APPENDIX V
KIELPA GROUNDWATER SUPPLY STUDY

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CENTRAL EYRE IRON PROJECT
DEFINITIVE FEASIBILITY STUDY REPORT

KIELPA GROUNDWATER SUPPLY STUDY

E-F-66-RPT-2001

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Executive Summary

Overview

A groundwater supply with sufficient capacity to meet Iron Road Limited's (IRD) Central Eyre Iron Project (CEIP) 15 GL/year water demand has been identified approximately 60 km south of the mine site, along the project utilities corridor. The target aquifer comprises thickened Tertiary sands from approximately 100 to 300m depth hosted in a graben structure labelled the Polda Trough.

It is important to differentiate between the "Polda Trough" and the "Polda Lens" which are separate and distinct geological units.

The Polda Trough is a intracratonic graben (fault bounded trough structure) which extends approximately 400km east- west from beneath the Great Australian Bight, to the Central Eyre Peninsula. The trough is infilled with up to 1200 m thickness of Neoproterozoic to Jurassic aged sediments. Tertiary cover also thickens across the structure. Groundwater contained within the trough is saline.

The Polda Lens is a thin (approximately 5 – 15m thick) layer of Quaternary limestone which lays on top of Tertiary clay and is exposed or covered with a thin veneer of soil. The lens extends some 7 km west-east and 9km north-south and is located 30 km west of Lock township. It holds fresh groundwater which is perched on top of the underlying clay. Recharge is by infiltration of rainfall into the highly porous limestone at surface. The Polda Lens is used to supply potable water.

The scope of the current study comprised geological review of existing data, groundwater investigation comprising construction and testing of bores at three sites, and use of the data to construct a three dimensional groundwater flow model. The flow model was used to validate a borefield design comprising 10 production bores located 2000m apart and each pumping 4000 m^3/day. Water level drawdown impacts were simulated using the model.

Geological Review

Geological review comprised analysis of 194 historic uranium, coal and stratigraphic exploration holes for a total of 20,800 m drilling. Drillhole lithological logs and geophysical logs were reviewed to develop a database of lithology with depth. The extent and thickness of the target Tertiary aquifer was defined. The saturated thickness generally exceeds 100m and in the deepest parts of the through exceeds 160m. The total extent of Tertiary sediments hosted in the Polda Trough is approximately 1050 km^2

Groundwater is saline, salinity ranges from 25,000 to 41,300 mg/l, and the potentiometric surface indicates an east-west gradient of 0.0003 from 84 mAHD at the planned borefield to 74 mAHD at Lock Township some 32km to the west.

Field Investigations

Investigation drilling comprised installation and test pumping of bores at three sites to depths ranging from 234 to 302m. Bore yields were constrained by pump capacity. Transmissivity estimates were 120m^2/day at two sites and 1100-2700 m2/day with lower transmissivity boundary conditions at the third site. A test production bore at the third site yielded 50 L/s for 12m drawdown indicating a very high potential yield.

Groundwater Flow Modelling

A groundwater flow model was constructed using data from the geological review and field investigations. The Model is developed as a Class 1 confidence level model as defined by the Australian Groundwater Modelling Guidelines (Barnett et al 2012). The level is defined as suitable for predicting long-term impacts of proposed developments in low-value aquifers. The model objectives were to

1. Calculate drawdown at each production well at the completion of 20 years abstraction to validate borefield desgin.
2. Calculate drawdown with distance from the borefield at the completion of 20 years abstraction.

Drawdown at each pumped bore was exported from the model. Well losses and near-well drawdown were calculated using analytical equations. Calculated drawdown at each production bore is summarised in Table E1.

The outcome of the modelling work is that sufficient drawdown is available at each site to support the planed pumping rate.

Table E1: Calculated drawdown at the completion of 20 years pumping

Production Bore Site	SWL (m depth)	Pump Setting (m depth)	Available Drawdown (m)	Transmissivity(4) (m^2/day)	Flow Rate (m^3/day)	Near well drawdown(2) (m)	Well Loss (1) (m)	Numerical Model Drawdown (3) (m)	Total Drawdown(5) (m)
KPB01	50.0	140	90	450	4000	9.8	12	48	70
IC4 / KPB02	50.0	140	90	450	4000	9.8	12	60	82
KPB03	39.8	140	100	1000	4000	3.9	12	67	83
KPB04	39.8	140	100	1000	4000	3.9	12	71	87
KPB05	39.8	140	100	1000	4000	3.9	12	72	88
KPB06	34.4	160	125	130	4000	33.8	12	70	115
KPB07	34.4	160	125	130	4000	33.8	12	67	113
KPB08	34.4	160	125	130	4000	33.8	12	66	112
KPB09	26.8	150	123	120	4000	36.8	12	62	110
KPB10	26.8	150	123	120	4000	36.8	10	60	107

Notes
(1) Well Losses based on KPBp04 pumping test.
(2) Drawdown from 0.1 to 100m radius calculated using Theis equation.
(3) Numerical Model used to calculate well interference and aquifer boundary effects.
(4) Transmissivity estimate from nearest investigation bore site.
(5) Sum of numerical model drawdown, near-well drawdown, and well losses.

The radius of drawdown impact is 7.5 km from the borefield to the calculated 2m drawdown contour.

Borefield Design

The borefield design comprises 10 bores each with the capacity to yield 180 m^3/hr . The target aquifer interval is approximately 150 to 300m depth. Each bore will be drilled to approximately 300 m depth and cased with 300mm DN Class 12 PVC casing to 150m, the underlying aquifer from 150m to 300m will be screened with 200mm DN 316 grade stainless steel wire wound screens. Bores will be equipped with electric submersible pumps with the capacity to deliver 180 m^3/hour – nominally 150 – 200 kW pumps. Detailed pump specification for each bore is dependent on individual bore efficiency and will be determined following bore construction.

Bore heads comprise a concrete pad, 316 grade stainless steel bore head-works, pump control panel, and flanged connection to the collector pipeline.

1 Introduction

1.1 Background

The Central Eyre Iron Project (CEIP) is located to the east of Warramboo. The project comprises an open pit mine, processing plant, camp, infrastructure corridor, and port facility. The area is arid. No significant surface water supplies exist in proximity to the project. The local reticulated water supply is constrained by the capacity of infrastructure.

The planned long-term water supply for the project will be groundwater pumped from the Kielpa borefield, approximately 60 km south of the mine and delivered to site via a pipeline. Potable water will be generated via reverse osmosis of the groundwater supply.

1.2 Purpose

The purpose of this work program is to

- Confirm the availability of groundwater to meet the project water demand.
- Provide an estimate of the drawdown impacts of groundwater extraction

The proposed bore field will abstract saline groundwater from the Tertiary aquifer identified between 100 and 300m beneath ground surface.

1.3 Scope of Work

The scope of work comprised

- Geological review of the target aquifer
- Field investigation comprising bore installation and testing at three sites
- Groundwater flow modelling
- Borefield design

2 Hydrogeological Review

2.1 Overview

The Kielpa groundwater supply borefield targets an aquifer comprised of thickened Tertiary sediments across the Polda Trough structural depression. The Polda Trough is a west – east tending structural depression faulted at the northern boundary and extending west from Kielpa to beneath the Great Australian Bight (Figure 2-1). The trough is infilled with Neoproterozoic, Paleozoic, and Jurassic sediments to a maximum intersected thickness of approximately 1200m. The western Eyre Peninsula is draped with Tertiary Sediments; the lower part of the Tertiary sediment, the Poelpena Formation is typically sandy. These sediments thicken across the northern, fault bounded part of the Trough, and the thick sandy facies form the target aquifer for the Kielpa groundwater supply.

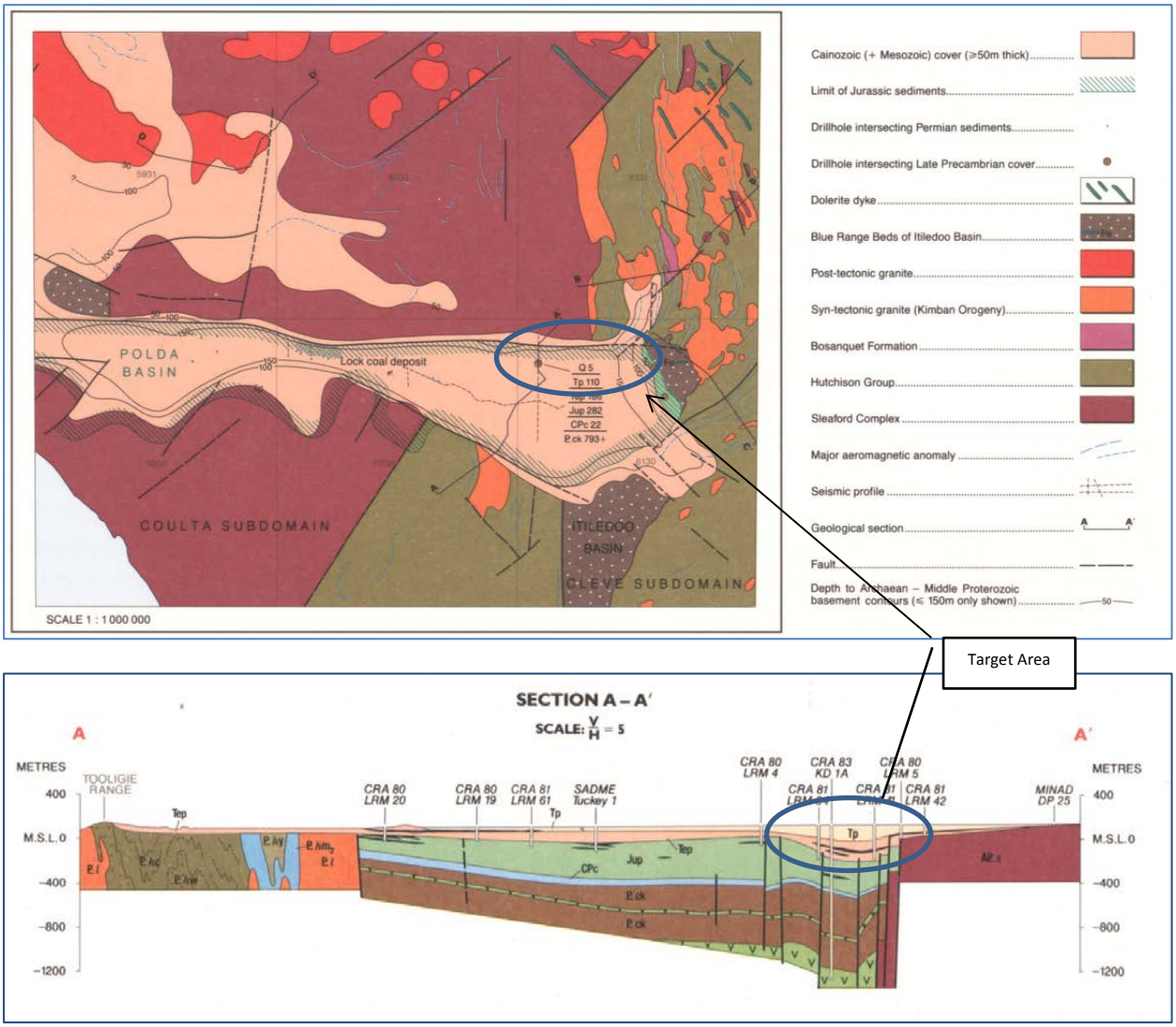


Figure 2-1: Polda Trough and Borefield target area

2.2 Data Sources

A geological model of the Tertiary aquifer has been developed through interrogation of existing exploration reports and other geological data. These data sets are summarised in Table 2-1. Data sets were interrogated to develop a database of lithology for each drillhole. For each historic drillhole, intervals were logged as:

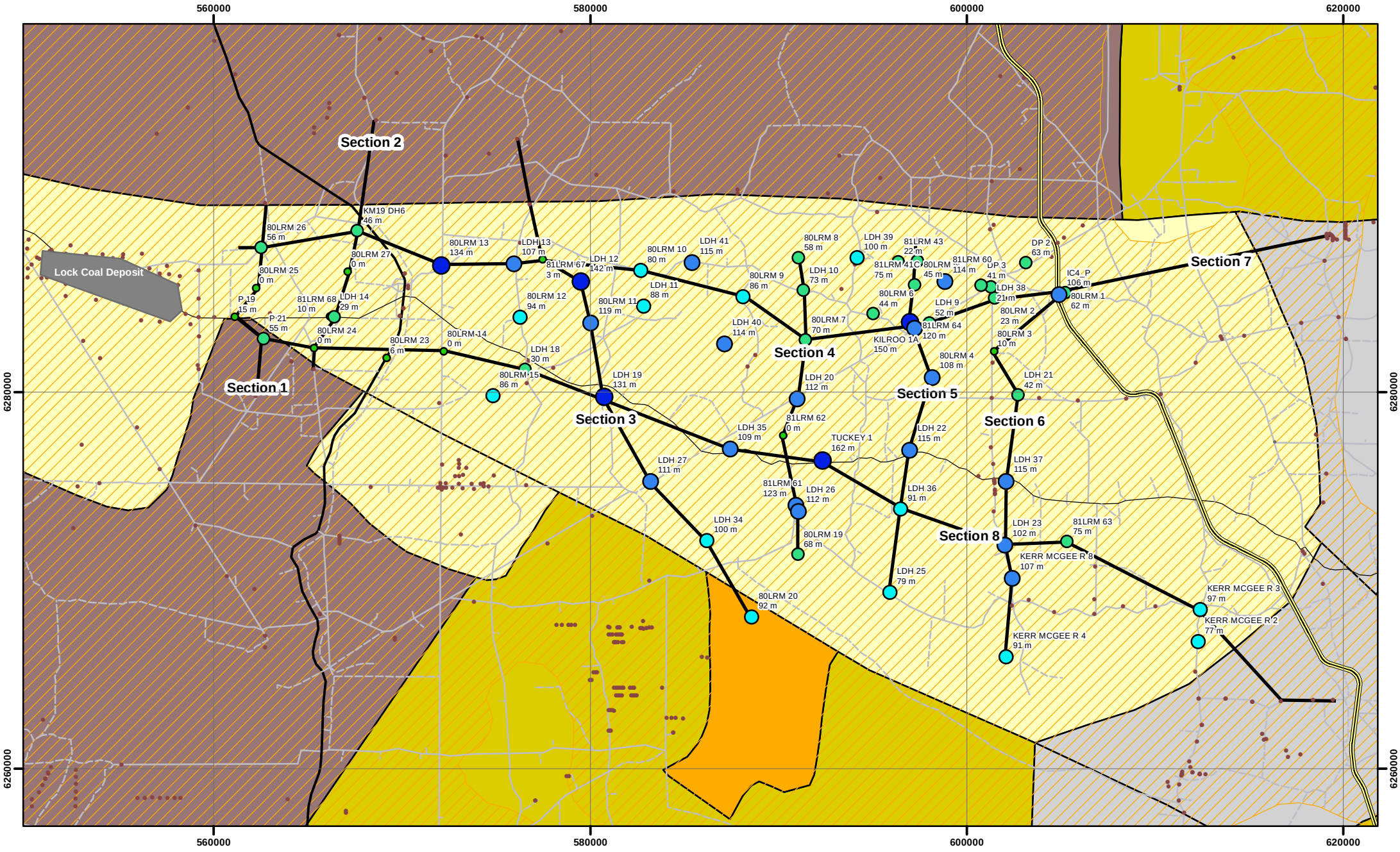
- Sand- Aquifer
- Silt- Aquitard
- Clay – Confining Layer
- Lignite – Confining layer
- Basement – Low transmissivity aquifer
- Saprolite (weathered basement) – confining layer.

Table 2-1: Source Data for Geological Model

Data Source	Description
Water Connect Database	Database of all permitted water bores in the state. Includes stratigraphic, water level and water quality data. https://www.waterconnect.sa.gov.au/Systems/GD/Pages/default
SARIG Database	Database of all exploration drillholes in South Australian. Includes reference to open file exploration reports. https://sarig.pir.sa.gov.au
ENV02256	Chevron Exploration Corp 1974. Open File Exploration Report. LDH Series Drilling
ENV03973	CRA Exploration 1985. Open File Exploration Report 80LRM and 81LRM series drilling.
ENV01108	KerMcgee Austrlia 1969. Open File Exploration Report 80LRM and 81LRM series drilling. R and V series Drilling
ENV5019	Pan Continental Mining Ltd 1993. Open File Exploration Report 32 Series Drilling
ENV1238	Mines Administration Pty Ltd – Teton Australia Joint Venture 1972. Open File Exploration report DP Series Drilling
SADME RB81/00019	South Australian Department of Mines and Energy 1981. Stratigraphic Hole "Tuckey 1" Well completion report. Report Book 81/00019

Drillholes included in the database are presented as Figure 2-2.

Groundwater level and salinity data in the area is sparse because high salinity precludes use for agriculture hence very few bores have been drilled. Data within the Polda Trough Tertiary sediments is limited to IRD's water investigation bores and hydrogeological studies into the Lock Coal deposit (Eberhard and Waterhouse, 19791).



Legend

Net_Sand_Thickness (m)

- 0-20
- 20-75
- 75-100
- 100-125
- 125-165

Exploration Drillholes

Section Lines

Basement Transmissivity

- Hutchinson Group - Very Low
- Sleaford Complex - Very Low
- Blue Range Beds - Medium
- Polda Trough
- Hutchinson Group - Very Low
- Lincoln Complex - - Very Low
- Extent of Tertiary Cover (PIRSA Paleochannels Dataset 2007)

Projection GDA 94 Zone 53

Groundwater Science

Figure 2.2
Geological Data Review
Source Data, Net Sand Thicknes and Cross Section Lines

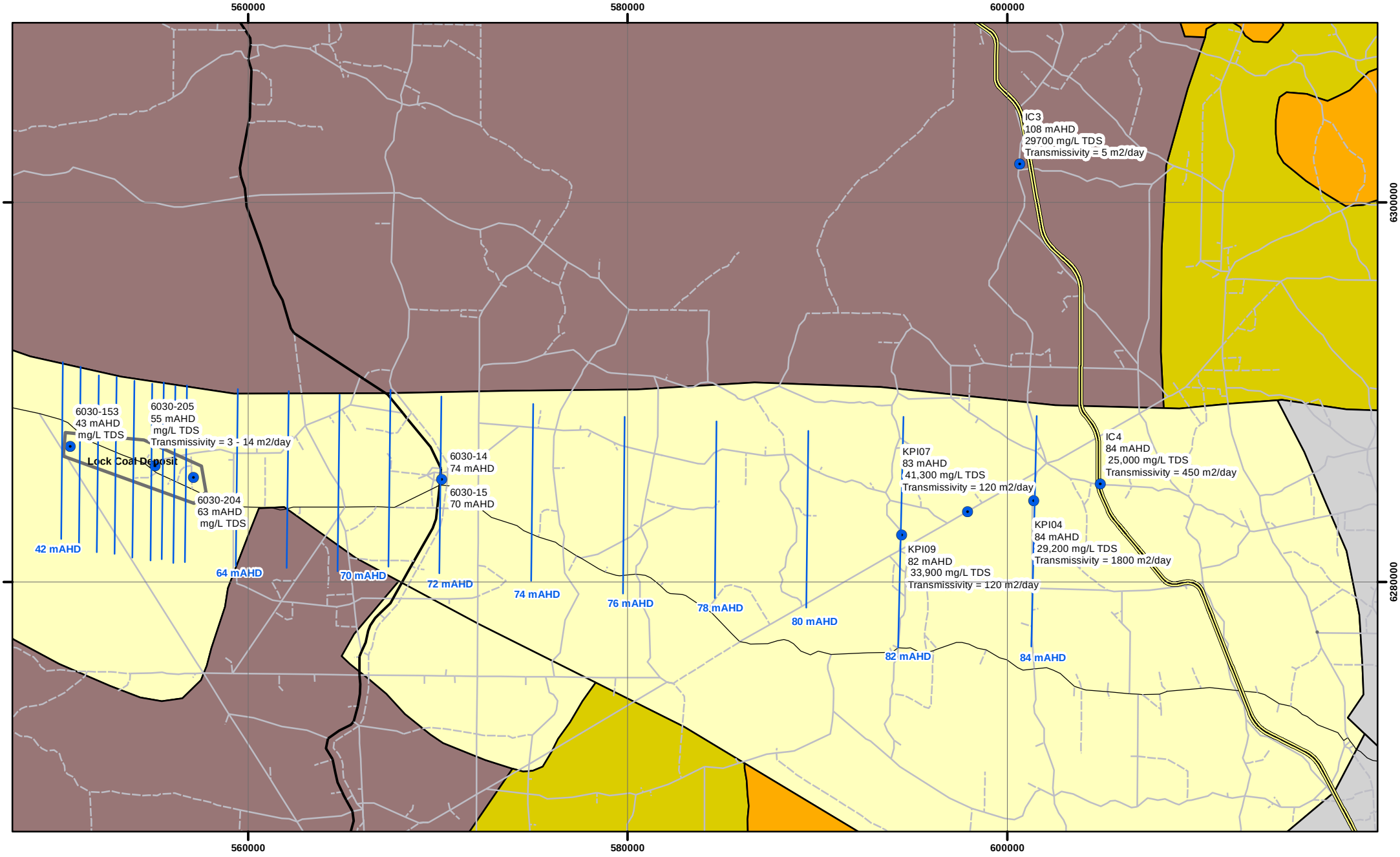


Figure 2.3
Groundwater Level and Salinity Data

2.3 Hydrogeological Structure

2.3.1 Tertiary Basin Fill

The hydrogeological structure was ascertained by developing a series of cross sections across the trough. Cross section locations are shown on Figure 2-2. Cross Sections are presented as Figure 2-4.

To the west of the trough, represented by Sections 1 and 2, the lithology logged below the water table is predominately fine grained silts and clays, and the north-south extent is approximately 6km. The transmissivity through this section is expected to be relatively low.

Section 3 further east shows that the lithology of Tertiary Sediments below the water table changes to a predominately sandy facies, with in excess of 100m of sand logged in drillholes. None of the drillholes fully penetrate the Tertiary aquifer thickness in this section.

Section 4 defines the northern margin of the deepest part of the Trough. Basement is intersected at drillhole 80LRM8 at approximately 20 mAHD (85m drilled depth). Further south predominately sandy facies are logged beneath the water table, with a maximum thickness of 123m logged at drillhole 81LRM61. None of the drillholes on this section fully penetrate the thickened Poelpena Formation aquifer.

Section 5 again defines the northern margin of the deepest part of the Trough. Basement is intersected at drillhole 80LRM5c at approximately 0 mAHD (85m drilled depth). Further south the full thickness of the Poelpena aquifer is intersected at drillhole Kilroo 1A, which reports 130m thickness of sand from -5 to -135 mAHD. Further south drillholes do not fully penetrate the Poelpena Formation aquifer. Net sand thickness beneath the water table is approximately 100 m in each of the drillholes.

Section 6 presents the eastern part of the trough. Net sand thickness beneath the water table ranges between 80 and 100m, however none of the drillholes fully penetrate the aquifer. Fine grained lithology is reported for two drillholes 80LRM3 and LDH 21, indicative of reduced transmissivity in this area.

Section 7 presents a west-east section though the northern part of the trough. Net saturated sand thickness ranges from 80 to 160m. Only drillhole Kilroo1a and the adjacent 81LRM64 fully penetrate the Poelpena Formation aquifer.

Section 8 presents a west-east section though the southern part of the trough. Drillholes west of chainage 20,000m exhibit predominately fine grained lithology and are net sand thickness below the water table at these holes is generally less than 20m. To the east drillholes consistently penetrate in excess of 100m saturated sands. Stratigraphic drillhole Tuckey 1 is notable that it was cored, providing detailed lithological data. It reports 162m meters of saturated sand, predominately logged as medium to coarse grained indicative of moderate to high transmissivity.

2.3.2 Basement

The inferred geology of basement rock surrounding the Polda Trough is presented in Figure 2-2. To the north and west of the basin, basement rock comprises the gneiss and granite of the Sleaford complete. Aquifer testing of this formation by IRD to support mine dewatering studies and construction water supply indicate a regional transmissivity of approximately 2 – 4 m2/day (SKM 2013, Groundwater Science 2013).

Basement to the east comprises the Blue ranges beds, described as a consolidated sandstone, and gritty conglomeritic sandstone. A single aquifer test in this unit (Groundwater Science 2013) yielded a transmissivity estimate of 16 m^2/day.

To the south the trough is bounded by schist and gneiss of the Hutchinson group. Aquifer tests into the Wilgerup ore body yielded high transmissivity estimates of 90 m2/day. However the study authors proposed that these values were due to localised fracturing, and that the regional transmissivity was likely to be lower; drawdown estimates for the mine were calculated using a transmissivity estimate of 10 m^2/day (SKM 2008).

2.3.3 Groundwater

Salinity ranges from 25,000 mg/L to 41,300 mg/L in the area of the proposed borefield, and ranges from 35,000 to 45,000 mg/L at the Lock Coalfield (Eberhard and Waterhouse, 1981). Groundwater level and salinity data is presented as Figure 2-3. A very low hydraulic gradient is measured across the Polda Trough East of the Lock Coal field, indicative of very high transmissivity. A relatively high gradient is reported across the coal deposit. This trend indicates that the aquifer is markedly less transmissive in the area around the coal field and Lock township, and that this area acts as a hydraulic restriction effectively supporting elevated water levels in the eastern part of the basin.

Contained Groundwater resource

The total volume of groundwater contained within the Tertiary aquifer can be calculated as the product of the bulk volume of the aquifer and the porosity. Bulk volume is the product of the area and the average saturated thickness. The area is defined by DMITRE data set showing the extent of the Polda Trough structure east of Lock (Figure 4-3). The average thickness can be assigned a conservative value of 100m on the basis of geological Sections presented in Section 2. Typical porosity of sediment is approximately 0.3 (Fetter, 1994).

1050,000,000 m^2 area x 100 m thickness x 0.3 porosity = 3 x10^{10} m^3 contained groundwater.

The total project water requirement is 3 x 10^8 over 20 years, or 1% of the contained volume.

Estimated natural through flow

The volume of groundwater that moves through the aquifer annually can be estimated from the transmissivity of the aquifer, and measured hydraulic gradient as follows:

$$Q = T \times G \times W$$

Where

Q = Flow rate (m3/day)

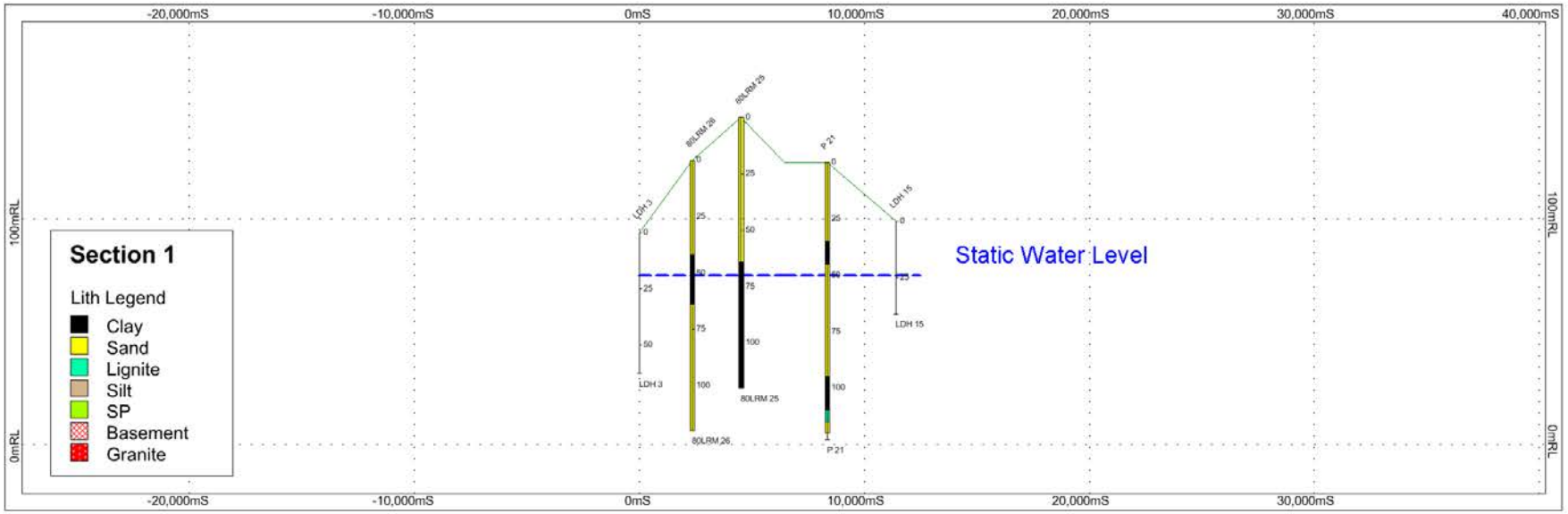
T = Transmissivity (m3/day/m)

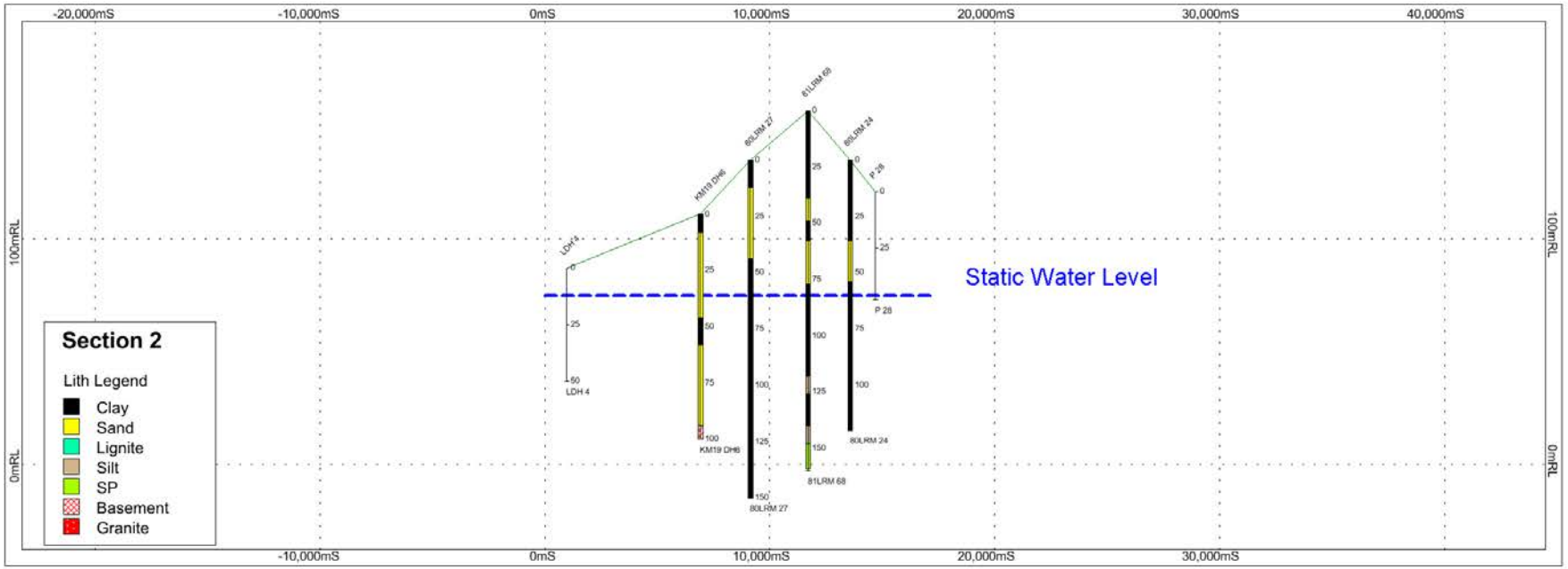
G = Hydraulic gradient (m/m)

L = Width of Section

The Tertiary aquifer in the Polda Trough exhibits a transmissivity of approximately 120 m^2/day (Section 3.8), measured hydraulic gradient across the planned borefield is 0.0003 and the width of the radius of pumping impact is approximately 15,000m (Section 4.4) which equates to an estimated daily through-flow of 500 m^3/day.

Planned borefield pumping is approximately 43,000 m^3/day. The through-flow estimate is approximate, however it is clear that the borefield will be "mining" the stored water resource over the duration of operation, and complete water level recovery following closure will occur slowly.


-20,000mS
-10,000mS
0mS
10,000mS
20,000mS
30,000mS
40,000mS
100mRL
0mRL
Section 1
Lith Legend
Clay
Sand
Lignite
Silt
SP
Basement
Granite
Static Water Level
LDH 3
80LRM 26
80LRM 25
P 21
LDH 15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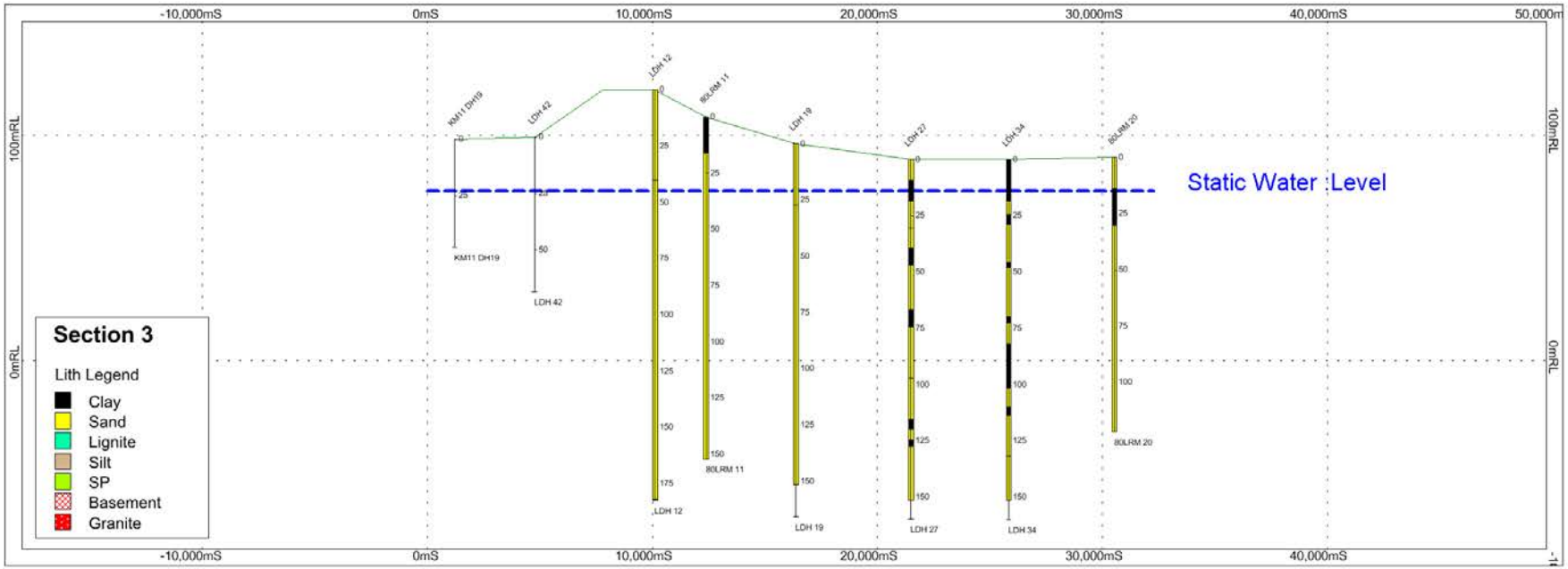
-10,000mS
0mS
10,000mS
20,000mS
30,000mS
40,000mS
100mRL
0mRL
Static Water Level
Section 2
Lith Legend
Clay
Sand
Lignite
Silt
SP
Basement
Granite
LDH 4
KM19 DH6
80LRM 27
81LRM 68
80LRM 24
P 28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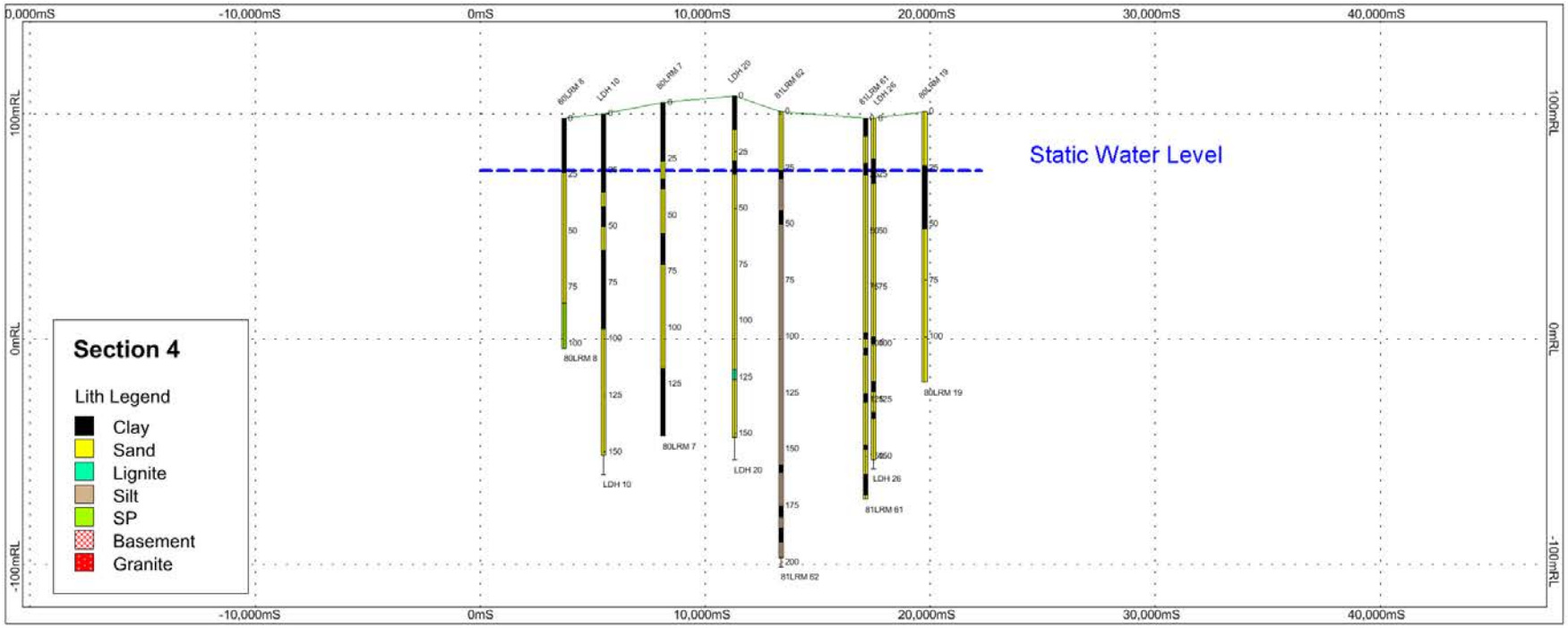
30,000mS
40,000mS
50,000mS
100mRL
0mRL
Static Water Level
Section 3
Lith Legend
Clay
Sand
Lignite
Silt
SP
Basement
Granite
KM11 DH19
LDH 42
LDH 12
80LRM 11
LDH 19
LDH 27
LDH 34
80LRM 20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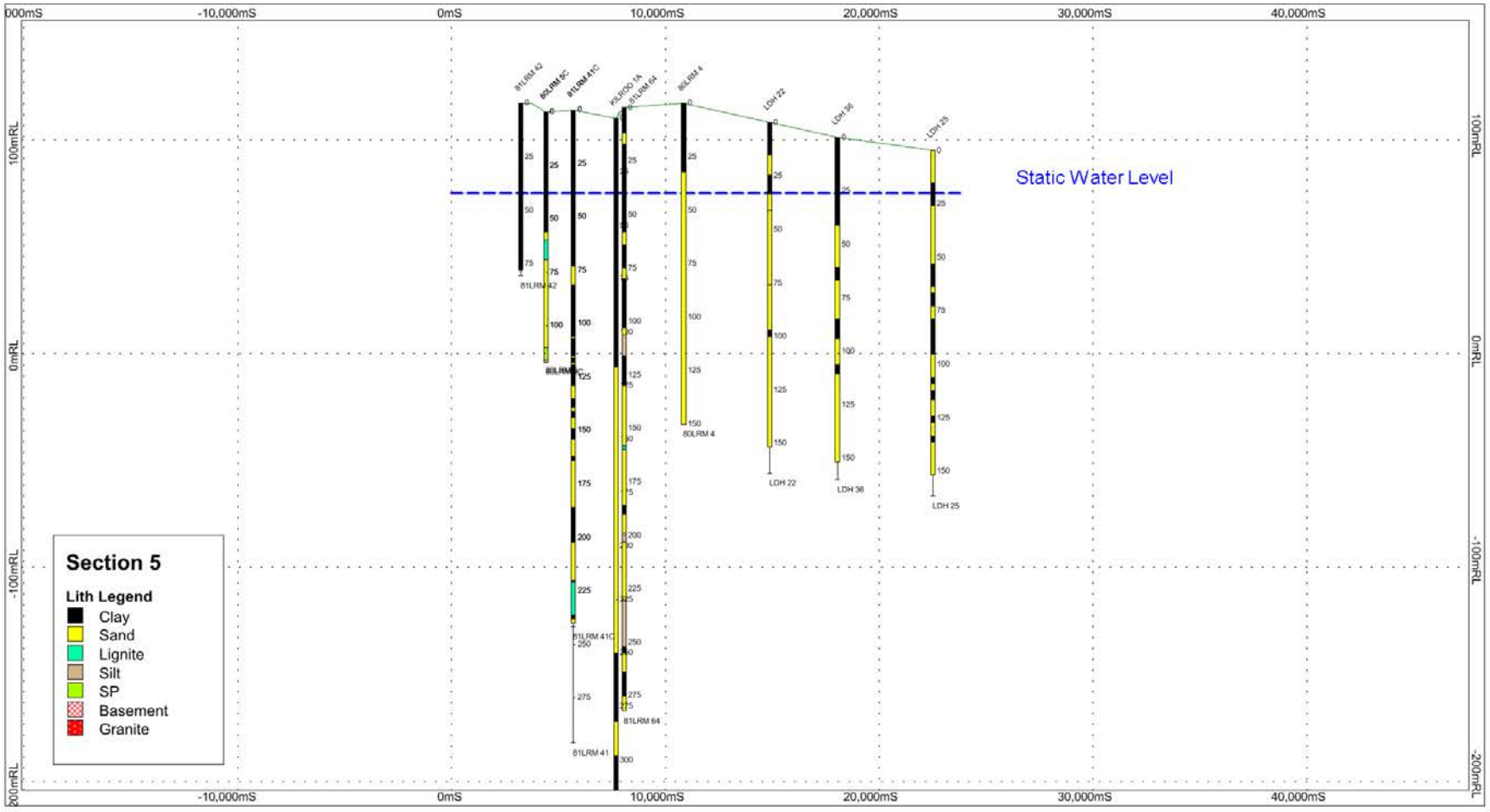
0mRL
-100mRL
Static Water Level
Section 4
Lith Legend
Clay
Sand
Lignite
Silt
SP
Basement
Granite
80LRM 8
LDH 10
80LRM 7
LDH 20
81LRM 62
81LRM 61
LDH 26
80LRM 19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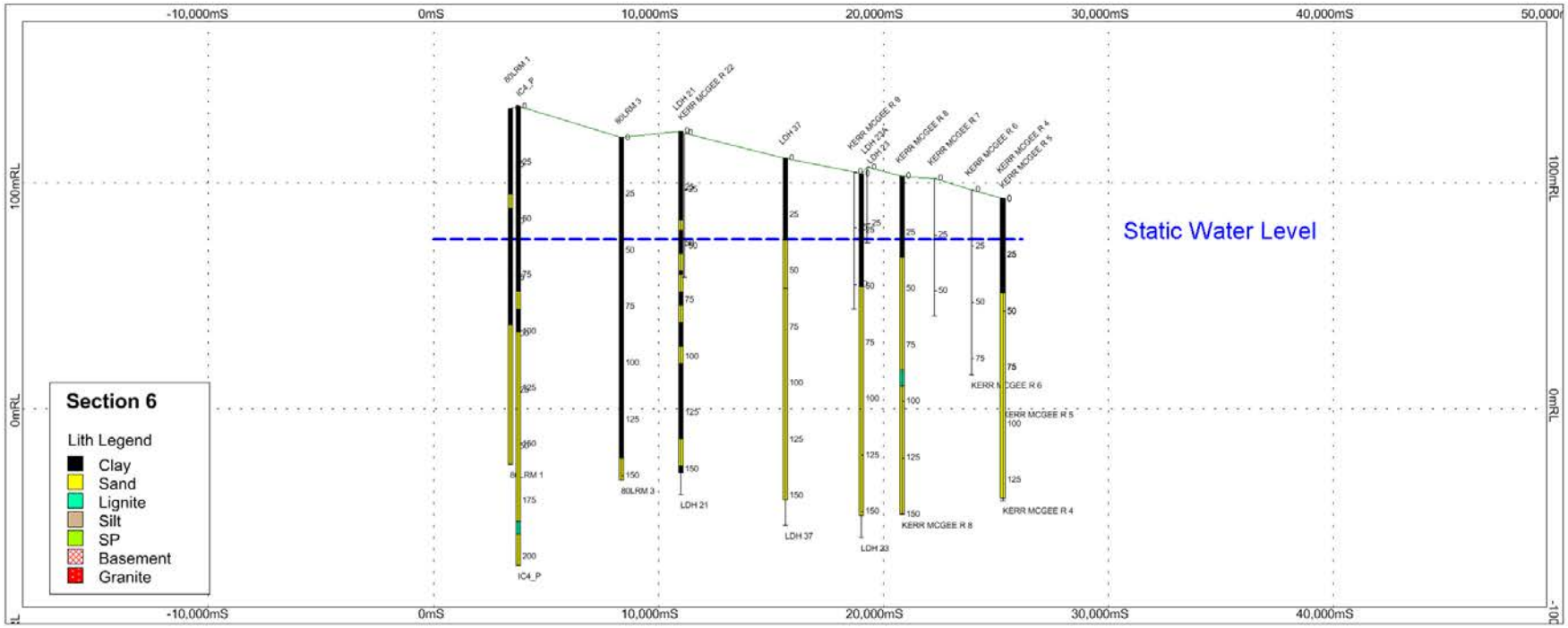
0mRL
-100mRL
-200mRL
Static Water Level
Section 5
Lith Legend
Clay
Sand
Lignite
Silt
SP
Basement
Granite
81LRM 42
80LRM 5C
81LRM 41C
KELROD 1A
81LRM 64
80LRM 4
LDH 22
LDH 36
LDH 25
81LRM 41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Lignite
Silt
SP
Basement
Granite
IC4_P
80LRM 3
LDH 21
LDH 37
KERR MCGEE R 8
KERR MCGEE R 4

