandstone, siltstone and shale, with minor coal.
- The Devonian basement rock includes sandstones and metasediments.

At the Ivanhoe Rail Facility site, potential groundwater targets include sand zones within the Calivil Formation and Renmark Group and possibly in the deeper Monash Formation.

The geological log for NSW Government monitoring bore GW036919, located approximately 4.4 km to the north-east of the proposed Ivanhoe Rail Facility groundwater supply bore (Figure 3) is reproduced in Table 1.

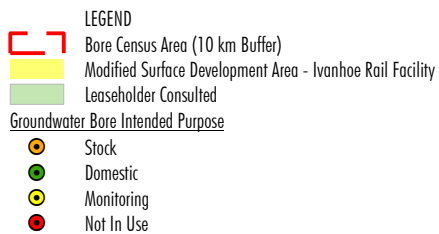
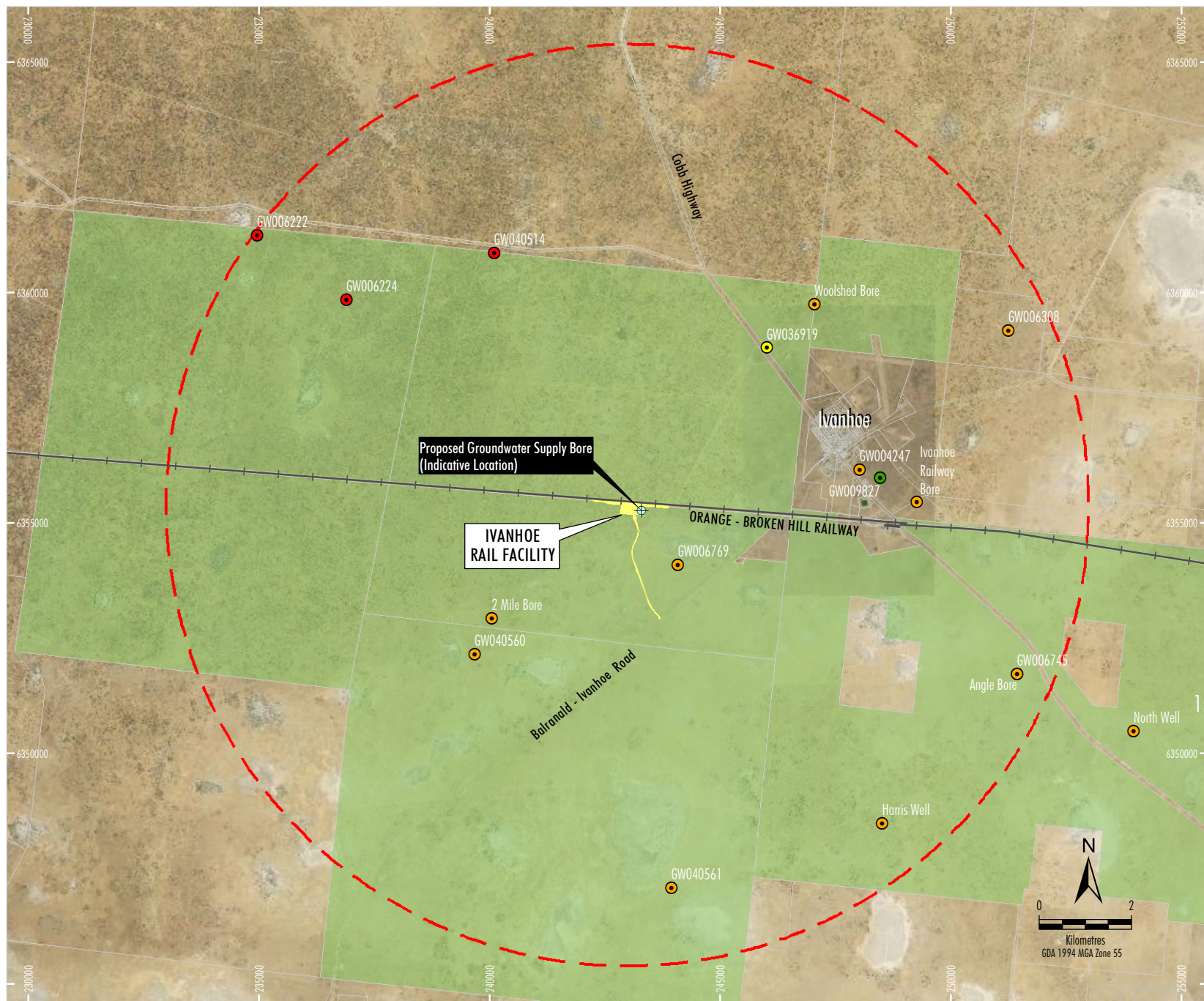
Based on the drilling log for GW036919, it is expected that reasonable water yields could be obtained at a depth of about 50 m to 70 m. The Lower Lachlan Groundwater model indicates the Renmark Group Aquifer is between about 38 m and 84 m depth. The Renmark Group Aquifer is the target aquifer for the proposed Ivanhoe Rail Facility groundwater supply bore.

2.5 LICENSING

The Ivanhoe Rail Facility is located within the Lower Lachlan Alluvium Groundwater Source (GS30) as defined in the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* under the NSW *Water Management Act, 2000*. It is noted that the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019* has been published on the NSW Department of Industry website and is scheduled to commence on 1 July 2019. The Ivanhoe Rail Facility remains in the Lower Lachlan Alluvium Groundwater Source under the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019*.

The long-term annual extraction limit stipulated in the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* for the Lower Lachlan Alluvium Groundwater Source, in addition to basic landholder rights, is 108,000 ML/yr and is fully allocated. The majority of water use in the Lower Lachlan Alluvium Groundwater Source is along the Lachlan River, and in the eastern portion of the catchment, where water quality is good.

Tronox has obtained a total of 100 share components (units or million litres) in the Lower Lachlan Alluvium Groundwater Source for the Ivanhoe Rail Facility. In accordance with Condition 24, Schedule 3 of Development Consent (SSD_5012), Tronox will hold sufficient water entitlements under the NSW *Water Management Act, 2000* for all stages of the Project.



Source: © NSW Department of Finance, Services & Innovation (2019), WaterNSW (2019).
 Orthophoto: © NSW Department of Finance, Services & Innovation (2019)

TRONOX
 OPTIMISATION MODIFICATION
 Ivanhoe Rail Facility Bore Census Results

Figure 3

Table 1. GW036919 Geological Record.

Depth (m)		Lithology
From	To	
0	3	Sandy clay; red-brown, grading to clayey sand with nodular calcrete
3	5.5	Silcrete/ferricrete; massive, red-brown, yellow-brown and pale grey, very hard drilling
5.5	16	Sandstone; coarse, soft, white-grey, sub-rounded, moderately sorted, quartz, with some thin hard silcrete bands
16	21	Sandstone; coarse, soft, white, slightly clayey, sub-rounded, poorly sorted, quartz, with white pigmentation due to kaolinitic matrix and grain coatings
21	23	Sandstone; banded white and pale pink-grey, soft, clayey, coarse, (with quartz, sub-angular, poorly sorted, 10% opaque and frosted grains) and minor white kaolinitic bands
23	26	Clay & sand; interbedded, clay, kaolinitic, white, and sand, weakly cemented, medium to coarse, quartz, sub-rounded, poorly sorted, with some pink-grey sand beds and pink pigmentation, possibly due to chamosite grain coatings
26	31	Sand & sandy clay; sand, medium, clayey, white-grey, with bands of sandy clay, white, kaolinitic, with minor pink-grey fine sand grains in 29-31m
31	32	Sandy clay & clayey sand; interbedded, sandy clay, pink-grey and pale grey, and clayey sand, fine
32	33	Silty clay; yellow-brown, with thin dark grey-brown clay bands and some pale grey fine sand beds
33	35	Sandy clay; grey, with some yellow-brown, weakly ferruginised clayey, fine sand bands
35	37	Clay; mottled, pale grey and yellow-brown, with a trace of fine sand bands
37	39	Sand; fine, clayey, yellow-grey
39	41	Silty clay & clayey sand; interbedded, silty clay, pale grey, and clayey sand, fine, with minor yellow-grey clayey fine sand bands
41	42	Sandy clay; dark grey
42	43	Sandy clay; pale brown-grey, with fine to medium sand, in bands
43	44	Sandy clay; mottled, pale grey and yellow-brown, with fine sand bands
44	45	Clay; dark grey with minor bronze, possibly pyritic fine sand bands
45	47	Silty clay; pale grey, with yellow-brown fine sand bands
47	49	Sandy clay; plastic, slightly carbonaceous, dark grey
49	51	Silty clay; pale grey, with fine sand bands, and minor yellow-brown mottles
51	61	Sand & sandy clay; interbedded, sand, fine, yellow-grey, and sandy clay, pale grey, with a trace of thin, black, carbonaceous clay bands
61	62	Sandy clay & sand; sandy clay, mottled, pale grey and yellow-brown, and sand, in beds, medium, sub-angular to sub-rounded, poorly sorted, quartz
62	72	Sand; sand, coarse, sub-rounded, very poorly sorted, quartz, pale brown, and clay, in bands throughout, but mostly in 62-64m and 71-72m
72	91	Mudstone; pale blue-grey, very softy, with minor fine sand bands throughout and trace of brown carbonaceous clay bands
91	92	Sandstone; fine, pale grey, becoming hard
92	95	Sandstone; core, mostly massive, pale grey quartzose sandstone (quartz grains, sub-rounded to sub-angular, poorly sorted). diffuse dark grey carbonaceous zone 92.4-92.55m with the carbonaceous material appearing entirely in the matrix

Sand zones highlighted in grey.

2.6 GROUNDWATER BORE CENSUS

A bore census in the vicinity of the Ivanhoe Rail Facility was conducted by Tronox in April 2019 (Attachment A). The bore census covered a 10 km radial buffer around the Ivanhoe Rail Facility groundwater supply bore (or approximately 314 square kilometres) and included a review of NSW Government records and consultation with surrounding landholders.

The bore census confirmed the existence of 10 groundwater bores. The closest groundwater bore is located approximately 2 km south-east of the proposed Ivanhoe Rail Facility groundwater supply bore (Figure 3).

Of the 10 groundwater bores, seven were confirmed to be in use and three are not in use (Attachment A). The purposes of the seven groundwater bores in use included (Figure 3):

- monitoring (one bore); and
- stock (six bores).

The lack of active bores in the region is understandable given the poor quality of the groundwater (Section 2.9).

2.7 GROUNDWATER DEPENDENT ECOSYSTEMS

There are currently no high priority groundwater dependent ecosystems (GDEs) identified in the Lower Lachlan Alluvium Groundwater Source defined in the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* or the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019* under the NSW *Water Management Act, 2000* within which the Ivanhoe Rail Facility is located.

The *Groundwater Dependent Ecosystems Atlas* (BOM, 2019) identifies potential GDEs at locations of dry lake beds, which occasionally capture rainfall run-off, in the vicinity of the Ivanhoe Rail Facility as having a low potential for groundwater interaction.¹¹ As these surface features are disconnected from the groundwater table, which is located approximately 30 m below ground level, it is considered that they are not groundwater dependent.

Notwithstanding, *NSW State Groundwater Dependent Ecosystems Policy* (Department of Land and Water Conservation, 2002) recognises the four Australian GDE types (Hatton and Evans, 1998) that can be found in NSW, namely:

- Terrestrial vegetation;
- Baseflows in streams;
- Aquifer and cave ecosystems; and
- Wetlands.

11. Bureau of Meteorology, *Groundwater Dependent Ecosystems Atlas*.
<<http://www.bom.gov.au/water/groundwater/gde/map.shtml>> accessed March 2019.

The *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (NSW Office of Water [NOW], 2012) also identifies four above ground ecosystems that are considered GDEs, as follows:

- Groundwater dependent wetlands;
- Baseflow streams (surface water ecosystems);
- Estuarine and near shore marine ecosystems; and
- Phreatophytes – groundwater dependent terrestrial ecosystems.

No GDEs are considered to be present within the locality of the proposed Ivanhoe Rail Facility groundwater supply bore.

2.8 BASELINE GROUNDWATER LEVEL DATA

NSW Government monitoring bore GW036919 is located about 3 km north-west of Ivanhoe and approximately 4.4 km NE of the proposed Ivanhoe Rail Facility groundwater supply bore (Figure 3). The surface level is approximately RL 89 m AHD. It is a nested pair monitoring bore and the upper bore screen is indicated to be set at 39 m to 45 m depth (about RL 44 m to RL 50 m AHD) in sandy-clay and clayey sand zone (possibly the base of the Calivil Formation). The lower bore screen is indicated to be set at about 58 m to 70 m depth (RL 19 m to RL 31 m AHD) in a section with fine to coarse sand bands (likely within the Renmark Group Aquifer).

Hydrographs for the shallow (s) and deep (d) standpipes at GW036919 are shown in Figure 4.

The water levels in the two bores are very similar, and have risen by only about 0.1 m, over 20 years since construction, indicating stable groundwater conditions (Figure 4).

It is likely that the shallow screen is poorly connected to the regional aquifer(s) as the geological log indicates the screen was placed in a sandy clay zone. This could explain the slow recovery of about 0.2 m since construction in 1995, to a relatively stable level since 2002 (Figure 4).

Since 2003 the groundwater levels in both standpipes have been fairly stable. The fluctuation in levels is very small and likely primarily due to changes in atmospheric pressure at the time of readings. The difference in level between the two standpipes is about 2 cm and may indicate a small upward gradient, or inaccuracy in measurements. There is a very small long-term trend of rising water level of about 0.1 m in the lower standpipe between 1995 and 2015 (Figure 4).

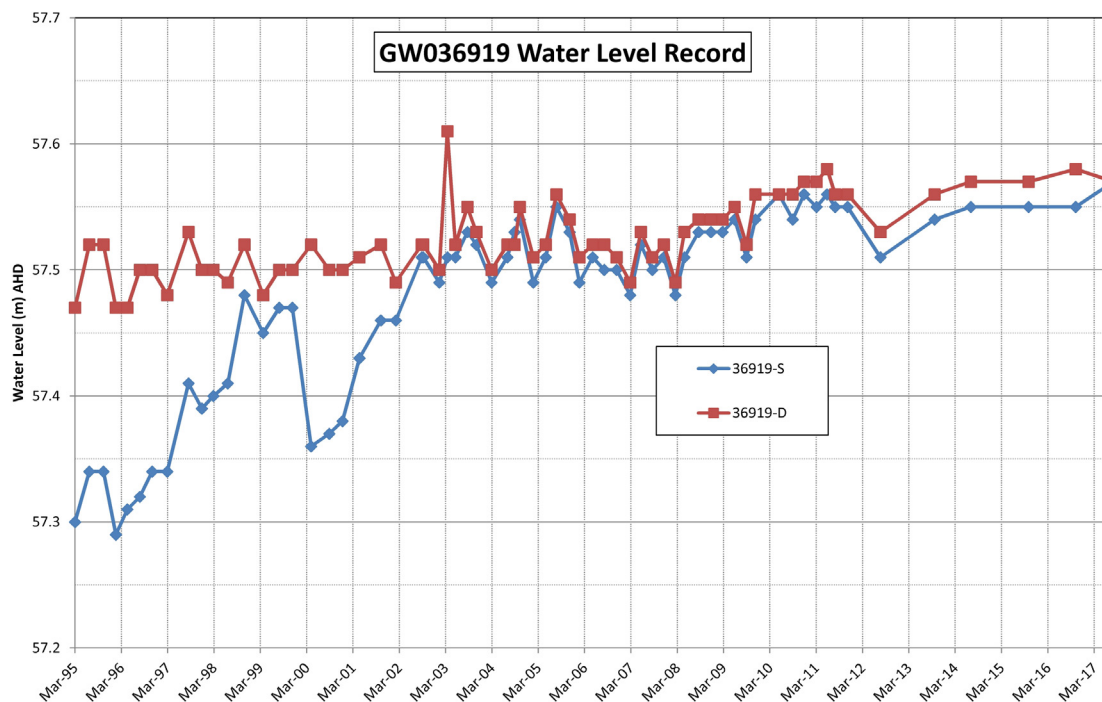


Figure 4. GW036919 Groundwater Level Records.

2.9 BASELINE GROUNDWATER CHEMISTRY DATA

Groundwater salinity mapping of the region (Murray Darling Basin Authority, 2008) indicates salinity of about 10,000 milligrams per litre (mg/L).

This elevated salinity is consistent with the limited groundwater use in the Ivanhoe area (Section 2.6).

