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Memo

To	Fabian Goddard	Company	CZR Resources
From	Basia Kozikowska / Alastair Hoare	Job No.	385E
Date	08/10/2024	Doc No.	037a
Subject	Response to DWER Comments on Bore PB13-3 Groundwater Licence Application H2 Report		

Fabian,

The following memo details AQ2's response to comments made by DWER on the H2 hydrogeological assessment report written in support of a groundwater licence application to the Department of Environment and Water Resources (DEWR) for a 17 L/s abstraction rate for bore PB13-3.

1. RESPONSE TO DWER MATTERS

1.1 DWER Comment 1

"Geological and hydrogeological information for any additional bores drilled in the Duck Creek Dolomite which support the modelling parameters selected in the AQ2's pumping test analysis (Attachment C)."

AQ2 Response:

As outlined in the Section 5.1 of H2 Assessment report, production bore PB13-3 was drilled and constructed in fault Breccia within the Duck Creek Dolomite. Breccia is a common rock type found in faulted zones, like the regional fault running through bore PB13-3. Breccia outcrops in fault 'push ups' immediately north and south of production bore PB13-3. The bedrock geology of the immediate area is shown in Figure 1.1.

The hydrogeological information on the faulted/fractured aquifer in our assessment was based on the comprehensive test pumping programme undertaken at PB13-3. A constant rate test (CRT) was undertaken for 7 days (168 hours), well above the normal standard of 1 to 3 days of CRT pumping commonly used in the Pilbara, therefore providing greater confidence in the results. The purpose of this extended CRT were to:

- Estimate hydraulic conductivity of the fractured/faulted aquifer (i.e. along strike of the main fault zone)
- Confirm the along-strike continuity of the fractured/faulted aquifer.
- Confirm the presence of aquifer barrier conditions.
- Assess the long-term sustainable yield of PB13-3.

The test results have shown the presence of an aquifer barrier boundary (i.e. likely to be a result of the cone of depression reaching the edge of the fractured/faulted bedrock aquifer system) after approximately 500 minutes (~8hrs) of the CRT, which resulted in an increase in the drawdown rate (i.e. the drawdown propagating along the fault line north towards the Robe River and south along the fault). Therefore, a conservative assessment has been made of aquifer parameters (i.e. the calculated bulk average transmissivity of 230 m^2/d and the bulk average hydraulic conductivity of 3.2 m/d, based on an estimated aquifer thickness from drilling information of 72 m). Tt should be noted that the calculated transmissivity and permeability values are bulk values for all of the aquifer material, none of the values apply to individual features (e.g. faults, fractures or shears) of higher permeability. The use of late-time drawdown data and subsequently recovery data for the potential long-term drawdown predictions are considered the most reliable data at the time of assessment (i.e. the expected case).

There are no specific reports publicly available that detail the hydrogeological characteristics of the local area Duck Creek Dolomite. However, production bore PB13-3 was drilled in December 2010 as part of the water supply network for the construction of a railway for Australian Premium Iron's (API) West Pilbara Iron Ore Project. The railway was never built, but many water supply bores were drilled along its proposed route. There are two production bores (PB11-5 and PB14-8) drilled, constructed and tested that are believed to target the fractured Duck Dolomite (refer to Figure 1.1 showing the locations of API production bores with basement geology).

Bore PB14-8 is located approximately 5.4 km to the north of PB13-3 and approximately 520 m to the north of the Robe River. Lithological and construction logs for PB14-8 have been provided by API and are shown in Attachment A. It should be noted that the clay, sand and gravels with BIF between 39 and 63 metres below ground level (mbgl) were incorrectly logged by RPS (2010), and are more likely to correspond to the fractured Duck Creek Dolomite. A 24-hour CRT was conducted at PB14-8 at 22 L/s for the first 60 minutes, then immediately increased to 28 L/s until the end of the test (refer to Attachment A). A bulk average transmissivity of 174 m^2/d was used to calculate sustainable pumping yields. This corresponds to a bulk average hydraulic conductivity of 2.7 m/d, based on the aquifer thickness of 64 m)

Bore PB11-5 is located approximately 7 km to the south-west of PB13-3. Lithological and construction logs for PB11-5 have been provided by API and are shown in Attachment B. It should be noted that detritals (sand, chert with BIF) and underlying weathered basalt between 30 to 80 mbgl (EOH) were incorrectly logged by RPS (2010), and are also more likely to correspond to the fractured Duck Creek Dolomite. A 24-hour CRT was undertaken at PB11-5 at 6 L/s (pumping rate being restricted to the maximum capacity of the 4" pump used). A bulk average transmissivity of 368 m^2/d was used to calculate sustainable pumping yields (refer to Attachment B). This corresponds to a bulk average hydraulic conductivity of 6.8 m/d, based on the aquifer thickness of 54 m).

It should be noted that production bores PB14-8 and 11-5 do not appear to run through the regional fault that production bore PB13-3 targeted (as shown on Figure 1.1). However, there may be some local scale faults/fractured zones within the Duck Creek Dolomite (i.e. CRT results at PB11-5 shows the presence of the aquifer barrier boundary after 100 minutes of the CRT, suggesting limited extent of the fractured zones).

To sum up, the calculated aquifer parameters used in our assessment are based on the extended test pumping programme at PB13-3 and are comparable to the results from the nearby production bores PB14-8 and PB11-5. Therefore, providing greater confidence in the drawdown assessment results.