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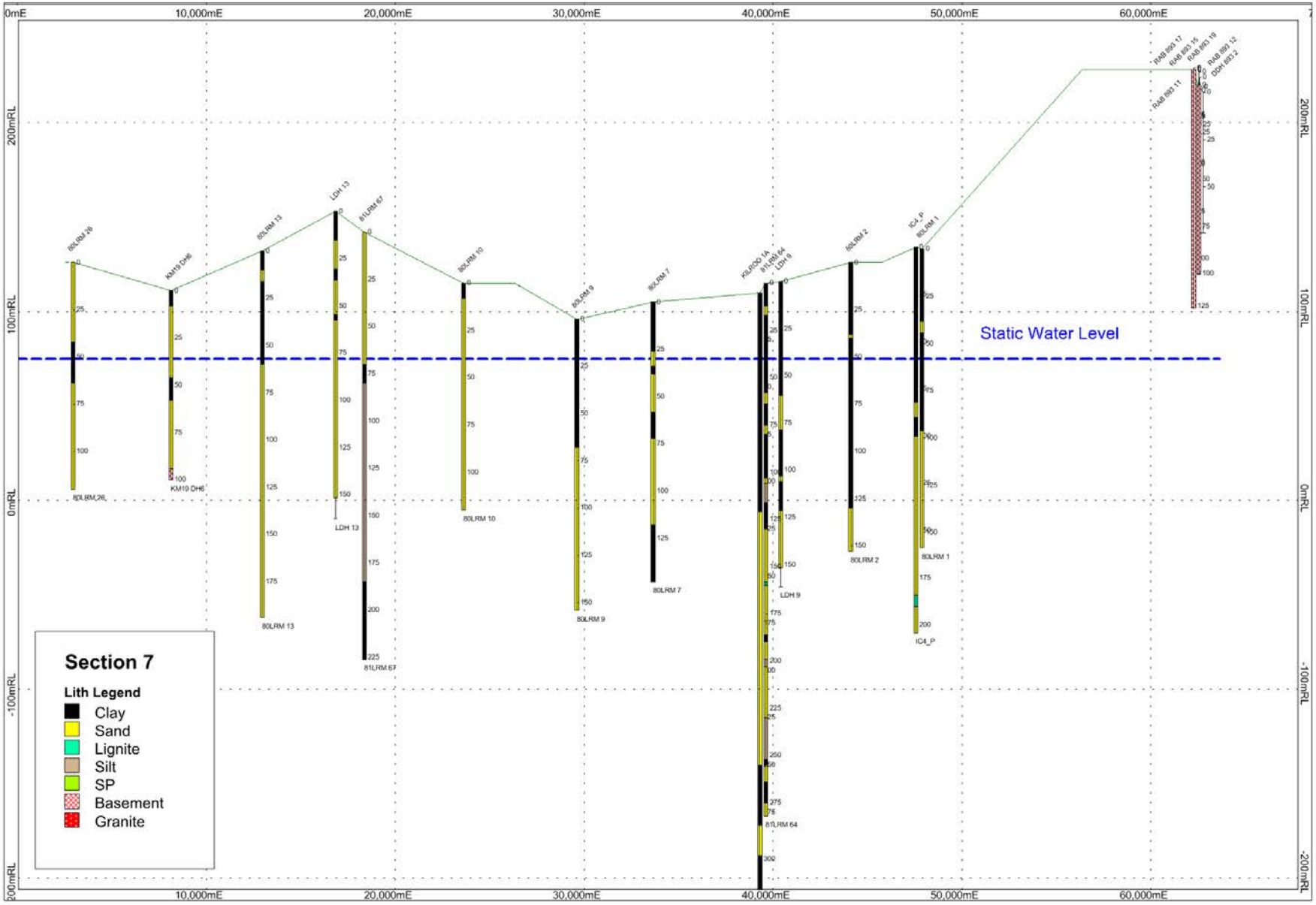


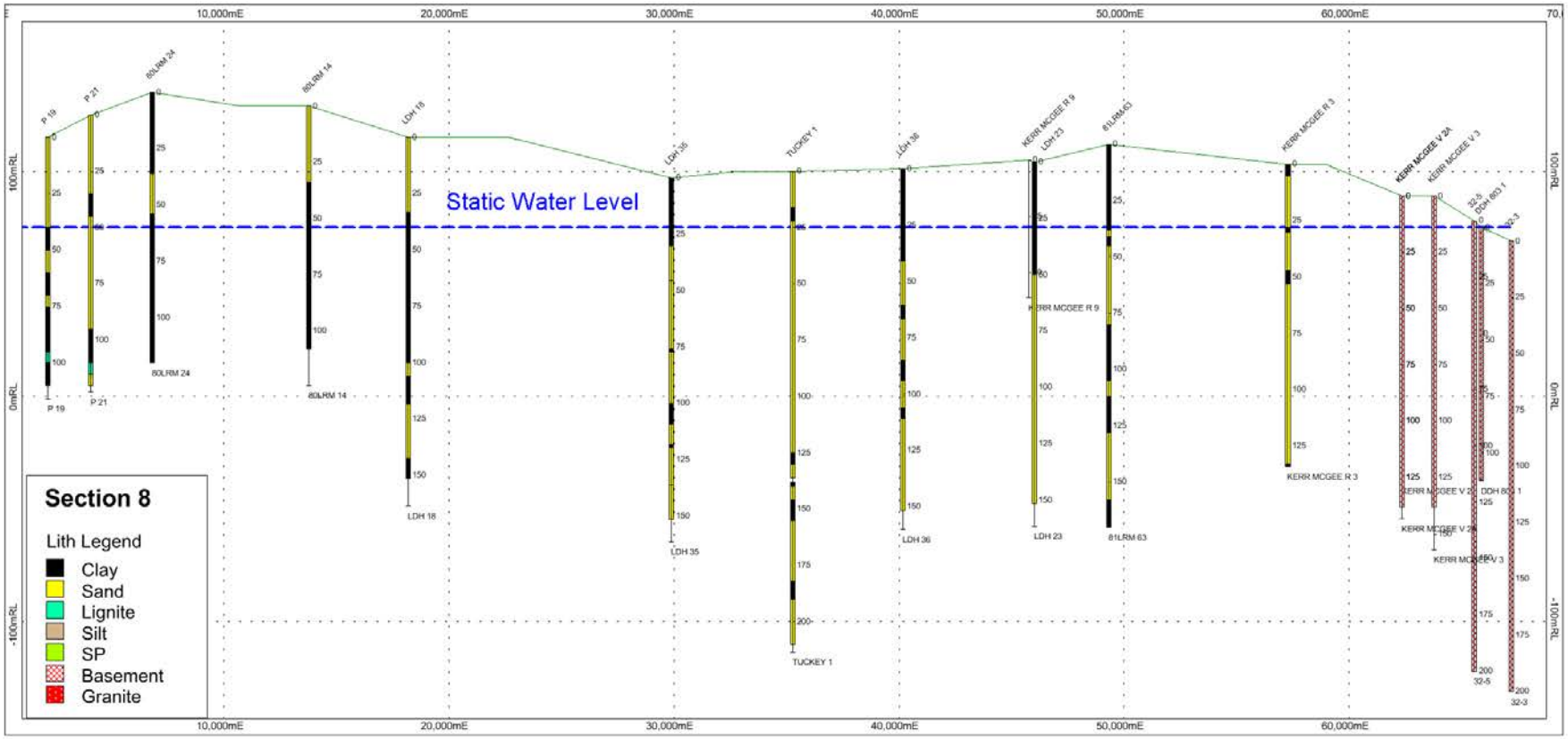


Figure 2-4: Cross Sections

3 Field Investigation Work Program and Results

3.1 Overview

The scope of work involved on-ground identification of drilling locations and supervision of drilling, testing and bore installation. Specifically;

- Site pegging and clearance
- Contractor engagement
- Drilling, design and installation of 3 x 125mm PVC cased investigation bores
- Drilling, design and installation of 1 x 250mm PVC/Stainless Steel cased test production bore
- The logging of drill cuttings, yield and salinity of produced groundwater
- Downhole gamma survey logs of completed bores
- Gauging of water levels, and
- Undertaking pumping tests and data analysis on all bores.

Drilling works were undertaken by Thompson Drilling Pty Ltd under the supervision of Groundwater Science Pty Ltd (GWS). Table 3-1 outlines the details of drilling rig and support equipment used. Drilling and testing of bores commenced in February 2014 and concluded in early March 2014.

A total of four bores were drilled with mud rotary techniques, comprising three investigations and one production bore to assess the hydrogeological conditions west of Kielpa (See Figure 3-1). Bore depth designs were based on drilling information obtained during the recent drilling program (GWS 2013 - Corridor Groundwater Supply Investigations), historical drilling logs from within the surrounding area and gamma logs following completion of drilling. Details of gamma logs are provided as Appendix C .

Pumping tests at all bores were undertaken by Department of Environment, Water and Natural Resources (DEWNR) Resource Monitoring Unit. These works commenced on 4 March 2014 and were completed on 17 March 2014.

Upon completion of the work, each site ~~will be~~ rehabilitated by Fosters Earthmoving. The bore will remain as an approximately 1m high standpipe with lockable casing.

The nomenclature applied in the program is as follows:

KPBXX: Site ID

KPBiXX: Investigation bore (125mm cased bore)

KPBpXX: Test Production bore (250mm cased bore)

Table 3-1: Description of drill rig and pumping test equipment

DRILLING	
RIG 18	
Make and Model	RIG 18 - Bourne 1250 Drill Rig mounted on late model 8x8 truck
Compressor specifications (for airlifting)	Sullair 425cfm air compressor
Mud Pumps	5x6 Garden Denver *2
Drilling method	Mud rotary
PUMPING TEST	
Pumping test rig	Mitsubishi Pump Truck
Make and model of submersible pump	Grundfos SP604
Generator specifications	80 kVa
Flow control specifications	Calibrated water flow meter (siemens mag 5000)
Equipment for manually and automatically recording water levels	Downhole probes – Mines Dept , rugged troll 100 30 mts, 90FL microprocessor field analyser

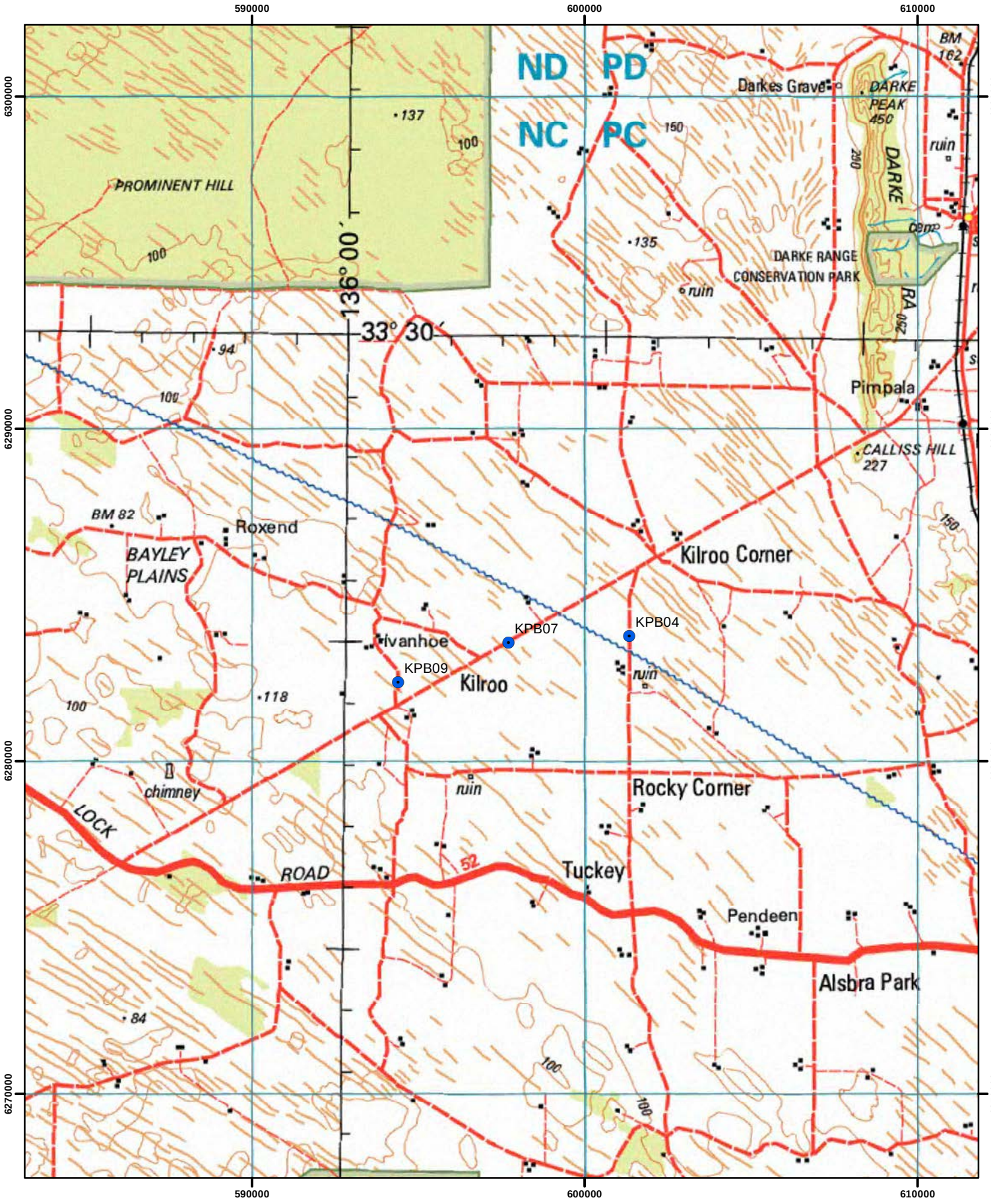


Figure 3.1
Kielpa Water Supply
Investigation bore locations

3.2 Approvals, Clearances and Permits

The following approvals, clearances and permits were obtained prior to commencement of drilling;

- Well Permits obtained from DEWNR to comply with South Australian government regulations. (Appendix A)
- Dial Before Your Dig Surveys for location of general underground services (i.e. Telstra, electrical cables and water pipes).
- On-site Location of SA-Water Pipeline at KPB04 site by SA Water representative Andrew Grey.
- Local Council approvals from District Councils of Cleve to undertake water investigations within public road reserves.

3.3 Field Supervision and Data Collection

GWS hydrogeologists supervised the drilling, completion and pumping tests of all bores. In addition, the GWS hydrogeologist acted as Iron Road's HSEC representative on the drill site.

Data collected during the field investigations included:

- Lithology based on drill cutting sampled over 2 m intervals.
- Collection of chip trays (2m intervals) during drilling with supporting photo.
- Field water quality parameters including; airlift yield (L/s), temperature, electrical conductivity (EC as mS/cm) and pH measured during airlift following the completion of drilling.
- Recovered groundwater levels upon completion of drilling.
- Grain size sieve analysis with samples weighed wet and drained.
- Downhole gamma logs of all bores to assist with well construction.
- End of day photos of each drill site.
- Drill site fence maintenance.
- Daily Rig Inspection Form and Hydrogeological Drilling Site Supervision Sign-off Sheet.
- Daily diary, including rig active and inactive time, water carting, well construction details and rig maintenance and/or breakdown time.

3.4 Well Construction

All bores were constructed by a licensed driller in accordance with well permits obtained from DEWNR and Minimum Standards for Water Bore Construction in Australia (National Uniform Drillers Licensing Committee 2011). Table 3-2 presents the corresponding well permit reference for each drill site. Details of well permits are attached as Appendix A.

Upon completion of each bore, standpipes were fitted with 12" (test production bore) and 10" (investigation bores) lockable steel monuments.

3.5 Investigation and Production Bores

Three investigation bores and one production bore (KPBi04, KPBi07, KPBi09, KPBp04 - see Figure 3-1) were drilled to determine the prospective saline groundwater supplies within the thickened Tertiary sediments across the Polda Trough within the Kielpa Domain.

All investigation bores were completed with 125mm DN Class 12 PVC casing while the production bore was completed with 250mm DN Class 18 PVC reducing down to 150mm DN Class 18 PVC and stainless

steel wire wound screens. All screens were 0.5mm aperture. Screens were naturally packed. A cement/grout seal to surface was installed, typically above a cement boot.

Table 3-2 provides a summary of bore location, drilling method and completion formation. Table 3-3 provides details on final construction. Detailed drilling summaries, including lithological logs, airlift yield and groundwater conductivity are presented in Appendix B. Grain size sieve analysis for KPB04 site is presented in Appendix D.

Table 3-2: Kielpa Water Supply Bore Details

Bore ID	Well Permit Number	MGA 93 Zone 53*		Surface Elevation (mAHD)*	Total Drilled Depth (m bgl)	Date Start	Date Finish	Drill Method	Target Aquifer
		Easting	Northing						
KPBi04	229768	601413	6284304	122	310	21/02/14	23/02/14	Mud Rotary	Tertiary (Poelpena Formation)
KPBp04	229769	601414	6284357	125	304	03/03/14	08/03/14	Mud Rotary	Tertiary (Poelpena Formation)
KPBi07	229772	597907	6283718	117	310	25/02/14	26/02/14	Mud Rotary	Tertiary (Poelpena Formation)
KPBi09	229774	594439	6282471	109	254	28/02/14	01/03/14	Mud Rotary	Tertiary (Poelpena Formation)

Notes: *GPS Coordinates taken with handheld GPS +/- 5m accuracy. Surface elevation from Geoscience Australia 3-second DEM.

Table 3-3: Kielpa Water Supply Bore Construction Details

Bore ID	Casing Material & Grade	Casing Diameter (mm)	Seal (m)	Cement Boot (m)	Gravel Fill (m)	Depth Setting (m)	Purpose
KPBi04	PVC / Class 12	125	0 – 125 (Cement Grout)	125 - 128	138-290 (Natural pack)	0 – 184 184 – 190 190 – 222 222 – 228 228 – 282 282 – 288 288 – 290 290 - 310	Blank casing Screen, machine slotted, 0.5mm Blank casing Screen, 0.5mm Blank casing Screen, 0.5mm Sump (blank casing with end cap Collapsed hole
KPBp04	PVC Class 18 / Stainless Steel	250mm (0 – 144m) 150mm (134.5 – 284m) 125mm (284 – 302m)	0 – 145 (Cement Grout)	-	145 – 302 (Natural Pack)	0-144 134.5-135 135 - 182 182 - 188 188 - 202 202 - 208 208 - 248 248 - 254 254 - 278 278 - 284 284 - 302	PVC blank casing - first stage J-latch / cone packer PVC blank casing - riser Screen, wire wound 0.5mm PVC blank casing Screen, wire wound 0.5mm PVC blank casing Screen, wire wound 0.5mm PVC blank casing Screen, wire wound 0.5mm Sump (PVC)
KPBi07	PVC / Class 12	125	0 – 108 (Cement Grout)	108, 110, 114	114 – 288 (Natural Pack)	0 - 216 216 - 222 222 - 248 248 - 254 254 - 280 280 - 286 286 - 288 288 - 310	Blank casing Screen, 0.5mm Blank casing Screen, 0.5mm Blank casing Screen, 0.5mm Sump, blank casing with end cap Collapsed hole
KPBi09	PVC / Class 12	125	0 – 108 (Cement Grout)	108	108 – 254 (Natural Pack)	0 - 150 150 - 156 156 - 186 186 - 192 192 - 224 224 - 230 230 - 232 232 - 254	Blank casing Screen, 0.5mm Blank casing Screen, 0.5mm Blank casing Screen, 0.5mm Sump, blank casing with end cap Collapsed hole

3.6 Bore Development Groundwater Yield and Conductivity

Table 3-4 provides a summary of field water quality parameters. Average airlift yields from investigation bores ranged from 3.7 to 13L/s. The lower yield encountered at KPBi09 is likely the result of a higher clay content in the sand and incomplete bore development (Airlift pumping to remove fines and clean the well screen) due to limited water storage capacity at this site.

The average airlift yield from the production well at KPBp04 was 15 L/s.

Conductivity ranged from 41.6mS/cm at KPBi04 in the east up to 62.2mS/cm at KPBi07 (west).

3.7 Groundwater Levels

The depth to water recorded at each bore is presented in Table 3-4. Water levels range from approximately 39m in the east at KPBi04 to 27.38m in the west at KPBi09.

Table 3-4: Water Quality Field Measurements

Bore ID	pH	Conductivity (mS/cm)	Temperature (°C)	Airlift Yield* (L/s)	Depth to Water (m)**	Date Measured
KPBi04	6.96	41.6	25.1	13	38.96	14/03/14
KPBi07	7.01	62.2	27.1	9.14	35.41	14/03/14
KPBi09	7.69	47.1	22.6	3.7	27.38	14/03/14
KPBp04	7.4	45.3	24.9	15	39.54	15/03/14

Notes:

*Depth to Water – metres below top of steel casing

**Airlift yields are an average over the full airlift period (hours).

3.8 Pumping Tests

3.8.1 Overview

Pumping tests were undertaken by DEWNR Groundwater Resource Monitoring Unit from 4 March to 17 March 2014.

Testing at each bore included (where possible):

- A multi rate step test comprising 3 x 100 minute steps, and
- A constant rate test at the maximum achievable rate for a period of up to 8 hours. The actual duration of each test was constrained by turkey nest capacity.

During each test the water level in the pumped well was recorded and at observation wells. Groundwater samples were obtained from each bore and submitted for Laboratory analyses. Water quality data is presented as Appendix F.

Water was disposed of by discharge to a turkeys nest dam constructed at each site.

3.8.2 Bore Performance and Constant Rate Tests

The Cooper-Jacob straight line method was used to calculate Transmissivity from drawdown data, whilst recovery data was analysed using the Theis recovery method (Krusemann and De-ridder 1994).

The Clarke Groundwater software (Clarke 1982) was also used to calculate Transmissivity and boundary conditions from drawdown data at KPBi04 observation bores measured during pumping from KPBp04.

The results of each bore performance (step test) and constant rate test is summarised in Table 3-5 with detailed results and graphs presented in Appendix E.

KPBi07

A step test was not undertaken. A constant rate test was undertaken pumping at 5 L/s for 8 hours starting at 5/3/2014 9:40. Flow rate was constrained by the size of the pump that would fit inside the casing. Maximum drawdown was 11.89m. Estimated Transmissivity is 119 m^2/day on the basis of drawdown and recovery data.

KPBi09

A constant rate test was attempted at on 6/3/2014 at 9:20 pumping at 5 L/s however the water level reached the pump inlet after 3 minutes pumping. The test was discontinued.

A step test was undertaken to determine a sustainable bore yield for the CRT. The step test commenced on 6/3/2014 at 11:00 am. The bore was pumped at 2, 3 and 4 L/s for 100 minute steps. Drawdown at the end of each step was 16, 28m respectively. The final 4L/s step could not be sustained and the water level reached the pump inlet.

A second constant rate test commenced on 7/3/2014 at 8:40 pumping at a rate of 3L/s for 8 hours. The drawdown data shows ongoing bore development (pumping of fines) during pumping and is not suitable for analysis. Recovery data is not impacted by bore development. Analysis of recovery data using the Theis recovery method yielded a transmissivity estimate of 119 m^2/day.

KLBp04

<u>Development</u>

Production bore KPBp04 was developed by jetting and airlift with the drill rig at a rate of approximately 1m screen per hour. Subsequent development was undertaken by pumping with the submersible pump on the 12/3/2014. Maximum flow rate as 50 L/s. flow rate was constrained by the size of the pump.

<u>Bore Efficiency Step Test</u>

A step test was undertaken pumping at 20, 30 and 50L/s for 100 minute steps commencing on 13/3/2014 at 10:30 am. Maximum drawdown was 11.18m. Data was analysed using the Clarke Groundwater Suite of software. The calculated well equation is:

$$S = (0.0016\ Q) + (0.0002\ Q\ \mathrm{Log}(t)) + (2.7 \times 10^{-7} \times Q^2).$$

Where

S = Drawdown in the pumped well (m)

Q = Flow rate (m^3/day)

T = duration of pumping (days)

This equation does not allow for bore interference effects or boundary conditions in the aquifer. For a flow rate of 50 L/s instantaneous well losses total 12 m drawdown. Treatment of interference effects and boundary condition is described in Section 4.6.

Constant Rate Test

A constant rate test commenced on 14/3/2014 at 10:00. The planned test comprised pumping at 5 L/s for 3 days. Flow rate was constrained by the size of the turkeys nest dam available for water storage. The long duration, low rate test was planned in order to identify leakage trends and boundary conditions. However the5 L/s flow rate did not produce measureable drawdown trends. The test was aborted after 24 hours.

Following overnight recovery a second CRT commenced on 16/3/2014 at 8:30 am. The bore was pumped at 30 L/s for 6 hours until the dam was full. Maximum drawdown in the pumped well was 5.8m. Maximum drawdown in KPBi04 obs well located 50m to the south was 0.45m. The following analyses were undertaken:

- Drawdown data in the pumped and observation well was analysed using the Cooper-Jacob straight line method.
- Recovery data in the pumped and observation well was analysed using the Theis recovery method.
- Drawdown data at the observation bore was analysed by fitting a Theis type-curve to the data. The data conform to the type curve consistent with a transmissivity of 3124 m^2/day and a storativity of 1.55 x 10^{-3}. The rate of drawdown increases and deviates from the type-curve at 0.11 days indicative of a boundary condition at approximately 700 m distance from the pumped well.
- Drawdown and recovery data was analysed using the Clarke Groundwater software package. Calculated aquifer properties are summarised in Table 3-5.

Pumping tests indicate high transmissivity of 120m2/day at two sites, and very high transmissivity at the KPB04 site. However the KPI04 test indicates lower transmissivity boundary conditions within 700 m of the tested bore. A transmissivity estimate of 120 m2/day is considered typical for the Lower Tertiary aquifer in the deeper part of the trough, with localised higher values as exhibited at KPB04 site, and the higher value of 450 m2/day derived from testing of IC4 in 2013 (GWS 2013).

Table 3-5: Pumping Test Analysis

Bore ID	Constant Rate Test (L/s)	Constant Rate Test Duration (hours)	Drawdown (m)	Transmissivity (m^2/day)				
				Clarke	Jacob straight line method	Theis recovery method	Theis Type Curve	Average[1]
KPBi07	5	7.5	11.89		105	132		120
KPBi09	3	8[2]	.33		-[3]	119		120
KPBp04	30	6	5.8	-	1129	1129	-	1100
KPBi04			0.45	2929	2635	2156	3124	2700
(Obs)	Storativity (unitless)			1.8 x 10^{-3}	2.1 x 10^{-3}		1.5 x 10^{-3}	1.8 x 10^{-3}

Notes:

(1) Average rounded to two significant figures.

(2) Test impacted by ongoing bore development during the test.

(3) Well not fully developed, data not suitable for analysis.

4 Modelling

4.1 Introduction

Numerical groundwater flow model construction was undertaken to provide a tool for assessing the long term yield and drawdown of a borefield constructed to develop the Kielpa Water Supply and yield the project water demand of 40,000 m^3/day for 20 years.

The model was constructed using Visual Modflow interface for the MODFLOW code. Visual Modflow is an industry standard package for numerical modelling of ground water flow.

4.1.1 Intended Use

The intended use of the model is to

1. confirm the availability of groundwater to meet the project water requirement,
2. validate the conceptual borefield design, and
3. estimate the radius of drawdown impact from borefield operation.

4.1.2 Objectives

The objectives of the model are to:

1. Calculate drawdown at each production well at the completion of 20 years abstraction.
2. Calculate drawdown with distance from the borefield at the completion of 20 years abstraction.

4.1.3 Scale

The model scale is designed to simulate the Tertiary aquifer hosted within the eastern Polda Trough. The model scale is designed to meet the following objectives:

1. Sufficiently large extent to prevent spurious boundary effects
2. Sufficient grid resolution to allow prediction of drawdown at each well to a usable scale.

4.1.4 Model Confidence Level Classification

The Model is developed as a Class 1 confidence level model as defined by the Australian Groundwater Modelling Guidelines (Barnett et al 2012). The level is defined as suitable for predicting long-term impacts of proposed developments in low-value aquifers.

4.2 Conceptualisation

The geological and hydrogeological setting is described in detail in Section 2, whilst the outcomes of investigation bore drilling and testing are summarised in Section 3.

The aquifer has been conceptualised as a simplified 3 dimensional flow model. This approach has been adopted because:

1. The approach is consistent with the model objective which comprises prediction of drawdown with time in response to abstraction.
2. The approach is consistent with the available data. Most drillholes in the Polda Trough Tertiary aquifers do not fully penetrate the Tertiary aquifer. For this reason the thickness of the unit is not well understood beyond the area of investigation by IRD in 2014.

The simplified model is divided into the domains summarised in Table 4-1 and shown graphically as Figure 4-1.

Table 4-1: Numerical Model Conceptualisation

Model Layer	Geological Formation	Description	Hydrostratigraphic Unit description	Thickness (m)	Hydraulic Conductivity (m/day)		Transmissivity (m^2/day)	Storage	
					Horizontal	Vertical		Specific Yield	Specific Storage
1	Quaternary	Partially saturated	Water table	50	0.1	0.01	2	0.05	-
2	Tertiary (upper)	Clay confining Layer	Confining Layer	50	0.01	0.001	0.5	0.05	1×10^{-5}
		Ubiquitous sheet sands	Regionally extensive aquifer	20	0.5	0.05	10	-	1×10^{-5}
3	Tertiary (Lower)	Polda Trough sheet sands	Moderately transmissive aquifer in trough	80	0.5	0.05	40	-	1×10^{-5}
		Deep Polda Trough coarse sands	Highly transmissive aquifer in deepest part of trough	80	1	0.1	80	-	1×10^{-5}
4,5,6	Blue Range Beds	Sandstone	Low transmissivity Basement aquifer	100-380	0.05	0.05	5-19	-	1×10^{-5}
4,5,6	Sleaford Complex	Granite and Gneiss	Negligible transmissivity basement aquifer	100-380	0.01	0.01	1-3.8	-	1×10^{-5}

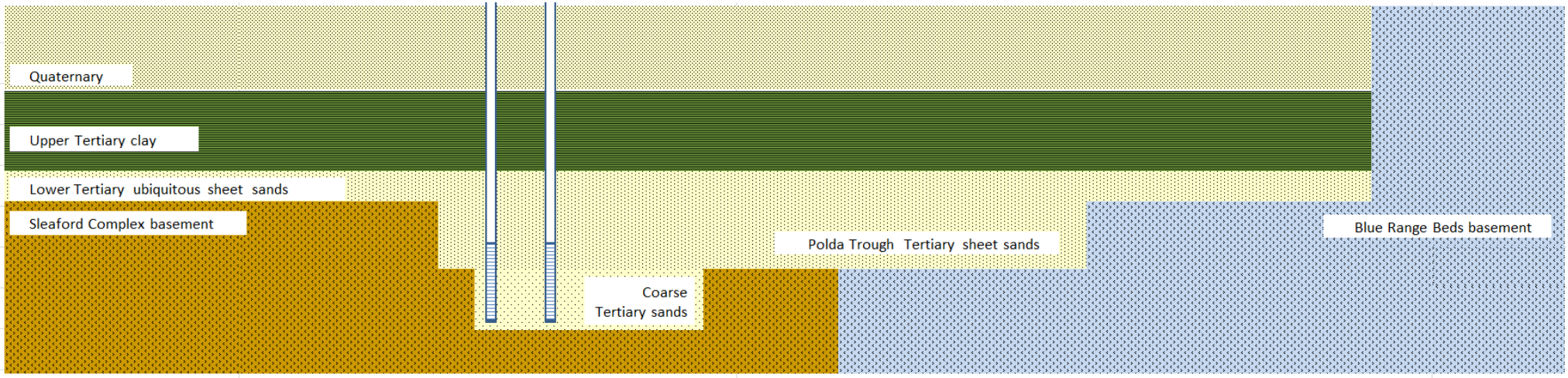


Figure 4-1: Hydrogeological Model Conceptualisation (North – South Section)

4.2.1 Aquifer Properties

Aquifer properties for each hydrostratigraphic units are described below

Quaternary

Where saturated the Quaternary aquifer comprising aeolian sands and calcrete which will exhibit some transmissivity. A nominal hydraulic conductivity of 0.5m/day consistent with fine sand, has been applied. Initial head is simulated at -30m which results in 20m saturated thickness in this unit.

Specific yield or "drainable porosity" simulated in the model is 0.05.

Upper Tertiary Clay

The upper tertiary clay will serve as a confining layer. Lithology comprises plastic clay with some sand inter-beds. Laboratory tests of clay core samples from this unit yielded hydraulic conductivity estimates ranging from 1×10^{-4} to 4.4×10^{-6} m/day (Dowie and Love, 1996). The unit is not continuous over the study area (Refer Cross Sections presented in Section 2). The unit will serve as a local confining layer, however regionally the aquifer will perform as a leaky – unconfined aquifer. This has been simulated with a vertical hydraulic conductivity of 1×10^{-3} m/day.

Lower Tertiary Sands

The lower tertiary sands comprise fine to gravel grainsize, with interbeds of fine grained silt and clay material and lignite. Vertical hydraulic conductivity is lower than horizontal hydraulic conductivity. The results of aquifer testing of this geological unit are summarized in Table 4-2. Hydraulic conductivity estimates generally range around 0.5m/day. This study identified values of conductivity ranging from 0.5 to 11 m/day in the deeper parts of the trough. The unit has been simulated with a regional hydraulic conductivity of 0.5m/day, and a localised higher value of 1 m/day in the deeper part of the trough. This set-up yields a total transmissivity of 130 m^2/day in the deepest parts of the trough, 50 m^2/day in the sheet sands outside the deepest part of the trough and 10 m^2/day regionally.

Specific Storage is simulated in the model at 1×10^{-5} m^{-1}, consistent with the results of the pumping tests at KPBp04. This value is typical for a confined sedimentary aquifer (Fetter 1994).