2.10 RAINFALL RECHARGE

Based on studies of chlorine input from rainfall, Kellet (1997) indicates that recharge varies from about 0.1% to 1.0% of rainfall, with the lowest infiltration over the western mallee of about 0.1 mm/year. Kellet (1997) estimated recharge across the Riverine Plain and Willandra Lakes depression to be up to 1.8 mm/year, with recharge of up to 3 mm/year along the Murray River boundary area (Kellet, 1997).

Mampitiya (2010) used a recharge rate of 1% of rainfall, which is equivalent to about 3 mm/year over the western part of the current groundwater model area, which overlaps with the Lower Lachlan Groundwater Model. Mampitiya (2010) noted that:

“Potential evaporation exceeds annual rainfall by a ratio of nearly 5:1 in the model area. Therefore, much of the rain received in the area is likely to evaporate before significant surface ponding, infiltration and runoff. Clay rich topsoil has a very low permeability resulting in low deep drainage from rainfall. The water table in most parts of the study area is about 25 m below ground level. All of these factors indicate that the model area is generally experiencing dry conditions and relatively low rates of rainfall recharge. Monitoring bore hydrographs do not indicate any noticeable response to rainfall, not even for sporadic high intensity events.”

2.11 HYDROGEOLOGICAL PARAMETERS

Hydrogeological parameters from the Lower Lachlan Groundwater Model for the proposed bore location are provided in Table 2.

Table 2. Hydrogeological Parameters.

	m AHD	K (m/d)	SY%	Ss	Leakance (1/d)
Surface	83.07				
Shepparton	69.97	1	7.24		1.14E-04
Calivil	45.06	13.4		1.00E-04	9.73E-05
Renmark	-1.33	15.61		1.00E-04	

Levels for base of formation.

K: Horizontal Hydraulic Conductivity

SY: Specific Yield

Ss: Specific Storage

Leakance: Measure of flow between layers.

3 GROUNDWATER MODEL

3.1 GROUNDWATER MODEL CONCEPTUALISATION

The conceptual understanding of the regional groundwater regime is based on the Lower Lachlan Groundwater Model and a review of existing hydrogeological data (Section 2).

The Lower Lachlan Groundwater Model indicates a relatively flat regional groundwater gradient flowing to the west at about 1 vertical (V) to 4,500 horizontal (H). The groundwater table in the vicinity of the Ivanhoe Rail Facility is approximately 32 m below ground level and generally sits in the Calivil Formation. The hydrographs in Figure 4 indicate relatively stable water level conditions, which is matched by the Lower Lachlan Groundwater Model simulated water levels.

Given these hydrogeological conditions and an assumed uniform confined aquifer the pumping effect from the proposed Ivanhoe Rail Facility water supply bore would be a localised symmetric cone.

3.2 MODEL SOFTWARE AND COMPLEXITY

An analytical model (axi-symmetric analytical methods for leaky confined aquifers) has been used to simulate the drawdown from the proposed Ivanhoe Rail Facility groundwater supply bore. The model type is considered appropriate given:

- The hydrogeological conditions at the Ivanhoe Rail Facility (i.e. uniform confined aquifer, with a very low regional gradient) as discussed in Section 3.1.
- The limited groundwater use in the vicinity of the Ivanhoe Rail Facility (Section 2.6).
- The expected limited drawdown associated with the proposed Ivanhoe Rail Facility groundwater supply bore.

Analysis has been carried out using AQTESOLV software (Duffield, G.M., 2007), using the Hantush solution for leaky confined aquifers.

The use of an analytical model is also consistent with the Murray-Darling Basin Commission (MDBC) Guideline. Under the MDBC Guideline, a “*simple model*” is considered appropriate to “*predict the long term drawdown due to abstractions from a proposed water supply bore*” (e.g. the proposed Ivanhoe Rail Facility groundwater supply bore). The MDBC Guideline states that the complexity of a “*simple model*” is “*basic*” and “*often uses analytical modelling approach*”.

The use of an analytical model is also consistent with Australian Groundwater Modelling (AGM) Guideline. Based on Table 2-1 (Model confidence level classification) of the AGM Guideline, as the model is required to provide predictions of *"long-term impacts of proposed developments in low-value aquifers"*, a "Class 1" model is appropriate. The AGM Guideline states that the confidence level of the "Class 1" model is low. The confidence level of the model could be considered to be low as the parameters adopted in the model are based on the Lower Lachlan Groundwater Model which has been carried out over a very large region, with minimal specific information for the Ivanhoe location. While the confidence in the model predictions could be low, the consequence of likely variance in those predictions is also low, given the low value of the aquifer and the significant distance to any receiving environment or groundwater users.

Given the above, the use of AQTESOLV software (Duffield, G.M., 2007), using the Hantush solution for leaky confined aquifers, is considered appropriate for the Ivanhoe Rail Facility groundwater supply bore.

3.3 IVANHOE RAIL FACILITY WATERSUPPLY BORE SCENARIO

The Modification includes the installation of a groundwater supply bore at the Ivanhoe Rail Facility (Figure 2). The groundwater supply bore would provide up to approximately 60 ML/yr (1.9 L/s) over the Project life (a 20 year period has been adopted for the model).

3.4 PARAMETERS ADOPTED

The following parameters for the Renmark Group Aquifer from the Lower Lachlan Groundwater Model (Section 2.10) have been adopted in the model:

- Hydraulic Conductivity (K)=15.6 m/d.
- Aquifer Thickness(B)=46 m.
- Specific Storage (Ss)=0.0001.
- Leakage from Calivil=9.7E-5 1/d.

3.5 MODEL RESULTS

The predicted maximum drawdown after 20 years at the Ivanhoe Rail Facility groundwater supply bore and 10 m, 20 m and 100 m from the bore is presented in Table 3.

Table 3 also includes the results of a sensitivity analysis that was carried out by varying several of the parameters by one order of magnitude. The Specific Storage (Ss) and Leakage parameters were not sensitive and were only varied towards the maximum case direction. Two values for the productive aquifer thickness (B) were considered based on the geological log for GW036919 (i.e. 11 m – Table 1) and the aquifer thickness adopted in the Lower Lachlan Groundwater Model (i.e. 46 m).

Table 3. Modelled Groundwater Drawdown After 20 Years at Radial Distances.

Scenario	K (m/d)	B (m)	T (m ² /d)	Ss	Leakance (1/d)	Maximum Drawdown			
						@Bore	10m	20m	100m
1	15.6	46	724	0.0001	9.7e-5	19cm	4cm	2cm	-
2	1.56	46	72.4	0.0001	9.7e-5	190cm	40cm	20cm	-
3	15.6	11	172	0.0001	9.7e-5	80cm	17cm	9cm	-
4	1.56	11	17.2	0.0001	9.7e-5	790cm	170cm	85cm	2cm
5	1.56	11	17.2	0.0000 1	9.7e-5	790cm	170cm	85cm	2cm
6	1.56	11	17.2	0.0001	9.7e-6	790cm	170cm	85cm	2cm
7	156	11	1717	0.0001	9.7e-5	8cm	2cm	1cm	-

K: Horizontal Hydraulic Conductivity

B: Aquifer Thickness.

T: Transmissivity

Ss: Specific Storage

The results show that drawdowns are low, stabilises quickly and are not significant beyond 100 m.

Comparison was made to the pumping test results for Bore AB1 in the Calivil/Loxton-Parilla Formation at the Atlas-Campaspe Mine site, which showed a similar characteristic to the drawdown curves (at a higher flow rate).

4 ASSESSMENT OF POTENTIAL IMPACTS

4.1 AQUIFER DRAWDOWN

Extraction of groundwater from the Ivanhoe Rail Facility groundwater supply bore would form a localised groundwater sink. As described in Section 3.5, the maximum predicted drawdown is low, stabilises quickly and is not significant beyond 100 m (i.e. predicted maximum drawdown 100 m from the bore is 2 cm) (Figure 5).

4.2 GROUNDWATER USERS

The closest groundwater bore to the proposed Ivanhoe Rail Facility groundwater supply bore is located approximately 2 km to the south-east (Section 2.6). The drawdown at this bore due to the proposed Ivanhoe Rail Facility groundwater supply bore is predicted to be negligible.

4.3 GROUNDWATER QUALITY

Given the limited drawdown impact of the proposed Ivanhoe Rail Facility groundwater supply bore and the poor (saline) quality of the groundwater resource, there is expected to be no significant change in groundwater quality as a result of the Modification.

4.4 GROUNDWATER DEPENDENT ECOSYSTEMS

As there are no GDEs present within the locality of the proposed Ivanhoe Rail Facility groundwater supply bore and the limited predicted drawdown, no impacts on GDEs are expected as a result of the Modification.

4.5 CUMULATIVE IMPACTS

As there are no significant groundwater users in the vicinity of the proposed Ivanhoe Rail Facility groundwater supply bore and the limited predicted drawdown, no cumulative impacts are expected as a result of the Modification.

4.6 CONSIDERATION OF THE AQUIFER INTERFERENCE POLICY

The Aquifer Interference Policy (AIP) has been developed by the NSW Government as a component of the NSW Government's *Strategic Regional Land Use Policy*. The AIP applies state wide and details water licence and impact assessment requirements.

The stated objective of the AIP is to ensure equitable water sharing between various water users and proper licensing of water that is taken by aquifer interference activities to ensure that the take is accounted for in the water budget and water sharing arrangements.

Water Source

The AIP requires all water taken by aquifer interference activities to be accounted for within the extraction limits set by the relevant Water Sharing Plan. The Water Sharing Plan relevant to the Ivanhoe Rail Facility is the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003*.

The draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019*, which has been published on the NSW Department of Industry website (Section 2.5) would become the relevant Water Sharing Plan for the Ivanhoe Rail Facility when it comes into force.

Licensing Requirements

The *Water Management Act, 2000* makes it an offence to "take" water without a water licence or in accordance with a lawful exemption.

The AIP states that all water taken by aquifer interference activities needs to be accounted for within the extraction limits set by the relevant water sharing plan.

As described in Section 2.5, Tronox has obtained a total of 100 share components (units or million litres) in the Lower Lachlan Alluvium Groundwater Source under the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* for the proposed Ivanhoe Rail Facility groundwater supply bore. Tronox therefore has adequate licences available to account for the proposed take of water associated with the Ivanhoe Rail Facility groundwater supply bore (i.e. 60 ML/yr).

Minimal Impact Considerations

The AIP establishes minimal impact considerations for groundwater categories of both 'highly productive' and 'less productive' groundwater. 'Highly productive groundwater' is defined by the AIP as groundwater which (NOW, 2012):

...is defined in this Policy as a groundwater source that is declared in the Regulations and will be based on the following criteria:

- a) has total dissolved solids of less than 1,500 mg/L, and*
- b) contains water supply works that can yield water at a rate greater than 5 L/sec.*

The AIP further groups groundwater in to categories (e.g. alluvial, porous rock).

The target aquifer for the proposed Ivanhoe Rail Facility groundwater supply bore (i.e. the Renmark Group Aquifer) is considered to be a 'less productive' alluvial aquifer, due to its high salinity, in accordance with the AIP. Table 4 provides an assessment of the watertable, water pressure and water quality minimal impact considerations.

The Modification would have "minimal impact" (as defined by the AIP) (Table 4).

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Table 4. Less Productive Alluvial Aquifer – Minimal Impact Considerations

Level 1 Minimal Impact Consideration	Assessment
<u>Water Table</u> 1. Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic “post-water sharing plan” ... variations, 40m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan; or A maximum of a 2m decline cumulatively at any water supply work unless make good provisions should apply.	<u>There are no high priority GDEs listed in the Water Sharing Plan for the Lower Lachlan Groundwater Source 2003 or the draft Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019.</u> <u>There are no high priority culturally significant sites listed in the Water Sharing Plan for the Lower Lachlan Groundwater Source 2003 or the Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019.</u> <u>Predicted drawdown at all privately-owned bores would be less than 2 m.</u> <u>There are no other relevant water supply works.</u> Complies with Level 1 minimal impact considerations.
<u>Water Pressure</u> 1. A cumulative pressure head decline of not more than 40% of the “post-water sharing plan”... pressure head above the base of the water source to a maximum of a 2m decline, at any water supply work. 2. If the predicted pressure head decline is greater than requirement 1. above, then appropriate studies are required to demonstrate to the Minister’s satisfaction that the decline will not prevent the longterm viability of the affected water supply works unless make good provisions apply.	<u>Predicted water pressure decline at all privately-owned bores would be less than 2 m.</u> <u>There are no other relevant water supply works.</u> Complies with Level 1 minimal impact considerations.

Level 1 Minimal Impact Consideration	Assessment
<u>Water Quality</u> (a) Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity; and (b) No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity. Redesign of a highly connected ... surface water source that is defined as a “reliable water supply”... is not an appropriate mitigation measure to meet considerations 1.(a) and 1.(b) above. (c) No mining activity to be below the natural ground surface within 200m laterally from the top of high bank or 100m vertically beneath (or the three dimensional extent of the alluvial material - whichever is the lesser distance) of a highly connected surface water source that is defined as a “reliable water supply”	Negligible impacts on groundwater quality are expected and therefore no change to the beneficial use category of the groundwater source. <u>There are no highly connected surface water sources in the vicinity of the Ivanhoe Rail Facility.</u> <u>No mining activities are proposed at the Ivanhoe Rail Facility.</u> Complies with Level 1 minimal impact considerations.

4.7 CONSIDERATION OF THE WATER SHARING PLAN FOR THE LOWER LACHLAN GROUNDWATER SOURCE 2003

Division 3 of Part 10 of the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* relates to the management of local impact on the groundwater resource. An assessment against the relevant provisions of Division 3 of Part 10 is provided in Table 5.

Section 4.41(1) of the *NSW Environmental Planning and Assessment Act, 1979* provides that water use approvals under section 89, water management work approvals under section 90 (which include water supply work approvals), or an activity approval (excluding an aquifer interference approval) under section 91 of the *Water Management Act, 2000* are not required for an approved State Significant Development Project. Therefore, restrictions set out in clause 36 of the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* do not apply to a bore approved as part of the Project. Notwithstanding the above, clause 36 is still considered in Table 5.

The proposed Ivanhoe Rail Facility groundwater supply bore would meet relevant management of local impact considerations in Division 3 of Part 10 of the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003*.

Table 5. Management of Local Impact Considerations

Requirement	Assessment	
36 Extraction interference between neighbouring bores		
1. <i>To minimise interference between extraction under different access licences in this groundwater source, extraction from a water supply work (bore) nominated by an access licence will not be permitted within:</i> (a) <i>1,000 metres of another water supply work (bore) nominated by an access licence authorised to extract up to, and including, 10 ML/day,</i> (b) <i>2,000 metres of another water supply work nominated by an access licence authorised to extract greater than 10 ML/day, and up to and including 15 ML/day, and</i> (c) <i>3,000 metres of another water supply work nominated by an access licence authorised to extract greater than 15 ML/day.</i>	Extraction from the proposed Ivanhoe Rail Facility groundwater supply bore would be less than 10 ML/day. No groundwater bores are located within 1,000 m of the proposed Ivanhoe Rail Facility groundwater supply bore.	
37 Water level management		
1. <i>The Minister may declare that, in order to protect water levels within this groundwater source, local access rules are to apply in a defined area known as a local impact area. ...</i>	The proposed Ivanhoe Rail Facility groundwater supply bore is not located within a local impact area, therefore clause 37 is not applicable to any dealing for the proposed Ivanhoe Rail Facility groundwater supply bore.	
38 Water quality management		
1. <i>The beneficial uses of this groundwater source based on the Australian and New Zealand Environment and Conservation Council Water Quality Guidelines 2000, and the National Health and Medical Research Council Raw Water for Drinking Purposes Guidelines 1996, are raw water for drinking supplies, and agriculture water.</i>	Negligible impacts on groundwater quality are expected and therefore no change to the beneficial use category of the groundwater source. Clauses 38(1) and 38(2) are therefore not applicable to any dealing for the Ivanhoe Rail Facility groundwater supply bore.	
2. <i>Water quality decline will be deemed unacceptable if extraction is likely to cause water quality to decline to a lower beneficial use class.</i>		
3. <i>The Minister may declare that, in order to protect water quality within this groundwater source, local access rules are to apply in a defined area known as a local impact area.</i>	The proposed Ivanhoe Rail Facility groundwater supply bore is not located within a local impact area, therefore clause 38(3) is not applicable to any dealing for the Ivanhoe Rail Facility groundwater supply bore.	
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Requirement	Assessment
39 Protection of groundwater dependent ecosystems and Aboriginal cultural heritage values	
(1) <i>Extraction of groundwater from a new or replacement water supply work (bore) is excluded:</i> (a) <i>for works nominated by an access licence, within 200 metres of high priority groundwater dependent ecosystems, or where impact may occur on Aboriginal cultural heritage values,</i> (b) <i>for those exercising basic landholder rights, within 100 metres of high priority groundwater dependent ecosystems, or where impact may occur on Aboriginal cultural heritage values, and</i> (c) <i>within 40 metres of any river for any works.</i>	There are no high priority GDEs listed in the <i>Water Sharing Plan for the Lower Lachlan Groundwater Source 2003</i>. There are no high priority culturally significant sites listed in the <i>Water Sharing Plan for the Lower Lachlan Groundwater Source 2003</i>. There is no river in the vicinity of the Ivanhoe Rail Facility groundwater supply bore.
40 Protection of aquifer integrity	
(1) <i>The Minister may declare that, in order to protect the integrity of the aquifers within this groundwater source, local access restrictions are to apply in a defined area known as a local impact area.</i>	The proposed Ivanhoe Rail Facility groundwater supply bore is not located within a local impact area, therefore clause 40 is not applicable to any dealing for the Ivanhoe Rail Facility groundwater supply bore.