Table 4-2: Lower Tertiary Formation aquifer testing results

Test	Transmissivity (m^2/day)	Aquifer thickness (m)	Hydraulic Conductivity (m/day)	Reference
IC4	450	104	4	GWS 2013
KPB_4i	1851	166	11	Current Study
KPB_7i	119	215	0.5	
KPB_9i	119	204	0.5	
SKM2	30	10	3	SKM 2013
SKM8	4	10	0.4	
SKM9	32	10	3	
SKM10	4	7	0.6	
P45 Lock Coal Study	3-14	6	0.4 - 2	Coffey 1981

Basement

To the north and west of the basin, basement rock comprises the gneiss and granite of the Sleaford complete. Aquifer testing of this formation by IRD to support mine dewatering studies and construction water supply indicate a very low regional transmissivity of approximately 2 – 4 m^2/day (SKM 2013, Groundwater Science 2013). Hydraulic conductivity of 0.01m/day was applied in the model.

Basement to the east comprises the Blue ranges beds, described as a consolidated sandstone, and gritty conglomeritic sandstone. A single aquifer test in this unit (Groundwater Science 2013) yielded a low transmissivity estimate of 16 m^2/day. Hydraulic conductivity of 0.05m/day was applied in the model.

Basement outcrops and subcrops beneath thin cover to the east and south of the model domain. The extent of basement outcrop is defined by PIRSA's (now DMITRE) 2007 Tertiary Neogene Coverage GIS datasets. This has been simulated in the model by removal of the Tertiary and Quaternary layer properties, and the application of basement properties to all model layers. The extent of basement outcrop is presented on Figure 4-3.

The deeper Jurassic and older sedimentary fill in the Polda Trough is not simulated. The Jurassic and deeper units are not sufficiently well defined to allow modelling. While the material may contribute some confined storage to the borefield, the total contribution will be negligible compared to downward leakage of unconfined storage from the overlying material (Confined storage coefficients are typically 3 to 4 orders of magnitude smaller than vertical leakage from unconfined storage).

4.2.2 Conceptual Boundaries, stresses and physical processes

The conceptual boundaries of the aquifer comprise:

- Recharge via rainfall and through-flow from basement outcrop to the east outside the model domain
- Discharge via through-flow to the west.
- Eventual subsurface groundwater discharge to the ocean some 75km west of the model domain.

Stresses to the aquifer in its currently un-used state are limited to the recharge and discharge processes above.

The current model is set up to simulate drawdown only. As such recharge, through flow and discharge are not simulated and the only simulated stress is groundwater pumping via 10 production bores at 4,000 m^3/day per bore. Pumping simply removes water from storage. This is a conservative approach with does not allow for aquifer recharge and through-flow.

Analytical estimates of aquifer through-flow are presented in Section 2.3.3. Estimated natural daily groundwater through-flow is 500 m^3/day; approximately 1% of the planned pumping rate. Hence the exclusion of these stresses is not expected to materially impact on model outcomes.

4.3 Model Setup

Model Setup is summarised in Table 4-3. Model extent and hydrogeological property zones are shown in Figure 4-3.

Table 4-3: Numerical Groundwater Flow Model Setup

Parameter		Description
Grid size	Extent	65,000 x 65,000 x 380 (north x south x thickness)
	Cell size	100 m x 100m at borefield, enlarging outwards up to 1500 m x 1500m.
	Layers	See Table 4-1and Figure 4-1.
Boundaries	Constant Head	Outer edges applied head of - 30m
	Borefield	10 bores, screened across layers 3 and 4. Each extracting 4,000 m3/day for 20 years (Stress period 1).
Properties	Hydraulic conductivity	See Table 4-1
	Storage	Layer 1: Sy = 0.05 Layers 2-6: Ss = 1 x 10^{-5}
Run Parameters	MODFLOW	• Transient, 2 stress periods: 1) Day 0-7300 pumping 2) Day 7,300 – 14,600 no pumping – recovery • 10 time steps per stress period • WHS Solver, 0.001m head change convergence criteria

4.4 Model Results

Model Results comprise:

- Time series of drawdown calculated at the following points:
    1. Each production bore
    2. A hypothetical observation bore located at Lock township
- Contours of drawdown exported at
    1. 20 years at the completion of pumping, and
    2. 40 years following 20 years recovery.

Time series of drawdown at monitoring points are presented as Appendix G and Figure 4-2. The calculated drawdown at production bores ranges from 48 to 72m. Further treatment of near bore drawdown, well losses and long term bore yield is discussed in Section 4.6. No drawdown is calculated at the lock township which remains beyond the zone of influence of pumping.

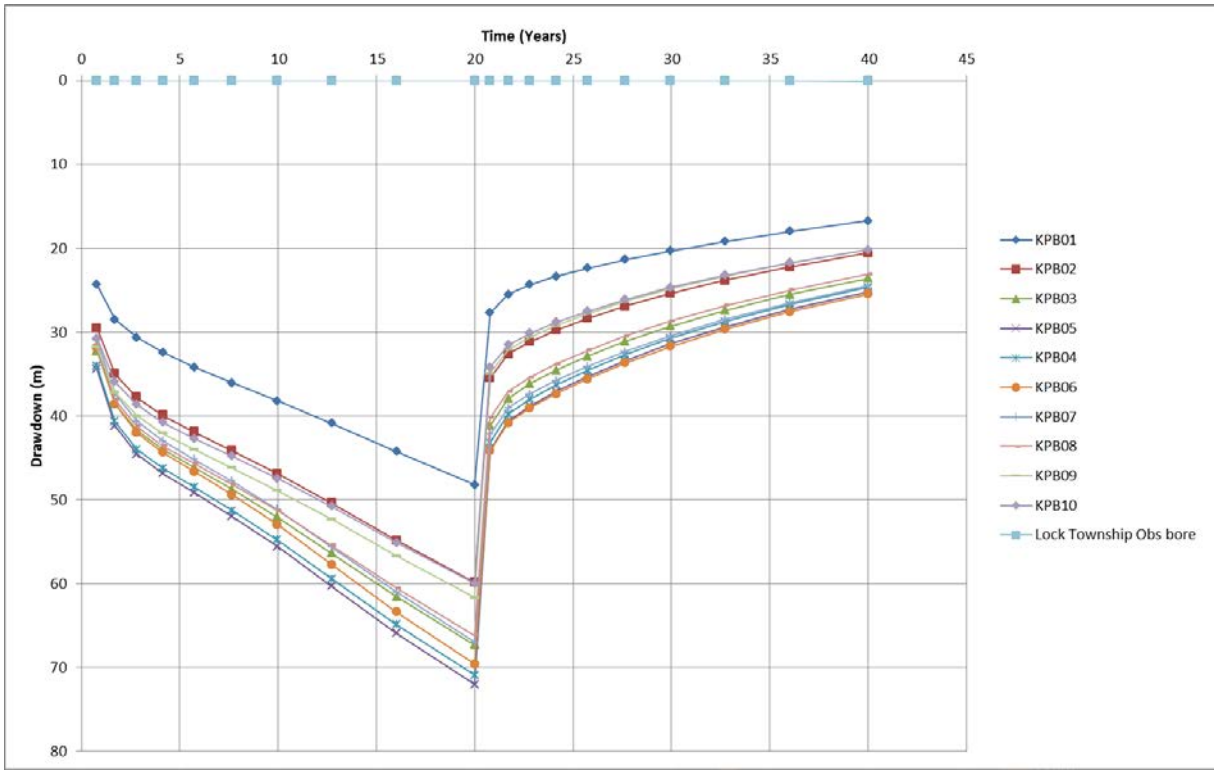


Figure 4-2: Modelled drawdown time series

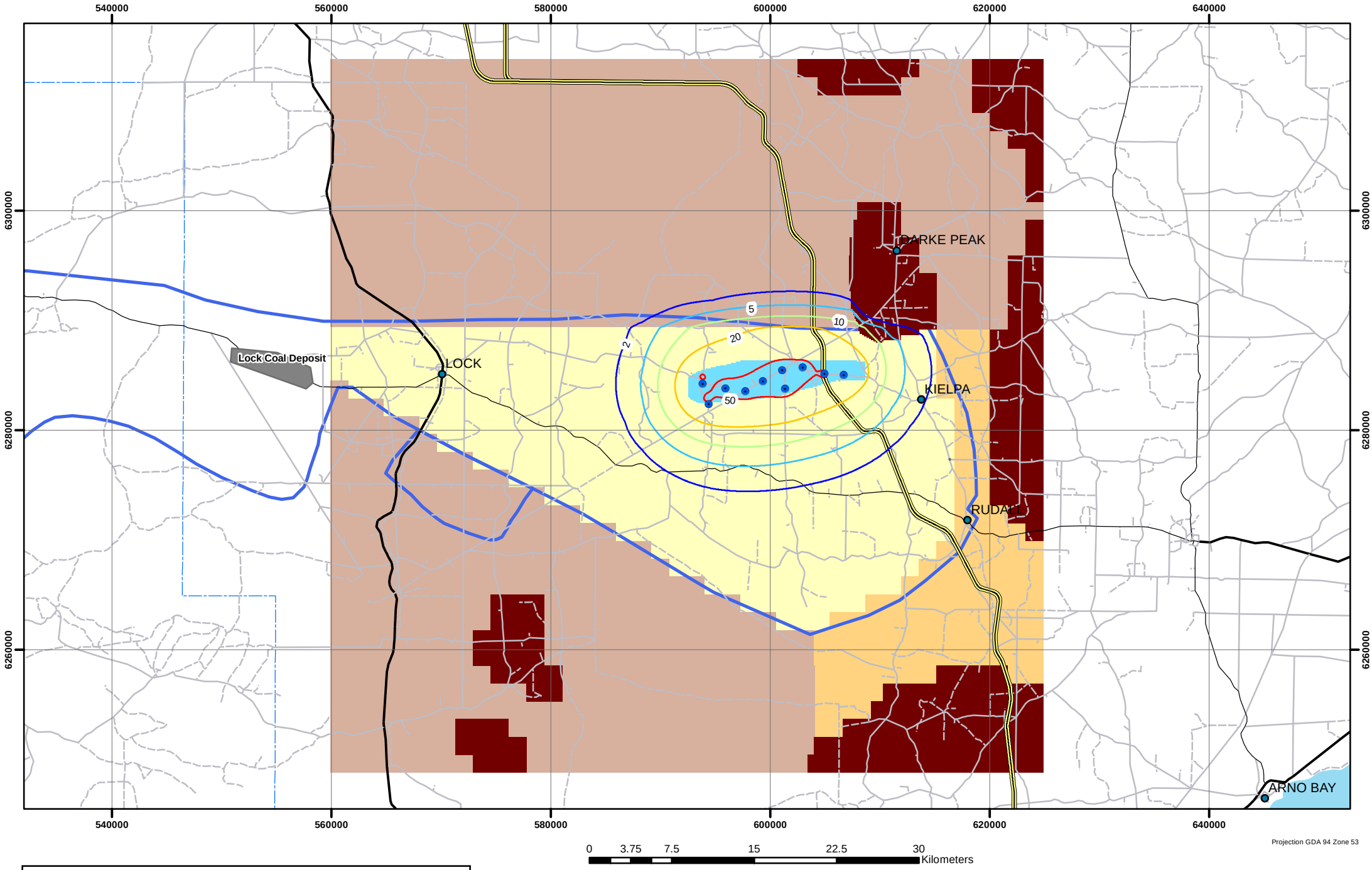
Contours of drawdown at 20 and 40 years are presented on Figure 4-3. Following 20 years pumping the radius of drawdown (defined by the 2m drawdown contour) extends approximately 7.5 km to the west. Following 20 years recovery, the radius increases to approximately 9 km.

4.5 Model Quality Checks

Model quality checks are summarised in Table 4-4 and are acceptable.

Table 4-4: Numerical Groundwater Flow Model Quality Checks

Quality Check	Result	Comments
Mass balance error	0% for all time steps	Acceptable
Flow through constant head boundary's	Less than 1% of total water balance	Constant head boundaries do not over-influence results
Flow from wells	40,000 m3/day all time steps in stress period 1.	Wells remain active for duration of pumping stress period.



Groundwater Science

Figure 4.3
Model Extent, Hydrogeological Zones and Modelled Drawdown

4.6 Production Borefield Capacity

Production bore yield is constrained by the water level drawdown induced by pumping and the available drawdown (distance from static water level to pump inlet) at each well.

Planned pumping rates at each production bore have been validated by comparing calculated drawdown to available drawdown as follows:

Drawdown at a pumped bore is the sum of

- aquifer drawdown
- near-well drawdown
- well losses (friction in the well screen and well column)

Each of these has been calculated as follows:

- Aquifer drawdown at each production well has been calculated using the numerical model described above. Drawdown is a factor of; aquifer transmissivity, leakage from overlying formations, storage coefficient of the pumped aquifer and overlying formations, and properties of adjacent aquifers.
- Near-well drawdown has been calculated using the Theis equation to determine the drawdown between 100m and 0.1m radius from the pumping well. This drawdown is calculated at a scale too fine to be simulated in the regional numerical model which has a cell size of 100 x 100m at the borefield. Aquifer transmissivity at each bore is taken from the nearest investigation bore pumping test. Theis worksheets are presented as Appendix H.
- Well losses have been calculated from the well equation derived from the step pumping test at test production bore KPBp04.

The results are summarised in Table 4-5. All bores have the capacity to meet the design flow rate of 4,000 m^3/day. There is some opportunity to optimise bore yield, particularly by increasing bore yield in the very high transmissivity zone identified at KPB04 and potentially reducing the total number of bores.

Table 4-5: Production bore drawdown calculation

Production Bore Site	SWL (m depth)	Pump Setting (m depth)	Available Drawdown (m)	Transmissivity(4) (m^2/day)	Flow Rate (m^3/day)	Near well drawdown(2) (m)	Well Loss (1) (m)	Numerical Model Drawdown (3) (m)	Total Drawdown (m)
KPB01	50.0	140	90	450	4000	9.8	12	48	70
IC4 / KPB02	50.0	140	90	450	4000	9.8	12	60	82
KPB03	39.8	140	100	1000	4000	3.9	12	67	83
KPB04	39.8	140	100	1000	4000	3.9	12	71	87
KPB05	39.8	140	100	1000	4000	3.9	12	72	88
KPB06	34.4	160	125	130	4000	33.8	12	70	115
KPB07	34.4	160	125	130	4000	33.8	12	67	113
KPB08	34.4	160	125	130	4000	33.8	12	66	112
KPB09	26.8	150	123	120	4000	36.8	12	62	110
KPB10	26.8	150	123	120	4000	36.8	10	60	107

Notes
(1) Well Losses based on KPBp04 pumping test
(2) Drawdown from 0.1 to 100m radius calculated using Theis equation
(3) Numerical Model used to calculate well interference and aquifer boundary effects
(4) Transmissivity estimate from nearest investigation bore site

5 Borefield Design

5.1 General Arrangement

The borefield design comprises 10 bores each with the nominal capacity to yield 180 m^3/hr. The target aquifer interval is approximately 150 to 300m depth. Each bore will be drilled to approximately 300 m depth and cased with 300mm DN Class 12 PVC casing to approximately 150m, the underlying aquifer from approximately 150m to 300m will be screened with 200mm DN 316 grade stainless steel wire wound screens with blank pvc sections placed against fine grained and lignite geological intervals.

Bore Locations are presented in Figure 5-1. The rationale behind the layout is to space bores 2000m apart to minimise interference effects, and to keep the bores within the defined deeper more transmissive part of the trough structure.

Bores will be equipped with electric submersible pumps with the capacity to deliver 180 m^3/hour – nominally 150 – 200 kW pumps. Detailed pump specification for each bore is dependent on individual bore efficiency and will be determined following bore construction and testing.

Bore heads comprise a concrete pad, 316 grade stainless steel bore head-works, pump control panel, and flanged connection to the collector pipeline.

5.2 Value Improvement Options

Additional value may be realised by:

1. Reducing the number of water bores in the borefield, by optimisation of each bore as it is constructed. Individual bore capacity is unknown until the bore is constructed and site specific aquifer properties can be tested. Preliminary investigations indicate that it may be possible to meet the project water demand with a lower number of higher yielding bores, with reduced capital cost.
2. Reducing bore spacing by optimisation of bore locations. In highly transmissive aquifers such as the aquifer intersected by KPBp04, bore spacing can be reduced due to reduced interference effects. This option can reduce the total length of pipe and power infrastructure.
3. Testing the salinity profile with depth to optimise water quality. It is possible that groundwater salinity varies with depth. The multiple screened intervals in investigation bores KPBi04,07 and 09 provide the opportunity to undertake packered sampling tests where each screen is isolated and pumped to yield a groundwater sample from that screened interval. In the event that salinity stratification does occur, the borefield design might be optimised to yield better quality water. The vertical anisotropy of the aquifer would need to be understood to predict the long term reliability of a vertically stratified borefield.

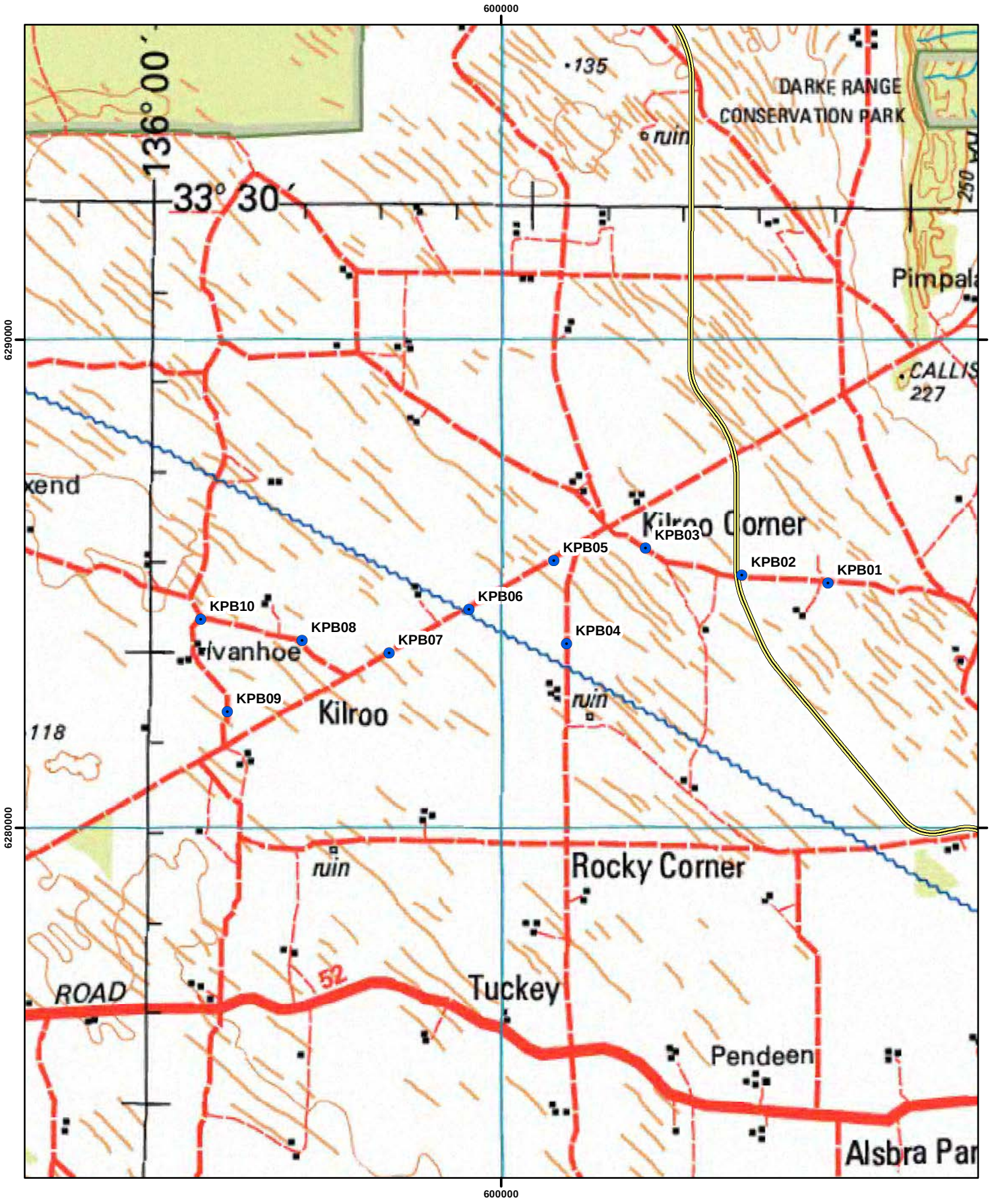


Figure 5.1
Kielpa Water Supply
Conceptual Borefield Layout

6 Limitations

The current study is limited by the available data relating to the target aquifer. The geology is reasonably well defined by a moderate density of historic exploration drilling though the majority of historic holes do not fully penetrate the aquifer and hence total thickness is unknown. The only groundwater data available is the 4 test sites studied by IRD (three as part of the current study and one studied in 2013 as part of construction water investigations). Hydrogeological testing was constrained due to land access, particularly the duration of pumping tests. As a result of these constraints aquifer boundary conditions and leakage are inferred from the geological model and have not been confirmed through testing.

It is recommended that subsequent detailed design work include long term pumping tests to provide:

- Data to calculate leakage and boundary effects from the pumping test data
- A data set sufficient to allow transient calibration of the numerical model to a Class 2 confidence level.

7 Acronyms and Abbreviations

Acronym or Abbreviations	Definition
DEWNR	Department of Environment Water and Natural Resources
CEIP	Central Eyre Iron Project
EC	Electrical Conductivity
GWS	Groundwater Science Pty Ltd
IRD	Iron Road Limited
mAHD	Metres Australian Height Datum
SKM	Sinclair Knight Merz Pty Ltd
TDS	Total Dissolved Solids

8 References

Document Number	Document Title	Author
	ETSA Lock Coal Deposit Dewatering Studies	Coffey, 1981
	Assessment of the Tertiary Sand Aquifer, County Musgrave PWA, Eyre Peninsula. DME Report Book 96/11. 1996.	Dowie and Love
	Lock Coalfield Hydrogeological Study – Progress Report No. 1. SADME Report Book 79/83. 1979.	Eberhard and Waterhouse
E-F-66-RPT-0039	Corridor Groundwater Supply Investigation report (FINAL). Report prepared for Iron Road Limited. 2013.	GWS
E-F-16-RPT-0005	CEIP Minesite Hydrogeological Studies	SKM, 2013
	https://www.waterconnect.sa.gov.au/Systems/GD/Pages/default	DEWNR
	https://sarig.pir.sa.gov.au	DMITRE
	Open File Exploration Report. LDH Series Drilling. 1974.	Chevron Exploration Corp
	Open File Exploration Report 80LRM and 81LRM series drilling. 1985.	CRA Exploration
	Open File Exploration Report 80LRM and 81LRM series drilling. R and V series Drilling. 1969	KerMcgee Austrlia
	Open File Exploration Report 32 Series Drilling.1993	Pan Continental Mining Ltd
	Open File Exploration report DP Series Drilling. 1972.	Mines Administration Pty Ltd – Teton Australia Joint Venture
	Clarke, D.K 1998 Groundwater Discharge Tests: Simulation and Analysis. ELSEVIER, Amsterdam`	Clarke, D
	Fetter, C. (1994): Applied Hydrogeology.- Prentice Hall, New Jersey, 691 pp.	Fetter C
	Krusemann and Deridder, 1994, Analysis and Evaluation of Pumping Test Data Publication 47 IILRI, Netherlands.	Krusemann and Deridder
	McDonald and Harbaugh (1988), A modular three-dimensional finite-difference groundwater flow model. USGS. Techniques of Water Resources Investigations book 6, chapter A1	McDonald and Harbaugh
	Barnett et al, 2012, Australian groundwater modelling guidelines, Waterlines report, National Water Commission, Canberra	Barnett et al.
	Stratigraphic Hole “Tuckey 1” Well completion report. Report Book 81/00019. 1981.	South Australian Department of Mines and Energy

9 List of Appendices

Document Number	Document Title	Author
Appendix A	Well Permits	DEWNR, 2014
Appendix B	Drilling Summary Data Sheets (including lith log, bore construction, air lift log and chip tray photo)	GWS, 2014
Appendix C	Downhole Gamma Survey Logs	GWS, 2014
Appendix D	Sieve Analysis Data Sheets	GWS, 2014
Appendix E	Pumping Test Data Sheets	GWS, 2014
Appendix F	Water Quality Data	GWS, 2014
Appendix G	Model Outputs – Drawdown Data	GWS, 2014
Appendix H	Theis Worksheets	GWS, 2014

Appendix A Well Permits

GOVERNMENT OF SOUTH AUSTRALIA

DEPARTMENT OF ENVIRONMENT, WATER AND NATURAL RESOURCES

PO Box 1046 Mt Gambier SA 5290
Ph: 8735 1134 Fax: 8735 1155

PERMIT to undertake a WATER AFFECTING ACTIVITY

pursuant to section 135 of the *Natural Resources Management Act 2004*

WELL PERMIT

Subject to full compliance with all the procedures, specifications and limitations contained or referred to, in the conditions set out below,

Permit No:	229774
Expiry Date:	31/01/2015

Permission is hereby granted to: IRON ROAD LTD
ACN 128 698 108
GPO BOX 1164
ADELAIDE SA 5001

To undertake the following water affecting activity:

Activity: Well Construction
Well Use: Investigation

CONDITIONS:

1. The activity authorised by this permit must only be undertaken on the land described below:

   CT 5495/684
   Section 8
   Hundred of Boonerdo

2. All work is to be carried out in accordance with the enclosed general specifications.
3. If the well is considered unsatisfactory, it may be abandoned and a replacement well may then be constructed provided that the abandoned well is backfilled prior to the drill rig leaving the site.
4. Water samples are required from all wells drilled in respect of this permit.
5. Strata samples are not required.
6. The licensed well driller must forward with his report a plan obtained from the permit holder, who must mark thereon the location of all wells drilled in respect of this permit.
7. All wells must be drilled vertical unless written permission is obtained from the Minister.
8. The equipment, materials and methods used in drilling, plugging, backfilling or sealing of a well, or the replacement or alteration of the casing, lining or screen of a well, shall not adversely affect the quality of an underground water resource.

9. Aquifers shall be protected during drilling, plugging, backfilling or sealing of a well, or the replacement or alteration of the casing, lining or screen of a well, to prevent adverse impacts upon the integrity of the aquifer.
10. This work may be subject to inspection by the Department's Drilling Inspectors.
11. If this well is incidental/ancillary to mining operations authorised under the Mining Act 1971, or a regulated activity under the Petroleum and Geothermal Energy Act 2000 (Acts), the well must be decommissioned (as outlined in the Minimum Construction Requirements for Water Bores in Australia Third Edition) prior to the relinquishment of the licence or lease under the associated Acts, unless alternative formal arrangements can be made with the owner or occupier of the land on which the well is located subject to approval by the relevant Minister or the Minister's agent.

NOTES:

1. Under section 202(1)(b)(ii) of the Natural Resources Management Act 2004, you have a right of appeal to the Environment, Resources and Development Court against the imposition of any condition on this permit. The appeal must be instituted within six weeks of the date of permit issue. The appeal must also be served upon this department within that time.
2. This permit is not transferable.
3. This well construction permit is not an authorisation for a person to enter private property and prior authority must be obtained from the land owner in all circumstances.
4. The issue of this permit does not negate the requirement to comply with the provisions of other Acts that may impact on the activity undertaken pursuant to this permit.

TAKE NOTE that the permit holder, or a person acting on behalf of the permit holder, who contravenes or fails to comply with a condition of this permit is guilty of an offence, and such acts or omissions may result in the variation, suspension or revocation of the permit.

Sonya Knight
WATER LICENSING OFFICER
Delegate of Minister for Sustainability, Environment and Conservation

Date: 31/01/2014

GOVERNMENT OF SOUTH AUSTRALIA
DEPARTMENT OF ENVIRONMENT, WATER AND NATURAL RESOURCES

PO Box 1046 Mt Gambier SA 5290
Ph: 8735 1134 Fax: 8735 1155

PERMIT to undertake a WATER AFFECTING ACTIVITY

pursuant to section 135 of the *Natural Resources Management Act 2004*

WELL PERMIT

Subject to full compliance with all the procedures, specifications and limitations contained or referred to, in the conditions set out below,

Permit No:	229772
Expiry Date:	30/01/2015

Permission is hereby granted to: IRON ROAD LTD
ACN 128 698 108
GPO BOX 1164
ADELAIDE SA 5001

To undertake the following water affecting activity:

Activity: Well Construction
Well Use: Investigation

CONDITIONS:

1. The activity authorised by this permit must only be undertaken on the land described below:

   CT 5192/469
   Section 48
   Hundred of Smeaton

2. All work is to be carried out in accordance with the enclosed general specifications.
3. If the well is considered unsatisfactory, it may be abandoned and a replacement well may then be constructed provided that the abandoned well is backfilled prior to the drill rig leaving the site.
4. Water samples are required from all wells drilled in respect of this permit.
5. Strata samples are not required.
6. The licensed well driller must forward with his report a plan obtained from the permit holder, who must mark thereon the location of all wells drilled in respect of this permit.
7. All wells must be drilled vertical unless written permission is obtained from the Minister.
8. The equipment, materials and methods used in drilling, plugging, backfilling or sealing of a well, or the replacement or alteration of the casing, lining or screen of a well, shall not adversely affect the quality of an underground water resource.

9. Aquifers shall be protected during drilling, plugging, backfilling or sealing of a well, or the replacement or alteration of the casing, lining or screen of a well, to prevent adverse impacts upon the integrity of the aquifer.
10. This work may be subject to inspection by the Department's Drilling Inspectors.
11. If this well is incidental/ancillary to mining operations authorised under the Mining Act 1971, or a regulated activity under the Petroleum and Geothermal Energy Act 2000 (Acts), the well must be decommissioned (as outlined in the Minimum Construction Requirements for Water Bores in Australia Third Edition) prior to the relinquishment of the licence or lease under the associated Acts, unless alternative formal arrangements can be made with the owner or occupier of the land on which the well is located subject to approval by the relevant Minister or the Minister's agent.

NOTES:

1. Under section 202(1)(b)(ii) of the Natural Resources Management Act 2004, you have a right of appeal to the Environment, Resources and Development Court against the imposition of any condition on this permit. The appeal must be instituted within six weeks of the date of permit issue. The appeal must also be served upon this department within that time.
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Sonya Knight
WATER LICENSING OFFICER
Delegate of Minister for Sustainability, Environment and Conservation

Date: 30/01/2014

GOVERNMENT OF SOUTH AUSTRALIA
DEPARTMENT OF ENVIRONMENT, WATER AND NATURAL RESOURCES

PO Box 1046 Mt Gambier SA 5290
Ph: 8735 1134 Fax: 8735 1155

PERMIT to undertake a WATER AFFECTING ACTIVITY

pursuant to section 135 of the *Natural Resources Management Act 2004*

WELL PERMIT

Subject to full compliance with all the procedures, specifications and limitations contained or referred to, in the conditions set out below,

Permit No:	229769
Expiry Date:	30/01/2015

Permission is hereby granted to: IRON ROAD LTD
ACN 128 698 108
GPO BOX 1164
ADELAIDE SA 5001

To undertake the following water affecting activity:

Activity: Well Construction
Well Use: Investigation

CONDITIONS:

1. The activity authorised by this permit must only be undertaken on the land described below:

   CT 5675/903
   Section 49
   Hundred of Smeaton

2. All work is to be carried out in accordance with the enclosed general specifications.
3. If the well is considered unsatisfactory, it may be abandoned and a replacement well may then be constructed provided that the abandoned well is backfilled prior to the drill rig leaving the site.
4. Water samples are required from all wells drilled in respect of this permit.
5. Strata samples are not required.
6. The licensed well driller must forward with his report a plan obtained from the permit holder, who must mark thereon the location of all wells drilled in respect of this permit.
7. All wells must be drilled vertical unless written permission is obtained from the Minister.
8. The equipment, materials and methods used in drilling, plugging, backfilling or sealing of a well, or the replacement or alteration of the casing, lining or screen of a well, shall not adversely affect the quality of an underground water resource.

9. Aquifers shall be protected during drilling, plugging, backfilling or sealing of a well, or the replacement or alteration of the casing, lining or screen of a well, to prevent adverse impacts upon the integrity of the aquifer.
10. This work may be subject to inspection by the Department's Drilling Inspectors.
11. If this well is incidental/ancillary to mining operations authorised under the Mining Act 1971, or a regulated activity under the Petroleum and Geothermal Energy Act 2000 (Acts), the well must be decommissioned (as outlined in the Minimum Construction Requirements for Water Bores in Australia Third Edition) prior to the relinquishment of the licence or lease under the associated Acts, unless alternative formal arrangements can be made with the owner or occupier of the land on which the well is located subject to approval by the relevant Minister or the Minister's agent.

NOTES:

1. Under section 202(1)(b)(ii) of the Natural Resources Management Act 2004, you have a right of appeal to the Environment, Resources and Development Court against the imposition of any condition on this permit. The appeal must be instituted within six weeks of the date of permit issue. The appeal must also be served upon this department within that time.
2. This permit is not transferable.
3. This well construction permit is not an authorisation for a person to enter private property and prior authority must be obtained from the land owner in all circumstances.
4. The issue of this permit does not negate the requirement to comply with the provisions of other Acts that may impact on the activity undertaken pursuant to this permit.

TAKE NOTE that the permit holder, or a person acting on behalf of the permit holder, who contravenes or fails to comply with a condition of this permit is guilty of an offence, and such acts or omissions may result in the variation, suspension or revocation of the permit.

Sonya Knight
WATER LICENSING OFFICER
Delegate of Minister for Sustainability, Environment and Conservation

Date: 30/01/2014

GOVERNMENT OF SOUTH AUSTRALIA
DEPARTMENT OF ENVIRONMENT, WATER AND NATURAL RESOURCES

PO Box 1046 Mt Gambier SA 5290
Ph: 8735 1134 Fax: 8735 1155

PERMIT to undertake a WATER AFFECTING ACTIVITY

pursuant to section 135 of the *Natural Resources Management Act 2004*

WELL PERMIT

Subject to full compliance with all the procedures, specifications and limitations contained or referred to, in the conditions set out below,

Permit No:	229768
Expiry Date:	30/01/2015

Permission is hereby granted to: IRON ROAD LTD
ACN 128 698 108
GPO BOX 1164
ADELAIDE SA 5001

To undertake the following water affecting activity:

Activity: Well Construction
Well Use: Investigation

CONDITIONS:

1. The activity authorised by this permit must only be undertaken on the land described below:

   CT 5675/903
   Section 49
   Hundred of Smeaton

2. All work is to be carried out in accordance with the enclosed general specifications.
3. If the well is considered unsatisfactory, it may be abandoned and a replacement well may then be constructed provided that the abandoned well is backfilled prior to the drill rig leaving the site.
4. Water samples are required from all wells drilled in respect of this permit.
5. Strata samples are not required.
6. The licensed well driller must forward with his report a plan obtained from the permit holder, who must mark thereon the location of all wells drilled in respect of this permit.
7. All wells must be drilled vertical unless written permission is obtained from the Minister.
8. The equipment, materials and methods used in drilling, plugging, backfilling or sealing of a well, or the replacement or alteration of the casing, lining or screen of a well, shall not adversely affect the quality of an underground water resource.

9. Aquifers shall be protected during drilling, plugging, backfilling or sealing of a well, or the replacement or alteration of the casing, lining or screen of a well, to prevent adverse impacts upon the integrity of the aquifer.
10. This work may be subject to inspection by the Department's Drilling Inspectors.
11. If this well is incidental/ancillary to mining operations authorised under the Mining Act 1971, or a regulated activity under the Petroleum and Geothermal Energy Act 2000 (Acts), the well must be decommissioned (as outlined in the Minimum Construction Requirements for Water Bores in Australia Third Edition) prior to the relinquishment of the licence or lease under the associated Acts, unless alternative formal arrangements can be made with the owner or occupier of the land on which the well is located subject to approval by the relevant Minister or the Minister's agent.

NOTES:

1. Under section 202(1)(b)(ii) of the Natural Resources Management Act 2004, you have a right of appeal to the Environment, Resources and Development Court against the imposition of any condition on this permit. The appeal must be instituted within six weeks of the date of permit issue. The appeal must also be served upon this department within that time.
2. This permit is not transferable.
3. This well construction permit is not an authorisation for a person to enter private property and prior authority must be obtained from the land owner in all circumstances.
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Sonya Knight
WATER LICENSING OFFICER
Delegate of Minister for Sustainability, Environment and Conservation

Date: 30/01/2014

GOVERNMENT OF SOUTH AUSTRALIA

DRILLERS WELL CONSTRUCTION REPORT

Water Resources Act, 1997

1. PERMIT NO: 229768 Site

NAME OF DRILLER Josh Pech Licence No: 131725

Contact Phone/Mobile No.: 0468 942 313

Name of plant operator if under supervision

PERMIT HOLDER or land occupier Iron Road LTD

Postal Address Gpo Box 1164

Adelaide SA Post Code 5001

2. LOCATION OF WELL

Date of Survey 24.2.2014 Surveyed by Sam M Method Hand held GPS

GPS COORDINATES

- ☑ GDA 94/WGS84
- ☐ AGD 66/84

~~AGD~~ Easting 601413

Northing 6284304

- ☐ ZONE 54
- ☑ ZONE 53
- ☐ ZONE 52

3. WELL NAME

4. LAND IDENTIFICATION

Hundred or Pastoral Lease No: Smeaton

File/Section/Parcel ID 49

Name of Property C.T 5675/903

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*

Date work Commenced 21.2.2014 Date work Completed 24.2.2014

Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☐

Is this a Replacement well? YES/NO if yes please quote replaced well number

Is this an Existing well? YES/NO **if yes please quote well number or mark location on map**

Was well Abandoned? YES/(NO) if yes please state method

Maximum Depth Drilled 310 (m) Final Depth 290 (m) Final Standing Water Level 35 (m) Final Yield 15 (L/sec)

6. DRILLING DETAILS

If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	310	200	Rotary	Mud

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste

7. CASING LEFT IN WELL

7.1 Dimensions / 7.2 Type / 7.3 Casing Cemented

From (m)	To (m)	Internal Diam. (mm)	Swell Joint, Welded Collar, Steel, FRP, PVC, etc.	Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
0	138	115	Class 18 P.V.C	☑	☐	0	138	80 by 20kg	1960	80kg Bent	Tremie	5% Bent
138	290	115	Class 18 P.V.C	☐	☑							
				☐	☐							
				☐	☐							

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 Method

- ☐ Open Hole
- ☑ Slotted Casing P.V.C
- ☐ Screen(s) P.V.C
- ☐ Other, give details: P.V.C slotted class 18

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Base
Slotted class 18	184	190	0.6	115	140	P.V.C		2m Sump+Cap
Slotted class 18	222	228	0.6	115	140	P.V.C		
Slotted class 18	282	288	0.6	115	140	P.V.C		

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)

8.4 Gravel Packing ○

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
Air lift	6hrs	

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

12. SAMPLES

The provision of the Water Resources Act 1997 and Regulations thereto require that strata and water

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	3	Lime Stone
3	14	Clay
14	22	Sand
22	34	Clay
34	38	Sand
38	84	Clay
84	88	Sand
88	112	Clay
112	124	Sand
124	130	Clay
130	136	Sand
136	142	Clay
142	268	Sand
268	274	Brown clay
274	310	Sand

GOVERNMENT OF SOUTH AUSTRALIA

DRILLERS WELL CONSTRUCTION REPORT

Water Resources Act, 1997

1. PERMIT NO: 229772 Site

NAME OF DRILLER Josh Pech Licence No: 131725

Contact Phone/Mobile No: 0468 942 313

Name of plant operator if under supervision

PERMIT HOLDER or land occupier Iron Road LTD

Postal Address Gpo Box 1164

Adelaide S.A. Post Code 5001

2. LOCATION OF WELL

Date of Survey 27.2.2014 Surveyed by Sam.M Method Hand held Gps

GPS COORDINATES

- ☑ GDA 94/WGS84
- ☐ AGD 66/84

Easting 597907

Northing 6283718

- ☐ ZONE 54
- ☑ ZONE 53
- ☐ ZONE 52

3. WELL NAME

4. LAND IDENTIFICATION

Hundred or Pastoral Lease No: Smeaton

File/Section/Parcel ID 48

Name of Property CT 5192/469

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*

Date work Commenced 25.2.2014 Date work Completed 27.2.2014

Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☐

Is this a Replacement well? YES/NO if yes please quote replaced well number

Is this an Existing well? YES/NO **if yes please quote well number or mark location on map**

Was well Abandoned? YES/(NO) if yes please state method

Maximum Depth Drilled 310 (m) Final Depth 288 (m) Final Standing Water Level 35 (m) Final Yield 10 (L/sec)

6. DRILLING DETAILS

If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	310	200	Rotary	Mud

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste

7. CASING LEFT IN WELL

7.1 Dimensions / 7.2 Type / 7.3 Casing Cemented

From (m)	To (m)	Internal Diam. (mm)	Swell Joint, Welded Collar, Steel, FRP, PVC, etc.	Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
0	108	115	Class 18 P.V.C	☑	☐	0	108	80 by	1960	80kg Bent	Tremie	5% Bent
108	288	115	Class 18 P.V.C	☐	☑			20kg				
				☐	☐							
				☐	☐							

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 Method

- ☐ Open Hole
- ☑ Slotted Casing
- ☐ Screen(s)
- ☐ Other, give details:

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Base
Class 18 Slotted	216	222	0.6	115	140	P.V.C		2m Sump
Class 18 Slotted	248	254	0.6	115	140	P.V.C		With
Class 18 Slotted	280	286	0.6	115	140	P.V.C		End Cap

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)

8.4 Gravel Packing

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
Air lift	6	

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

12. SAMPLES

The provision of the Water Resources Act 1997 and Regulations thereto require that strata and water

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	3	Lime Stone
3	12	Clay
12	20	Sand
20	32	Clay
32	36	Sand
36	84	Clay
84	88	Sand
88	110	Clay
110	120	Sand
120	130	Clay
130	136	Sand
136	142	Clay
142	310	Sand.

GOVERNMENT OF SOUTH AUSTRALIA

DRILLERS WELL CONSTRUCTION REPORT

Water Resources Act, 1997

1. PERMIT NO: 2 2 9 7 7 4 Site

NAME OF DRILLER Josh Pech Licence No: 131725

Contact Phone/Mobile No.: 0468 942 313

Name of plant operator if under supervision

PERMIT HOLDER or land occupier Iron Road LTD

Postal Address Gpo Box 1164 Adelaide S.A. Post Code 5001

2. LOCATION OF WELL

Date of Survey 2.3.2014 Surveyed by Sam.m Method Hand held Gps

GPS COORDINATES

☑ GDA 94/WGS84
☐ AGD 66/84

Easting 594439
Northing 6282471

☐ ZONE 54
☑ ZONE 53
☐ ZONE 52

3. WELL NAME

4. LAND IDENTIFICATION

(Hundred) or Pastoral Lease No: Boonerdo

File/(Section)/Parcel ID 8

Name of Property CT 5495/684

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*

Date work Commenced 28.2.2014 Date work Completed 2.3.2014

Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☐

Is this a Replacement well? YES/NO if yes please quote replaced well number

Is this an Existing well? YES/NO **if yes please quote well number or mark location on map**

Was well Abandoned? YES/(NO) if yes please state method

Maximum Depth Drilled 254 (m) Final Depth 232 (m) Final Standing Water Level 35 (m) Final Yield 4 (L/sec)

6. DRILLING DETAILS

If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	254	200	Rotary	Mud

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste

7. CASING LEFT IN WELL

7.1 Dimensions / 7.2 Type / 7.3 Casing Cemented

From (m)	To (m)	Internal Diam. (mm)	Swell Joint, Welded Collar, Steel, FRP, PVC, etc.	Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
0	108		Clas12 P.V.C	☑	☐	0	108	80x20kg	1960	80kg Bent	Tremie	5% Bent
108	232			☐	☐							
				☐	☐							
				☐	☐							

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 Method

☐ Open Hole
☑ Slotted Casing
☐ Screen(s)
☐ Other, give details:

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Base
Class 12 Slotted	150	156	0.6			P.V.C		2m Sump
Class 12 Slotted	186	192	0.6			P.V.C		With
Class 12 Slotted	224	230	0.6			P.V.C		End Cap

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)

8.4 Gravel Packing

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
Air lift	6	

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

12. SAMPLES

The provision of the Water Resources Act 1997 and Regulations thereto require that strata and water

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	3	Lime Stone
3	10	Sand
10	42	Clay
42	90	Sand
90	114	Clay
114	253	Sand
253	254	Hard Rock

GOVERNMENT OF SOUTH AUSTRALIA

DRILLERS WELL CONSTRUCTION REPORT

Water Resources Act, 1997

1. PERMIT NO: 229769 Site

NAME OF DRILLER Josh Pech Licence No: 131725

Contact Phone/Mobile No.: 0468 942 313

Name of plant operator if under supervision

PERMIT HOLDER or land occupier Iron Road LTD

Postal Address GPO Box 1164

Adelaide S.A Post Code 5001

2. LOCATION OF WELL

Date of Survey 10.3.2014 Surveyed by Sam. M Method Hand held GPS

GPS COORDINATES

- ☑ GDA 94/WGS84
- ☐ AGD 66/84

Easting 601414

northing 6284357

- ☐ ZONE 54
- ☑ ZONE 53
- ☐ ZONE 52

3. WELL NAME

4. LAND IDENTIFICATION

Hundred or Pastoral Lease No: Smeaton

File/Section/Parcel ID 49

Name of Property CT 5675/903

5. SUMMARY *(Please tick appropriate boxes and complete all relevant details)*

Date work Commenced 3.3.2014 Date work Completed 10.3.2014

Work carried out: New Well ☑ Deepen ☐ Enlarge ☐ Rehabilitate ☐ Backfill ☐

Is this a Replacement well? YES/NO if yes please quote replaced well number

Is this an Existing well? YES/NO **if yes please quote well number or mark location on map**

Was well Abandoned? YES/NO if yes please state method

Maximum Depth Drilled 304 (m) Final Depth 302 (m) Final Standing Water Level 35 (m) Final Yield 40 (L/sec)

6. DRILLING DETAILS

If not a drilled well, please complete Sections: 6.2, 9, 10, 11, 12 and 13 as necessary

6.1 Construction Details

From (m)	To (m)	Diam (mm)	Drilling Method Cable Tool, Rotary Auger, Down Hole Hammer, etc.	Fluid Used (Air, Water, Mud Type)
0	145	370	Rotary	mud
145	304	230	Rotary	mud

6.2 Water Cut Details (measurements from natural surface to nearest 0.1 m)

Date	Water Cut From (m)	Water Cut To (m)	Standing Water Level (m)	Estimated Yield (L/sec)	Hole Depth at Test (m)	Casing at Test (m)	Test Method	Salinity (mg/L) or Taste

7. CASING LEFT IN WELL

7.1 Dimensions / 7.2 Type

From (m)	To (m)	Internal Diam. (mm)	Swell Joint, Welded Collar, Steel, FRP, PVC, etc.
0	144	252	Class 18 P.V.C
144	302	134	Class 18 P.V.C

7.3 Casing Cemented

Yes	No	From (m)	To (m)	Cement (bags)	Water (litres)	Other Additives	Cementing Method Used	Comments
☑	☐	0	144	240x20kg	8280	480kg Bent	Drill pipe	10% Bent
☐	☑							
☐	☐							
☐	☐							

8. CONSTRUCTION AT PRODUCTION LEVEL

8.1 Method

- ☐ Open Hole
- ☐ Slotted Casing
- ☑ Screen(s)
- ☐ Other, give details:

8.2 Screen or Casing (*If variable aperture screen used give limits)

Type	From (m)	To (m)	Aperture* (mm)	Inner Diam (mm)	Outer Diam (mm)	Material	Trade Name	Completion of Base
S/S Screen	182	188	0.5	150	165	S/S	Johnson	18m Sump
S/S Screen	202	208	0.5	150	165	S/S	Johnson	With
S/S Screen	248	254	0.5	150	165	S/S	Johnson	End Cap

8.3 Liner Seal (Packer)

Material	Depth (m)	Internal Diam (mm)
10" to 6" Rubber K-packer	134	134

8.4 Gravel Packing

Method of Placement	Gravel Passing Mesh Size	From (m)	To (m)

9. IF NOT A DRILLED WELL

Method	Depth (m)	Length (m)	Width (m)	Diam (m)	Lining Material	From (m)	To (m)

10. DEVELOPMENT (State methods and time taken)

Method	Hours	Minutes
Jet Screen & Air lift	20	
Airlift	2	

11. PUMPING TEST (measurements from natural surface to nearest 0.1m)

Interval Tested From (m)	Interval Tested To (m)	Water Level (m)	Test Method	Pump Depth (m)	Discharge Rate (L/sec)	Method of Measuring Discharge	Hours Pumped	Draw Down (m)

12. SAMPLES

The provision of the Water Resources Act 1997 and Regulations thereto require that strata and water

13. FORMATION LOG

From (m)	To (m)	Description of Material
0	3	Lime Stone
3	14	Clay
14	22	Sand
22	34	Clay
34	38	Sand
38	84	Clay
84	88	Sand
88	112	Clay
112	124	Sand
124	130	Clay
130	136	Sand
136	142	Clay
142	268	Sand
268	274	Brown clay
274	304	Sand.

Appendix B Drilling Summaries

Drilling summary report

Hole: KPBi04

Date started:	21/02/2014		Date completed:	23/02/2014	
Drilling Co./Rig:	Thompson / Rig 18		Co-ordinates (GDA94, Z54): E	601413	GPS
Driller:	Josh Pech		N	6284304	coordinates/elevation taken with handheld GPS on 25/2/2014
			Natural surface elevation. (mAHD)	123	

HSEC

Incident description	Action	Follow up

Field observations

EOH Airlifting Summary

Depth of airline (m)	Post-test SWL (m)[2]	Airlift yield (L/s)	Airlift period (hours)	EC (mS/cm)	pH	Temp. (ºC)	Other Observations
100	38.96 (14/03/14)	13 (average)	8.25	41.6	6.96	25.1	SWL m below top of steel casing

Notes: 2. SWL as meters below ground level

Lithological Summary (refer full lithological log for full details)

Depth to	Interp. Log[1]	Description
0.2	Qh	Topsoil and Calcrete
14	Qh	Sandy clay: red
22	Qh	Clayey sand: yellow and white, medium-very coarse
30	T (Upper)	Sandy clay: grey and red
32	T (Upper)	Clay: grey and red, sand in places
86	T (Upper)	Clay: grey, grading to Lignite
88	T (Upper)	Lignite
102	T (Upper)	Clay: grey and dark grey
114	T (Upper)	Clay: grey, with Sand: coarse to very coarse
120	T (Upper)	Sand: coarse to very coarse
124	T (Upper)	Sandy Clay: grey, with Sand: coarse to very coarse, minor Lignite
128	T (Upper)	Sandy Clay: grey, minor Lignite
130	T (Upper)	Clay: grey with brown and black
136	T (Upper)	Sandy Clay: grey and dark grey
140	T (Upper)	Sandy Clay: grey and dark grey, with Sand: coarse sub-rounded
142	T (Upper)	Clay, grey with dark lignitic lenses and pale sandy lenses
144	T (Upper)	Clay: pale grey/dark grey/brown, with Sand: med-coarse clean
168	T (Lower)	Sand: med-very coarse, clean, with minor Sandy Clay: pale grey and Lignite
184	T (Lower)	Lignite
190	T (Lower)	Granules (2-4mm): poorly sorted sub-angular, with Pebbles (to 8mm) and Sand: med-ve
200	T (Lower)	Sand: med-coarse, brown, with Lignite
208	T (Lower)	Sand: med-very coarse, brown, with Pebbles (to 8mm) sub-angular and Lignite
214	T (Lower)	Lignite
220	T (Lower)	Sand: med-very coarse, brown
228	T (Lower)	Granules, Pebbles (to 8mm) and Sand, brown, minor Lignite
230	T (Lower)	Sand: med-coarse, brown, minor Lignite
232	T (Lower)	Granules, Pebbles (to 8mm) and Sand, brown, with Lignite
234	T (Lower)	Sand: coarse, with Granules, minor Lignite
238	T (Lower)	Lignite, with Granules and Pebbles
240	T (Lower)	Lignite
244	T (Lower)	Lignite, with Sand: med-coarse
246	T (Lower)	Clay: pale grey, with Sand: med-coarse
250	T (Lower)	Sand: med-coarse, clean, minor grey Clay cuttings
262	T (Lower)	Lignite, with Sand: med-coarse
270	T (Lower)	Sand: med-very coarse and Granules, with Lignite
278	T (Lower)	Lignite
280	T (Lower)	Lignite, with Sand: med-coarse
282	T (Lower)	Sand: coarse-very coarse
284	T (Lower)	Sand: coarse-very coarse and Granules, with Lignite
286	T (Lower)	Sand: med-very coarse, with Lignite
302	T (Lower)	Granules and Sand: med-very coarse, with minor Lignite
304	T (Lower)	Lignite, with minor Sand
310	T (Lower)	Sand: med-very coarse, with Granules, minor lignite

Notes: 1. Interpretted log: Qh (quarternary), T (Tertairy - Upper and Lower)

Grey Clay cuttings' recorded in some intervals are likely to be contamination from an overlying interval of unstable Clay

Bit log

Depth (m)	Type (inches)
0 - 310	Drag Bit 7 7/8 in

Mud log

Depth (m)	Description
0 - 310	

Construction log

Depth setting	Material/grade	Diameter/size	Purpose[4]
Casing			
0 - 184	PVC Class 12	125 mm / 5 in	Blank casing
184 - 190	PVC Class 12	125 mm / 5 in	Screen, machine slotted, 0.5 mm
190 - 222	PVC Class 12	125 mm / 5 in	Blank casing
222 - 228	PVC Class 12	125 mm / 5 in	Screen, machine slotted, 0.5 mm
228 - 282	PVC Class 12	125 mm / 5 in	Blank casing
282 - 288	PVC Class 12	125 mm / 5 in	Screen, machine slotted, 0.5 mm
288 - 290	PVC Class 12	125 mm / 5 in	Sump, blank casing wth end cap
290 - 310	-	-	Collapsed hole
Seal			
0 - 125	Cement grout		Seal in borehole annulus
125	Cement boot		Contain cement grout in overlying interval
128	Cement boot		Contain cement grout in overlying interval (back-up)
Gravel Fill:			
138 - 290	Natural pack		Gravel not placed in borehole annulus
Stand Pipe:			
0.81	STL		Stand Pipe
1m x 1m x .3m	Cement		Cement Block

Notes: 4. Purpose e.g:

Casing: Surface Casing, Pre-collar, Production Casing, Screened Production

Seal: Cement Pad, Well Seal, Cement in Casing, Cement boot

Gravel Fill: Filter Pack, Backfill, Natural pack, Collapsed Hole

Drilling summary report — Hole: KPBi04

Date started: 21/02/2014 **Date completed:** 23/02/2014

Drilling Co./Rig: Thompson / Rig 18
Driller: Josh Pech

Co-ordinates (GDA94, Z54): E 601413
N 6284304
Natural surface elevation. (mAHD) 123

Airlift Development

Date:	1-2/03/2014	**Airlifted by:**	TDC (Lloyd M)	
Start Time:	1/3/14 1400	**Post airlift SWL (m bgl):**	38.25	3/3/14 1500
Finish Time	2/3/14 1325	**Lift Flow Rate (L/s):**	13	
Total Time Airlifted (hr):	8.25	**Volume Lifted (m3):**	386.1	
		Depth of Airline (m):	100	

Time	EC (mS/cm)	pH	Temp (°C)	Comments
1/3/14 1400				Start airlifting (flow rate visual estimate 10 L/s)
1/3/14 1730				Cease airlifting (flow rate visual estimate 10 L/s)
2/3/14 0740				Resume airlifting (flow rate visual estimate 15 L/s)
2/3/14 0950	39.8	6.86	-	Rotten egg smell, clear but tainted grey/brown
2/3/14 1005	40	7.12	23.7	Rotten egg smell, clear but tainted grey/brown
2/3/14 1040				Cease airlifting (air stopped working, troubleshooting - found kink in 25mm poly)
2/3/14 1140				Resume airlifting
2/3/14 1150	40.8	7.18	25.1	
2/3/14 1155				Realised water temp is 25degrees so recalibrated pH to 7=7
2/3/14 1200	40.2	6.75	24.7	rotten egg smell dereased slightly?, clear, slightly tainted grey/brown
2/3/14 1215	40.7	6.94	25.3	as above
2/3/14 1230	41.9	6.86	25.3	as above
2/3/14 1240	41.6	6.87	24.9	as above
2/3/14 1250	41.6	6.88	25.1	as above
2/3/14 1305	41.6	6.86	25.2	as above
2/3/14 1320	41.6	6.96	25.1	as above
2/3/14 1325				Stop Airlifting (flow rate visual estimate 15 L/s)

Drilling summary report

Hole: KPBi04

Date started: 21/02/2014

Date completed: 23/02/2014

Drilling Co./Rig: Thompson / Rig 18

Driller: Josh Pech

Co-ordinates (GDA94, Z54): E 601413

N 6284304

Natural surface elevation. (mAHD) 123

Chip Tray Photos

NOTES:

Drilling summary report

Hole: KPBi07

Date started:	25/02/2014	Date completed:	26/02/2014	
Drilling Co./Rig:	Thompson / Rig 18	Co-ordinates (GDA94, Z54): E	597907	GPS
Driller:	Josh Pech	N	6283718	coordinates/elevation taken with handheld GPS on 28/2/2014
		Natural surface elevation. (mAHD)	117	

HSEC

Incident description	Action	Follow up

Field observations

EOH Airlifting Summary

Depth of airline (m)	Post-test SWL (m)	Airlift yield (L/s)	Airlift period (hours)	EC (mS/cm)	pH	Temp. (ºC)	Other Observations
100	35.41 (14/3/14)	9.14 (average)	7	62.2	7.01	27.1	SWL m below top of steel casing

Notes: 2. SWL as meters below ground level

Lithological Summary (refer full lithological log for full details)

Depth to	Interp. Log [1]	Description
1	Qh	Topsoil: brown and Calcrete, white
4	Qh	Sandy Clay: red
6	Qh	Sandy Clay: red, with Calcrete gravel
10	Qh	Clayey Sand: red/orange, with Calcrete gravel
14	Qh	Sandy Clay: red/pale grey
28	T (Upper)	Clayey Sand: orange and white grading to red and pale grey
32	T (Upper)	Clay: red/pale grey
34	T (Upper)	Clay: red/pale grey, with Sand and Granules
36	T (Upper)	Clayey Sand: red and pale grey, med-very coarse with Granules and Pebbles to 7mm
38	T (Upper)	Sandy Clay: pale gray and red
46	T (Upper)	Clay: pale grey and red
54	T (Upper)	Clay: pale grey with minor red and yellow mottling
62	T (Upper)	Clay: grey/green with minor yellow mottling
64	T (Upper)	Clay: grey/blue
68	T (Upper)	Sand: fine-med, white, clean, with Clay: grey/blue
72	T (Upper)	Sand: med, pale brown, clean, with Clay: grey/blue
78	T (Upper)	Clay: white and pale grey, with Sandy Clay: pale grey and blue/grey in lenses
86	T (Upper)	Clay: dark grey, black, lignitic
100	T (Upper)	Clay: blue/grey and dark grey, with Sand: med-coarse
114	T (Upper)	Clay: dark blue/grey, grading to black
124	T (Lower)	Sand: coarse, pale brown grading to brown
130	T (Lower)	Sand: coarse-very coarse, dark brown, lignitic
132	T (Lower)	Lignite
134	T (Lower)	Lignite, with Sand: coarse
136	T (Lower)	Sand: coarse, dark brown, with Lignite
138	T (Lower)	Lignite, with Sand: coarse
148	T (Lower)	Sand: coarse, with Lignite
160	T (Lower)	Lignite, with Sand: coarse-very coarse
162	T (Lower)	Sand: med-coarse, brown, lignitic
166	T (Lower)	Sand: med, brown
168	T (Lower)	Sand: med-coarse, brown, minor Lignite
178	T (Lower)	Sand: med-coarse, pale brown, clean
182	T (Lower)	Sand: coarse-very coarse and Granules
200	T (Lower)	Lignite
202	T (Lower)	Sand: med-coarse, pale brown, clean
204	T (Lower)	Sand: very coarse, pale brown, clean
206	T (Lower)	Lignite
236	T (Lower)	Sand: coarse-very coarse, pale brown, clean
238	T (Lower)	Sand: coarse-very coarse, pale brown, clean, with minor pale brown/white clay
242	T (Lower)	Sand: med, pale brown
290	T (Lower)	Sand: med-coarse, pale brown, clean
302	T (Lower)	Clay: grey and black (lignitic), with Sand: med-very coarse and Granules
310	T (Lower)	Sand: med-very coarse, with sand size white grains and minor grey clay

Notes: 1. Interpretted log: Qh (quarternary), T (Tertiary - Upper and Lower)

Bit log

Depth (m)	Type (inches)
0 - 310	Drag Bit 7 7/8 in

Mud log

Depth (m)	Description
0 - 310	

Construction log

Depth setting	Material/grade	Diameter/size	Purpose [4]
Casing			
0 - 216	PVC Class 12	125 mm / 5 in	Blank casing
216 - 222	PVC Class 12	125 mm / 5 in	Screen, machine slotted, 0.5 mm
222 - 248	PVC Class 12	125 mm / 5 in	Blank casing
248 - 254	PVC Class 12	125 mm / 5 in	Screen, machine slotted, 0.5 mm
254 - 280	PVC Class 12	125 mm / 5 in	Blank casing
280 - 286	PVC Class 12	125 mm / 5 in	Screen, machine slotted, 0.5 mm
286 - 288	PVC Class 12	125 mm / 5 in	Sump, blank casing wth end cap
288 - 310	-	-	Collapsed hole
Seal			
0 - 108	Cement grout		Seal in borehole annulus
108, 110 & 114	Cement boot		Contain cement grout in overlying interval
Gravel Fill:			
114 - 288	Natural pack		Gravel not placed in borehole annulus
Stand Pipe:			
0.83	STL		Stand Pipe
1m x 1m x .3m	Cement		Cement Block

Notes: 4. Purpose e.g:

Casing: Surface Casing, Pre-collar, Production Casing, Screened Production

Seal: Cement Pad, Well Seal, Cement in Casing, Cement boot

Gravel Fill: Filter Pack, Backfill, Natural pack, Collapsed Hole

Drilling summary report

Hole: KPBi07

Date started: 25/02/2014 **Date completed:** 26/02/2014

Drilling Co./Rig: Thompson / Rig 18
Driller: Josh Pech

Co-ordinates (GDA94, Z54): E 597907
N 6283718
Natural surface elevation. (mAHD) 117

Airlift Development

Date: 2/03/2014
Start Time: 2/3/14 1500
Finish Time 3/3/14 1232
Total Time Airlifted (hr): 7

Airlifted by: TDC (Lloyd M)
Post airlift SWL (m bgl): 34.4 4/3/14 0815
Lift Flow Rate (L/s): 9.14
Volume Lifted (m3): 230.3
Depth of Airline (m): 100

Time	EC (mS/cm)	pH	Temp (°C)	Comments
2/3/14 1500				Start Airlifting (flow rate estimate 5 L/s)
2/3/14 1607	65.5	7.25	27.1	dirty brown (flow rate estimate 8 L/s)
2/3/14 1640	67.7	7.19	27.0	cloudy brown
2/3/14 1715	66.7	7.17	27.0	cloudy brown
2/3/14 1740	68.0	7.16	26.6	cloudy light brown (flow rate estimate 8 L/s)
2/3/14 1800				cease airlifting
3/3/14 0830				resume airlifting, dirty brown/black during first hour (flow rate estimate 10 L/s)
3/3/14 1140				cease airlifting (hose became kinked)
3/3/14 1210				resume airlifting (flow rate estimate 10 L/s)
3/3/14 1215	62.2	6.92	27.2	clear
3/3/14 1224	62.4	6.97	27.0	clear
3/3/14 1232	62.2	7.01	27.1	clear
				Stop Airlifting

Drilling summary report

Hole: KPBi07

Date started: 25/02/2014

Date completed: 26/02/2014

Drilling Co./Rig: Thompson / Rig 18

Driller: Josh Pech

Co-ordinates (GDA94, Z54): E 597907

N 6283718

Natural surface elevation. (mAHD) 117

Chip Tray Photos

NOTES:

Drilling summary report

Hole: KPBi09

Date started:	28/02/2014		**Date completed:**	1/03/2014	
Drilling Co./Rig:	Thompson / Rig 18		**Co-ordinates (GDA94, Z54):**	E 594439	GPS
Driller:	Josh Pech			N 6282471	coordinates/elevation taken with handheld GPS on 5/3/2014
			Natural surface elevation. (mAHD)	109	

HSEC

Incident description	Action	Follow up

Field observations

EOH Airlifting Summary

Depth of airline (m)	Post-test SWL (m)	Airlift yield (L/s)	Airlift period (hours)	EC (mS/cm)	pH	Temp. (ºC)	Other Observations
100	27.38 (14/03/2014)	3.7 (average)	5.17	47.1	7.69	22.6	SWL below top of steel casing

Notes: 2. SWL as meters below ground level

Lithological Summary (refer full lithological log for full details)

Depth to	Interp. Log [1]	Description
1	Qh	Soil, sandy, red/brown
8	Qh	Clayey Sand: fine-med, red, yellow and white
10	Qh	Sandy Clay: beige and white/orange, med-coarse sand, soft
12	Qh	Sand: coarse, red, clay fines
14	T (Upper)	Silty Clay: pale grey
16	T (Upper)	Clay: pale grey and red
22	T (Upper)	Clay: pale grey with yellow mottling
26	T (Upper)	Clayey Sand: med, pale pink and pale grey and white
28	T (Upper)	Clay: pale grey
32	T (Upper)	Clayey Sand: med, white/beige and minor yellow
40	T (Upper)	Clayey Sand: med-coarse, blue/grey, hard, with Clay: dark grey
46	T (Lower)	Sand: coarse-very coarse, clean
50	T (Lower)	Sand: coarse-very coarse, trace lignite
52	T (Lower)	Sand: coarse-very coarse and Granules
62	T (Lower)	Sand: med-very coarse, with Lignite
66	T (Lower)	Sand: med-very coarse, with minor Lignite
70	T (Lower)	Sand: coarse-very coarse and Granules, trace lignite, dirty
94	T (Lower)	Sand: very coarse, with Granules and Pebbles to 6mm, clean
106	T (Lower)	Sand: coarse-very coarse, with Granules, clean
126	T (Lower)	Sand: coarse, minor clay fines, white/beige
150	T (Lower)	Sand: coarse-very coarse, minor clay fines, white/beige
152	T (Lower)	Sand: very coarse, minor clay fines, white/beige
154	T (Lower)	Clayey Sand: coarse, dark brown and beige
162	T (Lower)	Sand: coarse-very coarse
166	T (Lower)	Sand: coarse-very coarse, minor clay fines, pale grey
168	T (Lower)	Clayey Sand: med-very coarse, pale grey with minor white and orange
182	T (Lower)	Clay: dark grey and blue/grey
184	T (Lower)	Sand: coarse-very coarse, minor clay fines
186	T (Lower)	Sand: coarse-very coarse, clean
188	T (Lower)	Granules, with Sand: very coarse, minor clay fines
190	T (Lower)	Sand: coarse-very coarse, with Granules, clay fines
200	T (Lower)	Sand: coarse-very coarse, with Granules
242	T (Lower)	Sand: coarse-very coarse, with Granules, minor clay fines
244	T (Lower)	Lignite, dark brown/black, soft with very hard chips, with Sand: coarse-very coarse and Granules
248	T (Lower)	Sand: coarse-very coarse and Granules, with Clay: dark grey
254	Basement	Clay: dark grey
EOH	Basement	refusal (no sample return, suspect hard rock)

Notes: 1. Interpretted log: Qh (quarternary), T (Tertairy), Basement

Bit log

Depth (m)	Type (inches)
0 - 254	Drag Bit 7 7/8 in

Mud log

Depth (m)	Description

Construction log

Depth setting	Material/grade	Diameter/size	Purpose [4]
Casing			
0 - 150	PVC Class 12	125 mm / 5 in	Blank casing
150 - 156	PVC Class 12	125 mm / 5 in	Screen, machine slotted, 0.5 mm
156 - 186	PVC Class 12	125 mm / 5 in	Blank casing
186 - 192	PVC Class 12	125 mm / 5 in	Screen, machine slotted, 0.5 mm
192 - 224	PVC Class 12	125 mm / 5 in	Blank casing
224 - 230	PVC Class 12	125 mm / 5 in	Screen, machine slotted, 0.5 mm
230 - 232	PVC Class 12	125 mm / 5 in	Sump, blank casing wth end cap
232 - 254	-	-	Collapsed hole
Seal			
0 - 108	Cement grout		Seal in borehole annulus
108	Cement boot		Contain cement grout in overlying interval
Gravel Fill:			
108 - 254	Natural pack		Gravel not placed in borehole annulus
Stand Pipe:			
0.68	STL		Stand Pipe
1m x 1m x .3m	Cement		Cement Block

Notes:

4. Purpose e.g:

Casing: Surface Casing, Pre-collar, Production Casing, Screened Production

Seal: Cement Pad, Well Seal, Cement in Casing, Cement boot

Gravel Fill: Filter Pack, Backfill, Natural pack, Collapsed Hole

Drilling summary report

Hole: KPBi09

Date started: 28/02/2014 **Date completed:** 1/03/2014

Drilling Co./Rig: Thompson / Rig 18
Driller: Josh Pech

Co-ordinates (GDA94, Z54): E 594439
N 6282471
Natural surface elevation. (mAHD) 109

Airlift Development

Date:	4/03/2014	**Airlifted by:**	TDC (L Moore)
Start Time:	4/3/14 1300	**Post airlift SWL (m bgl):**	27.38 (14/03/2014)
Finish Time	5/3/14 0900	**Lift Flow Rate (L/s):**	3.7
Total Time Airlifted (hr):	5.17	**Volume Lifted (m3):**	68.9
		Depth of Airline (m):	100

Time	EC (mS/cm)	pH	Temp (°C)	Comments
4/3/14 1300				Start Airlifting (estimated flow rate 2 L/s), very dirty
				flow rate gradually increased to about 4 L/s by the end of the day
4/3/14 1615	47.6	7.30	25.7	slightly cloudy
4/3/14 1630	48.0	7.59	24.1	slightly cloudy
4/3/14 1638	48.1	7.65	24.1	slightly cloudy
4/3/14 1640				cease (estimated flow rate 4 L/s)
5/3/14 0730				resume (estimated flow rate 5 L/s)
5/3/14 0830	46.7	7.40	21.8	slightly cloudy
5/3/14 0845	46.9	7.68	22.3	slightly cloudy
5/3/14 0900	47.1	7.69	22.6	slightly cloudy (estimated flow rate 5 L/s)
5/3/14 0900				Stop Airlifting. Lloyd suspects that poorer yield is due to shorter chlorine time and higher clay content in the sand. Perhaps not all three screens are active. If a proper production screen was used and developed by jetting it would achieve a high yielding well more in line with KPBi04 and KPBi07

Drilling summary report

Hole: KPBp04

Date started:	3/03/2014		Date completed:	8/03/2014	
Drilling Co./Rig:	Thompson / Rig 18		Co-ordinates (GDA94, Z54): E	601414	**GPS**
Driller:	Josh Pech		N	6284357	coordinates/elevation taken with handheld GPS on 7/3/2014. accuracy to 3m
			Natural surface elevation. (mAHD)	125	

HSEC

Incident description	Action	Follow up

Field observations

EOH Airlifting Summary

Depth of airline (m)	Post-test SWL (m)	Airlift yield (L/s)	Airlift period (hours)	EC (mS/cm)	pH	Temp. (ºC)	Other Observations
~75	39.54 (15/03/14)	~15 (average)	32 (21 hours jetting, 11 hours airlifting)	45.3	7.4	24.9	swl m below top of steel casing

Notes: 2. SWL as meters below ground level

Lithological Summary (refer full lithological log for full details)

Depth to	Interp. Log [1]	Description
2	Qh	Topsoil and Calcrete
14	Qh	Clayey sand: red
26	Qh	Sand clay: yellow and white, medium
30	T (Upper)	Clayey sand: red and grey
42	T (Upper)	Clay: grey and red, minor sand
46	T (Upper)	Clayey sand: medium to granule, red
58	T (Upper)	Sandy silt: red and light greay, fine to medium grain
72	T (Upper)	CLAY: light grey, minor red mottling
84	T (Upper)	CLAY: light grey
88	T (Upper)	Clayey SAND medium well rounded grains. Light grey and light brown
112	T (Upper)	CLAY: light grey/light green. Minor black clay
128	T (Upper)	SAND: Medium light brown moderately sorted sub rounded
140	T (Upper)	Clayey SAND: medium, moderate rounding, light grey
158	T (Lower)	SAND: fine to medium, moderately sorted, light grey
166	T (Lower)	SAND: poorly sorted fine to couarse grained, some granules, light grey/dark grey
180	T (Lower)	SAND: medium to coarse grain, subrounded, moderate sort, light grey/dark grey
184	T (Lower)	SAND: Medium to course grain, medium grey, some pebble
198	T (Lower)	SAND: medium to pebble, poorly sorted, subrounded
208	T (Lower)	SAND: fine to meadium grain, subrounded, grey, some pebble
216	T (Lower)	SAND: medium to coarse grain, subrounded to subangular, grey
218	T (Lower)	clayey SAND: fine sand, minor clay, gery
226	T (Lower)	SAND: Coarse, minor pebble, grey
228	T (Lower)	clayey SAND: fine to coarse grain sand, minor clay, medium to dark grey
238	T (Lower)	SAND: very coarse to pebble, poorly sorted. Pebble up to 5mm
256	T (Lower)	SAND: medium to coarse, moderately sorte, subrounded, medium to dark grey
258	T (Lower)	clayey SAND: fine to medium, minor lignite
268	T (Lower)	SAND: medium to coarse grain, subrounded, moderate sorting
274	T (Lower)	CLAY: Lignite. Black
286	T (Lower)	SAND: medium to coarse grain, sub rounded to sub angular, medium grey, mod sort
298	T (Lower)	SAND: fine to coarse grain, poorly sorted, subrounded to subangular, grey
304	T (Lower)	SAND: medium to coarse grain, moderate sort, minor clay.

Notes: 1. Interpretted log: Qh (quarternary), T (Tertairy - Upper and Lower)

Grey Clay cuttings' recorded in some intervals are likely to be contamination from an overlying interval of unstable Clay

Bit log

Depth (m)	Type (inches)
0 - 154	14" rock roller
154-304	9" drag bit

Mud log

Depth (m)	Description

Construction log

Depth setting	Material/grade	Diameter/size	Purpose [4]
Casing			
0-144	PVC Class 18	250mm / 10"	Blank casing - first stage
134.5-135	PVC Class 18	150mm / 6"	J-latch / cone packer
135 - 182	PVC Class 18	150mm / 6"	Blank casing - riser
182 - 188	Stainless steel	150mm / 6"	wirewound 0.5mm apeture
188 - 202	PVC Class 18	150mm / 6"	Blank casing
202 - 208	Stainless steel	150mm / 6"	wirewound 0.5mm apeture
208 - 248	PVC Class 18	150mm / 6"	Blank casing
248 - 254	Stainless steel	150mm / 6"	wirewound 0.5mm apeture
254 - 278	PVC Class 18	150mm / 6"	Blank casing
278 - 284	Stainless steel	150mm / 6"	wirewound 0.5mm apeture
284 - 302	PVC Class 18	125mm / 5"	sump
Seal			
0 - 145m	Cement grout		Seal in borehole annulus
Gravel Fill:			
145 - 302	Natural pack		Gravel not placed in borehole annulus
Stand Pipe:			
0.6m	STL		Stand Pipe
1m x 1m x .3m	Cement		Cement Block

Notes: 4. Purpose e.g:

Casing: Surface Casing, Pre-collar, Production Casing, Screened Production

Seal: Cement Pad, Well Seal, Cement in Casing, Cement boot

Gravel Fill: Filter Pack, Backfill, Natural pack, Collapsed Hole

Drilling summary report — Hole: KPBp04

Date started: 3/03/2014 **Date completed:** 8/03/2014

Drilling Co./Rig: Thompson / Rig 18
Driller: Josh Pech

Co-ordinates (GDA94, Z54): E 601414
N 6284357
Natural surface elevation. (mAHD) 125

Airlift Development

Date:	7-11/03/2014	**Airlifted by:**	TDC (Lloyd M)
Start Time:	7/3/14 1715	**Post airlift SWL (m bgl):**	39.554
Finish Time	11/3/14 1230	**Lift Flow Rate (L/s):**	15
Total Time Airlifted (hr):	32	**Volume Lifted (m3):**	1728
		Depth of Airline (m):	75

15/03/2014

Time	EC (mS/cm)	pH	Temp (°C)	Comments
10/3/14 0800	43.3	7.53	23.5	Start airlifting (flow rate visual estimate 10 L/s)
10/3/14 1000	41.4	7.79	25.5	Some sands, murky, rotten egg smell
10/3/14 1400	36.7	7.93	30	Some sands, murky, rotten egg smell
10/3/14 1700	46.1	7.53	26.3	Some sands, murky, rotten egg smell
11/3/14 0830	45.3	7.51	24	Some sands, murky, rotten egg smell
11/3/14 0930	45.2	7.4	24.9	minor sands, sample clearing, rotten egg smell
11/3/14 1100	45.3	7.41	24.9	clearing, very little sands.