4.8 CONSIDERATION OF THE DRAFT WATER SHARING PLAN FOR THE LACHLAN ALLUVIAL GROUNDWATER SOURCES 2019

Part 9 of the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019* relates to rules for granting water supply work approvals.

As noted in Section 2.5, the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019* is scheduled to commence on 1 July 2019. Notwithstanding, an assessment against the relevant provisions of Part 9 is provided in Table 6.

Table 6. Rules for Water Supply Work Approvals

Requirement	Assessment
40 - Rules to minimise interference between water supply works	
(2) A water supply work approval must not be granted or amended in the Lower Lachlan Groundwater Source if located within: (d) 400 metres of a water supply work located on another landholding that is authorised to take water from the same groundwater source for basic landholder rights only, or (e) 200 metres from the boundary of the landholding on which the water supply work is located, unless the owner of the landholding adjoining the boundary has provided consent in writing, or (f) 600 metres of a water supply work that is nominated by a local water utility access licence or a major utility access licence to take water from the same groundwater source, unless the holder of the local water utility access licence or major utility access licence has provided consent in writing, or (g) 500 metres of a Government observation or monitoring bore, or (h) 1,000 metres of a water supply work located on another landholding within the same groundwater source that is authorised to take up to and including 2,000 ML/year, or (i) 2,000 metres of a water supply work located on another landholding within the same groundwater source that is authorised to take between 2,000 ML/year and 3,000ML/year, or (j) 3,000 metres of a water supply work located on another landholding within the same groundwater source that is authorised to take over 3,000ML/yr	No water supply works are located within 600 m of the proposed Ivanhoe Rail Facility groundwater supply bore. The proposed Ivanhoe Rail Facility groundwater supply bore is not located within 200 m of the boundary of the relevant landholding (i.e. Lot 931, DP761988). No Government observation or monitoring bores are located within 500 m of the proposed Ivanhoe Rail Facility groundwater supply bore. No water supply works are located on another landholding within 3,000 m of the proposed Ivanhoe Rail Facility groundwater supply bore which are authorised to take up to 3,000 ML/yr or over.

Requirement	Assessment
41 Rules for water supply works located near contamination sources	
(1) A water supply work approval must not be granted or amended if the water supply work is located: (a) within 500 metres of a contamination source listed in Schedule 1, or (b) within 250 metres of the edge of a plume associated with a contamination source listed in Schedule 1, or (c) between 250 metres and 500 metres from the edge of a plume associated with a contamination source listed in Schedule 1, unless the Minister is satisfied that no drawdown will occur within 250 metres of that plume.	The proposed Ivanhoe Rail Facility groundwater supply bore is not located within 500 m of a contamination source or the plume associated with a contamination source listed in Schedule 1.
42 Rules for water supply works located near groundwater-dependent ecosystems	
(2) A water supply work approval must not be granted or amended for the following water supply works: (a) a water supply work that is located within 40 metres of the top of the high bank of a river, (b) a water supply work for basic landholder rights that is located within 100 metres of any other high priority groundwater-dependent ecosystem shown on the GDE Map, (c) a water supply work, other than solely for basic landholder rights, that is located within 200 metres of any other high priority groundwater-dependent ecosystem shown on the GDE Map	There is no river in the vicinity of the Ivanhoe Rail Facility groundwater supply bore. There are no high priority GDEs listed in the draft <i>Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019</i>.
43 Rules for water supply works located near groundwater-dependent culturally significant areas	
(1) A water supply work approval must not be granted or amended if located within: (a) 100 metres of a groundwater-dependent culturally significant area, for a water supply work that will be used take water for basic landholder rights only, or (b) 200 metres of a groundwater-dependent culturally significant area, for a water supply work that is intended to be nominated by an access licence.	There are no groundwater-dependent culturally significant areas listed in the draft <i>Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019</i>.

5 RECOMMENDED MANAGEMENT AND MONITORING PROGRAMME

5.1 GROUNDWATER MANAGEMENT PLAN

A Groundwater Management Plan has been prepared for the Project in accordance with Condition 26(f), Schedule 3 of Development Consent (SSD_5012). The Groundwater Management Plan includes:

- Groundwater assessment criteria and associated trigger levels;
- Groundwater monitoring program;
- Plan to respond to Groundwater assessment criteria exceedances; and
- Program to validate the groundwater model.

It is recommended that the Groundwater Management Plan be revised to incorporate the Ivanhoe Rail Facility groundwater supply bore.

5.2 MONITORING

The revised Groundwater Management Plan should include the following additional monitoring:

- Meteorological data from the existing Atlas-Campaspe Mine automated weather station and from the BOM site at Ivanhoe.
- Groundwater level at the Ivanhoe Rail Facility groundwater supply bore (quarterly).
- Groundwater quality (Electrical Conductivity (EC), pH, standard anions and cations, and metals) at the Ivanhoe Rail Facility groundwater supply bore (quarterly).

5.3 COMPENSATORY WATER SUPPLY

Conditions 25, Schedule 3 of Development Consent (SSD_5012) state the following:

Compensatory Water Supply

The Applicant shall provide a compensatory water supply to any landowner or leaseholder of privately-owned land whose water supply is adversely and directly impacted (other than an impact that is negligible) as a result of the development, in consultation with NOW, and the satisfaction of the Secretary.

The compensatory water supply measures must provide an alternative long term supply of water that is equivalent to the loss attributed to the development.

The extent of adverse impact on water supply must be investigated in accordance with the procedures outlined in Condition 4 of Schedule 5. The compensatory water supply measures must provide an alternative long term supply of water that is equivalent to the loss attributable to the project. Equivalent water supply should be provided (at least on an interim basis) within 24 hours of the loss being identified, unless otherwise agreed with the landowner/leaseholder.

If the Applicant and landowner/leaseholder cannot agree on the measures to be implemented, or there is a dispute about the implementation of these measures, then either party may refer the matter to the Secretary for resolution.

If the Applicant is unable to provide an alternative long term supply of water, then the Applicant shall provide alternative compensation to the satisfaction of the Secretary.

In the unlikely event that a leaseholder's water supply is adversely and directly impacted (other than an impact that is negligible) as a result of the Ivanhoe Rail Facility groundwater supply bore, Tronox would provide a compensatory water supply in accordance with Conditions 25, Schedule 3 of Development Consent (SSD_5012).

5.4 GROUNDWATER MODEL VALIDATION AND REVIEW

The groundwater model should be used as a management tool for the periodic review and calibration of predicted groundwater drawdown from the Ivanhoe Rail Facility groundwater supply bore during the life of the Project.

Revised outputs from the groundwater model will be reported periodically over the life of the Project. In the event that the actual groundwater drawdown levels exceed the predicted groundwater drawdown levels over the life of the Project, the groundwater model will be further refined using any new data available to characterise the aquifer system.

5.5 GROUNDWATER LICENSING

Tronox has obtained a total of 100 share components (units or million litres) in the Lower Lachlan Alluvium Groundwater Source of the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* for the Ivanhoe Rail Facility.

In accordance with Condition 24, Schedule 3 of Development Consent (SSD_5012), Tronox will hold sufficient water entitlements under the *NSW Water Management Act, 2000* for all stages of the Project.

6 GROUNDWATER MODEL LIMITATIONS

The predictive ability of groundwater modelling is generally related to the availability of geological and hydrogeological data (i.e. knowledge) of the area. Given the remote location of the site, substantial historic datasets are not available. Notwithstanding, sensitivity variations were modelled for conservative (i.e. maximum case) conditions (Section 3.5) to identify an envelope of maximum potential limit of impact. Given the conservative nature of the assessment undertaken in this report, the model accuracy is expected to be adequate for the required purpose of assessing the range of potential impacts surrounding the proposed Ivanhoe Rail Facility groundwater supply bore.

7 CONCLUSIONS

Tronox proposes to modify Development Consent (SSD_5012) for the Project to allow for changes to optimise the Project. The Modification would include the installation of a groundwater supply bore at the Ivanhoe Rail Facility that would provide up to approximately 60 ML/yr (1.9 L/s) over the Project life.

This Groundwater Review has assessed the potential groundwater impacts associated with the proposed Ivanhoe Rail Facility groundwater supply bore and concluded the following:

- The maximum predicted drawdown is low and is not significant beyond 100 m (i.e. predicted maximum drawdown 100 m from the bore is 2 cm);
- There is expected to be no significant change in groundwater quality as a result of the proposed groundwater bore;
- The closest groundwater bore to the proposed Ivanhoe Rail Facility bore is located approximately 2 km to the south-east and the drawdown at this bore due to the proposed IRF bore is predicted to be negligible;
- There are no GDEs present within the locality of the proposed Ivanhoe Rail Facility groundwater supply bore and therefore no impacts on GDEs are expected;
- There are no significant groundwater users in the vicinity of the proposed Ivanhoe Rail Facility groundwater supply bore and therefore no cumulative impacts are expected;
- The proposed IRF groundwater supply bore would have “minimal impact” as defined in the NSW AIP;
- The proposed Ivanhoe Rail Facility groundwater supply bore would meet relevant management of local impact considerations in Division 3 of Part 10 of the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003*;
- The proposed Ivanhoe Rail Facility groundwater supply bore would meet relevant rules for granting water supply work approvals in Part 9 of the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019*;
- Tronox has obtained a total of 100 share components (units or million litres) in the Lower Lachlan Alluvium Groundwater Source under the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* for the proposed Ivanhoe Rail Facility groundwater supply bore and therefore has adequate licences available to account for the proposed take of water associated with the Ivanhoe Rail Facility groundwater supply bore (i.e. 60 ML/yr); and

- It is recommended that the Groundwater Management Plan be revised to incorporate the Ivanhoe Rail Facility groundwater supply bore and include the following additional monitoring:
 - Meteorological data from the existing Atlas-Campaspe Mine automated weather station and from the BOM site at Ivanhoe.
 - Groundwater level at the Ivanhoe Rail Facility groundwater supply bore (quarterly).
 - Groundwater quality (EC, pH, standard anions and cations, and metals) at the Ivanhoe Rail Facility groundwater supply bore (quarterly).

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Attachment A

Ivanhoe Rail Facility Bore Census

ATLAS-CAMPASPE OPTIMISATION MODIFICATION

IVANHOE RAIL FACILITY GROUNDWATER BORE CENSUS REPORT



MAY 2019
Project No. CMA 18-07
Document No. Version 1
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1 INTRODUCTION

The Atlas-Campaspe Mineral Sands Project (the Project) operates in accordance with Development Consent (SSD_5012) issued under Part 4 of the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW, and approximately 270 km south-east of Broken Hill, NSW. The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km south-west of the township of Ivanhoe.

The Project is being developed by Tronox Mining Australia Limited, which acquired Cristal Mining Australia Limited in April 2019.

Tronox proposes to modify Development Consent (SSD_5012) for the Project to allow for changes to optimise the Project (herein referred to the Optimisation Modification or Modification). The Modification would, among other things, include the installation of a groundwater bore at the modified Ivanhoe Rail Facility.

This report presents the findings of a groundwater bore census conducted by Tronox for the area surrounding the Ivanhoe Rail Facility. The findings of the Bore Census will assist in understanding groundwater use within the vicinity of the Ivanhoe Rail Facility.

2 CENSUS AREA

The Bore Census Area consists of a 10 km radial buffer centred on the Ivanhoe Rail Facility (the Bore Census Area). The Bore Census Area covers approximately 314 square kilometres (km²).

The Bore Census Area includes the town of Ivanhoe, while the remainder of land in the Bore Census Area is dominated by agricultural land uses (predominantly grazing). Groundwater use within the Bore Census Area is understood to be sparse and primarily used for domestic and agricultural purposes.

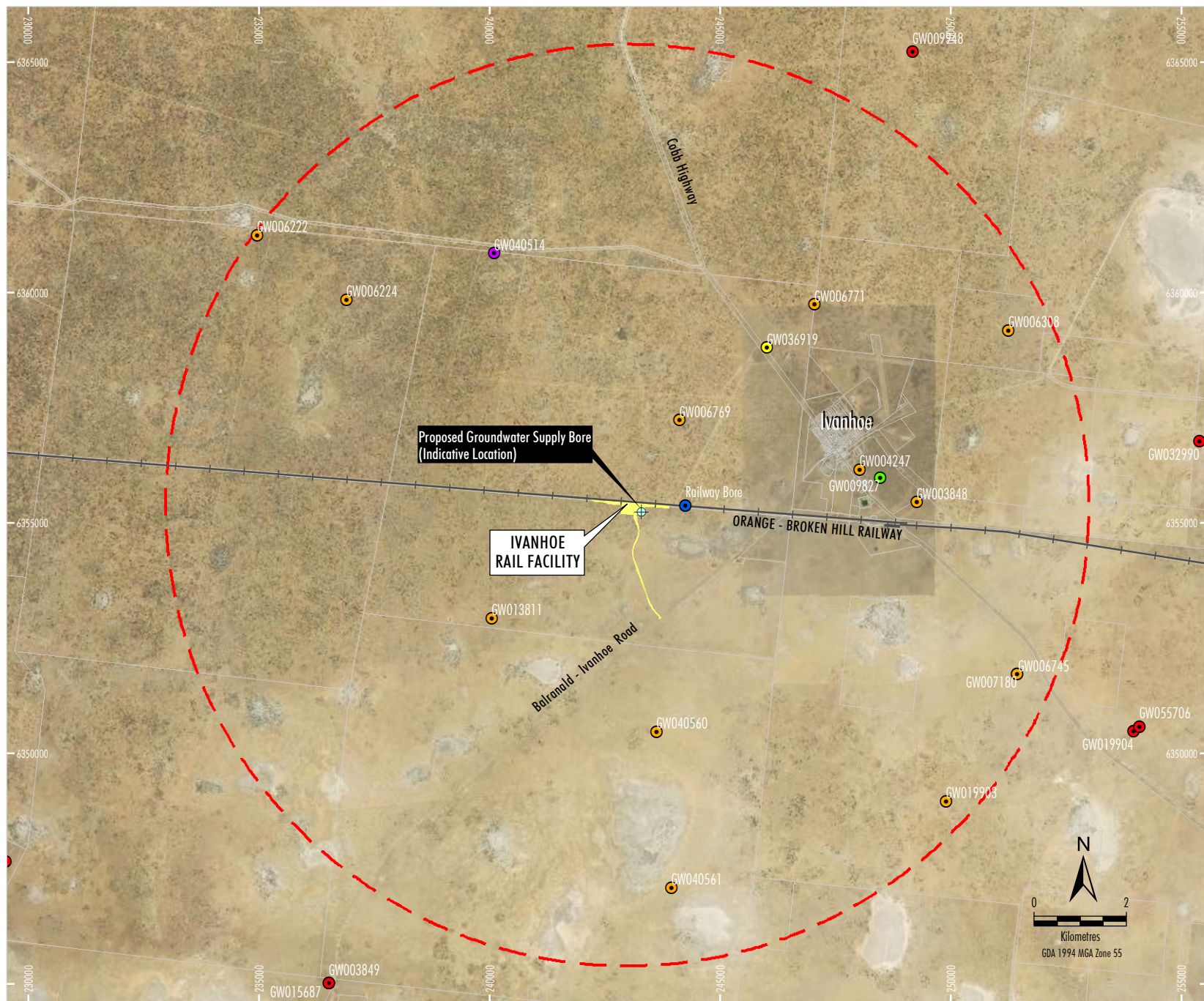
3 DESKTOP ANALYSIS

A desktop analysis was undertaken to identify any potential groundwater bores within the Bore Census Area. The sources of information reviewed for the desktop analysis are described in Sections 3.1–3.3. Potential groundwater bores identified during the desktop analysis are shown on Figure 1.