Drilling summary report

Hole: KPBp04

Date started: 3/03/2014

Date completed: 8/03/2014

Drilling Co./Rig: Thompson / Rig 18

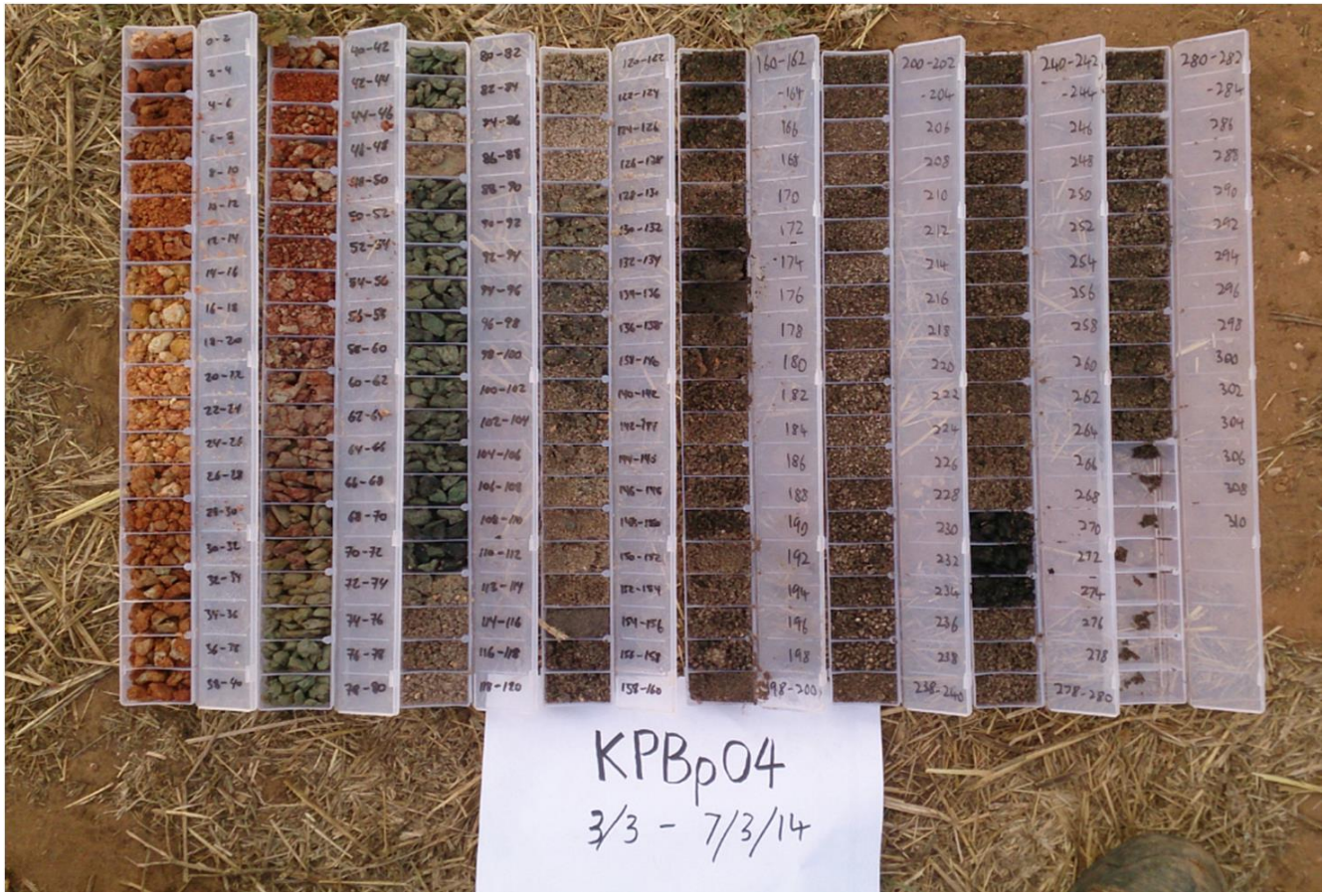
Driller: Josh Pech

Co-ordinates (GDA94, Z54): E 601414

N 6284357

Natural surface elevation. (mAHD) 125

Chip Tray Photos



NOTES:

Appendix C Downhole Gamma Logs

Scale
1:200

Well name
KPBi09

Surveys
Gamma

Location
Kielpa

Field
Kielpa

Company
Iron Road

Service company
Groundwater Science

Operator
David Poulsen

Start date
1/03/2014 3:13:04 PM

Finish date
1/03/2014 3:54:33 PM

Run
Gamma 43mm-A031-S000--15-13-04-01-03-2014

Project name
Iron Road

Drill date
01/01/04

Drillers depth
0.000000

Inclination
0.000000

Heading
0.000000

Elevation
0.000000

Co-ord system

X

Y

Latitude

Longitude

Perm datum

Well name KPBi09 Surveys Gamma

Channels

Name	Unit	Offset(m)	Filter	Calibration	Model	Serial
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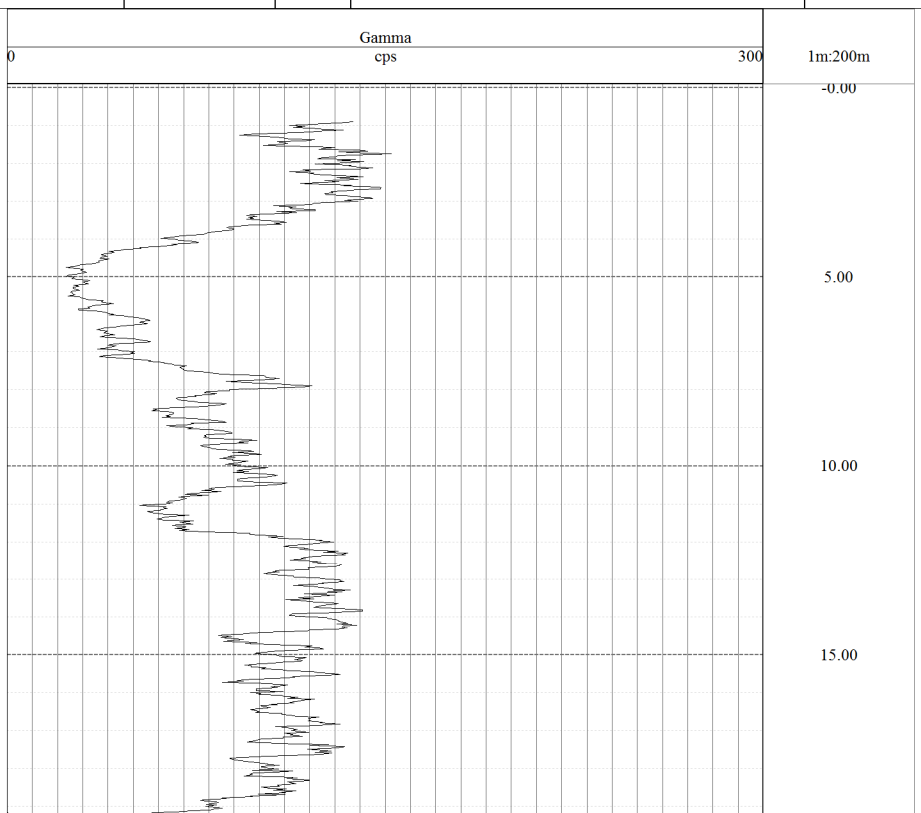

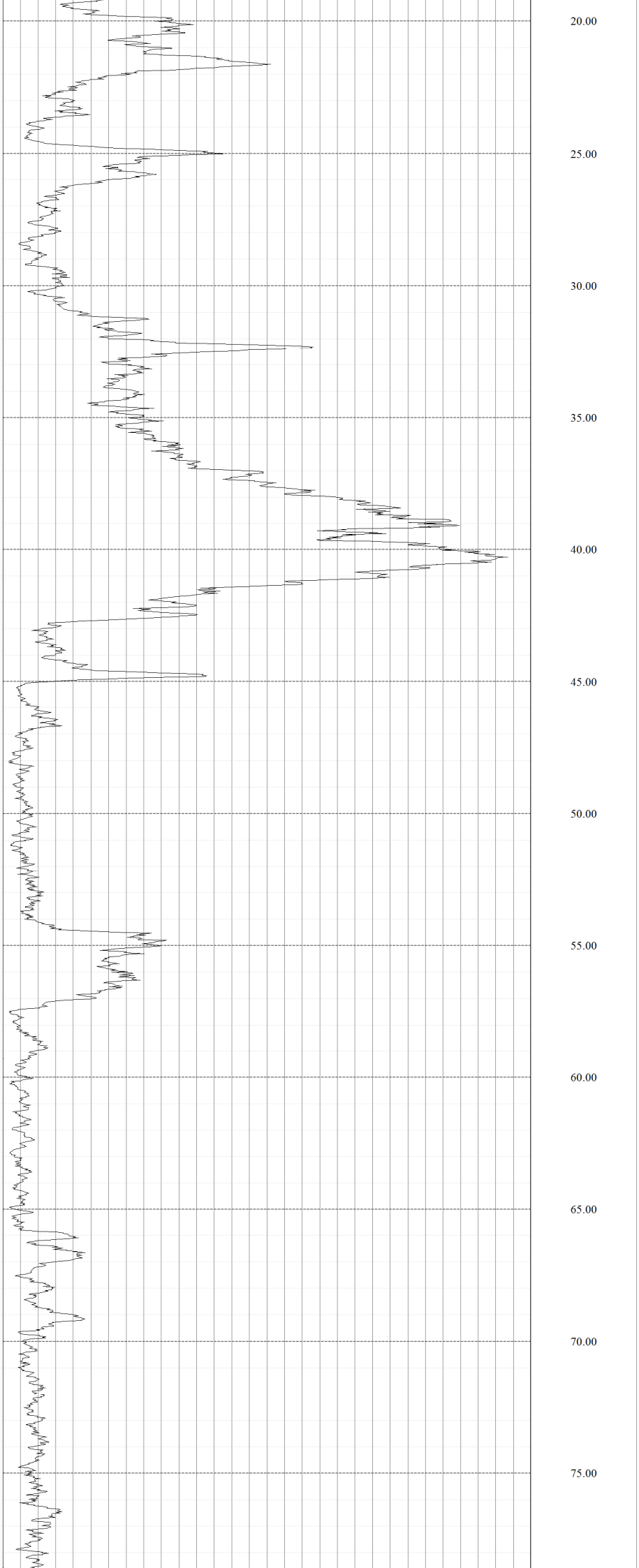
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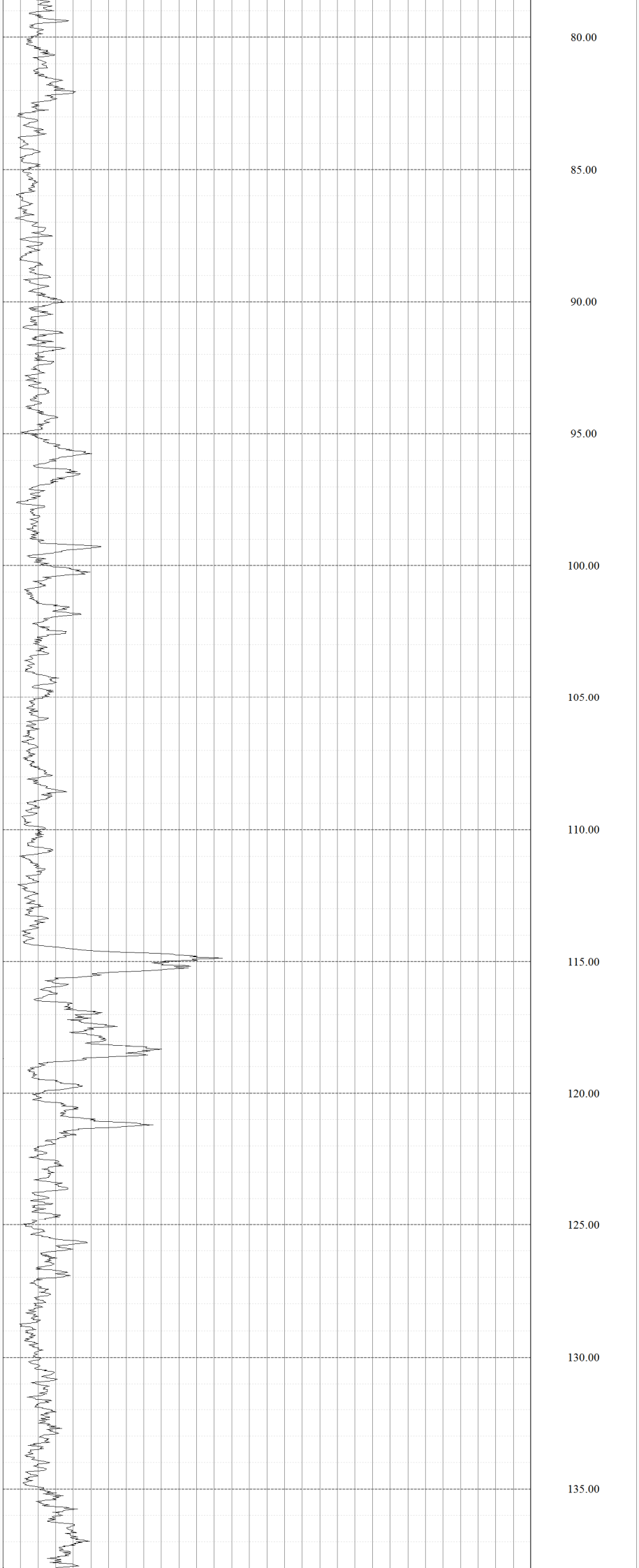
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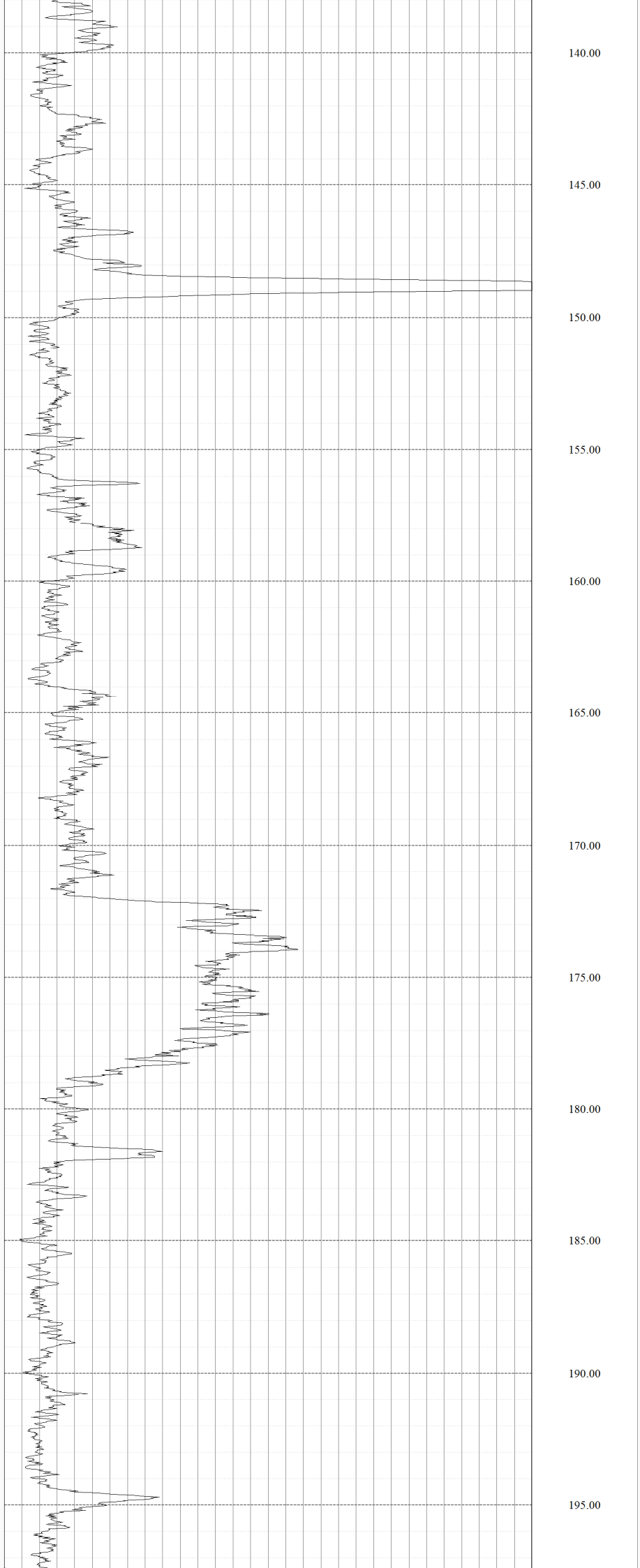
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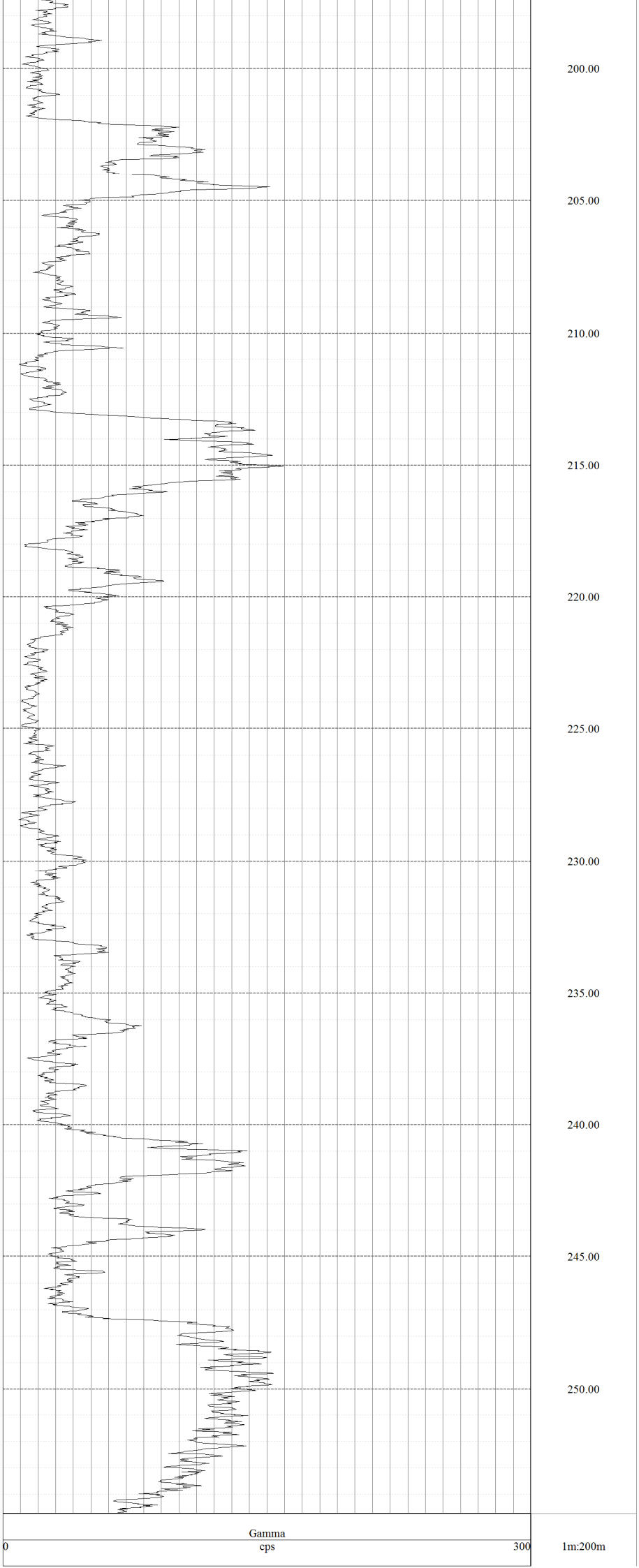
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cps
300
1m:200m

Channels

Name	Unit	Offset(m)	Filter	Calibration	Model	Serial
Gamma	cps	1.000000	5	Raw	A031	S000

Scale
1:200

Well name
KPBi07

Surveys
Gamma

Location
Kielpa

Field
Kielpa

Company
Iron Road

Service company
Groundwater Science

Operator
David Poulsen

Start date
26/02/2014 5:44:43 PM

Finish date
26/02/2014 6:33:45 PM

Run
Gamma 43mm-A031-S000--17-44-43-26-02-2014

Project name
Iron Road

Drill date
01/01/04

Drillers depth
0.000000

Inclination
0.000000

Heading
0.000000

Elevation
0.000000

Co-ord system

X

Y

Latitude

Longitude

Perm datum

Well name KPBi07

Surveys Gamma

Channels

Name	Unit	Offset(m)	Filter	Calibration	Model	Serial
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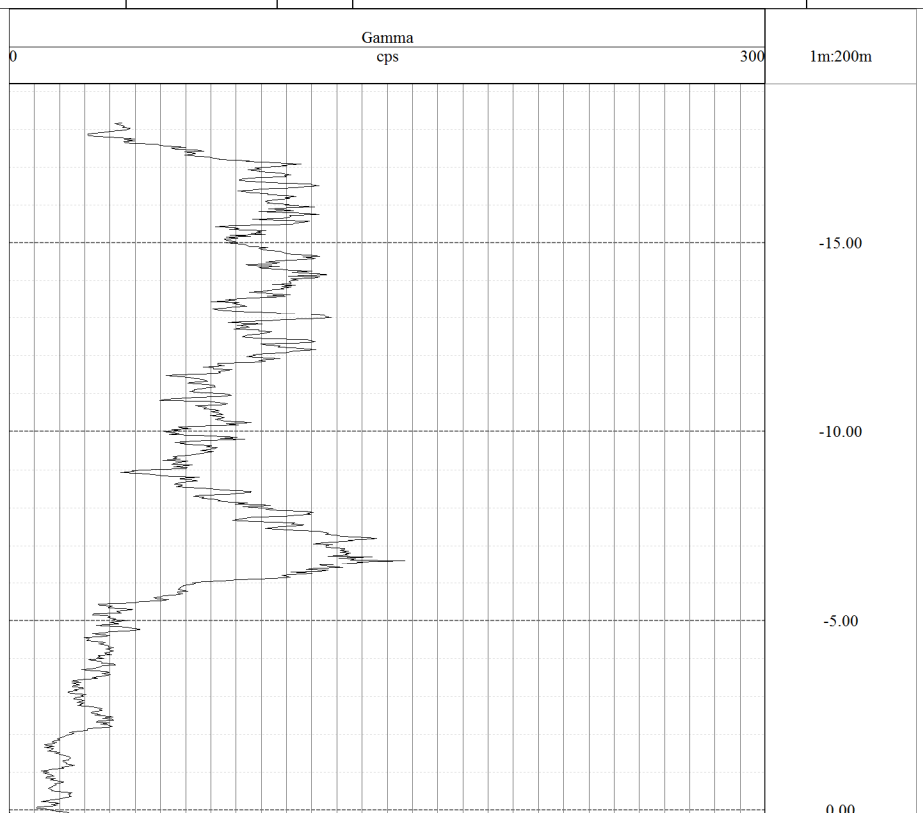

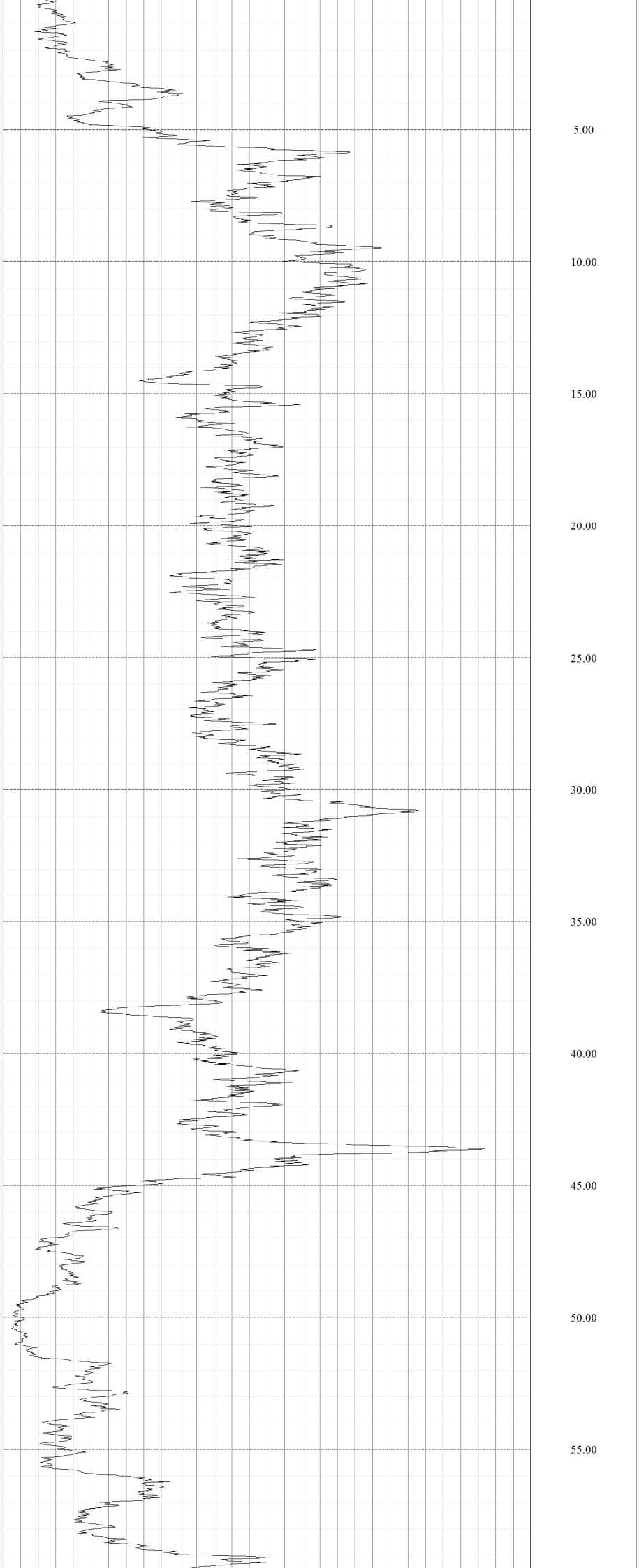
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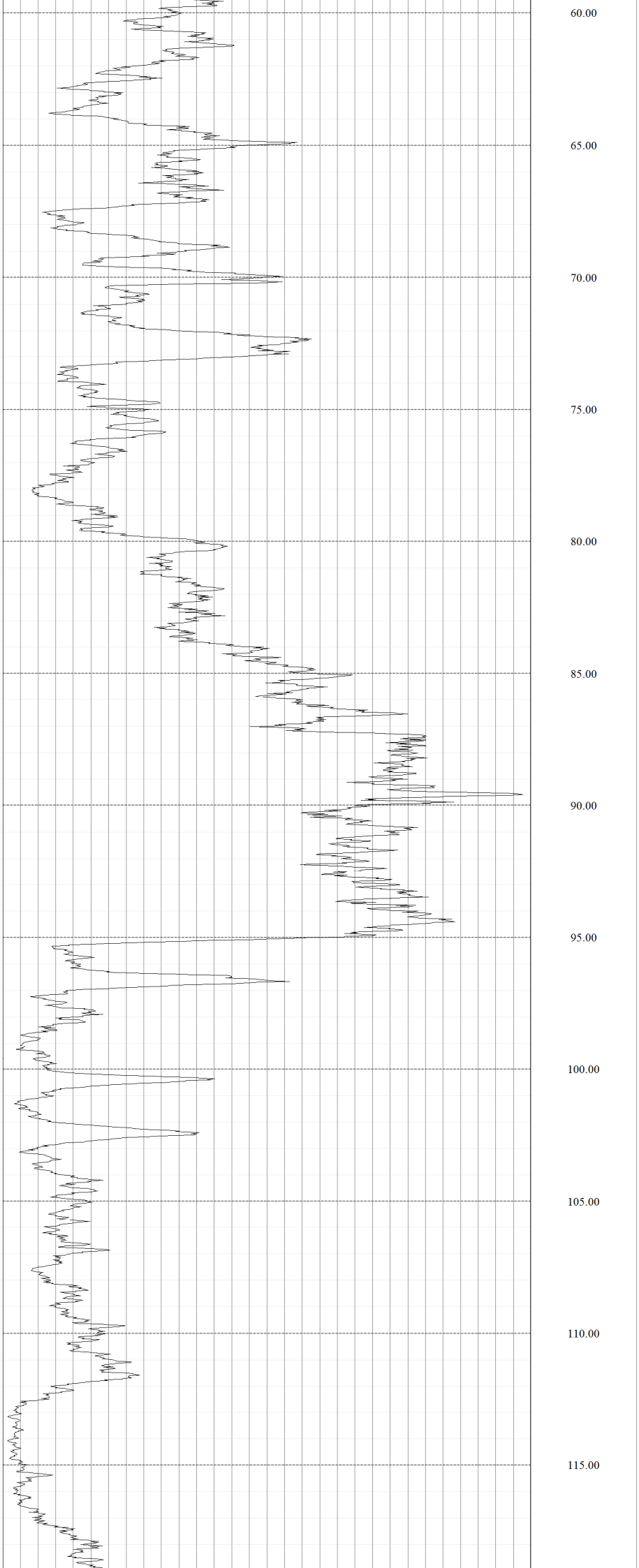
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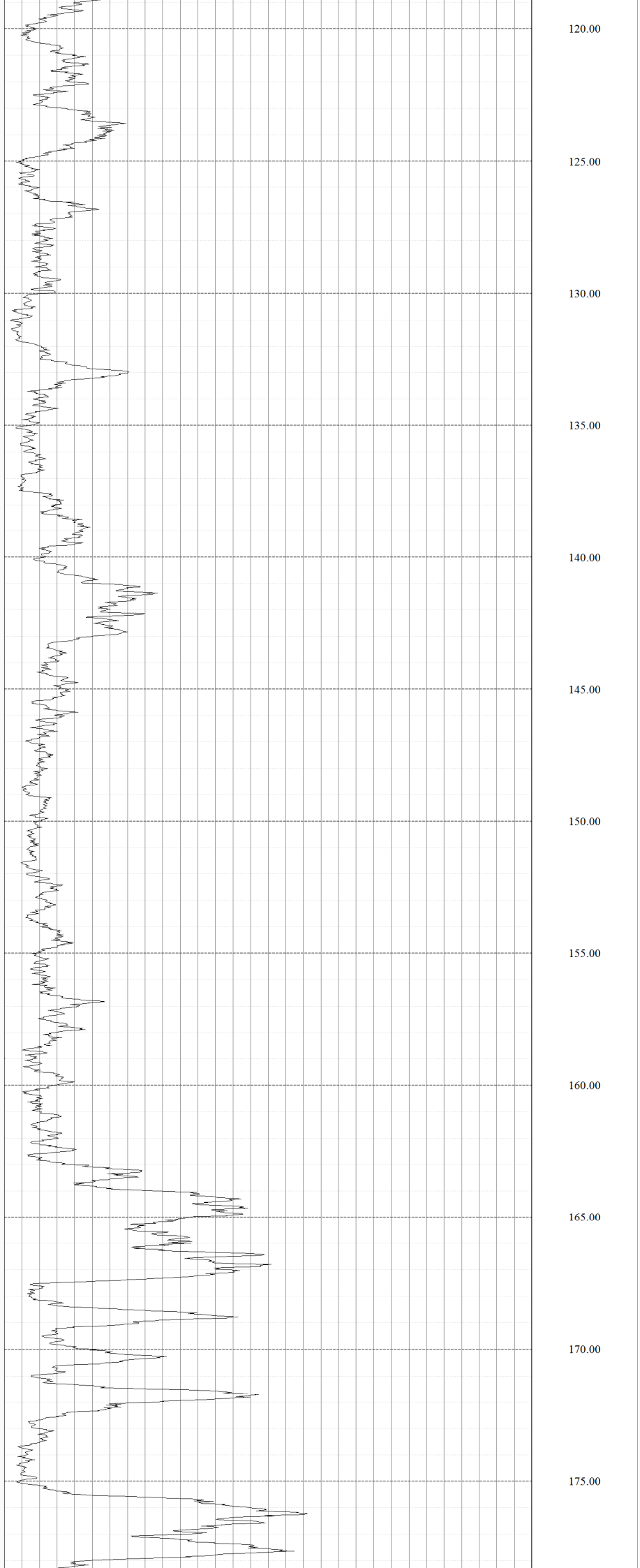
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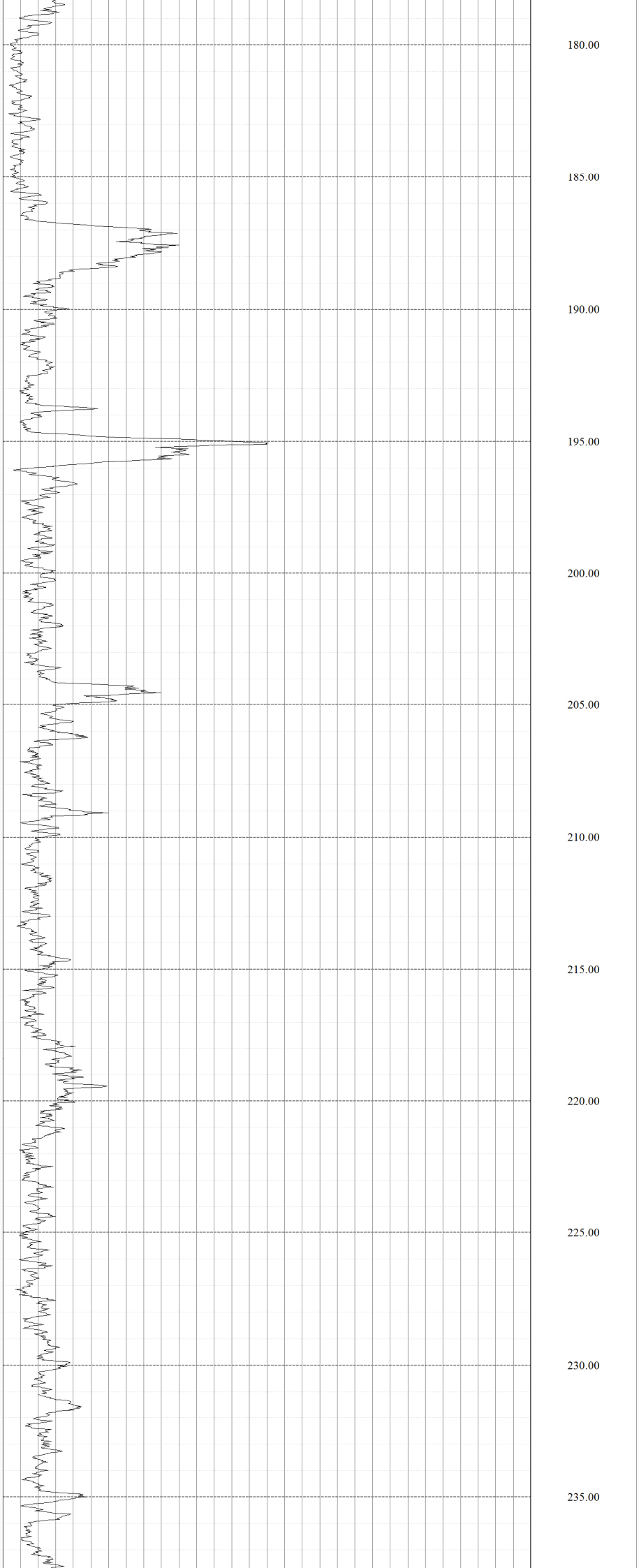
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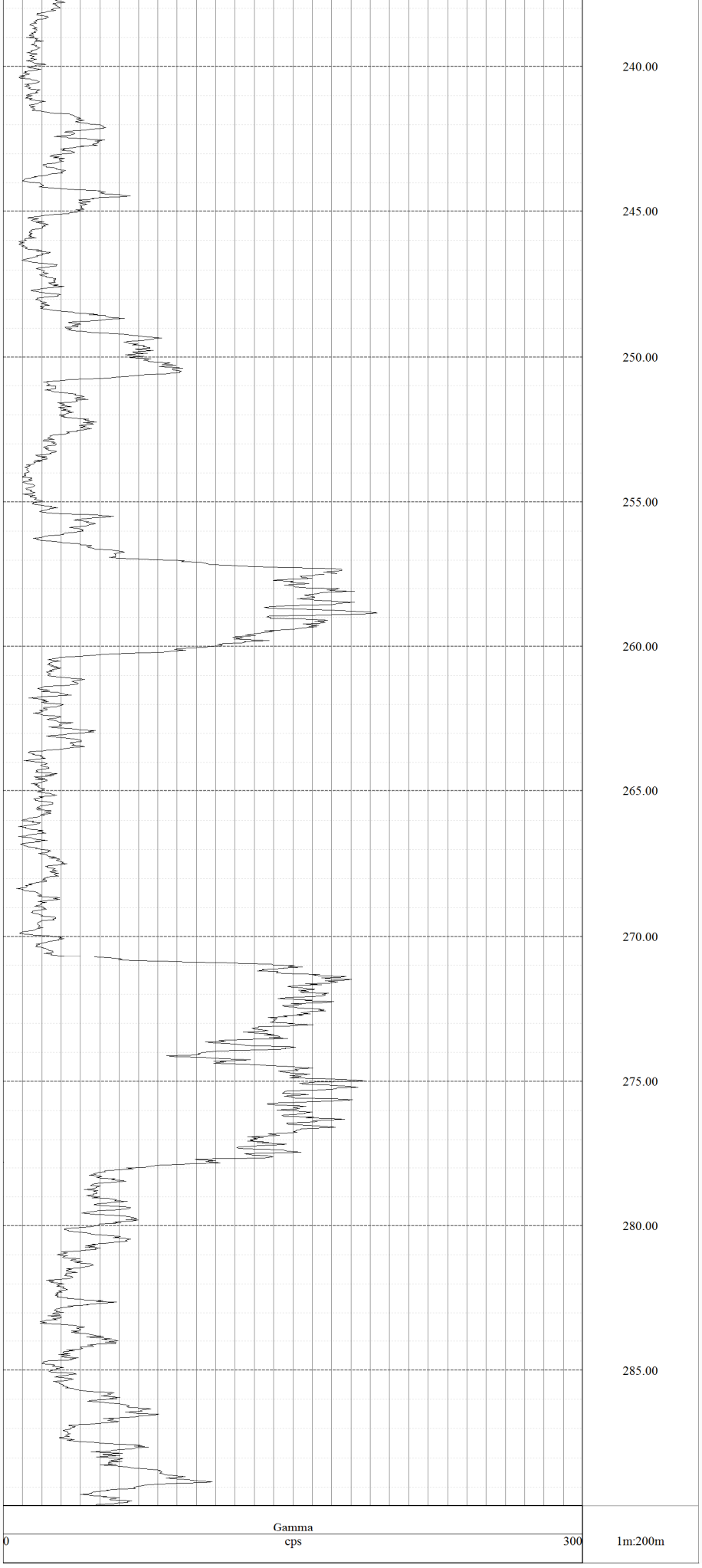

Channels

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Scale
1:200

Well name
KPBi04

Surveys
Gamma

Location
Kielpa

Field
Kielpa

Company
Iron Road

Service company
Groundwater Science

Operator
David Poulsen

Start date
23/02/2014 2:58:24 PM

Finish date
23/02/2014 3:39:43 PM

Run
Gamma 43mm-A031-S000--14-58-24-23-02-2014

Project name
Iron Road

Drill date
01/01/04

Drillers depth
0.000000

Inclination
0.000000

Heading
0.000000

Elevation
0.000000

Co-ord system

X

Y

Latitude

Longitude

Perm datum

Well name KPBi04

Surveys Gamma

Channels

Name	Unit	Offset(m)	Filter	Calibration	Model	Serial
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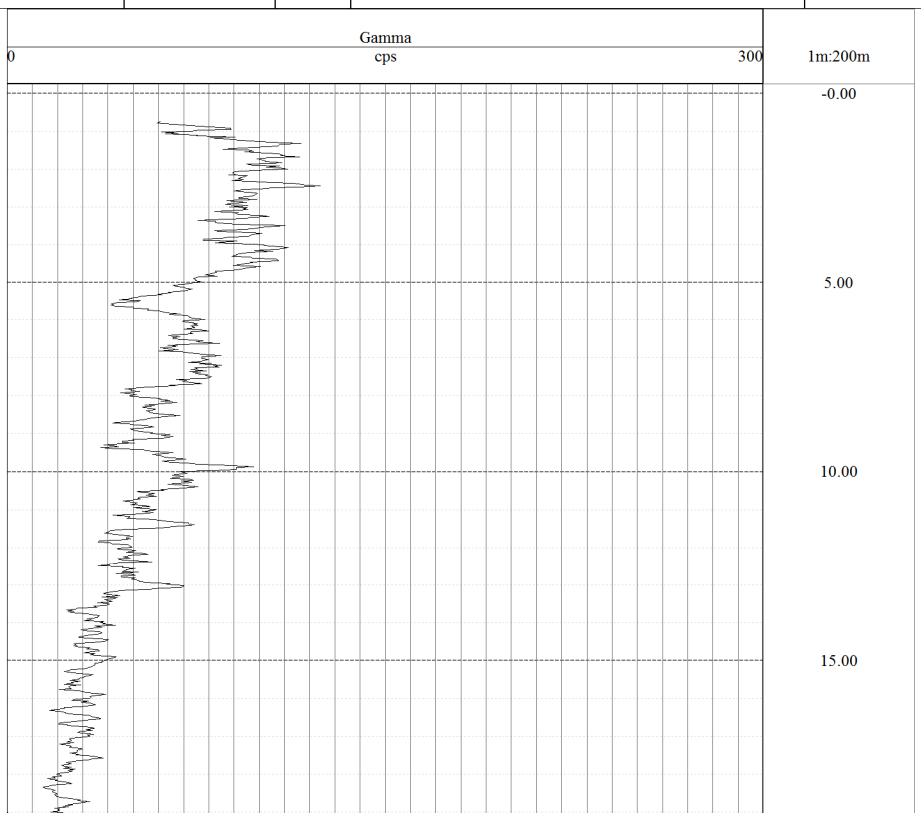

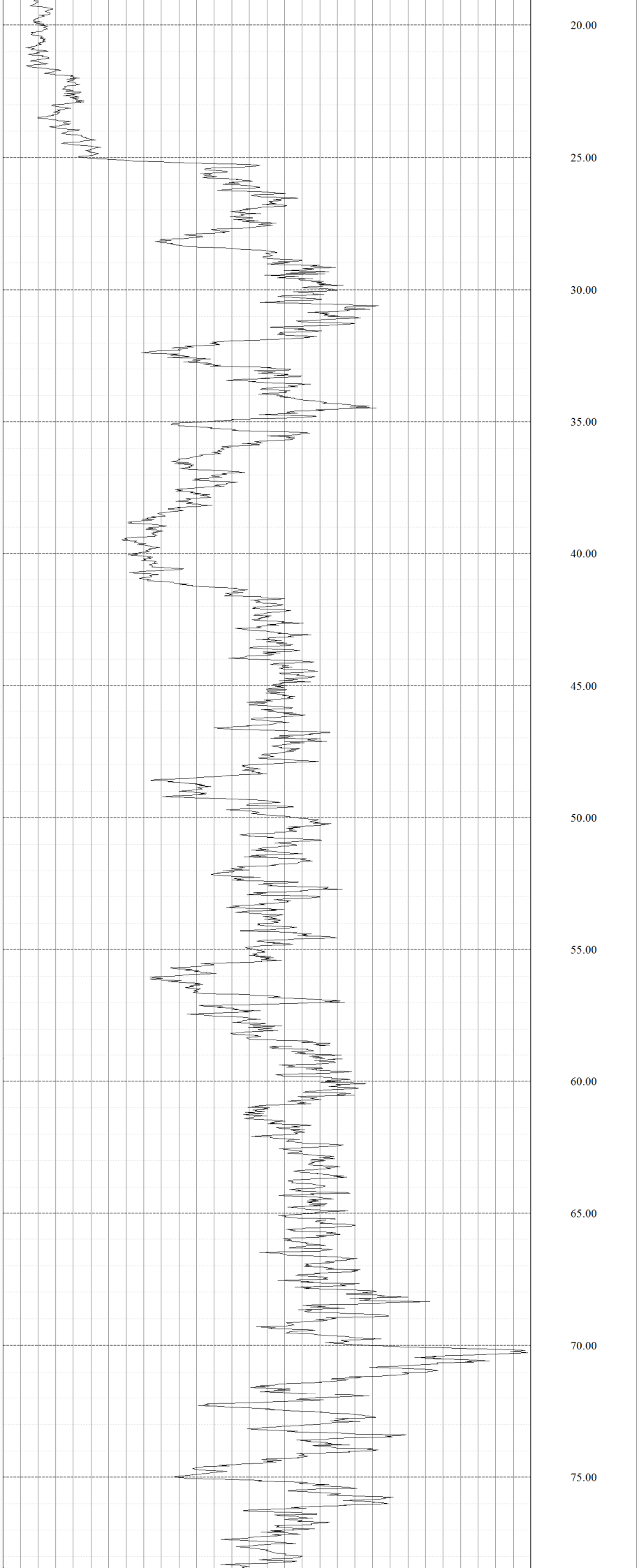
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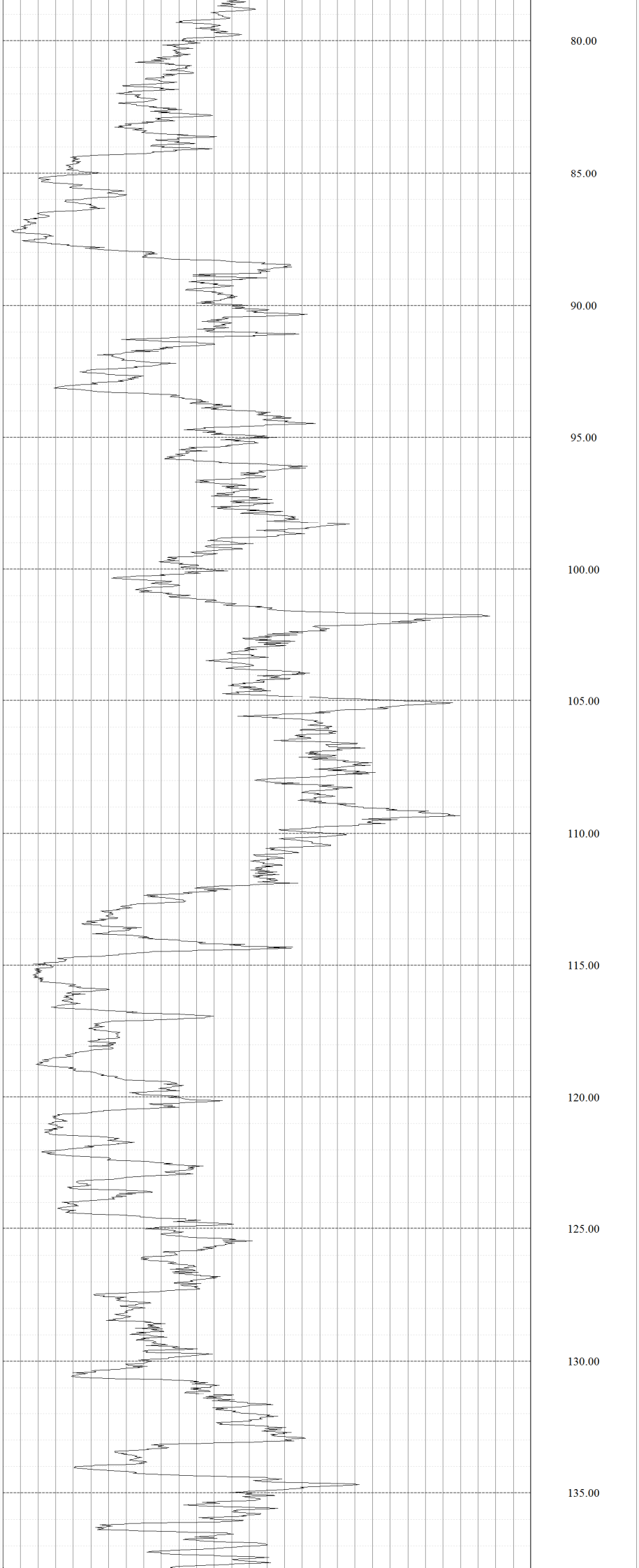
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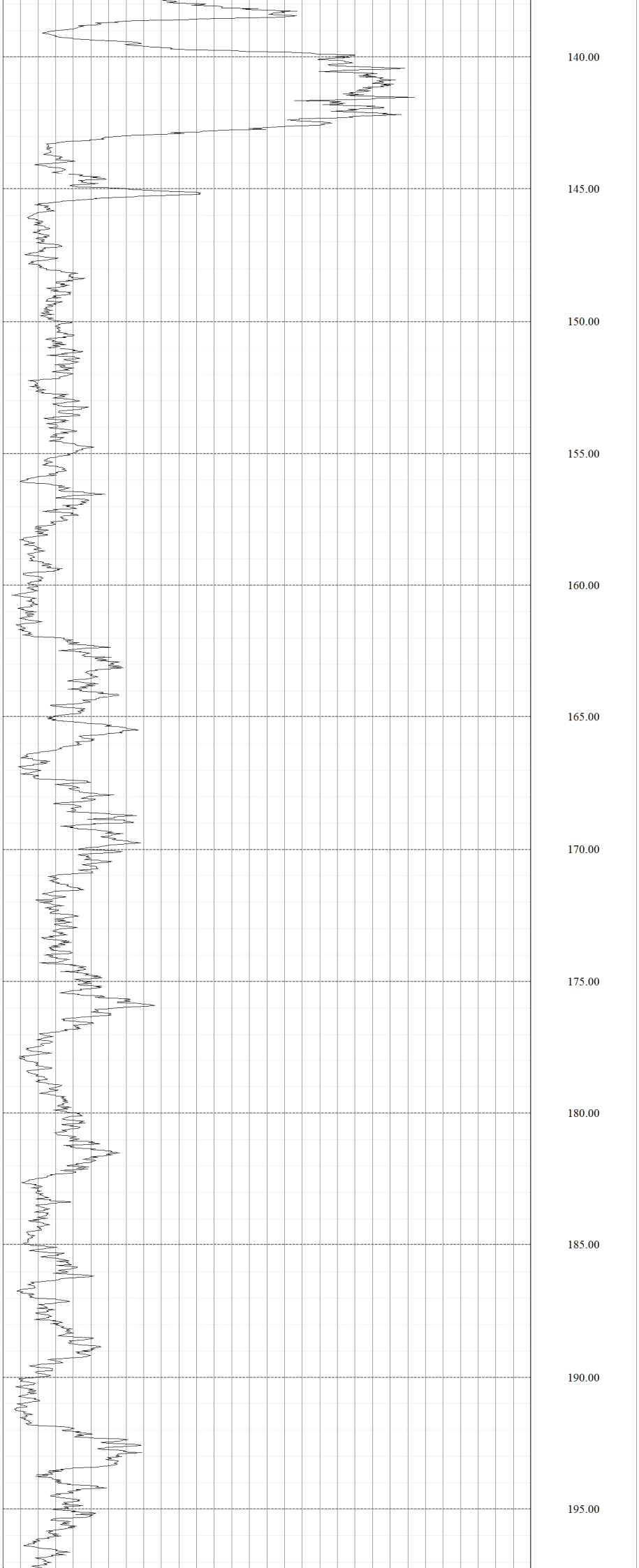
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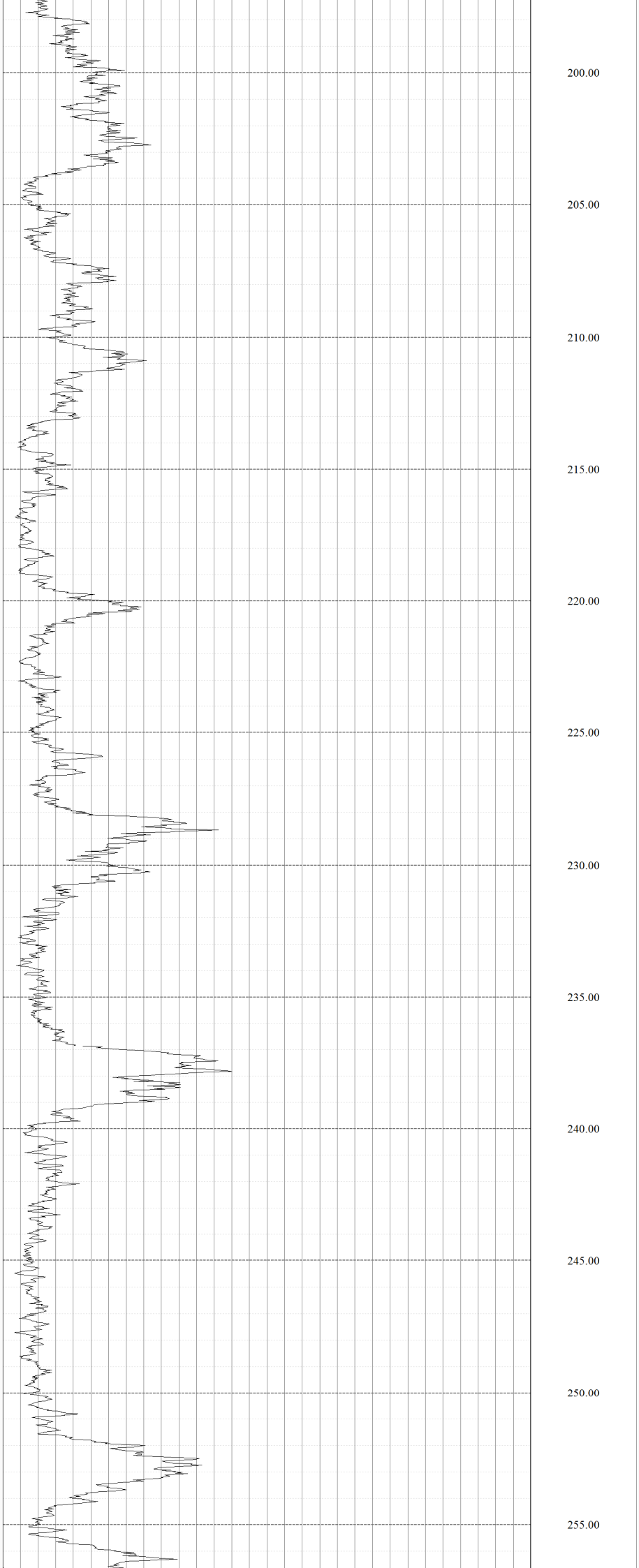
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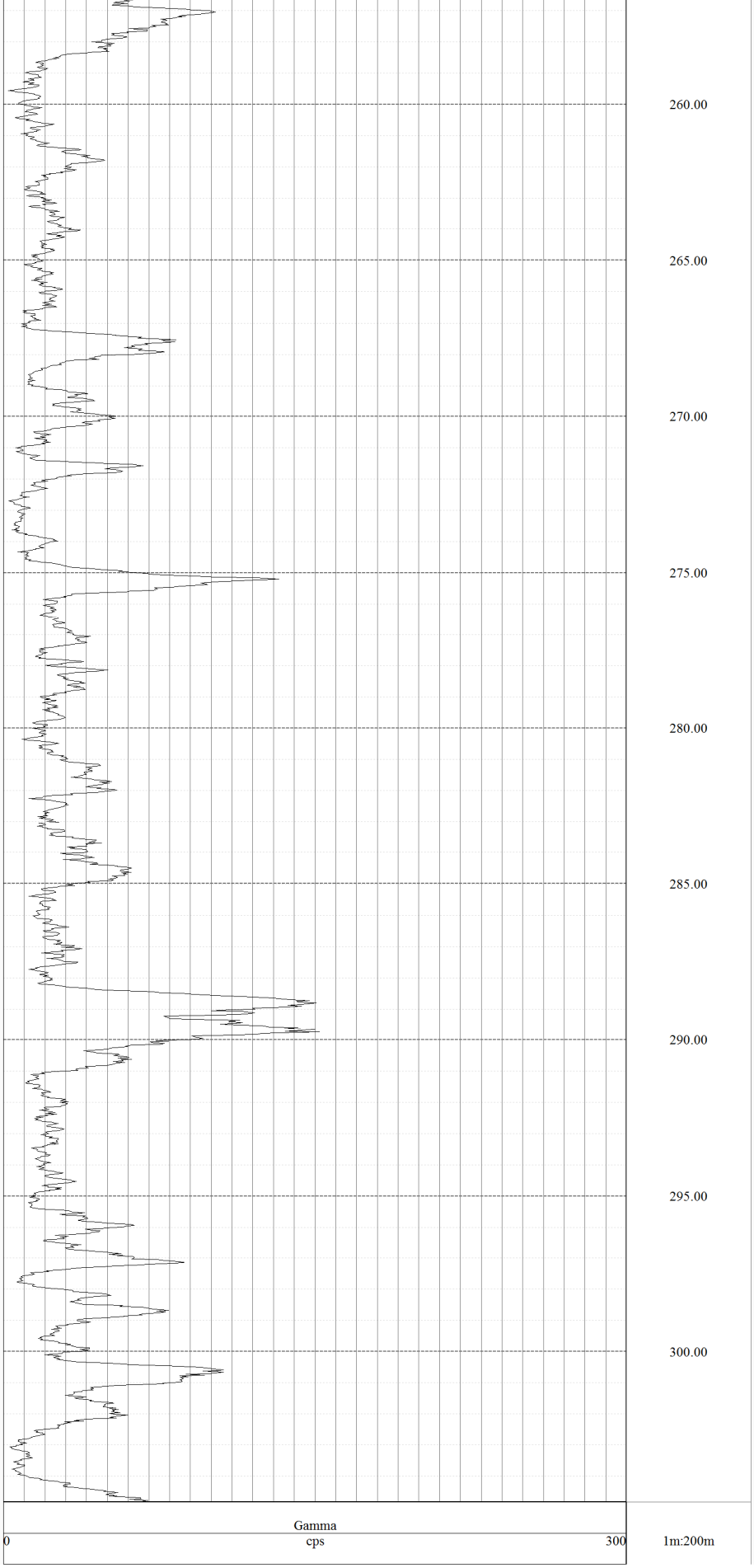

Channels

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Scale
1:200

Well name
KPBp04

Surveys
Gamma

Location
Kielpa

Field
Kielpa

Company
Iron Road

Service company
Groundwater Science

Operator
David Poulsen

Start date
7/03/2014 10:07:55 AM

Finish date
7/03/2014 11:03:12 AM

Run
Gamma 43mm-A031-S000--10-07-55-07-03-2014

Project name
Iron Road

Drill date
01/01/04

Drillers depth
0.000000

Inclination
0.000000

Heading
0.000000

Elevation
0.000000

Co-ord system

X

Y

Latitude

Longitude

Perm datum

Well name KPBp04
Surveys Gamma

Channels

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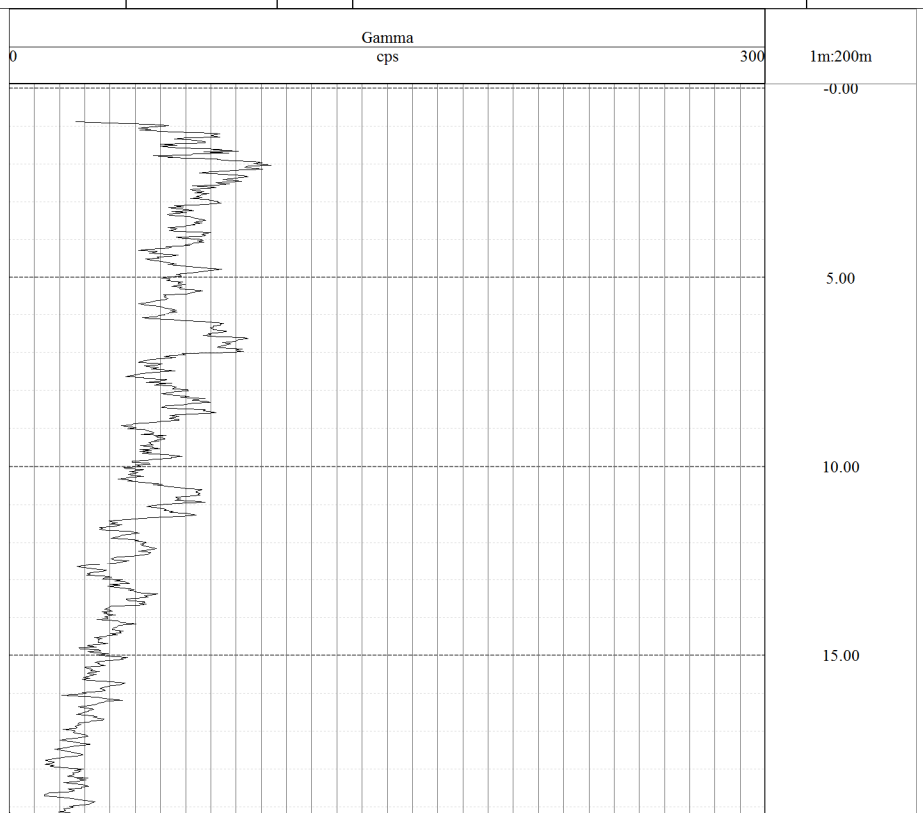

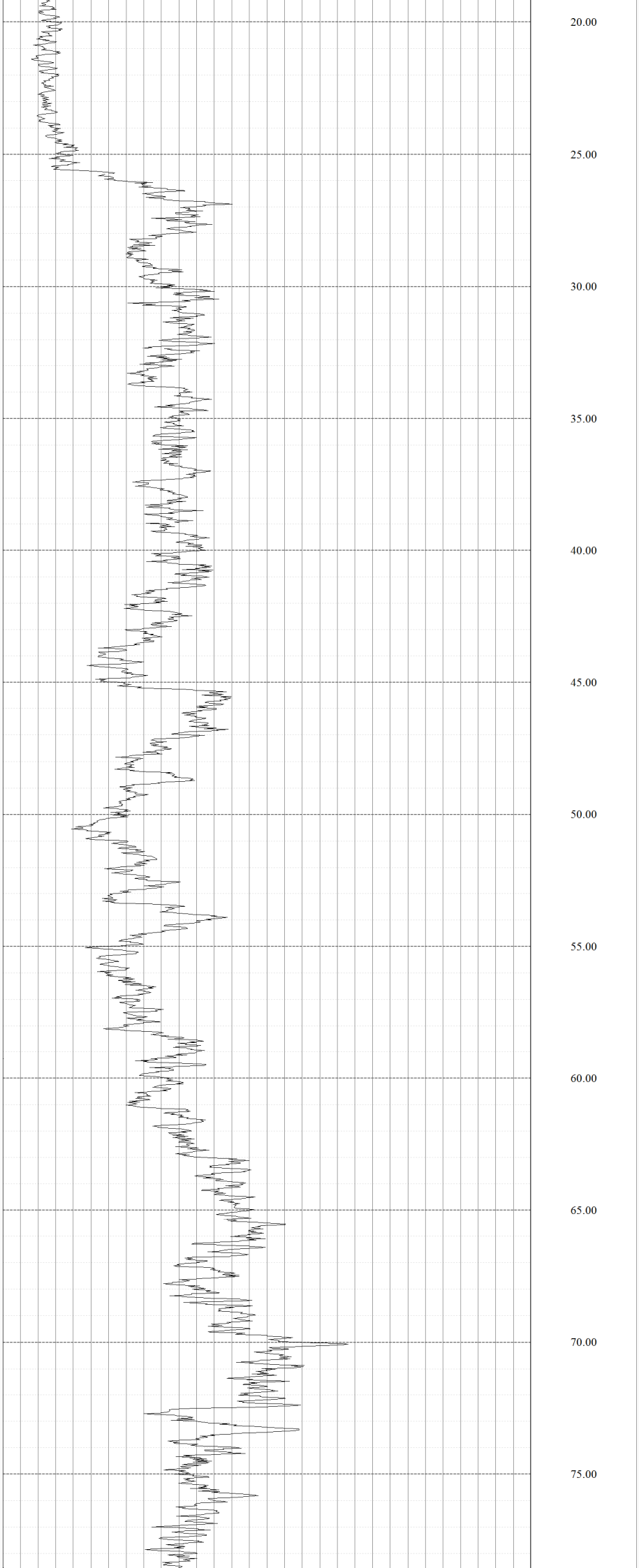
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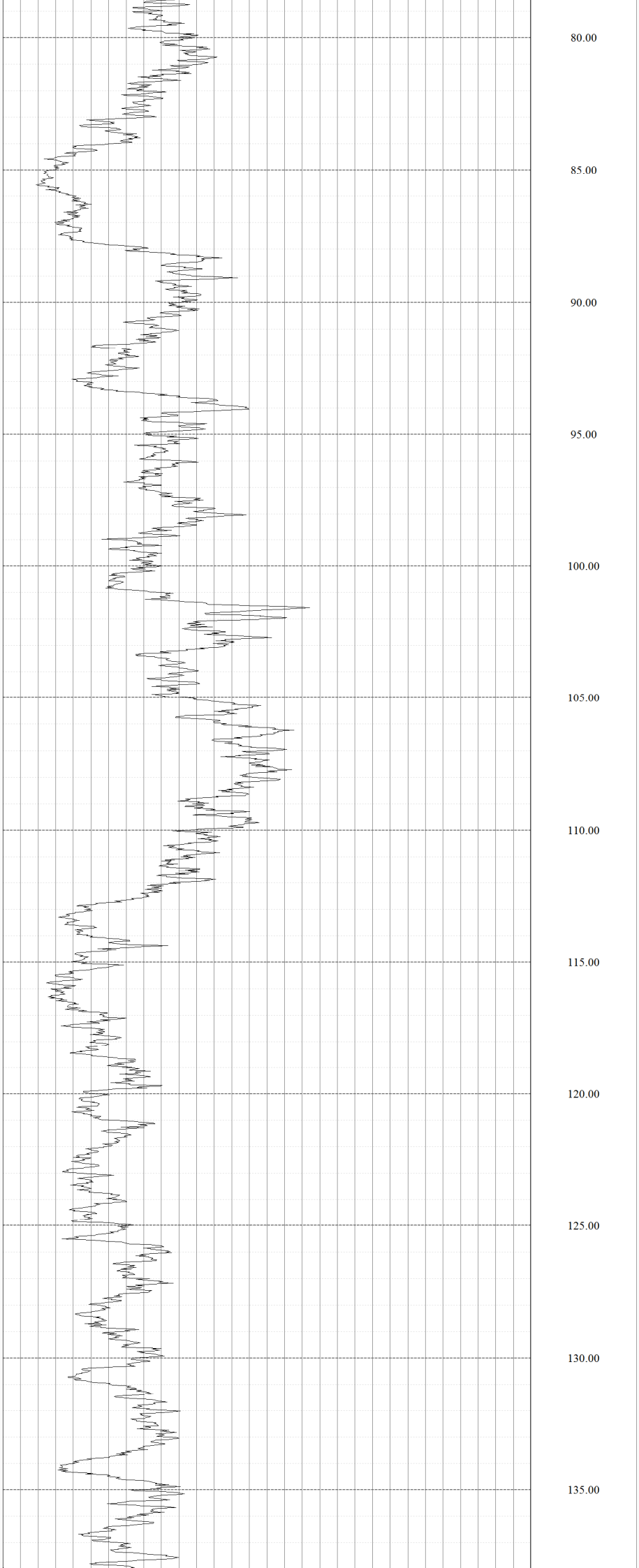
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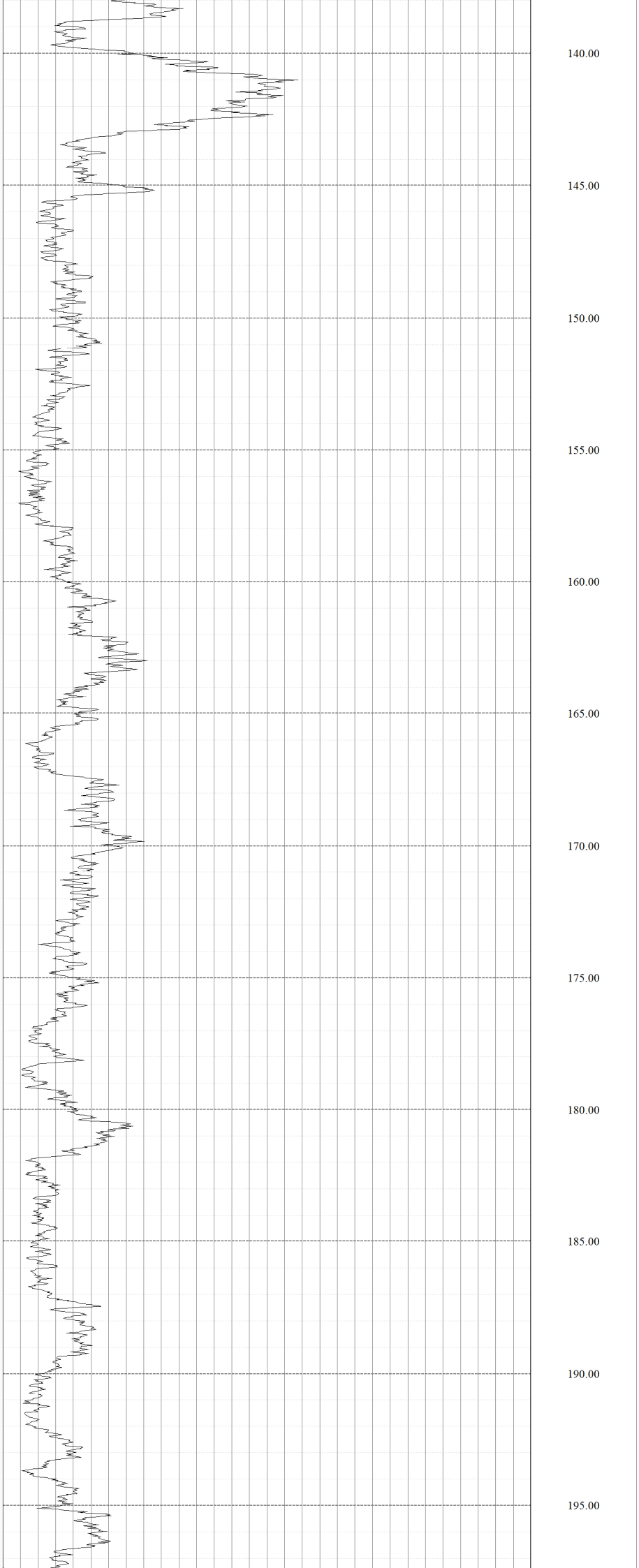
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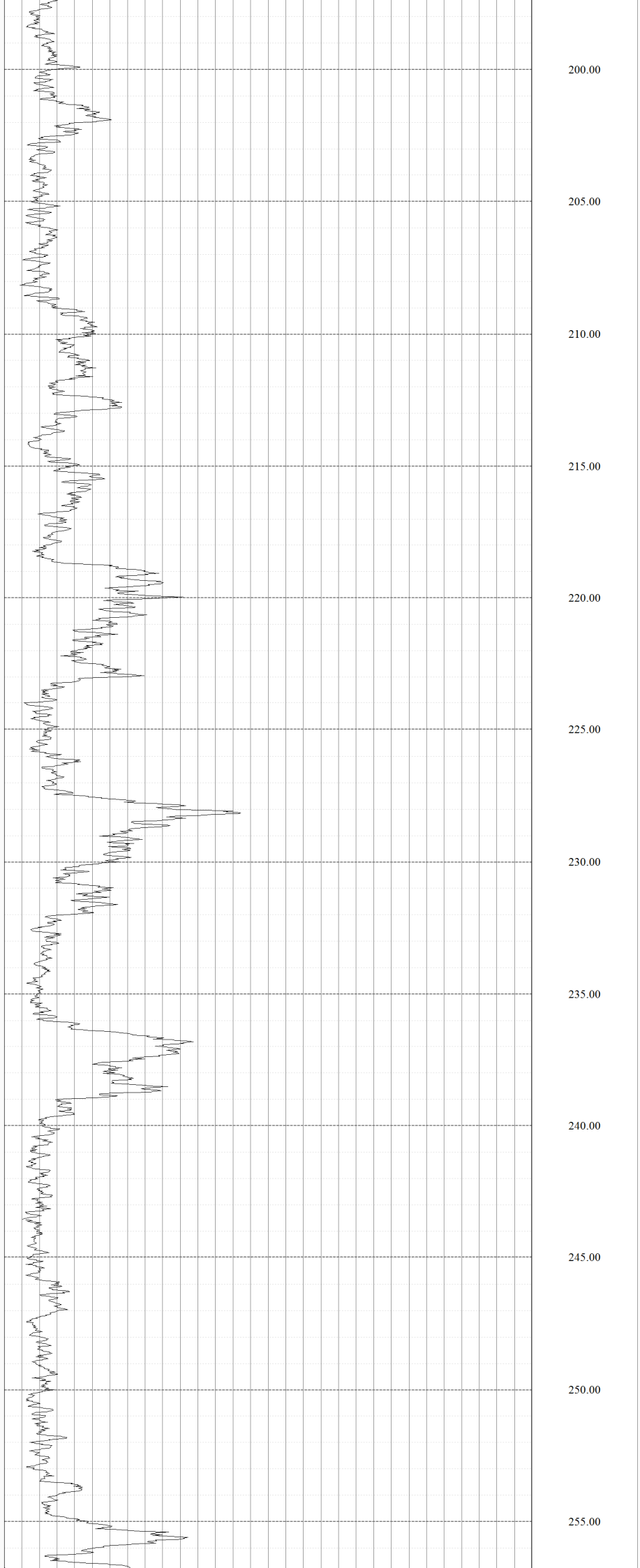
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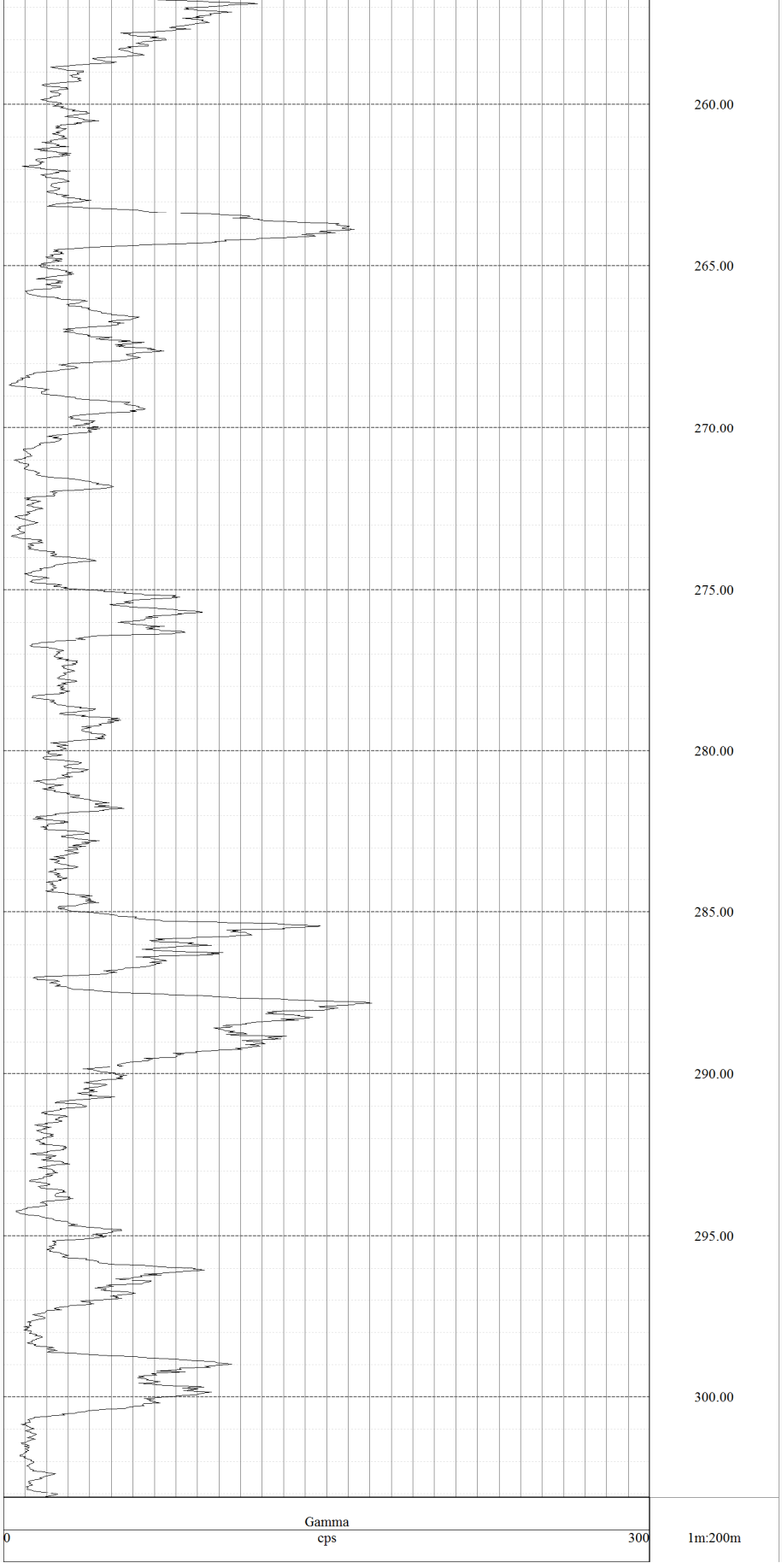
255.00



Channels

Name	Unit	Offset(m)	Filter	Calibration	Model	Serial
Gamma	cps	1.000000	5	Raw	A031	S000

Appendix D Sieve Analysis

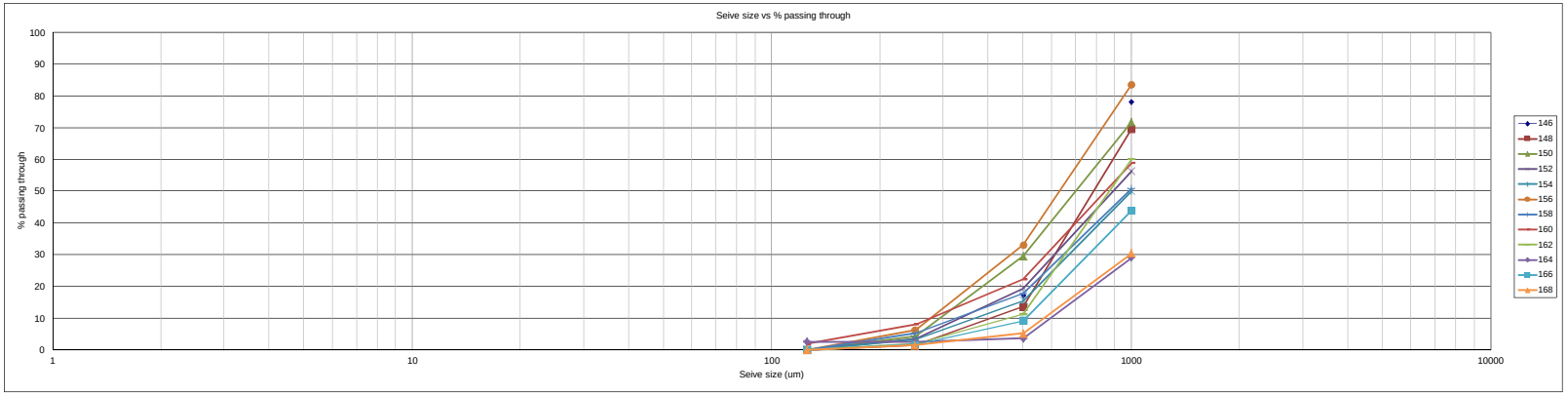
Aquifer Interval grainsize log

Drillhole: KPBi04
Date: 22/02/2014
Sampled by D Poulsen

All samples sieved for 3 mins fully immersed in water
All samples are weighed wet and drained
wiped away excess water with finger around inside bottom rim

Tares (weighed wet, grams)	
Sample Cup	7
1mm sieve	347
500um sieve	306
250um sieve	284
125um sieve	272
Total	**1209**

2m Interval Depth to (mbgl)	Total Sieve and Sample Weight (gm)										Sample retained (g)				Percentage weight					Cumulative sample passing (%)			
	Sample weight (incl sample cup)	Clay/Lignite weight (incl sample cup)	Sample weight adjusted (incl sample cup)	125um	250um	500um	1mm	Sample gain or loss g	Total retained g	Passed through 125um	125um	250um	500um	1mm	Passed 125um	Retained 125um	Retained 250um	Retained 500um	Retained 1mm	125	250	500	1000
146	209	44	172	275	314	423	389	27	192	0	3	30	117	42	0	2	16	61	22	0	2	17	78
148	200	16	191	275	309	421	409	21	205	0	3	25	115	62	0	1	12	56	30	0	1	14	70
150	203	17	193	281	338	396	407	27	213	0	9	54	90	60	0	4	25	42	28	0	4	30	72
152	219	15	211	280	322	393	450	32	236	0	8	38	87	103	0	3	16	37	44	0	3	19	56
154	217	16	208	280	313	388	466	37	238	0	8	29	82	119	0	3	12	34	50	0	3	16	50
156	222	36	193	285	340	411	381	22	208	0	13	56	105	34	0	6	27	50	16	0	6	33	84
158	193	16	184	282	308	369	441	14	191	0	10	24	63	94	0	5	13	33	49	0	5	18	51
160	195	34	168	282	307	365	413	-3	158	3	10	23	59	66	2	6	14	37	41	2	8	22	59
162	195	7	195	276	305	414	435	33	221	0	4	21	108	88	0	2	10	49	40	0	2	11	60
164	198	7	198	267	286	356	486	-5	191	5	0	2	50	139	3	0	1	26	71	3	3	4	29
166	222	10	219	276	303	393	487	38	250	0	4	19	87	140	0	2	8	35	56	0	2	9	44
168	196	10	193	275	292	359	493	24	210	0	3	8	53	146	0	1	4	25	70	0	1	5	30



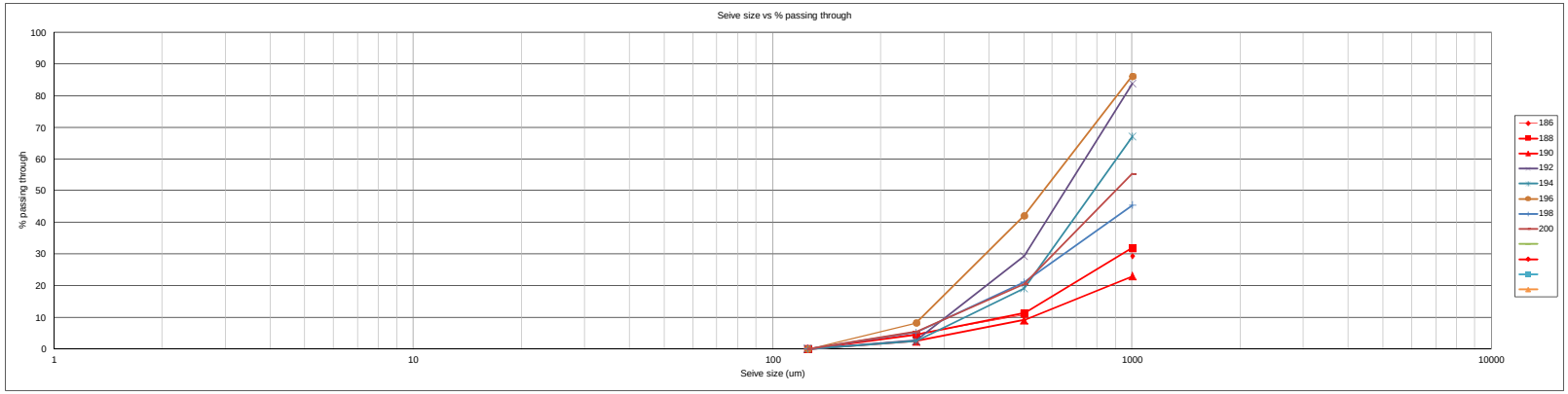
Aquifer Interval grainsize log

Drillhole: KPBi04
Date: 22/02/2014
Sampled by D Poulsen

All samples sieved for 3 mins fully immersed in water
All samples are weighed wet and drained
wiped away excess water with finger around inside bottom rim