3.1 WATERNSW GROUNDWATER DATABASE

Registered groundwater bores within the Bore Census Area were identified through a search of the WaterNSW 'Real-time Data' database (WaterNSW, 2019) to provide a basis for consultation with relevant landholders and/or leaseholders in the Bore Census Area.

16 registered groundwater bores (Appendix A) were identified through the WaterNSW groundwater database within the Bore Census Area (Figure 1).



- LEGEND**
- Bore Census Area (10 km Buffer)
 - Modified Surface Development Area - Ivanhoe Rail Facility
- NSW Pineena Groundwater Database**
- Stock
 - Domestic
 - Monitoring
 - Irrigation
 - Groundwater Bore outside Bore Census Area
- Topographic Mapping**
- Potential Bore

Source: Tronox (2019), © NSW Department of Finance, Services & Innovation (2019), WaterNSW (2019).
 Orthophoto: © NSW Department of Finance, Services & Innovation (2019)

TRONOX
 OPTIMISATION MODIFICATION
 Potential Groundwater Bores
 Identified by Desktop Analysis

Figure 1

The following intended purposes were attributed to the registered groundwater bores in the Bore Census Area (Figure 1):

- Monitoring (one bore).
- Domestic (one bore).
- Irrigation (one bore).
- Stock (13 bores).

3.2 AERIAL IMAGERY AND TOPOGRAPHIC MAPPING

The Bore Census Area was investigated for infrastructure typically associated with groundwater bores such as windmills, wells and pumps, through an analysis of current and historical NSW Government Topographic Mapping (SIX Maps) (NSW Department of Finance Services and Innovation, 2019). Each identified location was then validated via high-resolution aerial imagery (Google Earth and Six Maps) to confirm the presence of a potential groundwater bore.

The Railway Bore (Figure 1) was identified on topographic mapping as a potential additional bore within the Bore Census Area. No registered bore details are available for the Railway Bore and no infrastructure could be located through aerial imagery. Further, consultation with the leaseholder (Richard Gates) did not indicate that the groundwater bore exists. For the purposes of this Bore Census, the Railway Bore is taken to not exist at the location shown on Figure 1, and is not referred to further in this report.

3.3 PREVIOUS REPORTS

It is understood that the Bore Census Area has not been subject to any recent groundwater studies.

4 CONSULTATION

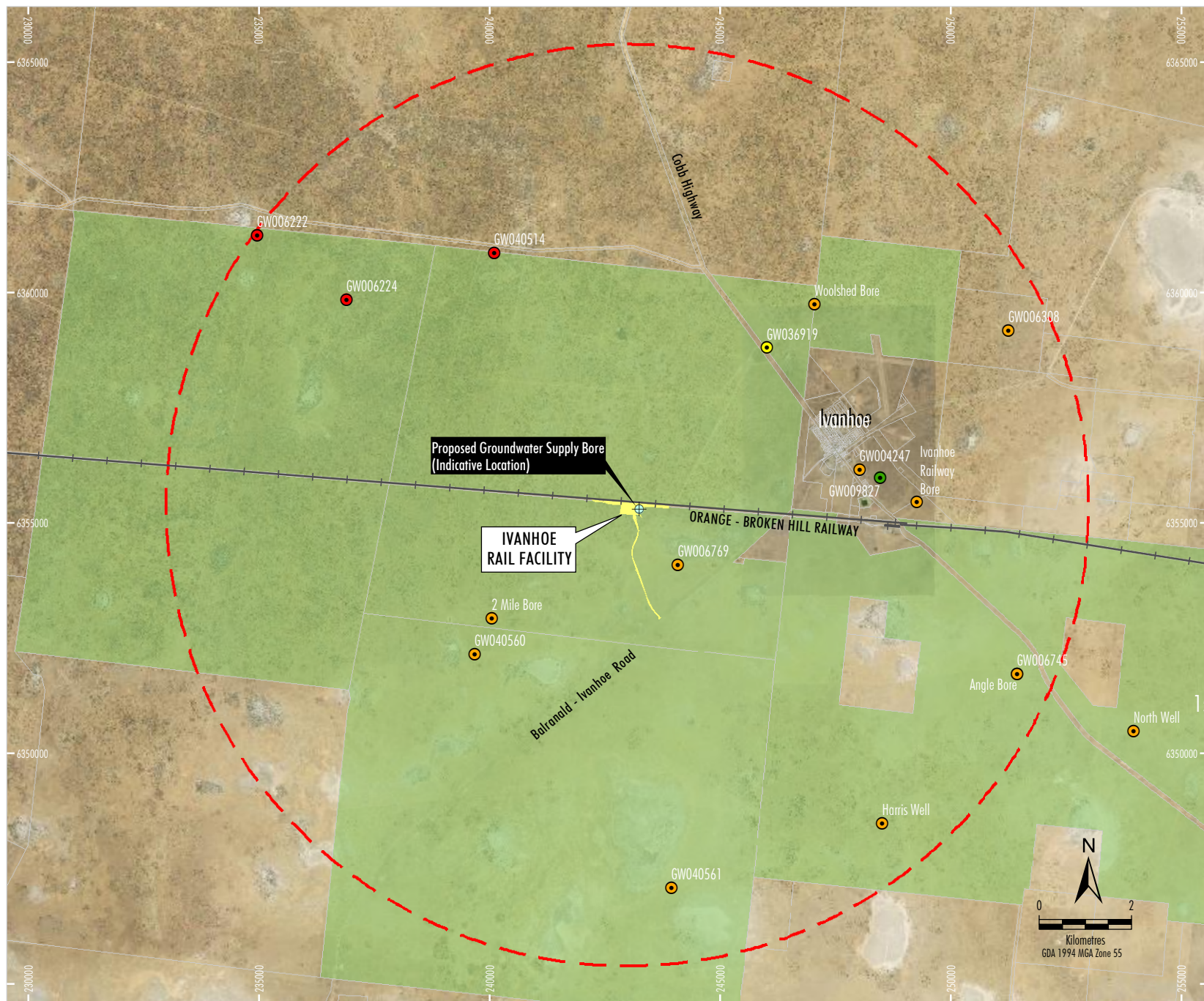
The leaseholders/landholders of the Lots/DP's within the Bore Census Area were identified through a tenure search to provide contact details for consultation purposes. Seven Lots/DP's containing registered groundwater bores were identified within the Bore Census Area. The leaseholders of four lots (Richard Gates and Gregory Turner) were contacted to validate the location of any groundwater bores identified on their properties from the desktop analysis (Section 3) and to provide any further information (i.e. depth to water, pumping rate, etc.) where possible.

The following landholders/leaseholders did not participate in the consultation process:

- Robert Newnham.
- The State of NSW.

Details of 10 of the 16 registered groundwater bores identified in the Bore Census Area were able to be verified through consultation with Richard Gates and Gregory Turner¹. Approximately 70% (219 km²) of the Bore Census Area was accounted for through consultation with the leaseholders (Figure 2). Details of six bores identified in the Bore Census Area (Section 3) were unable to be verified through consultation with the relevant landholders/leaseholders.

¹ Gregory Turner provided information on an additional two bores (namely GW019904 and GW055706) located outside the Bore Census Area (Appendices B and C). Gregory Turner also provided information on one bore (GW004247) located on land owned by the State of NSW.



- LEGEND**
- Bore Census Area (10 km Buffer)
 - Modified Surface Development Area - Ivanhoe Rail Facility
 - Leaseholder Consulted
- Groundwater Bore Intended Purpose**
- Stock
 - Domestic
 - Monitoring
 - Not In Use

Source: © NSW Department of Finance, Services & Innovation (2019), WaterNSW (2019).
 Orthophoto: © NSW Department of Finance, Services & Innovation (2019)

TRONOX
 OPTIMISATION MODIFICATION
 Ivanhoe Rail Facility Bore Census Results

Figure 2

5 BORE CENSUS RESULTS SUMMARY

A summary of the Bore Census findings are presented below. Detailed results are provided in Appendix C.

Through consultation with the relevant leaseholders, and the WaterNSW groundwater database (for bores that were not able to be verified with the relevant landholder/leaseholder), the 16 registered bores identified within the Bore Census Area were defined as either:

- in use (i.e. currently accessing groundwater) (13 bores); or
- not in use (i.e. not currently accessing groundwater or not capable of accessing groundwater i.e. collapsed) (three bores).

As described in Section 4, the details of six bores in the Bore Census Area were unable to be verified with the relevant landholder/leaseholder. This Bore Census conservatively assumes these bores are in use (Figure 2 and Appendix C). The Bore Census Database (Appendix C) therefore adopts the information from the relevant WaterNSW Works Summary for these six bores (Appendix A).

Of the 10 verified groundwater bores located in the Bore Census Area, the location of three groundwater bores was corrected during consultation and verified through aerial imagery (Sections 3.2 and 4), namely:

- GW006769;
- GW040560; and
- GW019903.

Information provided by the relevant leaseholders and/or WaterNSW Works Summaries indicated that the 13 groundwater bores defined as 'in-use' are drilled to the following depths:

- 30 – 50 meters below ground level (mbgl) (three bores)
- 51 – 70 mbgl (six bores)
- >71 mbgl (two bores)
- No depth recorded (two bores).

6 REFERENCES

WaterNSW (2019) *Real-time water data*.

Website: <https://realtimedata.watarnsw.com.au/>

Dates Accessed: 24 April to 8 May 2019

NSW Department of Finance Services and Innovation (2019) *Spatial Information Exchange (SIX Maps)*.

Website: <https://six.nsw.gov.au/content/about>

Dates Accessed: 24 April to 8 May 2019

APPENDIX A
WATERNSW WORKS SUMMARIES

WaterNSW
Work Summary

GW003848

Licence: Licence Status:
Authorised Purpose(s):
Intended Purpose(s): STOCK
Work Type: Bore open thru rock
Work Status:
Construct.Method: Cable Tool
Owner Type: Other Govt
Commenced Date:
Completion Date: 01/12/1943
Final Depth: 54.90 m
Drilled Depth: 54.90 m
Contractor Name: (None)
Driller:
Assistant Driller:
Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: 3001-7000 ppm
Yield (L/s):

Site Details

Site Chosen By:
County Form A: MOSSGIEL
Parish invalid code
Cadastre TS&CR 66171
Region: 70 - Lachlan
River Basin: 412 - LACHLAN RIVER
Area/District:
CMA Map: 7732
Grid Zone:
Scale:
Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6355456.000
Eastings: 249265.000
Latitude: 32°54'37.5"S
Longitude: 144°19'08.5"E
GS Map: -
MGA Zone: 55
Coordinate Source: GD,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.50	52.10	152			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
38.10	38.40	0.30	(Unknown)	30.50		0.10			
51.80	54.80	3.00	Consolidated	30.50		0.63			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.22	1.22	Driller	(Unknown)	
1.22	4.27	3.05	Clay	Clay	
4.27	6.10	1.83	Sandstone	Sandstone	
6.10	7.92	1.82	Sand	Sand	
7.92	9.75	1.83	Sand Hard	Sand	
9.75	12.19	2.44	Sandstone Soft	Sandstone	
12.19	13.72	1.53	Sandstone Solid	Sandstone	
13.72	17.68	3.96	Sand Coarse Dry	Sand	
17.68	21.34	3.66	Sand	Sand	
21.34	22.56	1.22	Sandstone	Sandstone	
22.56	28.65	6.09	Sand	Sand	
28.65	29.87	1.22	Sandstone	Sandstone	
29.87	33.22	3.35	Sand	Sand	
33.22	36.58	3.36	Pipe Clay	Clay	
36.58	38.10	1.52	Clay	Clay	
38.10	38.40	0.30	Sand Water Supply	Sand	
38.40	51.82	13.42	Clay	Clay	
51.82	54.86	3.04	Sandstone Soft Water Supply	Sandstone	

Remarks

30/06/1982: PWP 66 ADJACENT IVANHOE RAILWAYSTATION
02/11/1987: RAILWAY BORE IVANHOE

*** End of GW003848 ***

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WaterNSW

Work Summary

GW004247

Licence:

Licence Status:

Authorised Purpose(s):

Intended Purpose(s): STOCK

Work Type: Bore open thru rock

Work Status:

Construct.Method: Cable Tool

Owner Type: Private

Commenced Date:

Completion Date: 01/06/1909

Final Depth: 63.70 m

Drilled Depth: 63.70 m

Contractor Name: (None)

Driller:

Assistant Driller:

Property:

GWMA:

GW Zone:

Standing Water Level (m):

Salinity Description: Good Stock

Yield (L/s):

Site Details

Site Chosen By:

County

Parish

Cadastre

Form A: MOSSGIEL

Licensed:

invalid code

TSR 1418

Region: 70 - Lachlan

CMA Map: 7732

River Basin: 412 - LACHLAN RIVER

Grid Zone:

Scale:

Area/District:

Elevation: 0.00 m (A.H.D.)

Northing: 6356164.000

Latitude: 32°54'13.5"S

Elevation Source: (Unknown)

Easting: 248024.000

Longitude: 144°18'21.5"E

GS Map: -

MGA Zone: 55

Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	47.50	152			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
15.80	17.00	1.20	(Unknown)						
27.00	27.00	0.00	(Unknown)						
34.70	34.90	0.20	(Unknown)						
37.60	38.40	0.80	(Unknown)						
40.20	40.80	0.60	(Unknown)						
47.50	49.30	1.80	(Unknown)	26.20		0.63			
54.90	54.90	0.00	(Unknown)						

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.66	3.66	Clay Hard Gypsum	Clay	
3.66	4.57	0.91	Pebbles White Red	Gravel	
4.57	14.94	10.37	Sand White Very Fine Some Cemented Layers	Sand	
14.94	15.85	0.91	Sandstone Hard Cemented	Sandstone	
15.85	17.98	2.13	Drift Coarse Soak Water Supply	Sand	
17.98	24.99	7.01	Sand Drift Pink	Sand	
24.99	25.60	0.61	Clay Sandy	Clay	
25.60	26.82	1.22	Pipe Clay White	Clay	
26.82	26.97	0.15	Sand Drift Water Supply	Sand	
26.97	28.04	1.07	Clay Yellow Sandy	Clay	
28.04	30.78	2.74	Clay Yellow	Clay	
30.78	31.09	0.31	Ironstone Rusty Nodular	Ironstone	
31.09	32.92	1.83	Clay White Yellow	Clay	
32.92	34.44	1.52	Clay White	Clay	
34.44	34.90	0.46	Sand Drift Water Supply	Sand	
34.90	35.20	0.30	Sandstone Yellow Hard	Sandstone	
35.20	35.51	0.31	Clay Yellow Sandy	Clay	
35.51	36.12	0.61	Clay	Clay	
36.12	37.03	0.91	Clay White	Clay	
37.03	37.34	0.31	Sandstone Nodular	Sandstone	
37.34	37.64	0.30	Sand Drift	Sand	
37.64	40.69	3.05	Clay Sandy	Clay	
40.69	40.84	0.15	Sand Drift Water Supply	Sand	
40.84	41.15	0.31	Stones Hard Nodular	Gravel	
41.15	43.89	2.74	Clay Sandy	Clay	
43.89	44.50	0.61	Clay	Clay	
44.50	45.11	0.61	Pipe Clay	Clay	
45.11	47.55	2.44	Pipe Clay White	Clay	
47.55	49.38	1.83	Sand Drift Water Supply	Sand	
49.38	49.99	0.61	Clay White	Clay	
49.99	54.86	4.87	Sand Drift	Sand	
54.86	59.13	4.27	Clay Sandy Some Very Hard Water Supply	Clay	
59.13	60.05	0.92	Clay Sandy	Clay	
60.05	61.26	1.21	Clay White	Clay	
61.26	63.70	2.44	Clay Dark Blue	Clay	

Remarks

09/05/1979: ADJACENT IVANHOE ASTRON. STATION
09/05/1979: ABADONED HOLE CLOSEBY WITH CASSTUCK IN SWELLING CLAY

*** End of GW004247 ***

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WaterNSW

Work Summary

GW006222

Licence:

Licence Status:

Authorised Purpose(s):

Intended Purpose(s): STOCK

Work Type: Bore

Work Status:

Construct.Method: Cable Tool

Owner Type: Private

Commenced Date:

Completion Date: 01/08/1937

Final Depth: 32.60 m

Drilled Depth: 32.60 m

Contractor Name: (None)

Driller:

Assistant Driller:

Property:

Standing Water Level (m):

GWMA:

Salinity Description: Poor Stock

GW Zone:

Yield (L/s):

Site Details

Site Chosen By:

County

Form A: MANARA

Parish

Cadastre

Licensed:

invalid code

WLL 2851

Region: 70 - Lachlan

CMA Map: 7732

River Basin: 412 - LACHLAN RIVER

Grid Zone:

Scale:

Area/District:

Elevation: 0.00 m (A.H.D.)

Northing: 6361248.000

Latitude: 32°51'17.5"S

Elevation Source: (Unknown)

Easting: 234962.000

Longitude: 144°10'04.5"E

GS Map: -

MGA Zone: 55

Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	30.50	152			
1	1	Opening	Screen	29.60	32.60			1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
27.40	27.40	0.00	(Unknown)	19.20		0.86			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.61	0.61	Loam Red	Loam	
0.61	5.49	4.88	Clay Light Reddish	Clay	
5.49	6.71	1.22	Clay Grey Gypsum	Clay	
6.71	8.23	1.52	Clay Light Yellow	Clay	
8.23	9.14	0.91	Clay White Hard Slippery	Clay	
9.14	10.97	1.83	Clay Grey Hard Crumbly	Clay	

10.97	14.63	3.66	Sandstone Grey	Sandstone	
14.63	17.98	3.35	Clay Light Yellow	Clay	
17.98	19.20	1.22	Sand White	Sand	
19.20	20.12	0.92	Sandstone	Sandstone	
20.12	20.73	0.61	Clay Yellow	Clay	
20.73	21.95	1.22	Clay Dark Coloured	Clay	
21.95	22.56	0.61	Clay Light Yellow Sandy	Clay	
22.56	27.43	4.87	Sand Yellow Fine	Sand	
27.43	32.61	5.18	Drift Yellow Fine Water Supply	Invalid Code	
32.61	32.63	0.02	Clay Yellow Hard	Clay	

*** End of GW006222 ***

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WaterNSW

Work Summary

GW006224

Licence:

Licence Status:

Authorised Purpose(s):

Intended Purpose(s): STOCK

Work Type: Bore

Work Status:

Construct.Method: Cable Tool

Owner Type: Private

Commenced Date:

Completion Date: 01/07/1937

Final Depth: 86.30 m

Drilled Depth: 86.30 m

Contractor Name: (None)

Driller:

Assistant Driller:

Property:

Standing Water Level (m):

GWMA:

Salinity Description: Stock

GW Zone:

Yield (L/s):

Site Details

Site Chosen By:

County

Form A: MANARA

Parish

Cadastre

Licensed:

invalid code

WLL 2851

Region: 70 - Lachlan

CMA Map: 7732

River Basin: 412 - LACHLAN RIVER

Grid Zone:

Scale:

Area/District:

Elevation: 0.00 m (A.H.D.)

Northing: 6359850.000

Latitude: 32°52'04.5"S

Elevation Source: (Unknown)

Easting: 236899.000

Longitude: 144°11'17.5"E

GS Map: -

MGA Zone: 55

Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	83.80	152			
1	1	Opening	Screen	83.20	86.20	76		1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
27.40	27.40	0.00	Unconsolidated						
39.60	39.60	0.00	Unconsolidated						
74.10	74.10	0.00	Unconsolidated						
86.30	86.30	0.00	Unconsolidated	26.80		0.82			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.91	0.91	Loam Red	Loam	
0.91	4.57	3.66	Clay Light Grey	Clay	
4.57	9.75	5.18	Sand White Coarse	Sand	

9.75	10.97	1.22	Clay Light Grey Soft	Clay	
10.97	12.80	1.83	Sandstone Hard	Sandstone	
12.80	14.33	1.53	Clay Black Yellow Dark Sandy	Clay	
14.33	17.07	2.74	Clay Light Grey Yellow	Clay	
17.07	18.29	1.22	Clay White Sandy	Clay	
18.29	21.34	3.05	Clay Yellow	Clay	
21.34	23.16	1.82	Sand Red	Sand	
23.16	27.43	4.27	Clay Yellow	Clay	
27.43	32.00	4.57	Clay Purple Water Bearing	Clay	
32.00	32.61	0.61	Clay White	Clay	
32.61	34.14	1.53	Clay Grey Crumbly	Clay	
34.14	36.27	2.13	Clay Red	Clay	
36.27	36.88	0.61	Clay Black White Red	Clay	
36.88	37.80	0.92	Clay White Soft	Clay	
37.80	39.62	1.82	Drift White	Invalid Code	
39.62	51.82	12.20	Drift Red Water Bearing	Invalid Code	
51.82	54.86	3.04	Drift Yellow	Invalid Code	
54.86	60.96	6.10	Sand Grey Coarse	Sand	
60.96	61.87	0.91	Clay White Soft	Clay	
61.87	62.48	0.61	Clay Light Grey	Clay	
62.48	74.07	11.59	Drift White Coarse Water Bearing	Invalid Code	
74.07	79.25	5.18	Clay Soft Light Coloured	Clay	
79.25	82.30	3.05	Clay White Drift	Clay	
82.30	86.26	3.96	Drift White Fine Water Supply	Invalid Code	
0.00	0.91	0.91	Clay Green Yellow	Clay	

*** End of GW006224 ***

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WaterNSW

Work Summary

GW006308

Licence:

Licence Status:

Authorised Purpose(s):

Intended Purpose(s): STOCK

Work Type: Bore

Work Status: Supply Obtained

Construct.Method: Cable Tool

Owner Type: Private

Commenced Date:

Completion Date: 01/01/1938

Final Depth: 54.90 m

Drilled Depth: 54.90 m

Contractor Name: (None)

Driller:

Assistant Driller:

Property:

GWMA:

GW Zone:

Standing Water Level (m):

Salinity Description: 10001-14000 ppm

Yield (L/s):

Site Details

Site Chosen By:

County

Parish

Cadastre

Form A: MOSSGIEL

invalid code

WLL 6614

Licensed:

Region: 70 - Lachlan

CMA Map: 7732

River Basin: 412 - LACHLAN RIVER

Grid Zone:

Scale:

Area/District:

Elevation: 0.00 m (A.H.D.)

Northing: 6359174.000

Latitude: 32°52'38.5"S

Elevation Source: (Unknown)

Easting: 251251.000

Longitude: 144°20'28.5"E

GS Map: -

MGA Zone: 55

Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	54.90	127			
1	1	Opening	Screen	51.80	54.80			1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
44.20	44.20	0.00	Unconsolidated						
53.30	54.80	1.50	(Unknown)	35.10					

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	6.10	6.10	Loam	Loam	
6.10	42.67	36.57	Sand Red Coarse	Sand	
42.67	44.20	1.53	Sandstone White	Sandstone	
44.20	50.29	6.09	Clay Red White Water Bearing	Clay	
50.29	53.34	3.05	Clay White	Clay	

53.34	54.86	1.52	Drift Fine Water Bearing	Invalid Code	
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*** End of GW006308 ***

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WaterNSW

Work Summary

GW006745

Licence:	Licence Status:
	Authorised Purpose(s): Intended Purpose(s): STOCK
Work Type: Bore	
Work Status:	
Construct.Method: Cable Tool	
Owner Type: Private	
Commenced Date:	Final Depth: 41.10 m
Completion Date: 01/11/1940	Drilled Depth: 41.20 m
Contractor Name: (None)	
Driller:	
Assistant Driller:	
Property:	Standing Water Level (m):
GWMA:	Salinity Description: 3001-7000 ppm
GW Zone:	Yield (L/s):

Site Details

Site Chosen By:			
	County Form A: MOSSGIEL Licensed:	Parish invalid code	Cadastre WLL 283
Region: 70 - Lachlan	CMA Map: 7732		
River Basin: 412 - LACHLAN RIVER Area/District:	Grid Zone:	Scale:	
Elevation: 0.00 m (A.H.D.) Elevation Source: (Unknown)	Northing: 6351719.000 Easting: 251439.000	Latitude: 32°56'40.5"S Longitude: 144°20'28.5"E	
GS Map: -	MGA Zone: 55	Coordinate Source: GD.,ACC.MAP	

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	39.00	127			
1	1	Opening	Screen	35.10	38.10			1	Copper Alloy

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.30	0.30	Soil Gibbers	Soil	
0.30	1.83	1.53	Clay	Clay	
1.83	2.44	0.61	Clay Sandy	Clay	
2.44	25.60	23.16	Sandstone Gravel	Sandstone	
25.60	32.61	7.01	Sandstone	Sandstone	
32.61	32.92	0.31	Clay Sandy	Clay	
32.92	35.05	2.13	Clay	Clay	
35.05	38.71	3.66	Drift Clay Bands Water Bearing	Invalid Code	
38.71	41.15	2.44	Drift Water Supply	Invalid Code	

Remarks

30/06/1982: WHEN YIELD DROPPED IN 1944 R/C ATTEMPT ABAND DVE SCRIN

***** End of GW006745 *****

Warning To Clients: This raw data has been supplied to the NSW Office of Water by drillers, licensees and other sources. The NOW does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

WaterNSW
Work Summary

GW006769

Licence: Licence Status:
Authorised Purpose(s): Intended Purpose(s): STOCK
Work Type: Bore
Work Status: Needs Reconditioning
Construct.Method: Cable Tool
Owner Type: Private
Commenced Date: Completion Date: 01/01/1941
Final Depth: 46.90 m
Drilled Depth: 80.20 m
Contractor Name: (None)
Driller:
Assistant Driller:
Property: GWMA: GW Zone:
Standing Water Level (m): Salinity Description: Salty
Yield (L/s):

Site Details

Site Chosen By:
County Form A: MANARA Licensed:
Parish invalid code
Cadastre WLL 3339
Region: 70 - Lachlan
River Basin: 412 - LACHLAN RIVER Area/District:
CMA Map: 7732
Grid Zone: Scale:
Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6357235.000 Easting: 244122.000
Latitude: 32°53'35.5"S Longitude: 144°15'52.5"E
GS Map: - MGA Zone: 55 Coordinate Source: GD,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	46.90	80.10	127			
1	1	Casing	Withdrawn	0.00	0.00	127			
1	1	Casing	Threaded Steel	0.00	46.90	152			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
46.90	46.90	0.00	Unconsolidated						
53.60	56.00	2.40	Unconsolidated						
64.60	65.20	0.60	Unconsolidated						
70.10	70.70	0.60	Unconsolidated						
73.80	74.40	0.60	Unconsolidated						
80.20	80.20	0.00	(Unknown)	28.00					

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	46.94	46.94	Water Bearing	(Unknown)	
46.94	48.16	1.22	Clay Sandy	Clay	
48.16	53.64	5.48	Clay	Clay	
53.64	56.08	2.44	Drift Water Bearing	Invalid Code	
56.08	59.13	3.05	Clay Very Sandy	Clay	
59.13	64.62	5.49	Clay	Clay	
64.62	65.23	0.61	Clay Porous Water Bearing	Clay	
65.23	70.10	4.87	Clay	Clay	
70.10	70.71	0.61	Clay Porous Water Bearing	Clay	
70.71	73.76	3.05	Clay Sandy	Clay	
73.76	74.37	0.61	Sandstone Water Bearing Wash	Sandstone	
74.37	79.55	5.18	Clay Very Sandy	Clay	
79.55	80.16	0.61	Clay	Clay	
80.16	80.18	0.02	Drift Water Bearing	Invalid Code	

Remarks

30/06/1982: R/C 23/1/42-DEEPENED TO 80.2M-WATER WORSE-SEE CAS 2&3

*** End of GW006769 ***

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WaterNSW

Work Summary

GW006771

Licence:

Licence Status:

Authorised Purpose(s):

Intended Purpose(s): STOCK

Work Type: Bore

Work Status:

Construct.Method: Cable Tool

Owner Type: Private

Commenced Date:

Completion Date: 01/02/1942

Final Depth: 53.00 m

Drilled Depth: 53.00 m

Contractor Name: (None)

Driller:

Assistant Driller:

Property:

GWMA:

GW Zone:

Standing Water Level (m):

Salinity Description: Good

Yield (L/s):

Site Details

Site Chosen By:

County

Form A: MOSSGIEL

Parish

Cadastre

Licensed:

invalid code

WLL 4578

Region: 70 - Lachlan

CMA Map: 7732

River Basin: 412 - LACHLAN RIVER

Grid Zone:

Scale:

Area/District:

Elevation: 0.00 m (A.H.D.)

Northing: 6359746.000

Latitude: 32°52'16.5"S

Elevation Source: (Unknown)

Easting: 247048.000

Longitude: 144°17'47.5"E

GS Map: -

MGA Zone: 55

Coordinate Source: GD,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	53.00	127			
1	1	Opening	Screen	51.50	53.00	76		1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
38.40	38.40	0.00	(Unknown)			0.04			
40.80	40.80	0.00	Consolidated			0.06			
53.00	53.00	0.00	(Unknown)	35.10					

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.30	0.30	Soil Clayey	Soil	
0.30	1.22	0.92	Clay Kopi (copi)	Clay	
1.22	2.74	1.52	Clay	Clay	
2.74	4.57	1.83	Clay Pebbles/pebbly	Clay	
4.57	7.01	2.44	Clay Gravel	Clay	
7.01	20.73	13.72	Sandstone	Sandstone	
20.73	23.16	2.43	Clay	Clay	
23.16	27.13	3.97	Clay Sandy	Clay	
27.13	28.65	1.52	Sandstone	Sandstone	
28.65	33.53	4.88	Sandstone Clayey	Sandstone	
33.53	38.10	4.57	Clay	Clay	
38.10	38.40	0.30	Sandstone	Sandstone	
38.40	40.23	1.83	Clay Sandy	Clay	
40.23	40.84	0.61	Sandstone Water Supply	Sandstone	
40.84	44.20	3.36	Clay Sandy	Clay	
44.20	49.38	5.18	Clay	Clay	
49.38	53.04	3.66	Drift Water Supply	Invalid Code	

*** End of GW006771 ***

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WaterNSW

Work Summary

GW007180

Licence:	Licence Status:
	Authorised Purpose(s): Intended Purpose(s): STOCK
Work Type: Bore	
Work Status:	
Construct.Method: Cable Tool	
Owner Type: Private	
Commenced Date:	Final Depth: 47.90 m
Completion Date: 01/02/1946	Drilled Depth: 47.90 m
Contractor Name: (None)	
Driller:	
Assistant Driller:	
Property:	Standing Water Level (m):
GWMA:	Salinity Description: Good Stock
GW Zone:	Yield (L/s):

Site Details

Site Chosen By:			
	County Form A: MOSSGIEL Licensed:	Parish invalid code	Cadastre WLL 283
Region: 70 - Lachlan	CMA Map: 7732		
River Basin: 412 - LACHLAN RIVER Area/District:	Grid Zone:	Scale:	
Elevation: 0.00 m (A.H.D.) Elevation Source: (Unknown)	Northing: 6351719.000 Easting: 251439.000	Latitude: 32°56'40.5"S Longitude: 144°20'28.5"E	
GS Map: -	MGA Zone: 55	Coordinate Source: GD.,ACC.MAP	

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.30	44.80	127			Suspended in Clamps
1	1	Opening	Screen	44.80	47.80			1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
37.90	38.10	0.20	(Unknown)						
44.80	44.80	0.00	(Unknown)	28.30		0.38			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	6.10	6.10	Loam	Loam	
6.10	13.72	7.62	Sand Dry Coarse	Sand	
13.72	16.76	3.04	Sandstone Grey	Sandstone	
16.76	18.29	1.53	Sand Dry Coarse	Sand	
18.29	19.20	0.91	Sandstone	Sandstone	

19.20	19.81	0.61	Clay White Sand Seams	Clay	
19.81	22.25	2.44	Sandstone White	Sandstone	
22.25	34.44	12.19	Sand Dry Very Coarse	Sand	
34.44	35.05	0.61	Clay Grey	Clay	
35.05	37.49	2.44	Clay Yellow	Clay	
37.49	37.95	0.46	Clay White	Clay	
37.95	38.10	0.15	Drift Water Bearing	Invalid Code	
38.10	38.40	0.30	Clay Grey	Clay	
38.40	42.98	4.58	Sand Clay Bands	Sand	
42.98	47.85	4.87	Sand Drift Water Supply	Sand	

*** End of GW007180 ***

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WaterNSW

Work Summary

GW009827

Licence:

Licence Status:

Authorised Purpose(s):

Intended Purpose(s): DOMESTIC

Work Type: Bore

Work Status:

Construct.Method: Cable Tool

Owner Type: Private

Commenced Date:

Completion Date: 01/08/1951

Final Depth: 46.90 m

Drilled Depth: 46.90 m

Contractor Name: (None)

Driller:

Assistant Driller:

Property:

GWMA:

GW Zone:

Standing Water Level (m):

Salinity Description: Fair

Yield (L/s):

Site Details

Site Chosen By:

County

Parish

Cadastre

Form A: MOSSGIEL

invalid code

TS&CR 9781

Region: 70 - Lachlan

CMA Map: 7732

River Basin: 412 - LACHLAN RIVER

Grid Zone:

Scale:

Area/District:

Latitude: 32°54'19.5"S

Elevation: 0.00 m (A.H.D.)