Tares (weighed wet, grams)	
Sample Cup	7
1mm sieve	347
500um sieve	306
250um sieve	284
125um sieve	272
Total	**1209**

2m Interval Depth to (mbgl)	Total Sieve and Sample Weight (gm)										Sample retained (g)				Percentage weight					Cumulative sample passing (%)			
	Sample weight (incl sample cup)	Clay/Lignite weight (incl sample cup)	Sample weight adjusted (incl sample cup)	125um	250um	500um	1mm	Sample gain or loss g	Total retained g	Passed through 125um	125um	250um	500um	1mm	Passed 125um	Retained 125um	Retained 250um	Retained 500um	Retained 1mm	125	250	500	1000
186	209	17	199	282	297	346	499	23	215	0	10	13	40	152	0	5	6	19	71	0	5	11	29
188	204	10	201	282	299	352	498	28	222	0	10	15	46	151	0	5	7	21	68	0	5	11	32
190	193	10	190	277	298	335	508	26	209	0	5	14	29	161	0	2	7	14	77	0	2	9	23
192	191	9	189	278	345	430	384	46	228	0	6	61	124	37	0	3	27	54	16	0	3	29	84
194	203	8	202	278	325	424	428	51	246	0	6	41	118	81	0	2	17	48	33	0	2	19	67
196	200	9	198	290	358	402	377	27	218	0	18	74	96	30	0	8	34	44	14	0	8	42	86
198	198	17	188	288	333	381	515	127	308	0	16	49	75	168	0	5	16	24	55	0	5	21	45
200	193	14	186	283	315	377	438	25	204	0	11	31	71	91	0	5	15	35	45	0	5	21	55



Aquifer Interval grainsize log

Drillhole: KPBi04
Date: 22/02/2014
Sampled by D Poulsen

All samples sieved for 3 mins fully immersed in water
All samples are weighed wet and drained
wiped away excess water with finger around inside bottom rim

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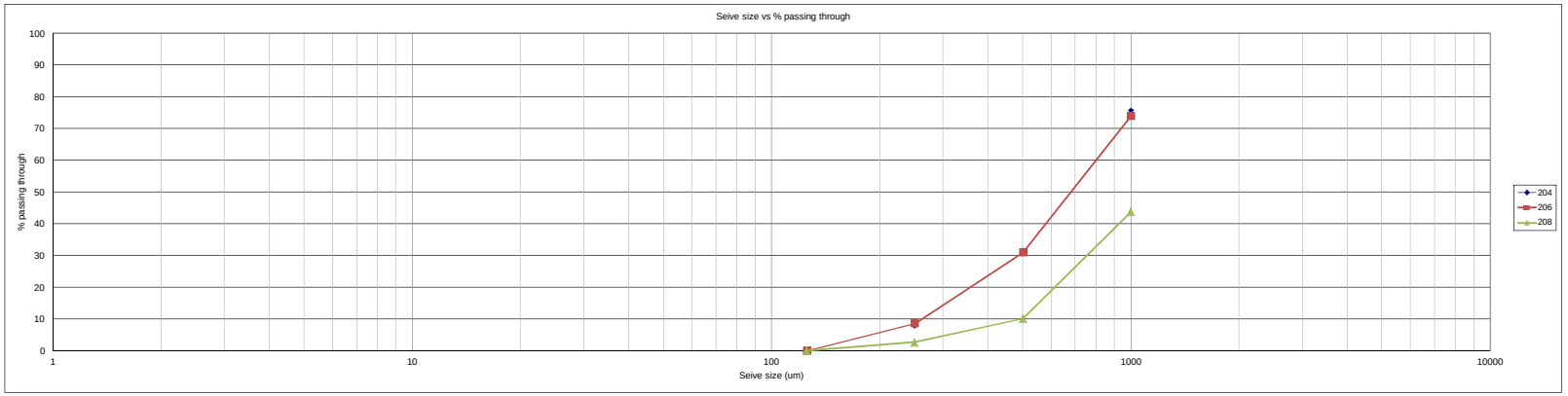
2m Interval Depth to (mbgl)	Total Sieve and Sample Weight (gm)										Sample retained (g)				Percentage weight					Cumulative sample passing (%)			
	Sample weight (incl sample cup)	Clay/Lignite weight (incl sample cup)	Sample weight adjusted (incl sample cup)	125um	250um	500um	1mm	Sample gain or loss g	Total retained g	Passed through 125um	125um	250um	500um	1mm	Passed 125um	Retained 125um	Retained 250um	Retained 500um	Retained 1mm	125	250	500	1000
204	222	8	221	291	342	413	406	29	243	0	19	58	107	59	0	8	24	44	24	0	8	32	76
206	198	16	189	289	328	391	398	15	197	0	17	44	85	51	0	9	22	43	26	0	9	31	74
208	196	9	194	278	301	383	475	41	228	0	6	17	77	128	0	3	7	34	56	0	3	10	44



Aquifer Interval grainsize log

Drillhole: KPBi04
Date: 22/02/2014
Sampled by D Poulsen

All samples sieved for 3 mins fully immersed in water
All samples are weighed wet and drained
wiped away excess water with finger around inside bottom rim

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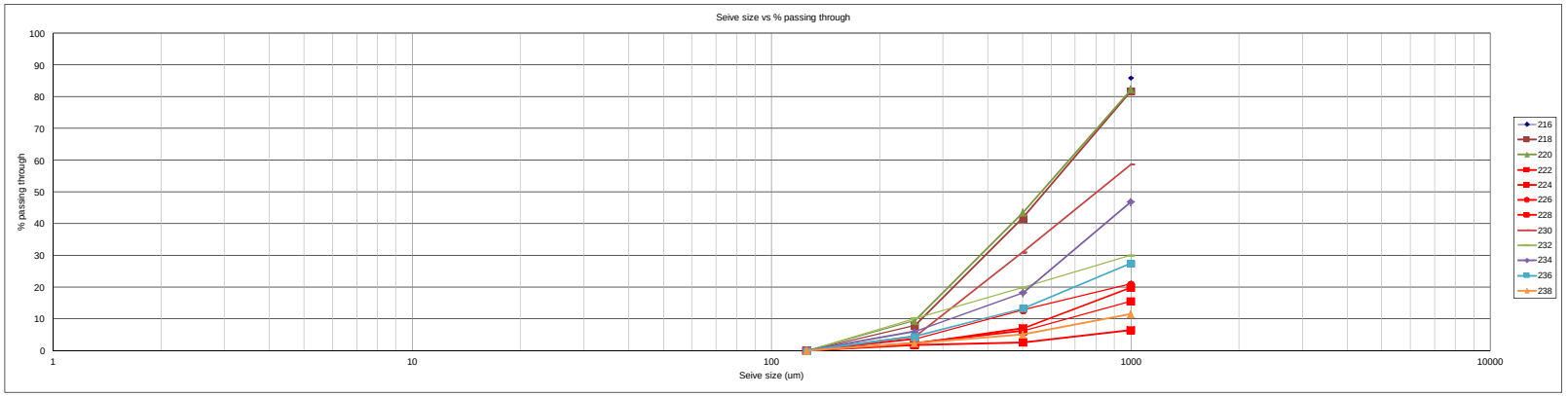
Sample Cup	7
1mm sieve	347
500um sieve	306
250um sieve	284
125um sieve	272
Total	**1209**

2m Interval Depth to (mbgl)	Total Sieve and Sample Weight (gm)										Sample retained (g)				Percentage weight					Cumulative sample passing (%)			
	Sample weight (incl sample cup)	Clay/Lignite weight (incl sample cup)	Sample weight adjusted (incl sample cup)	125um	250um	500um	1mm	Sample gain or loss g	Total retained g	Passed through 125um	125um	250um	500um	1mm	Passed 125um	Retained 125um	Retained 250um	Retained 500um	Retained 1mm	125	250	500	1000
216	216	11	212	290	361	401	378	16	221	0	18	77	95	31	0	8	35	43	14	0	8	43	86
218	211	10	208	290	361	397	388	26	227	0	18	77	91	41	0	8	34	40	18	0	8	42	82
220	209	15	201	292	356	388	384	17	211	0	20	72	82	37	0	9	34	39	18	0	9	44	82
222	218	8	217	276	286	315	565	23	233	0	4	2	9	218	0	2	1	4	94	0	2	3	6
224	221	9	219	277	296	337	540	29	241	0	5	12	31	193	0	2	5	13	80	0	2	7	20
226	210	11	206	280	304	324	519	19	218	0	8	20	18	172	0	4	9	8	79	0	4	13	21
228	217	23	201	277	292	326	526	18	212	0	5	8	20	179	0	2	4	9	84	0	2	6	16
230	228	7	228	284	355	380	457	46	267	0	12	71	74	110	0	4	27	28	41	0	4	31	59
232	204	8	203	292	303	326	484	0	196	0	20	19	20	137	0	10	10	10	70	0	10	20	30
234	209	10	206	286	313	374	472	37	236	0	14	29	68	125	0	6	12	29	53	0	6	18	47
236	205	15	197	282	304	338	510	35	225	0	10	20	32	163	0	4	9	14	72	0	4	13	28
238	211	13	205	277	290	320	538	18	216	0	5	6	14	191	0	2	3	6	88	0	2	5	12



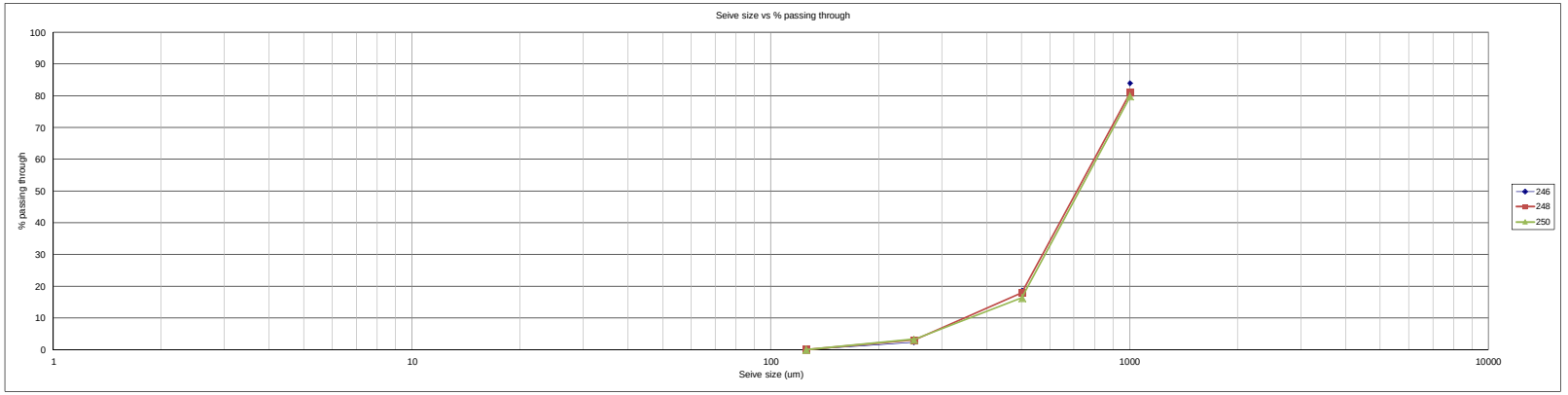
Aquifer Interval grainsize log

Drillhole: KPBi04
Date: 22/02/2014
Sampled by D Poulsen

All samples sieved for 3 mins fully immersed in water
All samples are weighed wet and drained
wiped away excess water with finger around inside bottom rim

Tares (weighed wet, grams)	
Sample Cup	7
1mm sieve	347
500um sieve	306
250um sieve	284
125um sieve	272
Total	**1209**

2m Interval Depth to (mbgl)	Total Sieve and Sample Weight (gm)										Sample retained (g)				Percentage weight					Cumulative sample passing (%)			
	Sample weight (incl sample cup)	Clay/Lignite weight (incl sample cup)	Sample weight adjusted (incl sample cup)	125um	250um	500um	1mm	Sample gain or loss g	Total retained g	Passed through 125um	125um	250um	500um	1mm	Passed 125um	Retained 125um	Retained 250um	Retained 500um	Retained 1mm	125	250	500	1000
246	188	19	176	277	319	446	381	45	214	0	5	35	140	34	0	2	16	65	16	0	2	19	84
248	200	17	190	279	318	449	390	44	227	0	7	34	143	43	0	3	15	63	19	0	3	18	81
250	208	18	197	280	316	461	396	54	244	0	8	32	155	49	0	3	13	64	20	0	3	16	80



Aquifer Interval grainsize log

Drillhole: KPBi04
Date: 22/02/2014
Sampled by D Poulsen

All samples sieved for 3 mins fully immersed in water
All samples are weighed wet and drained
wiped away excess water with finger around inside bottom rim

Tares (weighed wet, grams)	
Sample Cup	7
1mm sieve	347
500um sieve	306
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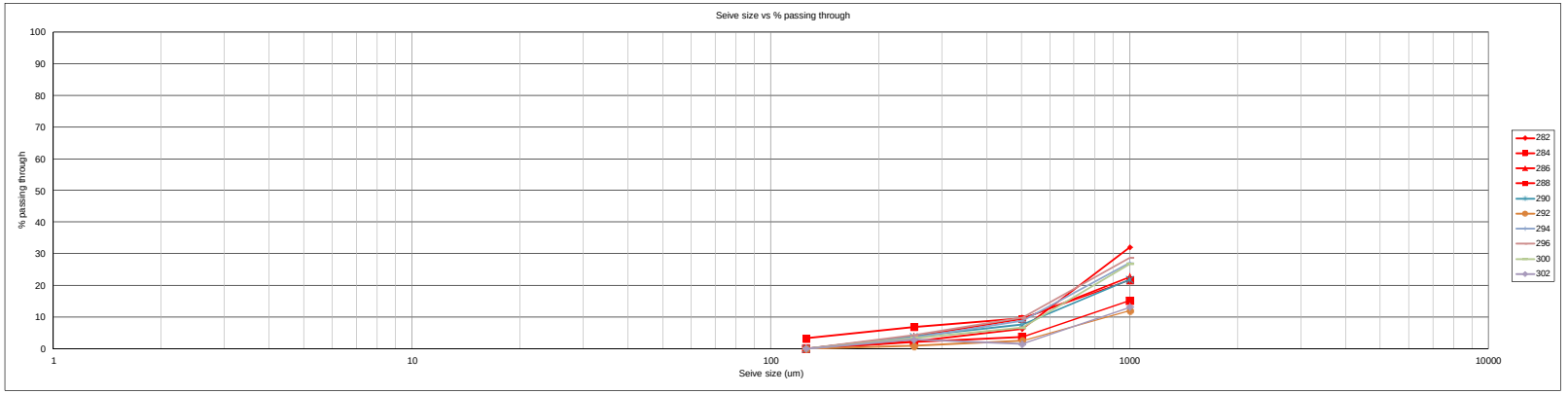
Total	**1209**

2m Interval Depth to (mbgl)	Total Sieve and Sample Weight (gm)									Sample retained (g)				Percentage weight					Cumulative sample passing (%)			
	Sample weight (incl sample cup)	Clay/Lignite weight (incl sample cup)	Sample weight adjusted (incl sample cup)	125um	250um	500um	1mm	Sample gain or loss g	Total retained g	Passed through 125um	125um	250um	500um	1mm	Passed 125um	Retained 125um	Retained 250um	Retained 500um	Retained 1mm	125	250	500	1000
282	263	9	261	278	294	372	520	1	255	0	6	10	66	173	0	2	4	26	68	0	2	6	32
284	204	15	196	279	289	329	495	-6	183	6	7	5	23	148	3	4	3	12	78	3	7	10	22
286	232	14	225	281	297	337	528	16	234	0	9	13	31	181	0	4	6	13	77	0	4	9	23
288	232	12	227	277	288	334	553	23	243	0	5	4	28	206	0	2	2	12	85	0	2	4	15
290	216	22	201	280	292	336	511	16	210	0	8	8	30	164	0	4	4	14	78	0	4	8	22
292	226	12	221	274	288	329	557	25	239	0	2	4	23	210	0	1	2	10	88	0	1	3	12
294	222	28	201	279	295	344	497	12	206	0	7	11	38	150	0	3	5	18	73	0	3	9	27
296	219	23	203	281	296	347	500	19	215	0	9	12	41	153	0	4	6	19	71	0	4	10	29
300	225	13	219	280	292	355	524	30	242	0	8	8	49	177	0	3	3	20	73	0	3	7	27
302	215	10	212	278	281	331	532	8	213	0	6	-3	25	185	0	3	-1	12	87	0	3	1	13



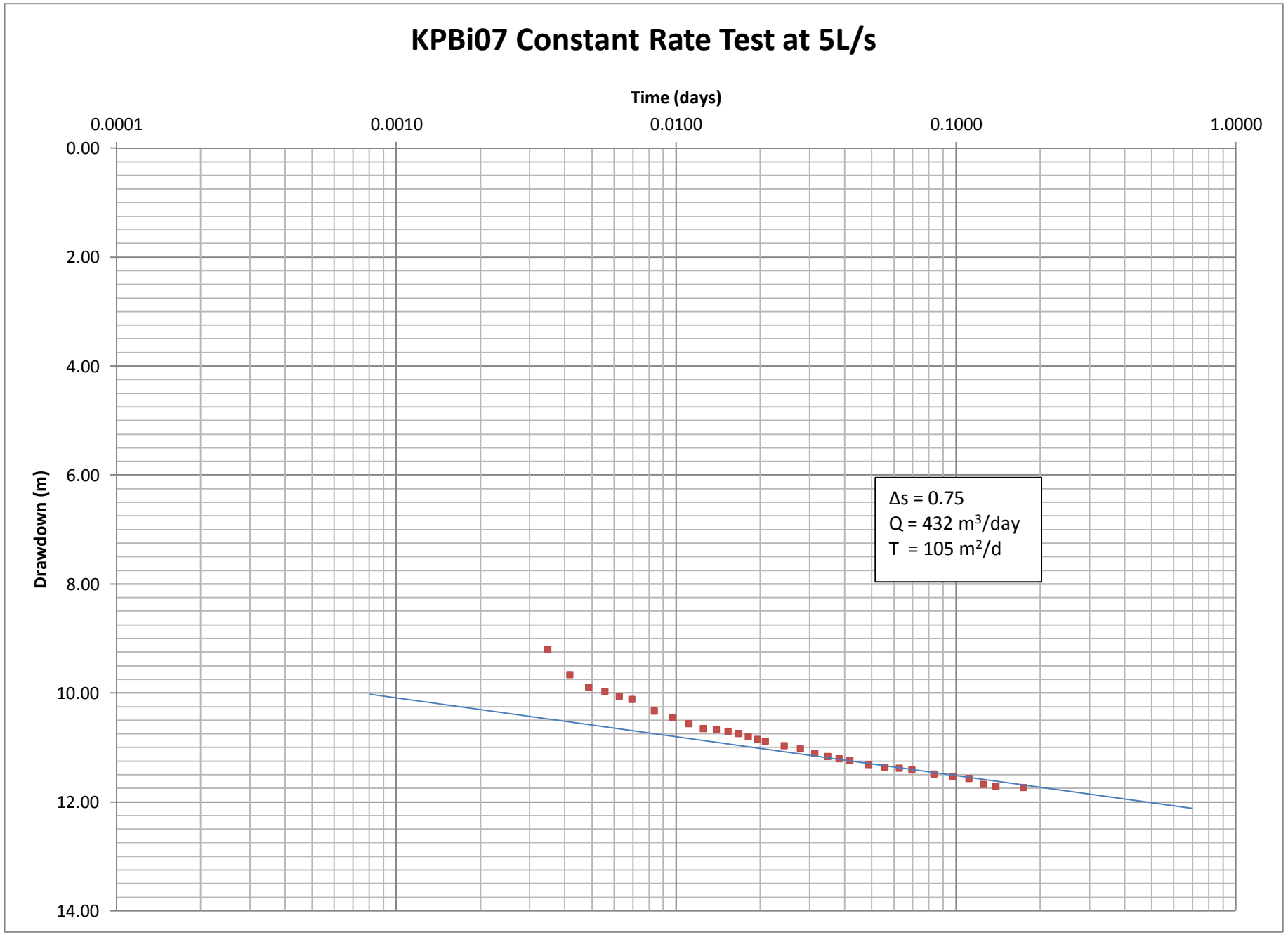
Appendix E Pumping Test Data

Iron Road CEIP Constant Rate Test and Recovery Data

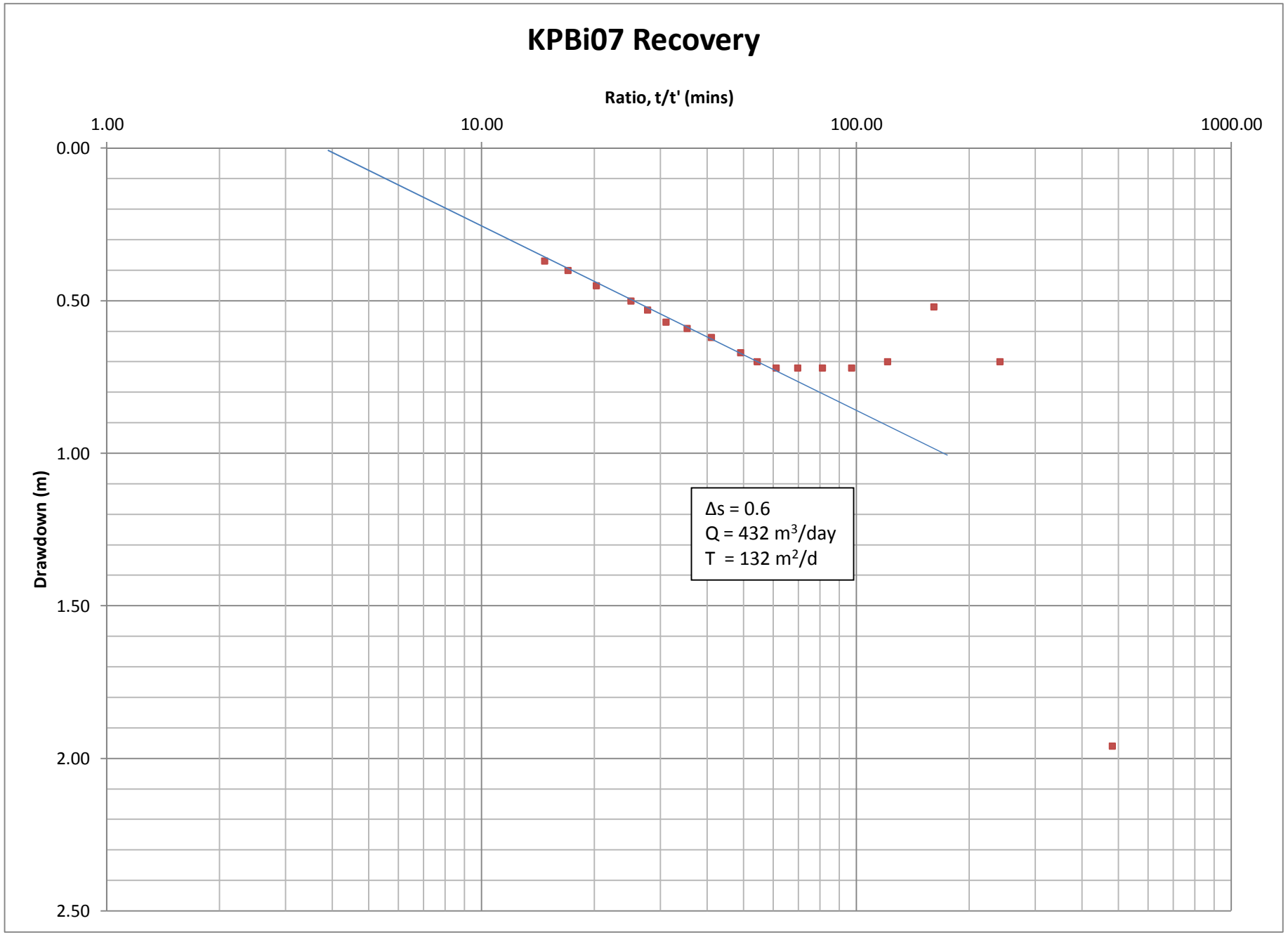
Site	**KPBi07**
Reference Point (RP)	**mTOC**
Date	**5/03/2014**
Start time	**9:40:00 AM**
Finish time	**17:40:00 PM**
Discharge rate (L/s)	**5**
Flow rate (m3/day)	**432**
SWL (m bRP)	**35.4**

Time (mins)	Time since pumping (t - days)	Water level (m bRP)	Drawdown (S)	Recovery (t')	Ratio t/t'
0	0.0000	35.40	0.00		
1	0.0007				
2	0.0014				
3	0.0021				
4	0.0028				
5	0.0035	44.60	9.20		
6	0.0042	45.06	9.66		
7	0.0049	45.29	9.89		
8	0.0056	45.37	9.97		
9	0.0063	45.46	10.06		
10	0.0069	45.51	10.11		
12	0.0083	45.73	10.33		
14	0.0097	45.85	10.45		
16	0.0111	45.96	10.56		
18	0.0125	46.05	10.65		
20	0.0139	46.07	10.67		
22	0.0153	46.10	10.70		
24	0.0167	46.14	10.74		
26	0.0181	46.20	10.80		
28	0.0194	46.25	10.85		
30	0.0208	46.28	10.88		
35	0.0243	46.36	10.96		
40	0.0278	46.42	11.02		
45	0.0313	46.50	11.10		
50	0.0347	46.56	11.16		
55	0.0382	46.60	11.20		
60	0.0417	46.64	11.24		
70	0.0486	46.71	11.31		
80	0.0556	46.76	11.36		
90	0.0625	46.78	11.38		
100	0.0694	46.81	11.41		
120	0.0833	46.88	11.48		
140	0.0972	46.93	11.53		
160	0.1111	46.97	11.57		
180	0.1250	47.07	11.67		
200	0.1389	47.11	11.71		
250	0.1736	47.13	11.73		
300	0.2083	47.17	11.77		
350	0.2431	47.21			
400	0.2778	47.27	11.87		
450	0.3125	47.29	11.89		
480	0.3333	47.32	11.92		
481	0.3340	37.36	1.96	1	481.00
482	0.3347	36.10	0.70	2	241.00
483	0.3354	35.92	0.52	3	161.00
484	0.3361	36.10	0.70	4	121.00
485	0.3368	36.12	0.72	5	97.00
486	0.3375	36.12	0.72	6	81.00
487	0.3382	36.12	0.72	7	69.57
488	0.3389	36.12	0.72	8	61.00
489	0.3396	36.10	0.70	9	54.33
490	0.3403	36.07	0.67	10	49.00
492	0.3417	36.02	0.62	12	41.00
494	0.3431	35.99	0.59	14	35.29
496	0.3444	35.97	0.57	16	31.00
498	0.3458	35.93	0.53	18	27.67
500	0.3472	35.90	0.50	20	25.00
505	0.3507	35.85	0.45	25	20.20
510	0.3542	35.80	0.40	30	17.00
515	0.3576	35.77	0.37	35	14.71

Pumped well	
Straight Line	
Δs	0.75
T (m^2/d)	105
Recovery	
Δs	0.6
T (m^2/d)	132


KPBi07 Constant Rate Test at 5L/s
Time (days)
0.0001
0.0010
0.0100
0.1000
1.0000
Drawdown (m)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Δs = 0.75
Q = 432 m³/day
T = 105 m²/d

KPBi07 Recovery

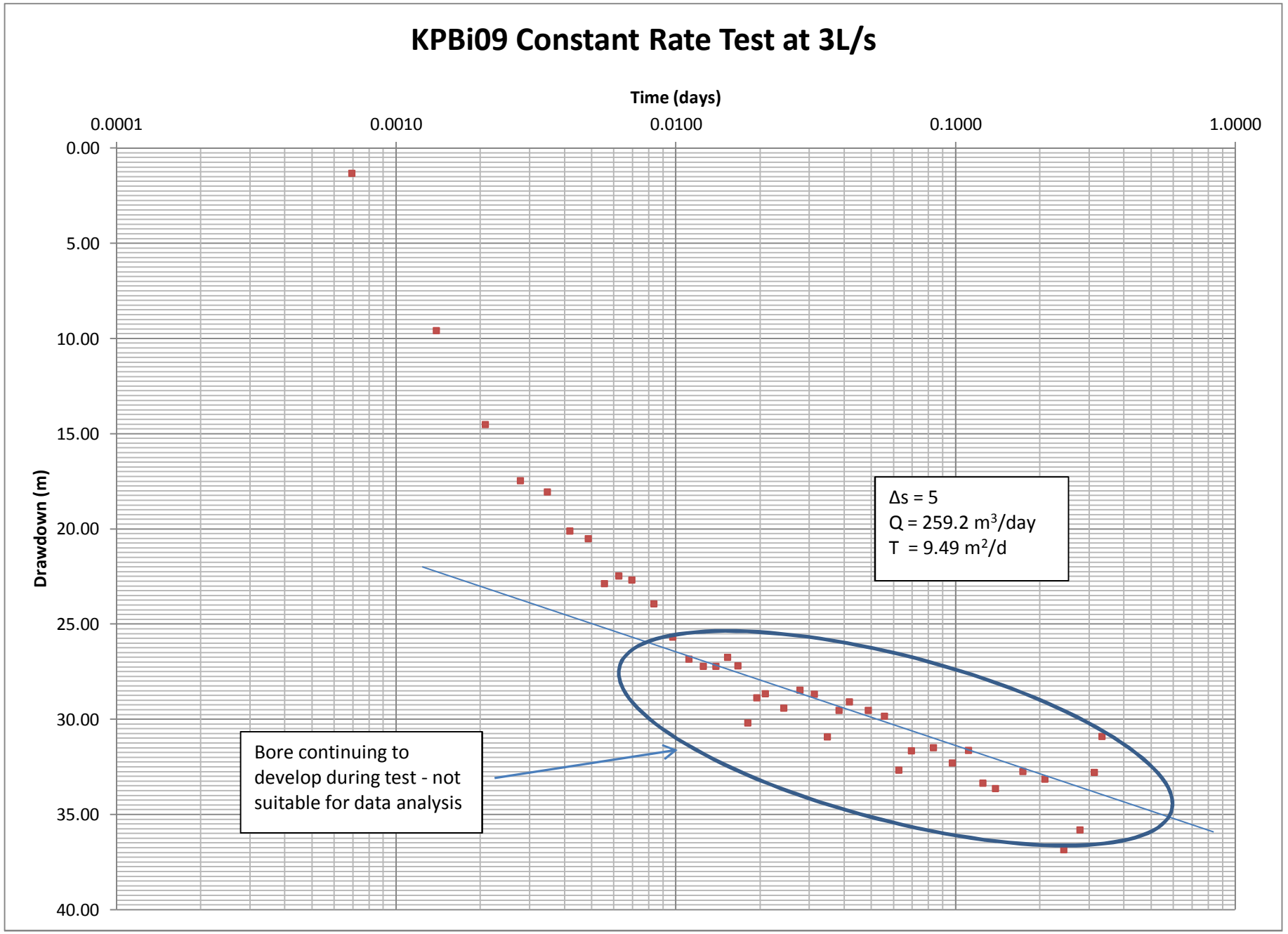


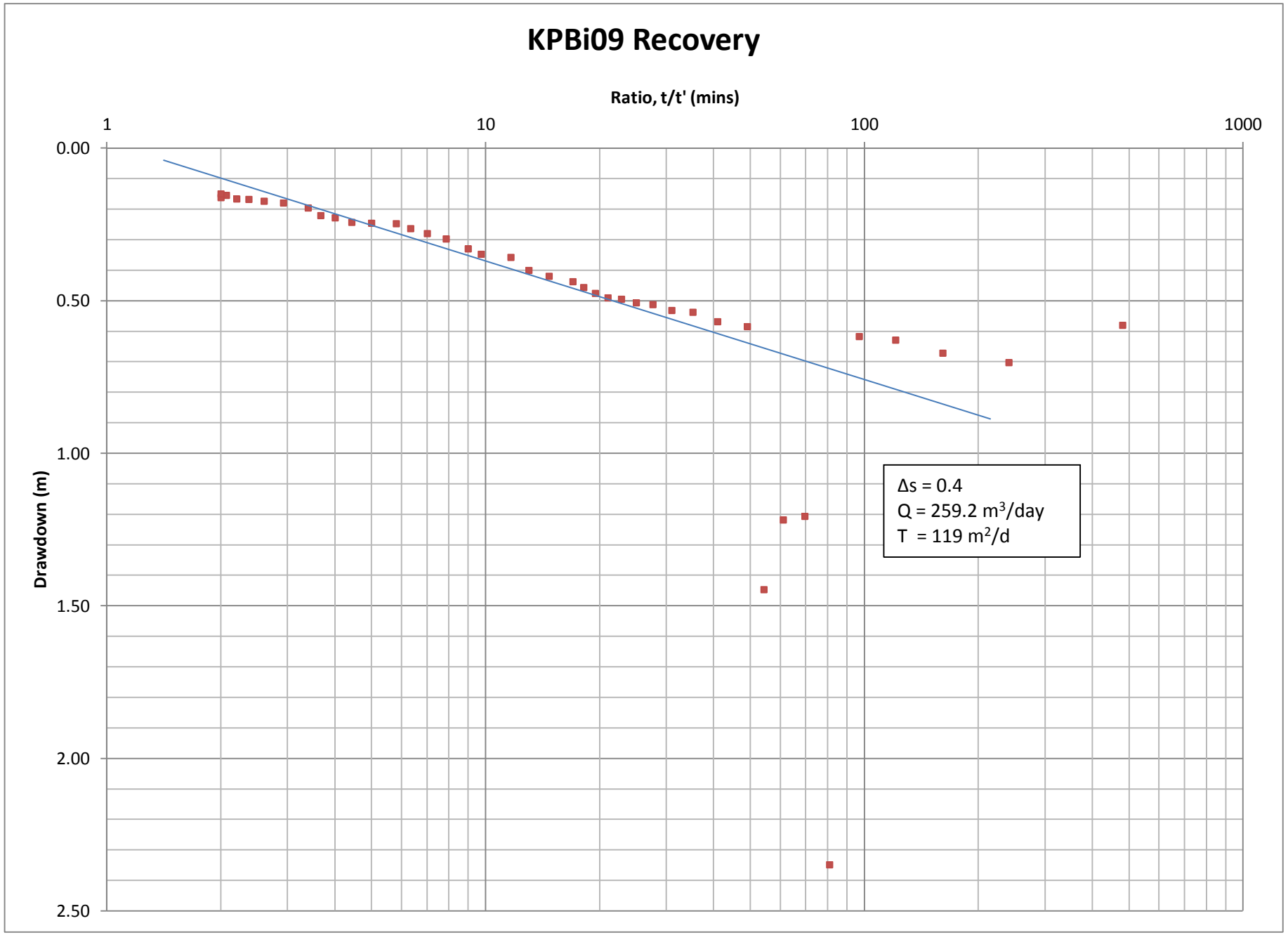
Iron Road CEIP Constant Rate Test and Recovery Data

Site	**KPBi09**
Reference Point (RP)	**mTOC**
Date	**7/03/2014 - 8/3/2014**
Start time	**8:38:00 AM**
Finish time	**12:39:18 AM**
Discharge rate (L/s)	**3**
Flow rate (m3/day)	**259.2**
SWL (m bRP)	**70.679** *(Depth of downhole logger)

Time (mins)	Time since pumping (t - days)	Water level (m bRP)*	Drawdown (S)	Recovery (t')	Ratio t/t'
0	0.0000	70.679	0.00		
1	0.0007	69.353	1.33		
2	0.0014	61.109	9.57		
3	0.0021	56.157	14.52		
4	0.0028	53.215	17.46		
5	0.0035	52.632	18.05		
6	0.0042	50.574	20.11		
7	0.0049	50.179	20.50		
8	0.0056	47.812	22.87		
9	0.0062	48.204	22.48		
10	0.0069	47.989	22.69		
12	0.0083	46.741	23.94		
14	0.0097	45.012	25.67		
16	0.0111	43.846	26.83		
18	0.0125	43.464	27.22		
20	0.0139	43.469	27.21		
22	0.0153	43.948	26.73		
24	0.0167	43.487	27.19		
26	0.0181	40.493	30.19		
28	0.0194	41.812	28.87		
30	0.0208	42.029	28.65		
35	0.0243	41.273	29.41		
40	0.0278	42.207	28.47		
45	0.0313	42.008	28.67		
50	0.0347	39.766	30.91		
55	0.0382	41.145	29.53		
60	0.0417	41.607	29.07		
70	0.0486	41.16	29.52		
80	0.0556	40.85	29.83		
90	0.0625	38.005	32.67		
100	0.0694	39.033	31.65		
120	0.0833	39.201	31.48		
140	0.0972	38.399	32.28		
160	0.1111	39.065	31.61		
180	0.1250	37.334	33.35		
200	0.1389	37.046	33.63		
250	0.1736	37.954	32.73		
300	0.2083	37.54	33.14		
350	0.2431	33.834	36.85		
400	0.2778	34.881	35.80		
450	0.3125	37.897	32.78		
480	0.3333	39.783	30.90	t'	t/t'
481	0.3340	49.992	20.69	0.0007	481
482	0.3347	70.099	0.58	0.0014	241
483	0.3354	69.976	0.70	0.0021	161
484	0.3361	70.008	0.67	0.0028	121
485	0.3368	70.051	0.63	0.0035	97
486	0.3375	70.062	0.62	0.0042	81
487	0.3382	68.331	2.35	0.0049	69.5714
488	0.3389	69.473	1.21	0.0056	61
489	0.3396	69.461	1.22	0.0062	54.3333
490	0.3403	69.232	1.45	0.0069	49
492	0.3417	70.094	0.59	0.0083	41
494	0.3431	70.11	0.57	0.0097	35.2857
496	0.3444	70.141	0.54	0.0111	31
498	0.3458	70.148	0.53	0.0125	27.6667
500	0.3472	70.167	0.51	0.0139	25
502	0.3486	70.172	0.51	0.0153	22.8182
504	0.3500	70.184	0.50	0.0167	21
506	0.3514	70.189	0.49	0.0181	19.4615
508	0.3528	70.203	0.48	0.0194	18.1429
510	0.3542	70.222	0.46	0.0208	17
515	0.3576	70.242	0.44	0.0243	14.7143
520	0.3611	70.26	0.42	0.0278	13
525	0.3646	70.278	0.40	0.0313	11.6667
535	0.3715	70.321	0.36	0.0382	9.72727
540	0.3750	70.331	0.35	0.0417	9
550	0.3819	70.35	0.33	0.0486	7.85714
560	0.3889	70.382	0.30	0.0556	7
570	0.3958	70.4	0.28	0.0625	6.33333
580	0.4028	70.415	0.26	0.0694	5.8
600	0.4167	70.432	0.25	0.0833	5
620	0.4306	70.434	0.25	0.0972	4.42857
640	0.4444	70.436	0.24	0.1111	4
660	0.4583	70.451	0.23	0.1250	3.66667
680	0.4722	70.458	0.22	0.1389	3.4
730	0.5069	70.484	0.20	0.1736	2.92
780	0.5417	70.499	0.18	0.2083	2.6
830	0.5764	70.506	0.17	0.2431	2.37143
880	0.6111	70.511	0.17	0.2778	2.2
930	0.6458	70.513	0.17	0.3125	2.06667
960	0.6667	70.525	0.15	0.3333	2
961	0.6674	70.518	0.16	0.3340	1.99792
962	0.6681	70.529	0.15	0.3347	1.99585

Pumped well	
Straight Line	
Δs	5
T (m^2/d)	9.49
Recovery	
Δs	0.4
T (m^2/d)	119


KPBi09 Constant Rate Test at 3L/s
Time (days)
0.0001
0.0010
0.0100
0.1000
1.0000
Drawdown (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
Δs = 5
Q = 259.2 m³/day
T = 9.49 m²/d
Bore continuing to develop during test - not suitable for data analysis