Eastng: 248471.000

Elevation Source: (Unknown)

Longitude: 144°18'38.5"E

GS Map: -

MGA Zone: 55

Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.30	43.00	127			
1	1	Opening	Screen	43.00	46.00	89		1	Copper Alloy

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
30.50	32.30	1.80	(Unknown)	30.50					
40.20	42.30	2.10	(Unknown)	30.50					
45.70	46.90	1.20	(Unknown)	30.50		0.38			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.66	3.66	Loam	Loam	
3.66	7.62	3.96	Clay	Clay	
7.62	10.36	2.74	Sandstone Limestone	Sandstone	
10.36	13.41	3.05	Sandstone Clay Bands	Sandstone	
13.41	28.65	15.24	Sand Dry Gravel	Sand	
28.65	35.66	7.01	Sand Drift Clay Bands Water Bearing	Sand	
35.66	46.02	10.36	Clay Sandy Bands Water Supply	Clay	
46.02	46.94	0.92	Drift Water Supply	Invalid Code	
0.00	3.66	3.66	Limestone Stones	Limestone	
3.66	7.62	3.96	Ironstone Rock	Ironstone	

*** End of GW009827 ***

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WaterNSW

Work Summary

GW013811

Licence:

Licence Status:

Authorised Purpose(s):

Intended Purpose(s): STOCK

Work Type: Bore

Work Status:

Construct.Method: Cable Tool

Owner Type: Private

Commenced Date:

Completion Date: 01/01/1959

Final Depth: 51.80 m

Drilled Depth: 51.80 m

Contractor Name: (None)

Driller:

Assistant Driller:

Property:

GWMA:

GW Zone:

Standing Water Level (m):

Salinity Description: Stock

Yield (L/s):

Site Details

Site Chosen By:

County

Form A: MANARA

Parish

Cadastre

Licensed:

invalid code

WLL 3339

Region: 70 - Lachlan

CMA Map: 7732

River Basin: 412 - LACHLAN RIVER

Grid Zone:

Scale:

Area/District:

Elevation: 0.00 m (A.H.D.)

Northing: 6352935.000

Latitude: 32°55'51.5"S

Elevation Source: (Unknown)

Easting: 240047.000

Longitude: 144°13'11.5"E

GS Map: -

MGA Zone: 55

Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.30	51.20	127			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
29.90	30.20	0.30	Unconsolidated	28.00		0.13			
32.00	32.30	0.30	Unconsolidated	28.00		0.13			
37.80	38.10	0.30	Consolidated	28.00		0.13			
40.80	42.30	1.50	Unconsolidated	27.40		0.25			
50.90	51.80	0.90	(Unknown)	27.40		0.63			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.05	3.05	Clay Red	Clay	
3.05	3.35	0.30	Gypsum	Gypsum	
3.35	25.60	22.25	Clay Grey Sand	Clay	
25.60	28.96	3.36	Clay Yellow	Clay	
28.96	29.87	0.91	Clay Yellow Sand	Clay	
29.87	30.18	0.31	Clay Sand Water Supply	Clay	
30.18	32.00	1.82	Clay Yellow Sand	Clay	
32.00	32.31	0.31	Clay Sand Water Supply	Clay	
32.31	35.36	3.05	Clay Yellow Sand	Clay	
35.36	36.58	1.22	Clay Yellow	Clay	
36.58	37.80	1.22	Clay Yellow Sand	Clay	
37.80	38.10	0.30	Sandstone Grey Water Supply	Sandstone	
38.10	39.62	1.52	Drift Grey	Invalid Code	
39.62	40.84	1.22	Clay Yellow	Clay	
40.84	42.37	1.53	Drift Grey Water Supply	Invalid Code	
42.37	50.29	7.92	Clay Yellow	Clay	
50.29	50.90	0.61	Sandstone Yellow	Sandstone	
50.90	51.82	0.92	Sandstone Drift Water Supply	Sandstone	

*** End of GW013811 ***

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WaterNSW

Work Summary

GW019903

Licence:	Licence Status:
	Authorised Purpose(s): Intended Purpose(s): STOCK
Work Type: Bore	
Work Status:	
Construct.Method: Cable Tool	
Owner Type: Private	
Commenced Date:	Final Depth: 55.80 m
Completion Date: 01/06/1962	Drilled Depth: 55.80 m
Contractor Name: (None)	
Driller:	
Assistant Driller:	
Property:	Standing Water Level (m):
GWMA:	Salinity Description:
GW Zone:	Yield (L/s):

Site Details

Site Chosen By:			
	County Form A: MOSSGIEL Licensed:	Parish invalid code	Cadastre WLL 283
Region: 70 - Lachlan	CMA Map: 7732		
River Basin: 412 - LACHLAN RIVER Area/District:	Grid Zone:	Scale:	
Elevation: 0.00 m (A.H.D.) Elevation Source: (Unknown)	Northing: 6348967.000 Easting: 249898.000	Latitude: 32°58'08.5"S Longitude: 144°19'26.5"E	
GS Map: -	MGA Zone: 55	Coordinate Source: PR.,ACC.MAP	

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.30	53.20	152			Suspended in Clamps
1	1	Opening	Screen	52.10	54.80	102		1	A: 0.25mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
39.60	55.10	15.50	(Unknown)	29.30		0.94			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.91	0.91	Sand	Sand	
0.91	3.35	2.44	Clay Grey	Clay	
3.35	4.27	0.92	Gravel	Gravel	
4.27	16.76	12.49	Sand	Sand	
16.76	18.29	1.53	Sandstone	Sandstone	
18.29	39.62	21.33	Clay	Clay	

39.62	55.17	15.55	Sand Water Supply	Sand	
55.17	55.47	0.30	Clay	Clay	
55.47	55.78	0.31	Sand	Sand	

Remarks

30/06/1982: 1M OF STONES PLACED IN BASE OF HOLE

*** End of GW019903 ***

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WaterNSW

Work Summary

GW019904

Licence:	Licence Status:
Authorised Purpose(s): Intended Purpose(s): STOCK	
Work Type: Bore	
Work Status:	
Construct.Method: Cable Tool	
Owner Type: Private	
Commenced Date:	Final Depth: 49.40 m
Completion Date: 01/06/1962	Drilled Depth: 49.40 m
Contractor Name: (None)	
Driller:	
Assistant Driller:	
Property:	Standing Water Level (m):
GWMA:	Salinity Description:
GW Zone:	Yield (L/s):

Site Details

Site Chosen By:			
County		Parish	Cadastre
Form A: MOSSGIEL	invalid code	WLL 283	
Licensed:			
Region: 70 - Lachlan		CMA Map: 7732	
River Basin: 425 - DARLING RIVER	Grid Zone:	Scale:	
Area/District:			
Elevation: 0.00 m (A.H.D.)	Northing: 6350488.000	Latitude: 32°57'22.5"S	
Elevation Source: (Unknown)	Easting: 253965.000	Longitude: 144°22'04.5"E	
GS Map: -	MGA Zone: 55	Coordinate Source: PR.,ACC.MAP	

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	46.30	152			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
43.60	43.60	0.00	Unconsolidated						
46.30	46.30	0.00	Unconsolidated	32.00		0.76			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.91	0.91	Topsoil	Topsoil	
0.91	5.49	4.58	Clay Red	Clay	
5.49	13.41	7.92	Clay Grey	Clay	
13.41	32.31	18.90	Clay Sandy	Clay	
32.31	41.45	9.14	Clay	Clay	
41.45	41.76	0.31	Sand	Sand	

41.76	49.38	7.62	Clay	Clay	
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*** End of GW019904 ***

Warning To Clients: This raw data has been supplied to the NSW Office of Water by drillers, licensees and other sources. The NOW does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

WaterNSW
Work Summary

GW036919

Licence: Licence Status:
Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE
Work Type: Bore - Nested (2)
Work Status: Manual Observations,Monthly
Construct.Method: Rotary Mud
Owner Type: NSW Office of Water
Commenced Date: Final Depth: 95.00 m
Completion Date: 20/08/1991 Drilled Depth:
Contractor Name: DWR GROUNDWATER DRILLING
Driller: Gerard Anthony Smit
Assistant Driller:
Property: Standing Water Level (m): 30.360
GWMA: Salinity Description:
GW Zone: Yield (L/s): 1.500

Site Details

Site Chosen By:
County: MANARA
Parish: YELTY
Cadastre: 931/761988
Form A: Licensed:
Region: 85 - Far West
CMA Map: 7732
River Basin: 412 - LACHLAN RIVER
Grid Zone: Scale:
Area/District:
Elevation: 89.33 m (A.H.D.)
Northing: 6358808.000
Latitude: 32°52'46.1"S
Elevation Source: (unknown) Easting: 246017.000 Longitude: 144°17'06.9"E
GS Map: - MGA Zone: 55 Coordinate Source: Surveyed

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	52.00	200			Rotary Mud
1		Annulus	Waterworn/Rounded	0.00	52.00	200	100		Q:1.000m3
1		Backfill	Backfill	51.00	52.00	200			
1	1	Casing	Steel	-1.20	1.80	200			Cemented, Driven into Hole
1	1	Casing	Pvc Class 12	-1.00	51.00	100			
1	1	Opening	Slots - Diagonal	39.00	45.00	100		1	Sawn, PVC Class 12, SL: 200.0mm, A: 1.50mm
2		Hole	Hole	0.00	92.00	200			Rotary Mud
2		Hole	Hole	92.00	95.00	100			Other
2		Annulus	Waterworn/Rounded	40.00	95.00	100			Q:2.000m3
2		Backfill	Backfill	76.00	95.00				
2	2	Casing	Steel	-1.20	1.80	200			Cemented
2	2	Casing	Pvc Class 12	-1.00	76.00	100			
2	2	Opening	Slots - Diagonal	58.00	70.00	100		2	Sawn, PVC Class 12, SL: 200.0mm, A: 1.50mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
39.00	45.00	6.00	Unknown	30.56		0.50			
58.00	70.00	12.00	Unknown	30.36		1.50			

Remarks

13/10/2008: Nat Carling, 13-Oct-2008: Updated RL's & coordinates, based in info provided in State Water Survey database, provided by Jim Salmon.
31/03/2011: Karla Abbs, 31-Mar-2011: Entered geology log

*** End of GW036919 ***

Warning To Clients: This raw data has been supplied to the NSW Office of Water by drillers, licensees and other sources. The NOW does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

WaterNSW

Work Summary

GW040514

Licence:	Licence Status:
	Authorised Purpose(s): Intended Purpose(s): IRRIGATION
Work Type: Bore	
Work Status:	
Construct.Method:	
Owner Type:	
Commenced Date:	Final Depth:
Completion Date:	Drilled Depth:
Contractor Name: (None)	
Driller:	
Assistant Driller:	
Property:	Standing Water Level (m):
GWMA:	Salinity Description:
GW Zone:	Yield (L/s):

Site Details

Site Chosen By:			
	County Form A: MANARA Licensed:	Parish invalid code	Cadastre WLL 3339
Region: 70 - Lachlan	CMA Map: 7732		
River Basin: 412 - LACHLAN RIVER Area/District:	Grid Zone:	Scale:	
Elevation: 0.00 m (A.H.D.) Elevation Source: (Unknown)	Northing: 6360860.000 Easting: 240099.000	Latitude: 32°51'34.5"S Longitude: 144°13'21.5"E	
GS Map: -	MGA Zone: 55	Coordinate Source: GD.,ACC.MAP	

Remarks

06/11/2009: Reviewed data - nothing to update.

*** End of GW040514 ***

Warning To Clients: This raw data has been supplied to the NSW Office of Water by drillers, licensees and other sources. The NOW does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

WaterNSW

Work Summary

GW040560

Licence:	Licence Status:
	Authorised Purpose(s): Intended Purpose(s): STOCK
Work Type: Bore	
Work Status:	
Construct.Method:	
Owner Type:	
Commenced Date:	Final Depth:
Completion Date:	Drilled Depth:
Contractor Name: (None)	
Driller:	
Assistant Driller:	
Property:	Standing Water Level (m):
GWMA:	Salinity Description:
GW Zone:	Yield (L/s):

Site Details

Site Chosen By:			
	County Form A: MANARA Licensed:	Parish invalid code	Cadastre WLL 2853
Region: 70 - Lachlan	CMA Map: 7732		
River Basin: 412 - LACHLAN RIVER	Grid Zone:	Scale:	
Area/District:			
Elevation: 0.00 m (A.H.D.)	Northing: 6350470.000	Latitude: 32°57'14.5"S	
Elevation Source: (Unknown)	Easting: 243622.000	Longitude: 144°15'26.5"E	
GS Map: -	MGA Zone: 55	Coordinate Source: GD,ACC.MAP	

Remarks

06/11/2009: Reviewed data - nothing to update.

*** End of GW040560 ***

Warning To Clients: This raw data has been supplied to the NSW Office of Water by drillers, licensees and other sources. The NOW does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

WaterNSW

Work Summary

GW040561

Licence:	Licence Status:
	Authorised Purpose(s): Intended Purpose(s): STOCK
Work Type: Bore	
Work Status:	
Construct.Method:	
Owner Type:	
Commenced Date:	Final Depth:
Completion Date: 19/06/1992	Drilled Depth:
Contractor Name: (None)	
Driller:	
Assistant Driller:	
Property:	Standing Water Level (m):
GWMA:	Salinity Description:
GW Zone:	Yield (L/s):

Site Details

Site Chosen By:			
	County Form A: MANARA Licensed:	Parish invalid code	Cadastre WLL 2853
Region: 70 - Lachlan	CMA Map: 7732		
River Basin: 412 - LACHLAN RIVER Area/District:	Grid Zone:	Scale:	
Elevation: 0.00 m (A.H.D.) Elevation Source: (Unknown)	Northing: 6347087.000 Easting: 243944.000	Latitude: 32°59'04.5"S Longitude: 144°15'35.5"E	
GS Map: -	MGA Zone: 55	Coordinate Source: GD.,ACC.MAP	

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	5.50	0			(Unknown)
1	1	Casing		0.00	0.00				

Remarks

06/11/2009: Reviewed data - nothing to update.
16/08/2013: Nat Carling, 16-Aug-2013; Added hole (based on deepest water level reading) & casing details, to enable data migration to HydstraGW.

Warning To Clients: This raw data has been supplied to the NSW Office of Water by drillers, licensees and other sources. The NOW does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

WaterNSW

Work Summary

GW055706

Licence:

Licence Status:

Authorised Purpose(s):

Intended Purpose(s): STOCK

Work Type: Bore

Work Status:

Construct.Method: Cable Tool

Owner Type: Private

Commenced Date:

Completion Date: 01/09/1981

Final Depth: 7.60 m

Drilled Depth: 76.20 m

Contractor Name: (None)

Driller:

Assistant Driller:

Property:

Standing Water Level (m):

GWMA:

Salinity Description: Good Stock

GW Zone:

Yield (L/s):

Site Details

Site Chosen By:

County

Form A: MOSSGIEL

Parish

Cadastre

Licensed:

invalid code

WLL 283

Region: 70 - Lachlan

CMA Map: 7732

River Basin: 412 - LACHLAN RIVER

Grid Zone:

Scale:

Area/District:

Elevation: 0.00 m (A.H.D.)

Northing: 6350583.000

Latitude: 32°57'19.5"S

Elevation Source: (Unknown)

Easting: 254093.000

Longitude: 144°22'09.5"E

GS Map: -

MGA Zone: 55

Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	P.V.C.	0.00	73.50	114			Suspended in Clamps
1	1	Opening	Screen	73.20	76.20	81		1	Stainless Steel, A: 0.25mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
36.60	41.20	4.60	Unconsolidated	31.40					
73.20	76.20	3.00	Unconsolidated	31.40		3.03			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	7.62	7.62	Clay	Clay	
7.62	32.00	24.38	Clay Sandy	Clay	
32.00	36.58	4.58	Clay Variegated	Clay	
36.58	41.15	4.57	Sand Fine Dirty	Sand	
41.15	57.91	16.76	Clay Sandy	Clay	

57.91	64.01	6.10	Clay	Clay	
64.01	73.15	9.14	Clay Sandy	Clay	
73.15	76.20	3.05	Sand Water Supply	Sand	

*** End of GW055706 ***

Warning To Clients: This raw data has been supplied to the NSW Office of Water by drillers, licensees and other sources. The NOW does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

APPENDIX B

LANDHOLDER/LEASEHOLDER CONSULTATION SUMMARY

Appendix B
Landholder Consultation

Ground Water ID	Local Bore Name	Lot	DP	Consultee	Bore Census Findings		
					Status	Location	TDS/Pumping Rate
GW004247	GW004247	56	DP767383	Gregory Turner	In Use.	Confirmed	Unknown
GW006222	GW006222	930	DP761987	Gregory Turner	Not in use.	Confirmed	-
GW006224	GW006224	930	DP761987	Gregory Turner	Not in use.	Confirmed	-
GW006769	GW006769	931	DP761988	Richard Gates	In Use.	Incorrect Location. Corrected to 32551745 S, 144154795 E	4500ppm/ 800G/hr (3,637L/hr).
GW006771	Woolshed Bore	931	DP761988	Richard Gates	In Use.	Confirmed	8000ppm/ 700G/hr (3182L/hr)
GW013811	2 Mile Bore	931	DP761988	Richard Gates	In Use.	Confirmed	4500ppm/ 800G/hr (3,671L/hr).
GW036919	GW036919	931	DP761988	Richard Gates	In Use.	Confirmed	-
GW040514	GW040514	931	DP761988	Richard Gates	Not in use.	Confirmed	-
GW040560	GW040560	932	DP761989	Gregory Turner	In Use.	Aerial imagery indicates the bore is incorrectly located and should be relocated to to 32561646 S, 144125645 E	6000ppm
GW019903	Harris Well	4568	DP768560	Gregory Turner	In Use.	Aerial imagery indicates the bore is incorrectly located and should be relocated to 32583832 S, 144185438 E.	1000 to 1200ppm.
GW019904	North Well	4568	DP768560	Gregory Turner	In Use	Confirmed	1000 to 1200ppm.
GW055706	Osbornes Bore	4568	DP768560	Graham Holbrook Turner and Judith Mary Turner	In Use	Aerial imagery indicates the bore is incorrectly located and should be relocated to 32581418 S, 144234570 E.	1000 to 1200ppm.
GW006745	GW006745	4568	DP768560	Gregory Turner	Leaseholder did not discuss bore.		
GW007180	Angle Bore	4568	DP768560	Gregory Turner	Leaseholder did not discuss bore.		
GW040561	GW040560	932	DP761989	Gregory Turner	Leaseholder did not discuss bore.		
GW003848	Ivanhoe Railway Bore	56	DP767383	The State of New South Wales	No consultation with landholder.		
GW009827	GW009827	56	DP767383	The State of New South Wales	No consultation with landholder.		
GW006308	GW006308	2140	DP765875	RI, AR Hiscock and MV and LJ Newnham	Leaseholder unable to be contacted.		

TDS = Total dissolved solids

APPENDIX C
GROUNDWATER BORE CENSUS DATABASE

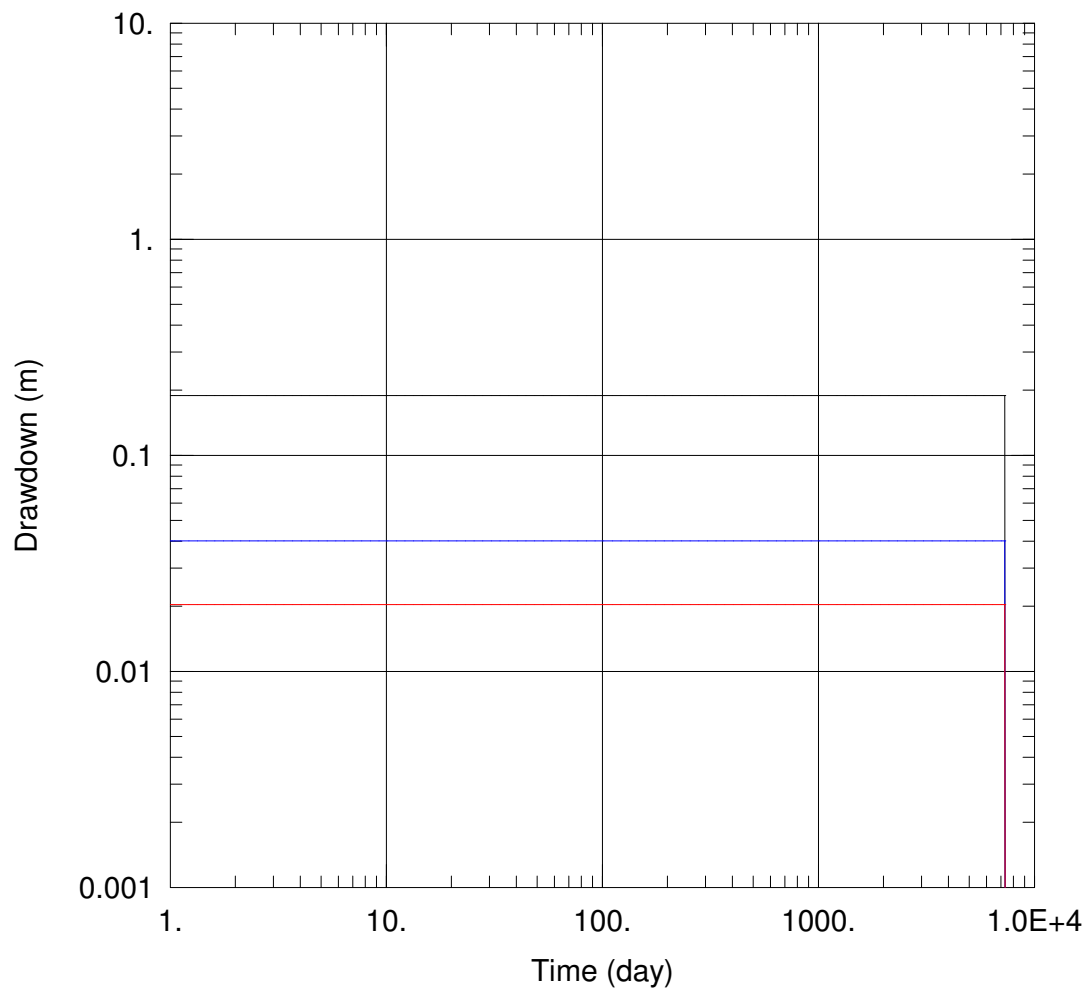
Appendix C

Groundwater Bore Census Database

[illegible]

Attachment B

AQTESOLV Predictive Analyses



IVANHOE RAIL SIDING BORE

AQUIFER DATA

Saturated Thickness: 11. m
Aquitard Thickness (b'): 10. m

Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b''): 20. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
IV1	243126	6355388

Observation Wells

Well Name	X (m)	Y (m)
□ IV1	243126	6355388
□ +10	243136	6355388
□ +20	243146	6355388
□ +100	243226	6355388

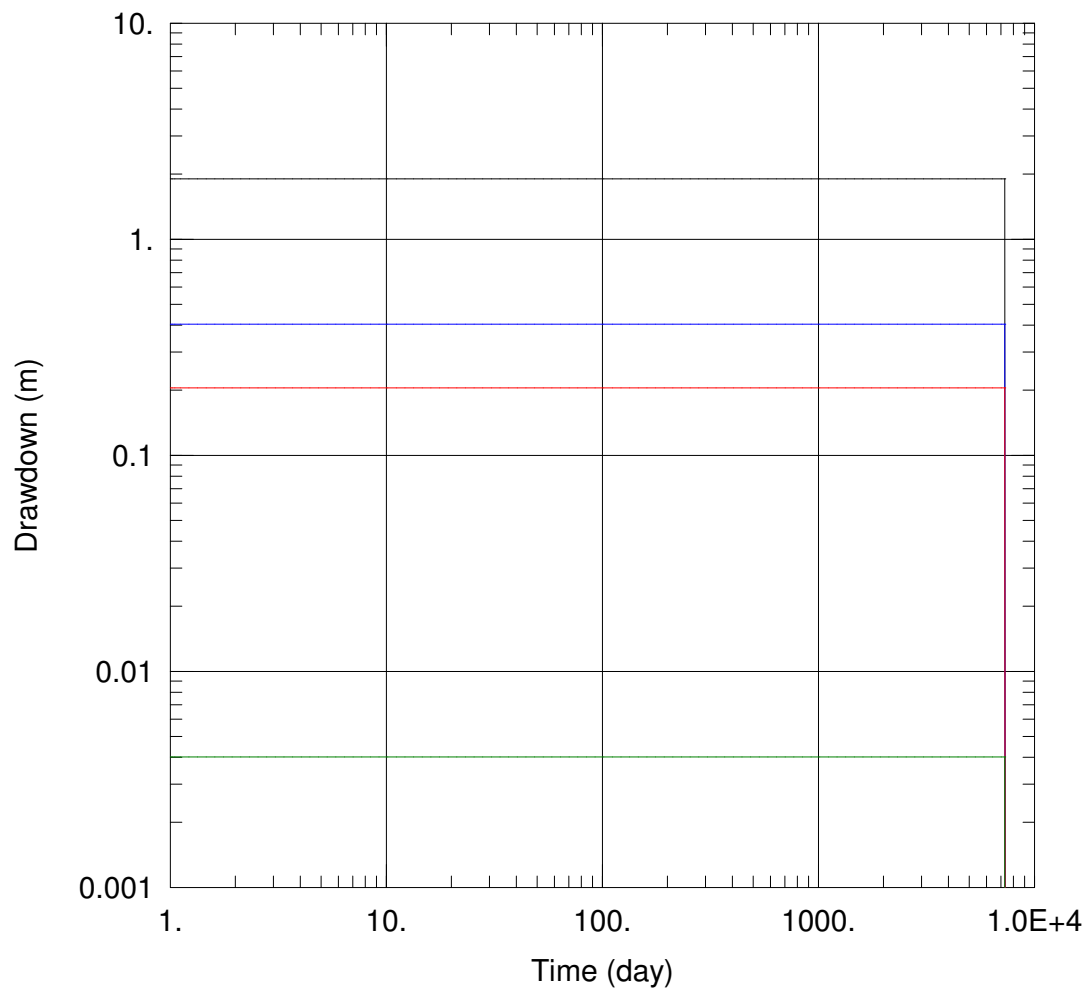
SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush

$T = 724. \text{ m}^2/\text{day}$
 $1/B' = 0.0401 \text{ m}^{-1}$
 $1/B'' = 0. \text{ m}^{-1}$

$S = 0.0001$
 $B'/r = 9.16\text{E-}5 \text{ m}^{-1}$
 $B''/r = 0. \text{ m}^{-1}$



IVANHOE RAIL SIDING BORE

AQUIFER DATA

Saturated Thickness: 11. m
Aquitard Thickness (b'): 10. m

Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b''): 20. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
IV1	243126	6355388

Observation Wells

Well Name	X (m)	Y (m)
□ IV1	243126	6355388
□ +10	243136	6355388
□ +20	243146	6355388
□ +100	243226	6355388

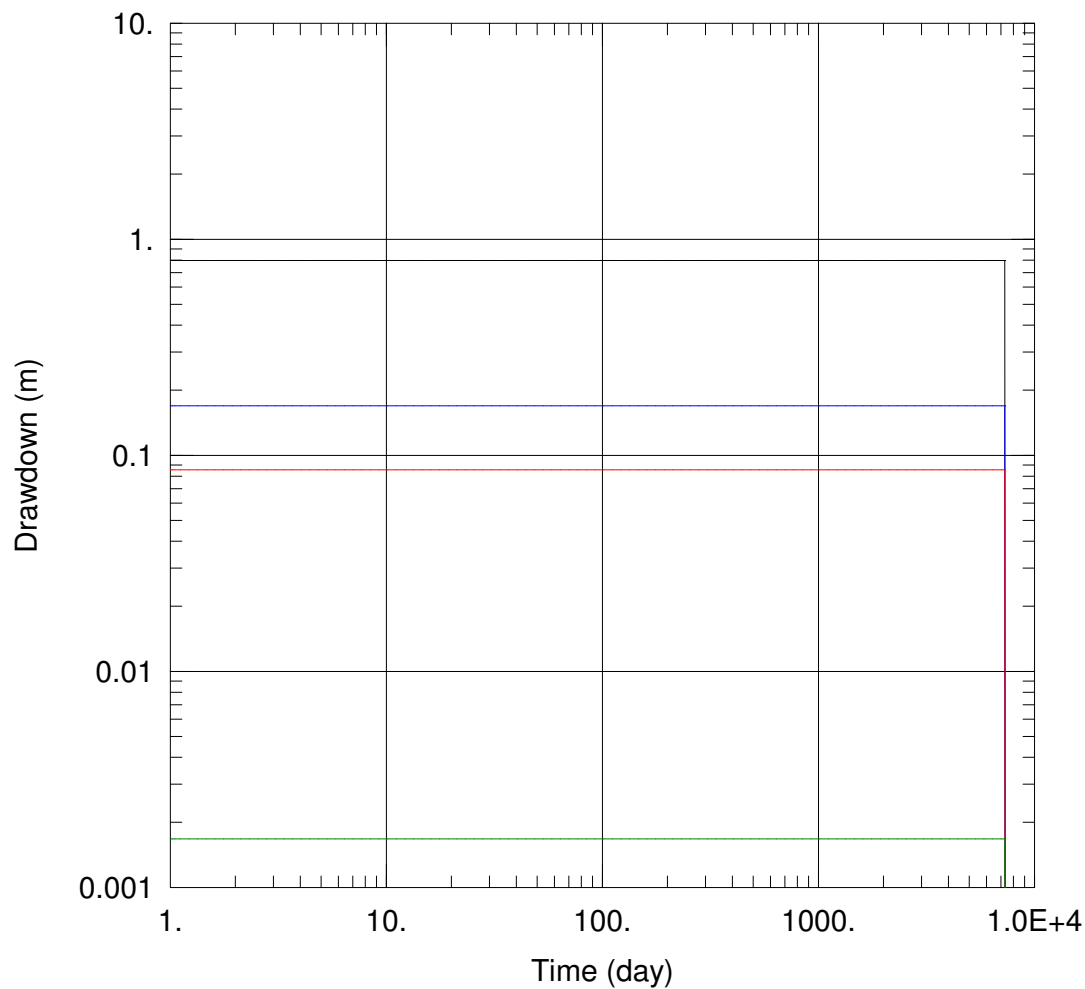
SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush

$T = 71.81 \text{ m}^2/\text{day}$
 $1/B' = 0.0401 \text{ m}^{-1}$
 $1/B'' = 0. \text{ m}^{-1}$

$S = 0.0001$
 $B'/r = 0.000291 \text{ m}^{-1}$
 $B''/r = 0. \text{ m}^{-1}$



IVANHOE RAIL SIDING BORE

AQUIFER DATA

Saturated Thickness: 11. m
Aquitard Thickness (b'): 10. m

Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b''): 20. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
IV1	243126	6355388

Observation Wells

Well Name	X (m)	Y (m)
□ IV1	243126	6355388
□ +10	243136	6355388
□ +20	243146	6355388
□ +100	243226	6355388