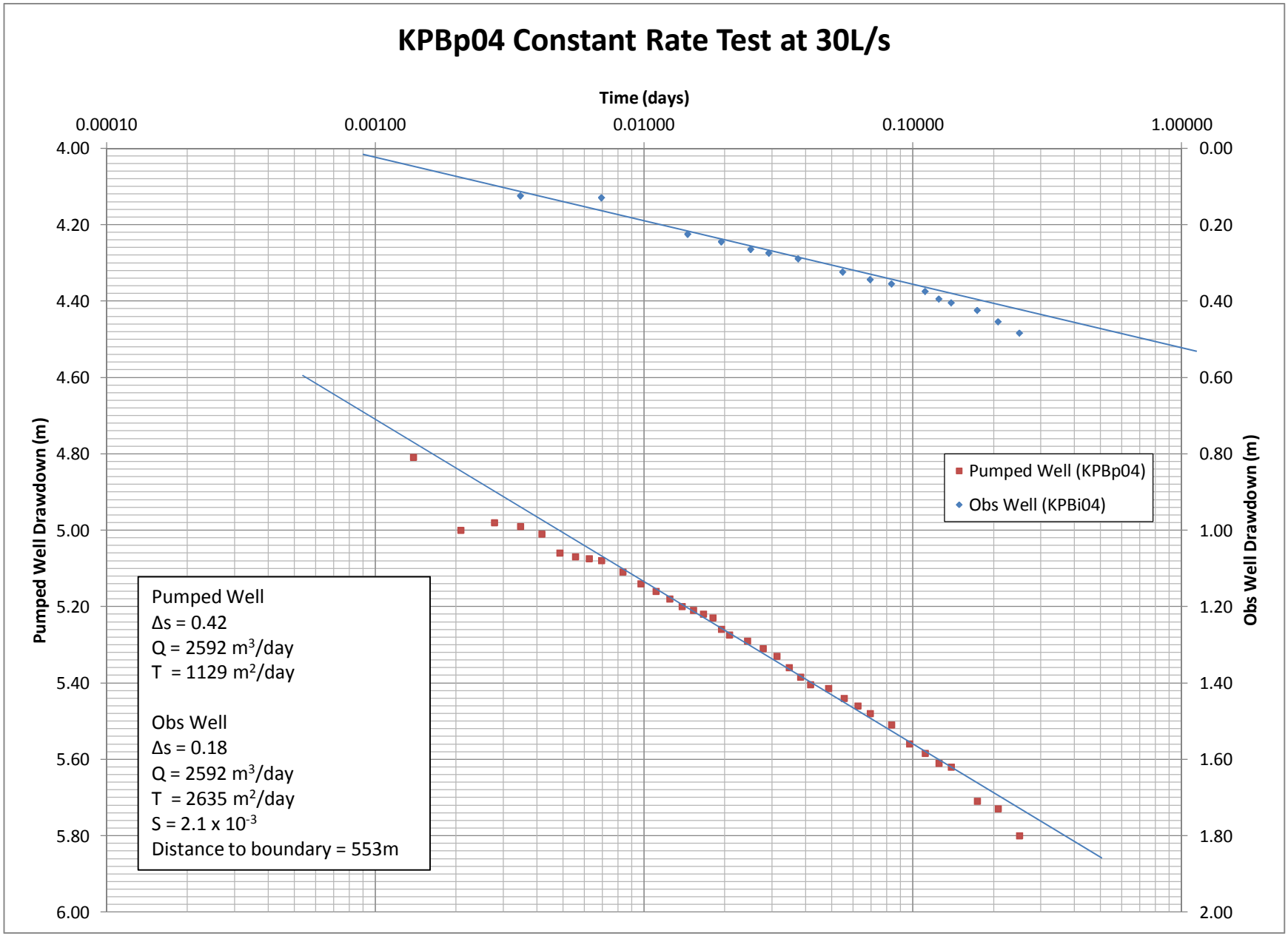

KPBi09 Recovery
Ratio, t/t' (mins)
1
10
100
1000
0.00
0.50
1.00
1.50
2.00
2.50
Drawdown (m)
Δs = 0.4
Q = 259.2 m³/day
T = 119 m²/d

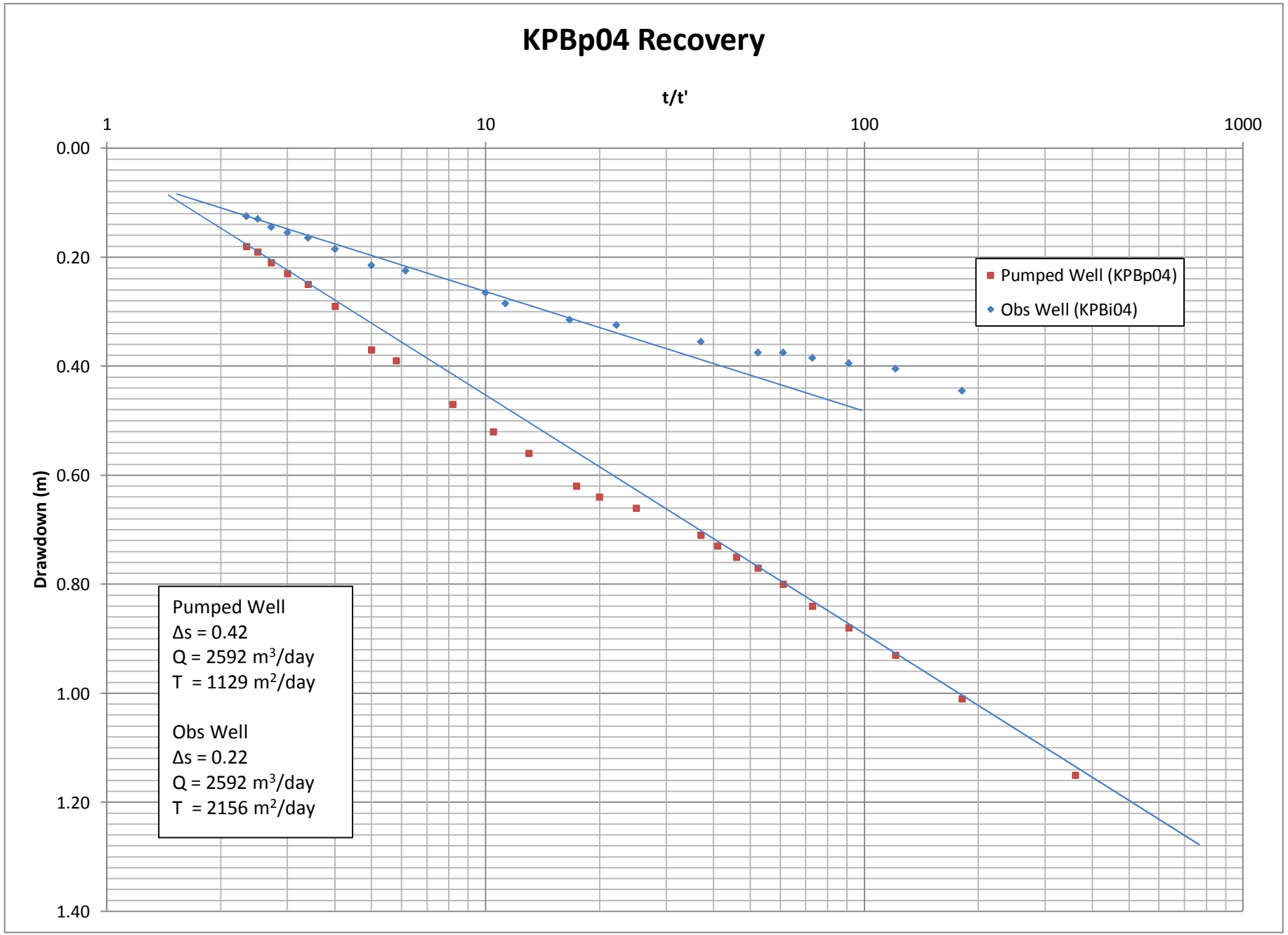
Pumped Well	KPBp04	**Obs 1**	KPBi04
Screen From	145	**Screen From**	144
Screen To	302	**Screen To**	288
Aquifer thickness	160	**Aquifer thickness**	160
Salinity	45.3	**Salinity**	41.6
Density	1	**Density**	1
Flow rate	2592	**Radius**	50

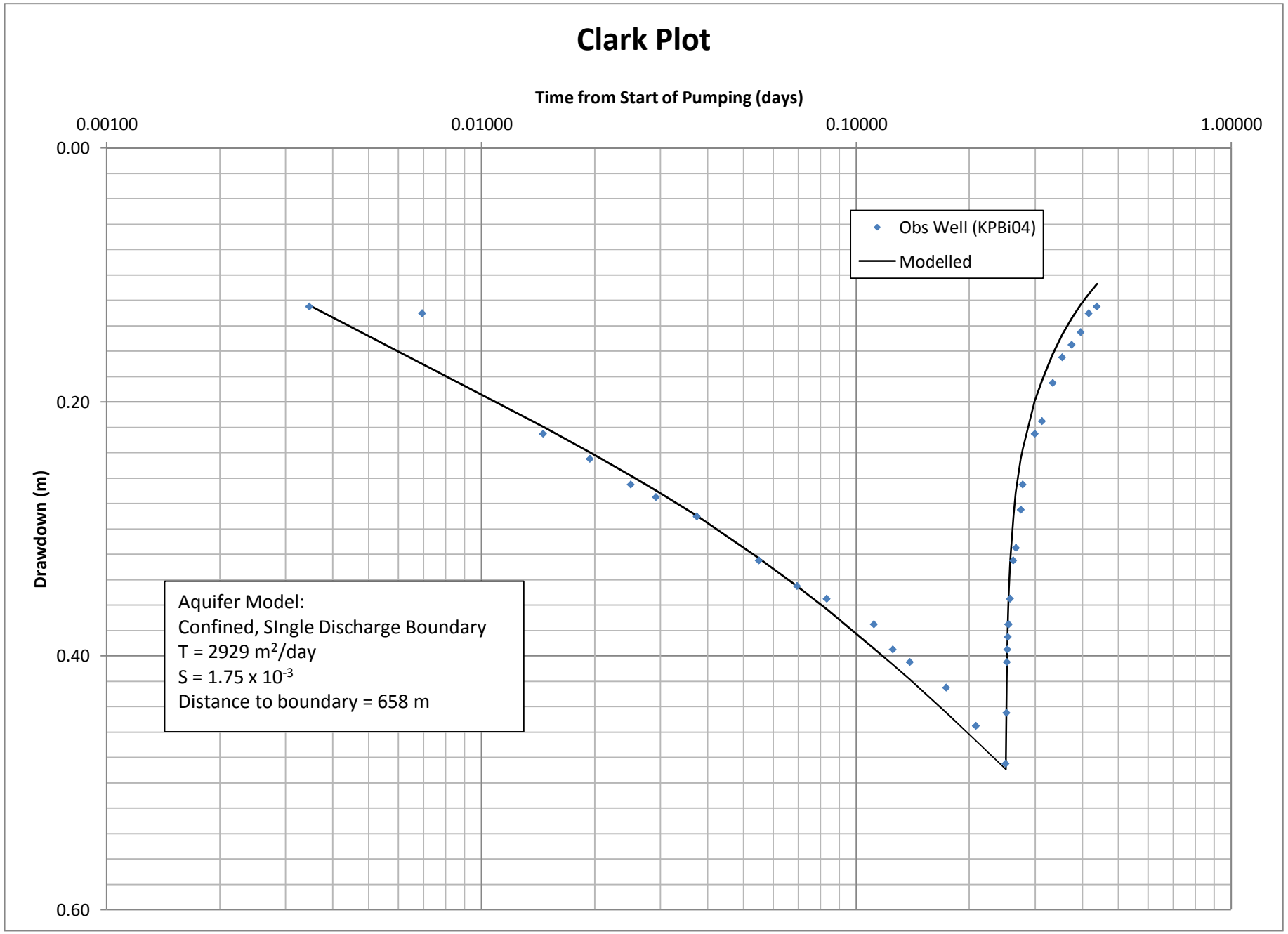
Pumped Well (KPBp04)		
t	t/t'	S
0.00000		0.00
0.00069		3.74
0.00139		4.81
0.00208		5.00
0.00278		4.98
0.00347		4.99
0.00417		5.01
0.00486		5.06
0.00556		5.07
0.00625		5.08
0.00694		5.08
0.00833		5.11
0.00972		5.14
0.01111		5.16
0.01250		5.18
0.01389		5.20
0.01528		5.21
0.01667		5.22
0.01806		5.23
0.01944		5.26
0.02083		5.28
0.02431		5.29
0.02778		5.31
0.03125		5.33
0.03472		5.36
0.03819		5.39
0.04167		5.41
0.04861		5.42
0.05556		5.44
0.06250		5.46
0.06944		5.48
0.08333		5.51
0.09722		5.56
0.11111		5.59
0.12500		5.61
0.13889		5.62
0.17361		5.71
0.20833		5.73
0.25000		5.80
0.25069	361	1.15
0.25139	181	1.01
0.25208	121	0.93
0.25278	91	0.88
0.25347	73	0.84
0.25417	61	0.80
0.25486	52	0.77
0.25556	46	0.75
0.25625	41	0.73
0.25694	37	0.71
0.26042	25	0.66
0.26319	20	0.64
0.26528	17	0.62
0.27083	13	0.56
0.27639	10	0.52
0.28472	8	0.47
0.30208	6	0.39
0.31250	5	0.37
0.33333	4	0.29
0.35417	3	0.25
0.37500	3	0.23
0.39583	3	0.21
0.41667	3	0.19
0.43750	2	0.18

Obs Well (KPBi04)		
t	t/t'	S
0.00000		0.00
0.00347		0.13
0.00694		0.13
0.01458		0.23
0.01944		0.25
0.02500		0.27
0.02917		0.28
0.03750		0.29
0.05486		0.33
0.06944		0.35
0.08333		0.36
0.11111		0.38
0.12500		0.40
0.13889		0.41
0.17361		0.43
0.20833		0.46
0.25000		0.48
0.25139	181	0.45
0.25208	121	0.41
0.25278	91	0.40
0.25347	73	0.39
0.25417	61	0.38
0.25486	52	0.38
0.25694	37	0.36
0.26181	22	0.33
0.26597	17	0.32
0.27431	11	0.29
0.27778	10	0.27
0.29861	6	0.23
0.31250	5	0.22
0.33333	4	0.19
0.35417	3	0.16
0.37500	3	0.16
0.39583	3	0.15
0.41667	3	0.13
0.43750	2	0.13

	Pumped well KPBp04	Obs1 KPBi04
Curve Fitting		
Curve Type		
Match Point		
s		0.066
t		0.00031
Delayed yield t		
r/L		
r/D		
D		#DIV/0!
Thickness of Confining Layer		100
Time to boundary		0.11
T		3125
S		1.5E-03
Sy		0.0E+00
L		#DIV/0!
c		#DIV/0!
K'		#DIV/0!
Kh		20
Kv		0.0000
Distance to Boundary		706
Straight Line		
Δs	0.42	0.180
t_0		0.0009
time to boundary 1		0.11
Time to boundary 2		
T	1129	2635
S		2.1E-03
Distance to Boundary		553
Recovery		
Δs	0.42	0.220
T	1129	2156


KPBp04 Constant Rate Test at 30L/s
Time (days)
0.00010
0.00100
0.01000
0.10000
1.00000
Pumped Well Drawdown (m)
4.00
4.20
4.40
4.60
4.80
5.00
5.20
5.40
5.60
5.80
6.00
Obs Well Drawdown (m)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
Pumped Well (KPBp04)
Obs Well (KPBi04)
Pumped Well
Δs = 0.42
Q = 2592 m3/day
T = 1129 m2/day
Obs Well
Δs = 0.18
Q = 2592 m3/day
T = 2635 m2/day
S = 2.1 x 10-3
Distance to boundary = 553m


KPBp04 Recovery
t/t'
1
10
100
1000
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Drawdown (m)
Pumped Well (KPBp04)
Obs Well (KPBi04)
Pumped Well
Δs = 0.42
Q = 2592 m3/day
T = 1129 m2/day
Obs Well
Δs = 0.22
Q = 2592 m3/day
T = 2156 m2/day


Clark Plot
Time from Start of Pumping (days)
0.00100
0.01000
0.10000
1.00000
0.00
0.20
0.40
0.60
Drawdown (m)
Obs Well (KPBi04)
Modelled
Aquifer Model:
Confined, SIngle Discharge Boundary
T = 2929 m²/day
S = 1.75 x 10⁻³
Distance to boundary = 658 m

Appendix F Water Quality Data

			KPBp04	KPBi07	KPBi09
Analyte grouping/Analyte		Sample dat	16/03/2014	5/03/2014	7/03/2014
	Units	LOR			
EA005: pH					
pH Value	pH Unit	0.01	6.55	6.62	6.57
Total Dissolved Solids (Calc.)	mg/L	1	29200	41300	33900
Suspended Solids (SS)	mg/L	5	181	194	279
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1	<1
Carbonate Alkalinity as CaCO3	mg/L	1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	mg/L	1	193	236	225
Total Alkalinity as CaCO3	mg/L	1	193	236	225
Silicon	mg/L	0.05	6.88	5.56	5.07
Sulfate as SO4 - Turbidimetric	mg/L	1	2350	3080	2630
Chloride	mg/L	1	16000	26500	19500
Calcium	mg/L	1	585	842	661
Magnesium	mg/L	1	962	1380	1130
Sodium	mg/L	1	8170	12800	9530
Potassium	mg/L	1	181	255	200
Aluminium	mg/L	0.01	<0.01	<0.10	<0.01
Arsenic	mg/L	0.001	<0.001	<0.010	<0.001
Beryllium	mg/L	0.001	<0.001	<0.010	<0.001
Barium	mg/L	0.001	0.04	0.044	0.03
Cadmium	mg/L	0.0001	<0.0001	<0.0010	<0.0001
Chromium	mg/L	0.001	0.02	0.01	0.017
Cobalt	mg/L	0.001	<0.001	<0.010	0.001
Copper	mg/L	0.001	0.004	0.017	0.01
Lead	mg/L	0.001	<0.001	<0.010	<0.001
Manganese	mg/L	0.001	1.81	2.77	1.98
Molybdenum	mg/L	0.001	0.001	<0.010	0.002
Selenium	mg/L	0.01	<0.01	<0.10	<0.01
Uranium	mg/L	0.001	<0.001	<0.010	<0.001
Vanadium	mg/L	0.01	<0.01	<0.10	<0.01
Zinc	mg/L	0.005	0.008	0.054	0.007
Boron	mg/L	0.05	1.49	2.4	1.28
Iron	mg/L	0.05	3.62	3.56	0.92
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001
Ammonia as N	mg/L	0.01	0.44	0.94	0.7
Nitrite as N	mg/L	0.01	0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	<0.01	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	0.01	<0.01	<0.01
Total Kjeldahl Nitrogen as N	mg/L	0.1	1.1	2.4	1.4
Total Nitrogen as N	mg/L	0.1	1.1	2.4	1.4
Total Phosphorus as P	mg/L	0.01	0.13	0.06	<0.01
Reactive Phosphorus as P	mg/L	0.01	0.1	<0.01	<0.01
Benzene	µg/L	1	<1	<1	<1
Toluene	µg/L	2	<2	<2	<2
Ethylbenzene	µg/L	2	<2	<2	<2
meta- & para-Xylene	µg/L	2	<2	<2	<2
ortho-Xylene	µg/L	2	<2	<2	<2
Total Xylenes	µg/L	2	<2	<2	<2
Sum of BTEX	µg/L	1	<1	<1	<1
Naphthalene	µg/L	5	<5	<5	<5
C6 - C9 Fraction	µg/L	20	<20	<20	<20
C10 - C14 Fraction	µg/L	50	<50	<50	<50
C15 - C28 Fraction	µg/L	100	<100	<100	<100
C29 - C36 Fraction	µg/L	50	<50	<50	<50
C10 - C36 Fraction (sum)	µg/L	50	<50	<50	<50
C6 - C10 Fraction	µg/L	20	<20	<20	<20
C6 - C10 Fraction minus BTEX (F1)	µg/L	20	<20	<20	<20
>C10 - C16 Fraction	µg/L	100	<100	<100	<100
>C16 - C34 Fraction	µg/L	100	<100	<100	<100
>C34 - C40 Fraction	µg/L	100	<100	<100	<100
>C10 - C40 Fraction (sum)	µg/L	100	<100	<100	<100
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	100	<100	<100	<100

CERTIFICATE OF ANALYSIS

Work Order	: **EM1402441**	Page	: 1 of 6
Client	: **GROUNDWATER SCIENCE**	Laboratory	: Environmental Division Melbourne
Contact	: MR BEN JEUKEN	Contact	: Kieren Burns
Address	: MINES & ENERGY HOUSE 290 GLEN OSMOND ROAD FULLARTON SOUTH AUSTRALIA 5063	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: ben.jeuken@groundwaterscience.com.au	E-mail	: kieren.burns@alsglobal.com
Telephone	: +61 0448 040 733	Telephone	: 61 8 8359 0890
Facsimile	: +61 08 8121 1839	Facsimile	: 61 8 8259 0875
Project	: Kielpa Water Supply	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 18-MAR-2014
Sampler	: SM	Issue Date	: 26-MAR-2014
Site	: ----		
		No. of samples received	: 3
Quote number	: ----	No. of samples analysed	: 3

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EA016: Calculated TDS is determined from Electrical conductivity using a conversion factor of 0.65.**
- **EG020F: Sample EM1402441-002 has been diluted prior to analysis and LORs have been raised accordingly.**
- **EP080: Particular sample (EM-1402441-002,003) show poor surrogates recovery due to the matrix interferrence. Confirmed by QC sample.**
- **Insufficient time was provided to conduct the analysis of alkalinity and mercury within the recommended holding times. ALS requires at least 50% of the recommended analytical holding time upon receipt.**
- **Ionic Balance out of acceptable limits for sample #2, #3 due to analytes not quantified in this report.**
- **Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.**
- **Samples were filtered through a 0.45um filter prior to the dissolved metals analysis.**

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics
Herman Lin	Laboratory Manager	Melbourne Inorganics
Nancy Wang	Senior Semivolatile Instrument Chemist	Melbourne Organics
Nikki Stepniewski	Senior Inorganic Instrument Chemist	Melbourne Inorganics

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	KPBp04	KPBi07	KPBi09	----	----
				Client sampling date / time	16-MAR-2014 15:00	05-MAR-2014 15:00	07-MAR-2014 15:00	----	----
Compound	CAS Number	LOR	Unit		EM1402441-001	EM1402441-002	EM1402441-003	----	----
EA005: pH									
pH Value	----	0.01	pH Unit		6.55	6.62	6.57	----	----
EA016: Non Marine - Estimated TDS Salinity									
Total Dissolved Solids (Calc.)	----	1	mg/L		29200	41300	33900	----	----
EA025: Suspended Solids									
Suspended Solids (SS)	----	5	mg/L		181	194	279	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		<1	<1	<1	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		193	236	225	----	----
Total Alkalinity as CaCO3	----	1	mg/L		193	236	225	----	----
ED040F: Dissolved Major Anions									
Silicon	7440-21-3	0.05	mg/L		6.88	5.56	5.07	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		2350	3080	2630	----	----
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		16000	26500	19500	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		585	842	661	----	----
Magnesium	7439-95-4	1	mg/L		962	1380	1130	----	----
Sodium	7440-23-5	1	mg/L		8170	12800	9530	----	----
Potassium	7440-09-7	1	mg/L		181	255	200	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		<0.01	<0.10	<0.01	----	----
Arsenic	7440-38-2	0.001	mg/L		<0.001	<0.010	<0.001	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.010	<0.001	----	----
Barium	7440-39-3	0.001	mg/L		0.040	0.044	0.030	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0010	<0.0001	----	----
Chromium	7440-47-3	0.001	mg/L		0.020	0.010	0.017	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.010	0.001	----	----
Copper	7440-50-8	0.001	mg/L		0.004	0.017	0.010	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	<0.010	<0.001	----	----
Manganese	7439-96-5	0.001	mg/L		1.81	2.77	1.98	----	----
Molybdenum	7439-98-7	0.001	mg/L		0.001	<0.010	0.002	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	KPBp04	KPBi07	KPBi09	----	----
				Client sampling date / time	16-MAR-2014 15:00	05-MAR-2014 15:00	07-MAR-2014 15:00	----	----
					EM1402441-001	EM1402441-002	EM1402441-003	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.10	<0.01	----	----
Uranium	7440-61-1	0.001	mg/L		<0.001	<0.010	<0.001	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.10	<0.01	----	----
Zinc	7440-66-6	0.005	mg/L		**0.008**	**0.054**	**0.007**	----	----
Boron	7440-42-8	0.05	mg/L		**1.49**	**2.40**	**1.28**	----	----
Iron	7439-89-6	0.05	mg/L		**3.62**	**3.56**	**0.92**	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.44**	**0.94**	**0.70**	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	----	0.01	mg/L		**0.01**	<0.01	<0.01	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	<0.01	<0.01	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.01**	<0.01	<0.01	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**1.1**	**2.4**	**1.4**	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									
^ **Total Nitrogen as N**	----	0.1	mg/L		**1.1**	**2.4**	**1.4**	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.13**	**0.06**	<0.01	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		**0.10**	<0.01	<0.01	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**504**	**816**	**609**	----	----
Total Cations	----	0.01	meq/L		**468**	**719**	**546**	----	----
Ionic Balance	----	0.01	%		**3.69**	**6.36**	**5.53**	----	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		<20	<20	<20	----	----
C10 - C14 Fraction	----	50	µg/L		<50	<50	<50	----	----
C15 - C28 Fraction	----	100	µg/L		<100	<100	<100	----	----
C29 - C36 Fraction	----	50	µg/L		<50	<50	<50	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	KPBp04	KPBi07	KPBi09	----	----
			Client sampling date / time	16-MAR-2014 15:00	05-MAR-2014 15:00	07-MAR-2014 15:00	----	----
Compound	CAS Number	LOR	Unit	EM1402441-001	EM1402441-002	EM1402441-003	----	----
EP080/071: Total Petroleum Hydrocarbons - Continued								
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	----	----
>C10 - C16 Fraction	>C10_C16	100	µg/L	<100	<100	<100	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	----	----
Toluene	108-88-3	2	µg/L	<2	<2	<2	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	----	----
^ Total Xylenes	1330-20-7	2	µg/L	<2	<2	<2	----	----
^ Sum of BTEX	----	1	µg/L	<1	<1	<1	----	----
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	**72.3**	**65.8**	**65.9**	----	----
Toluene-D8	2037-26-5	0.1	%	**85.1**	**80.5**	**83.8**	----	----
4-Bromofluorobenzene	460-00-4	0.1	%	**82.0**	**76.7**	**76.7**	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	70	132
Toluene-D8	2037-26-5	69	125
4-Bromofluorobenzene	460-00-4	61	129

Appendix G Drawdown Time Series

Time		Drawdown (m)										
Days	Years	KPB01	KPB02	KPB03	KPB05	KPB04	KPB06	KPB07	KPB08	KPB09	KPB10	Lock Township Obs bore
281.2	0.8	24.3	29.5	32.2	34.4	34.1	31.9	30.9	31.9	31.8	30.7	0.0
618.7	1.7	28.5	35.0	38.5	41.2	40.7	38.6	37.3	38.1	37.2	35.9	0.0
1023.6	2.8	30.7	37.8	41.7	44.6	44.0	42.0	40.6	41.2	40.0	38.6	0.0
1509.6	4.1	32.4	39.9	44.0	46.8	46.2	44.3	43.0	43.6	42.1	40.8	0.0
2092.7	5.7	34.2	41.9	46.1	49.1	48.5	46.6	45.1	45.6	44.0	42.7	0.0
2792.5	7.7	36.0	44.1	48.8	52.0	51.3	49.4	47.8	48.1	46.2	44.8	0.0
3632.2	10.0	38.2	46.9	52.1	55.6	54.8	53.0	51.2	51.3	48.9	47.4	0.0
4639.8	12.7	40.8	50.4	56.4	60.3	59.4	57.7	55.6	55.4	52.3	50.8	0.0
5849.0	16.0	44.2	54.8	61.6	65.9	64.9	63.4	61.0	60.5	56.7	55.1	0.0
7300.0	20.0	48.2	59.8	67.3	72.0	70.9	69.6	67.0	66.2	61.6	60.0	0.0
7581.2	20.8	27.7	35.4	41.1	44.1	43.1	44.1	42.2	40.2	34.9	34.2	0.0
7918.7	21.7	25.5	32.6	37.9	40.6	39.8	40.8	39.0	37.1	32.1	31.5	0.0
8323.6	22.8	24.3	31.1	36.2	38.8	38.0	39.0	37.4	35.4	30.6	30.1	0.0
8809.6	24.1	23.4	29.8	34.6	37.1	36.3	37.3	35.8	33.8	29.2	28.8	0.0
9392.7	25.7	22.4	28.3	32.9	35.3	34.5	35.6	34.1	32.2	27.8	27.5	0.0
10092.5	27.7	21.3	26.9	31.1	33.4	32.7	33.7	32.3	30.5	26.3	26.1	0.0
10932.2	30.0	20.3	25.4	29.3	31.4	30.7	31.7	30.4	28.7	24.8	24.7	0.0
11939.8	32.7	19.2	23.8	27.4	29.4	28.7	29.7	28.5	26.8	23.3	23.2	0.0
13149.0	36.0	18.0	22.2	25.5	27.3	26.7	27.6	26.5	25.0	21.8	21.7	0.0
14600.0	40.0	16.7	20.5	23.6	25.2	24.7	25.4	24.5	23.1	20.1	20.2	0.0

Appendix H Theis Worksheets

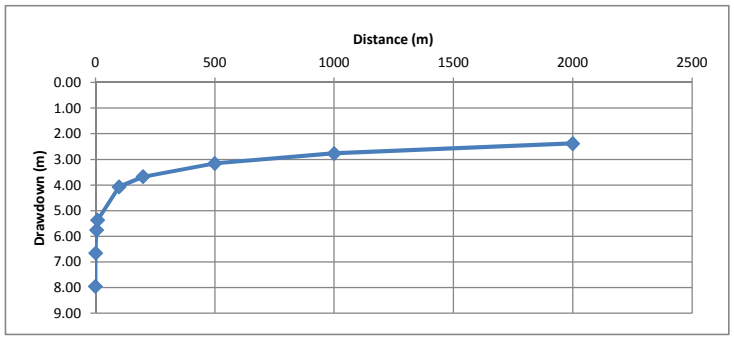
Thies Equation **KPBi04**

Flow Rate	Q	4000	m3/day
Transmissivty	T	1130	m2/day
Storativity	S	0.001	

Distance-drawdown

t 7300 days

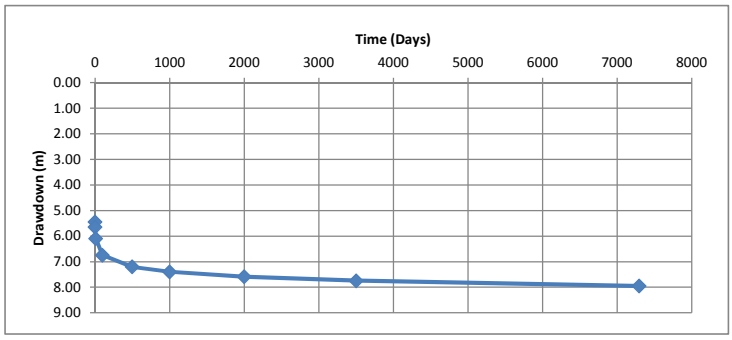
Distance	u	w(u)	Drawdown
0.1	3.03E-13	2.82E+01	7.96
1	3.03E-11	2.36E+01	6.66
5	7.58E-10	2.04E+01	5.75
10	3.03E-09	1.90E+01	5.36
100	3.03E-07	1.44E+01	4.06
200	1.21E-06	1.30E+01	3.67
500	7.58E-06	1.12E+01	3.16
1000	3.03E-05	9.83E+00	2.77
2000	1.21E-04	8.44E+00	2.38



Time-Drawdown

r 0.1 m

Time	u	w(u)	Drawdown
1	2.21E-09	1.94E+01	5.45
2	1.11E-09	2.00E+01	5.65
10	2.21E-10	2.17E+01	6.10
100	2.21E-11	2.40E+01	6.75
500	4.42E-12	2.56E+01	7.20
1000	2.21E-12	2.63E+01	7.40
2000	1.11E-12	2.70E+01	7.59
3500	6.32E-13	2.75E+01	7.75
7300	3.03E-13	2.82E+01	7.96



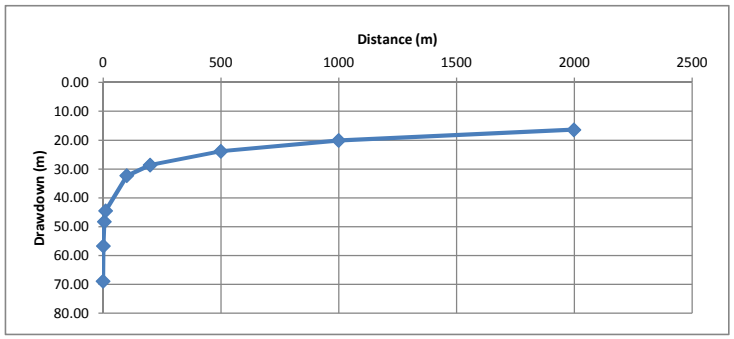
Thies Equation **KPBi09**

Flow Rate	Q	4000	m3/day
Transmissivty	T	120	m2/day
Storativity	S	0.001	

Distance-drawdown

t 7300 days

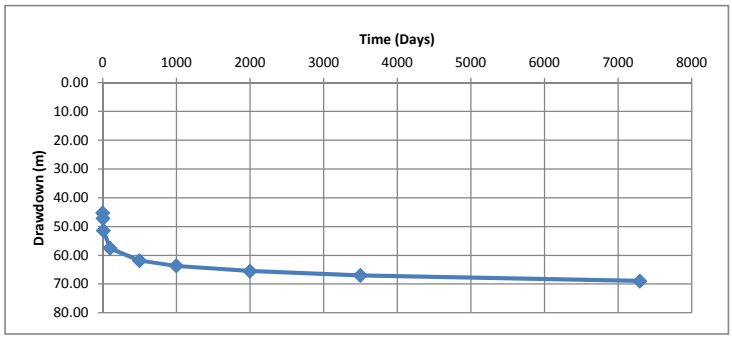
Distance	u	w(u)	Drawdown
0.1	2.85E-12	2.60E+01	68.97
1	2.85E-10	2.14E+01	56.76
5	7.13E-09	1.82E+01	48.22
10	2.85E-08	1.68E+01	44.54
100	2.85E-06	1.22E+01	32.33
200	1.14E-05	1.08E+01	28.65
500	7.13E-05	8.97E+00	23.79
1000	2.85E-04	7.58E+00	20.12
2000	1.14E-03	6.20E+00	16.44



Time-Drawdown

r 0.1 m

Time	u	w(u)	Drawdown
1	2.08E-08	1.71E+01	45.38
2	1.04E-08	1.78E+01	47.22
10	2.08E-09	1.94E+01	51.49
100	2.08E-10	2.17E+01	57.59
500	4.17E-11	2.33E+01	61.86
1000	2.08E-11	2.40E+01	63.70
2000	1.04E-11	2.47E+01	65.54
3500	5.95E-12	2.53E+01	67.02
7300	2.85E-12	2.60E+01	68.97



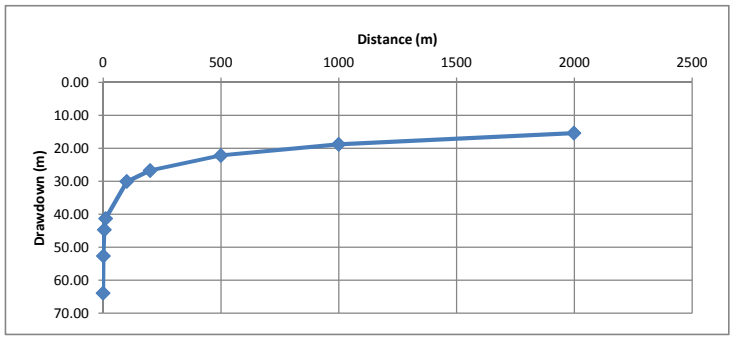
Thies Equation **KPBi07**

Flow Rate	Q	4000	m3/day
Transmissivty	T	130	m2/day
Storativity	S	0.001	

Distance-drawdown

t 7300 days

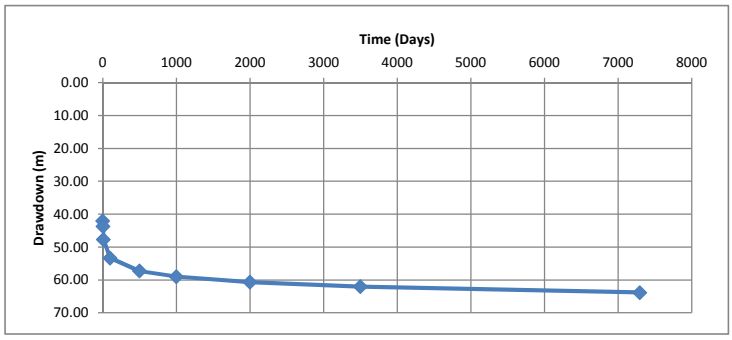
Distance	u	w(u)	Drawdown
0.1	2.63E-12	2.61E+01	63.86
1	2.63E-10	2.15E+01	52.59
5	6.59E-09	1.83E+01	44.71
10	2.63E-08	1.69E+01	41.31
100	2.63E-06	1.23E+01	30.04
200	1.05E-05	1.09E+01	26.64
500	6.59E-05	9.05E+00	22.16
1000	2.63E-04	7.66E+00	18.76
2000	1.05E-03	6.28E+00	15.37



Time-Drawdown

r 0.1 m

Time	u	w(u)	Drawdown
1	1.92E-08	1.72E+01	42.08
2	9.62E-09	1.79E+01	43.78
10	1.92E-09	1.95E+01	47.72
100	1.92E-10	2.18E+01	53.36
500	3.85E-11	2.34E+01	57.30
1000	1.92E-11	2.41E+01	59.00
2000	9.62E-12	2.48E+01	60.69
3500	5.49E-12	2.54E+01	62.06
7300	2.63E-12	2.61E+01	63.86



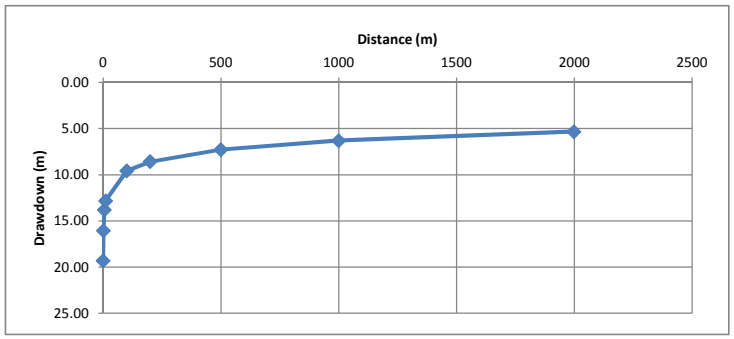
Thies Equation **IC4**

Flow Rate	Q	4000	m3/day
Transmissivty	T	450	m2/day
Storativity	S	0.001	

Distance-drawdown

t 7300 days

Distance	u	w(u)	Drawdown
0.1	7.61E-13	2.73E+01	19.33
1	7.61E-11	2.27E+01	16.07
5	1.90E-09	1.95E+01	13.79
10	7.61E-09	1.81E+01	12.81
100	7.61E-07	1.35E+01	9.56
200	3.04E-06	1.21E+01	8.58
500	1.90E-05	1.03E+01	7.28
1000	7.61E-05	8.91E+00	6.30
2000	3.04E-04	7.52E+00	5.32



Time-Drawdown

r 0.1 m

Time	u	w(u)	Drawdown
1	5.56E-09	1.84E+01	13.04
2	2.78E-09	1.91E+01	13.53
10	5.56E-10	2.07E+01	14.66
100	5.56E-11	2.30E+01	16.29
500	1.11E-11	2.46E+01	17.43
1000	5.56E-12	2.53E+01	17.92
2000	2.78E-12	2.60E+01	18.41
3500	1.59E-12	2.66E+01	18.81
7300	7.61E-13	2.73E+01	19.33