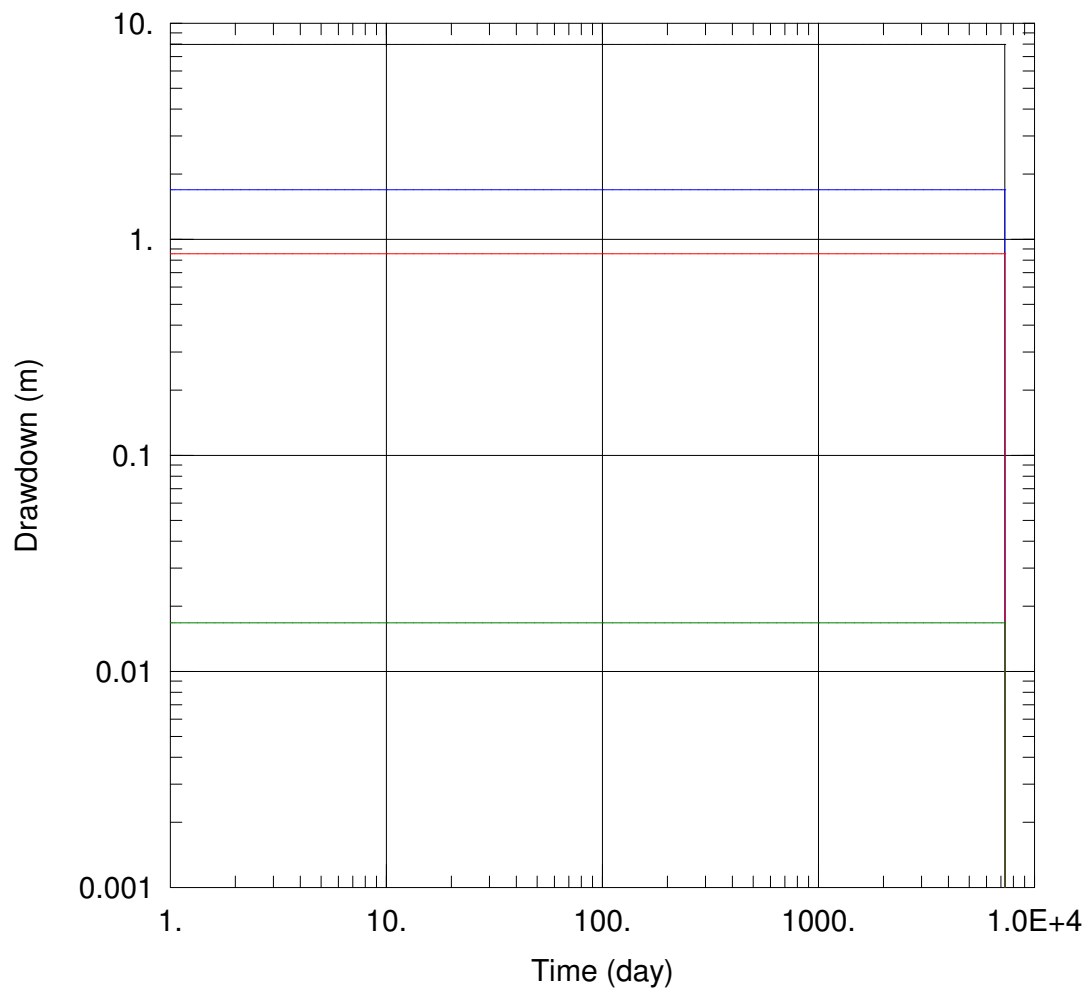
SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush

$T = 171.7 \text{ m}^2/\text{day}$
 $1/B' = 0.0401 \text{ m}^{-1}$
 $1/B'' = 0. \text{ m}^{-1}$

$S = 0.0001$
 $B'/r = 0.000188 \text{ m}^{-1}$
 $B''/r = 0. \text{ m}^{-1}$



IVANHOE RAIL SIDING BORE

AQUIFER DATA

Saturated Thickness: 11. m
Aquitard Thickness (b'): 10. m

Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b''): 20. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
IV1	243126	6355388

Observation Wells

Well Name	X (m)	Y (m)
□ IV1	243126	6355388
□ +10	243136	6355388
□ +20	243146	6355388
□ +100	243226	6355388

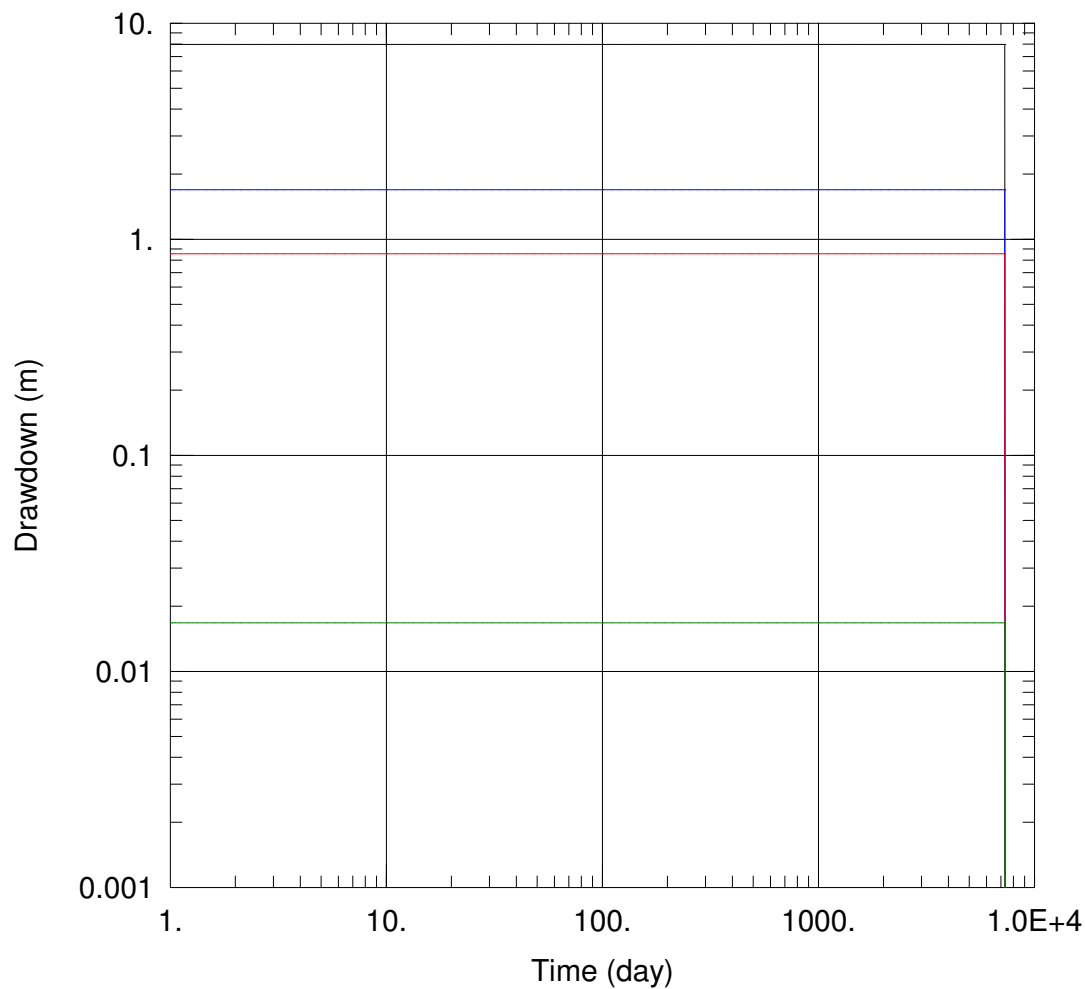
SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush

$T = 17.17 \text{ m}^2/\text{day}$
 $1/B' = 0.0401 \text{ m}^{-1}$
 $1/B'' = 0. \text{ m}^{-1}$

$S = 0.0001$
 $B'/r = 0.000595 \text{ m}^{-1}$
 $B''/r = 0. \text{ m}^{-1}$



IVANHOE RAIL SIDING BORE

AQUIFER DATA

Saturated Thickness: 11. m
Aquitard Thickness (b'): 10. m

Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b''): 20. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
IV1	243126	6355388

Observation Wells

Well Name	X (m)	Y (m)
□ IV1	243126	6355388
□ +10	243136	6355388
□ +20	243146	6355388
□ +100	243226	6355388

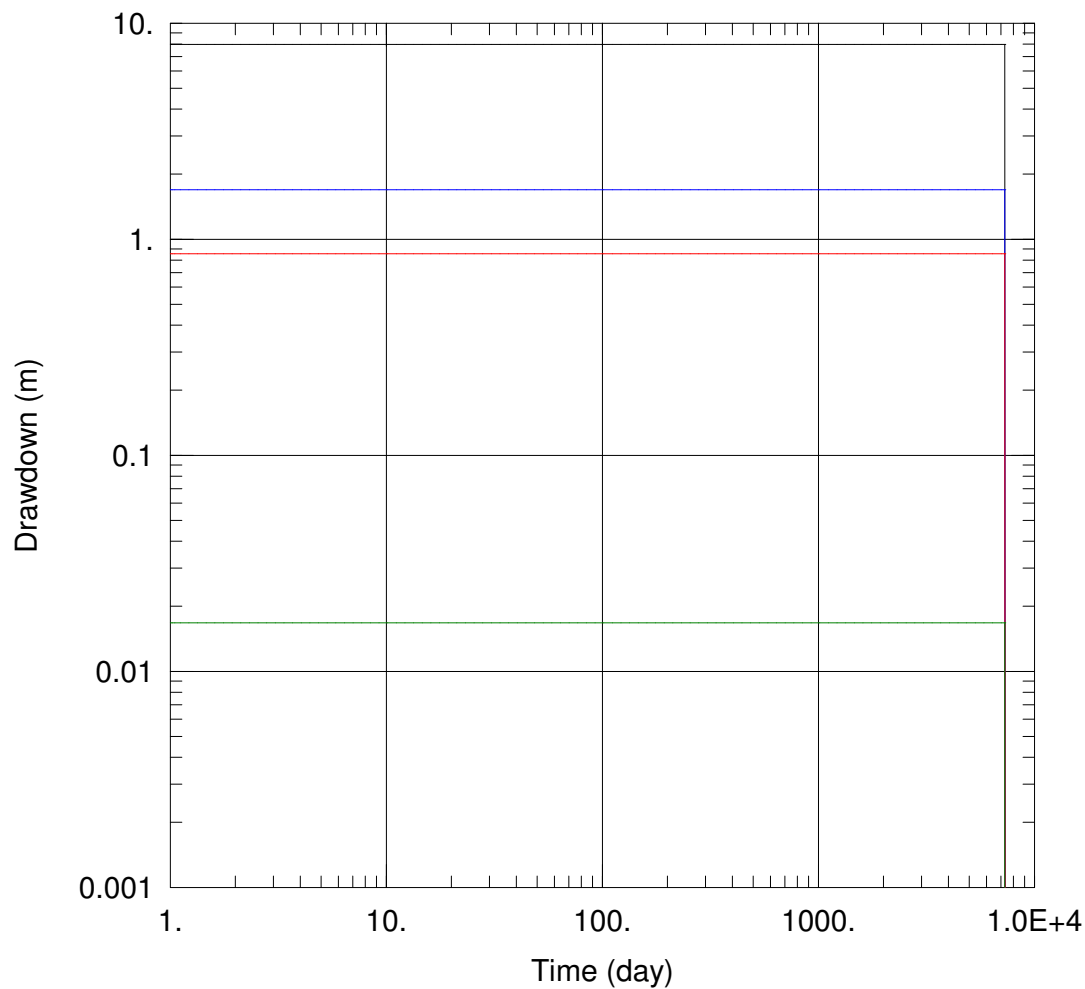
SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush

$T = 17.17 \text{ m}^2/\text{day}$
 $1/B' = 0.0401 \text{ m}^{-1}$
 $1/B'' = 0. \text{ m}^{-1}$

$S = 1.0\text{E-}5$
 $B'/r = 0.00188 \text{ m}^{-1}$
 $B''/r = 0. \text{ m}^{-1}$



IVANHOE RAIL SIDING BORE

AQUIFER DATA

Saturated Thickness: 11. m
Aquitard Thickness (b'): 10. m

Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b''): 20. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
IV1	243126	6355388

Observation Wells

Well Name	X (m)	Y (m)
□ IV1	243126	6355388
□ +10	243136	6355388
□ +20	243146	6355388
□ +100	243226	6355388

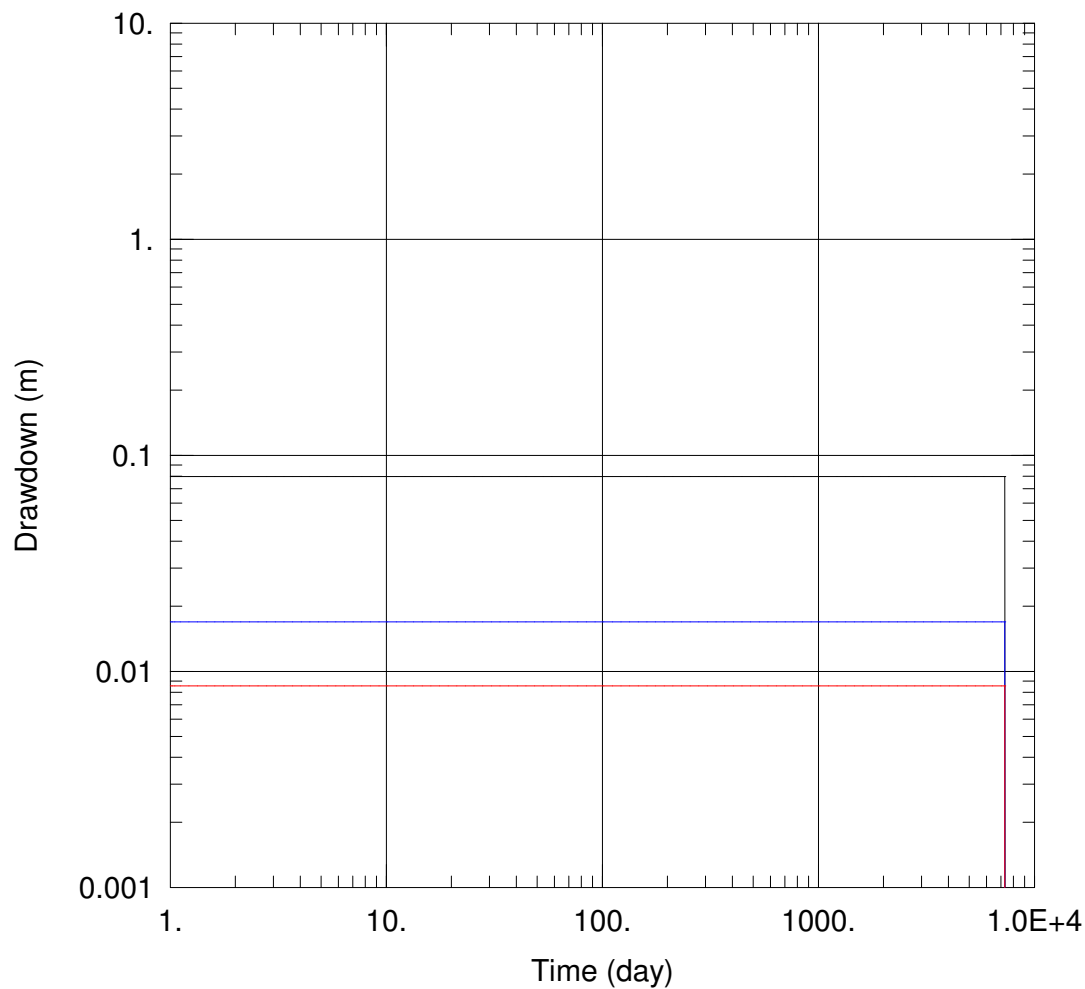
SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush

$T = 17.17 \text{ m}^2/\text{day}$
 $1/B' = 0.0401 \text{ m}^{-1}$
 $1/B'' = 0. \text{ m}^{-1}$

$S = 0.0001$
 $B'/r = 0.000188 \text{ m}^{-1}$
 $B''/r = 0. \text{ m}^{-1}$



IVANHOE RAIL SIDING BORE

AQUIFER DATA

Saturated Thickness: 11. m
Aquitard Thickness (b'): 10. m

Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b''): 20. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
IV1	243126	6355388

Observation Wells

Well Name	X (m)	Y (m)
□ IV1	243126	6355388
□ +10	243136	6355388
□ +20	243146	6355388
□ +100	243226	6355388

SOLUTION

Aquifer Model: Leaky

Solution Method: Hantush

$T = 1717. \text{ m}^2/\text{day}$
 $1/B' = 0.0401 \text{ m}^{-1}$
 $1/B'' = 0. \text{ m}^{-1}$

$S = 1.0\text{E-}5$
 $B'/r = 5.95\text{E-}5 \text{ m}^{-1}$
 $B''/r = 0. \text{ m}^{-1}$