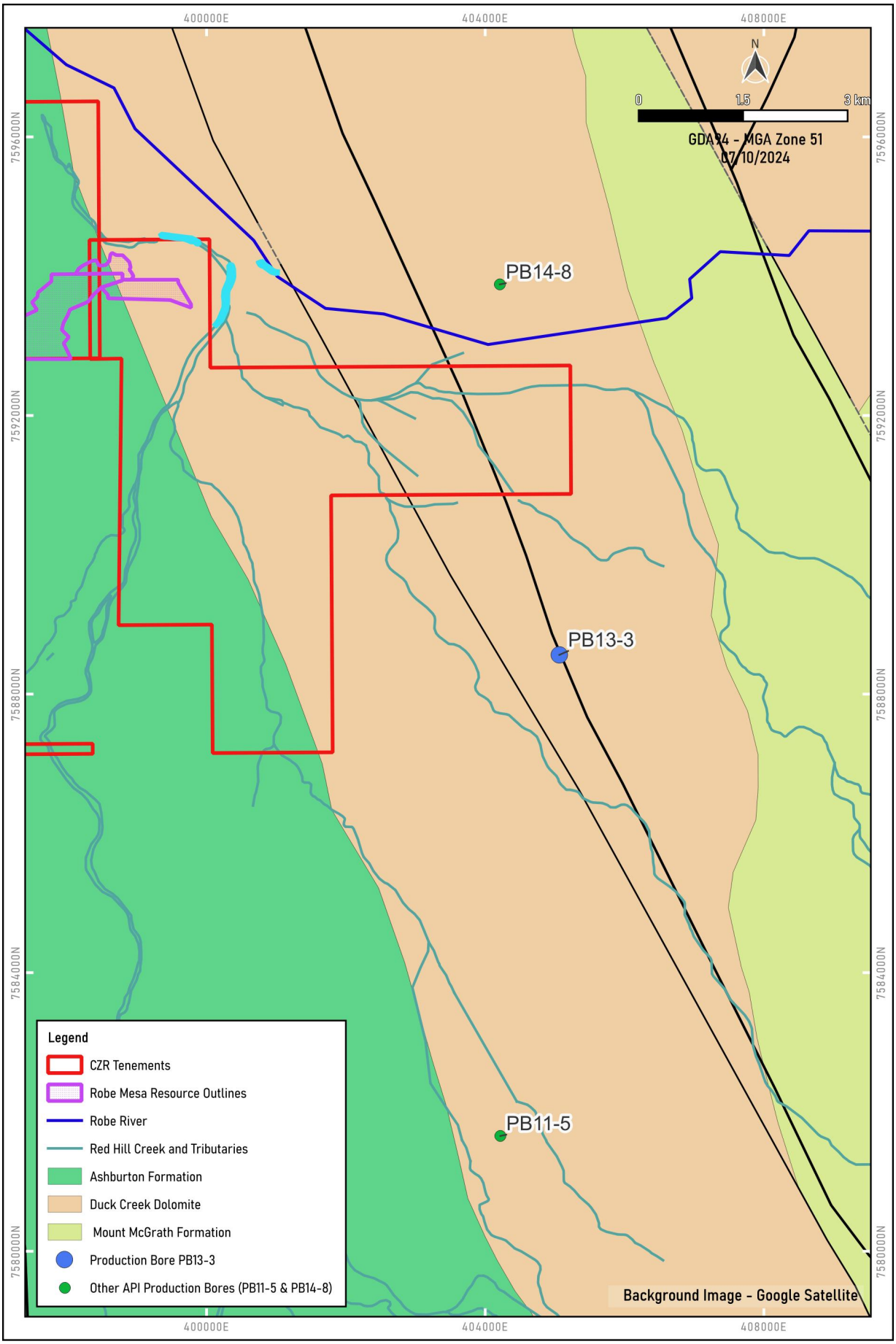

Figure 1.1 Basement Geology and Nearby API Production Bores

1.2 DWER Comment 2

"The AQ2 report discusses the fault zone to be 800m wide. Is this based on sound geological information?"

AQ2 Response:

There is no site-specific geological information in regard to the width of the regional fault zone at PB13-3. However, the assumptions on the width of the fault zone in the H2 assessment have been based on the following data:

- The PB13-3 constant rate test results have shown the presence of an aquifer barrier boundary (i.e. likely to be a result of the cone of depression reaching the edge of the fractured/faulted bedrock aquifer system) after approximately 500 minutes (~8hrs) of the CRT, which resulted in an increase in the drawdown rate. This is believed to be from the drawdown reaching the edge of the faulted and brecciated zone, perpendicular to the fault. The drawdown will also propagate along the fault line north towards the Robe River and south along the fault. The presence of the aquifer barrier boundary confirms the presence of lower permeability and potentially unfractured Duck Creek Dolomite perpendicular to the fault line (with a lower bulk permeability).
- The lithological log for exploration bore MB13-1, located approximately 300 m to the west of production bore PB13-3, was provided by API. The lithological log (refer to Attachment C) shows sand and gravels with BIF up to 46 m depth, underlain by basalt, which was incorrectly logged by RPS (2010) and is more likely to be associated with the fault Breccia (up to 46 mbgl) within the Duck Creek Dolomite.

Based on these limited data it has been assumed that the fault zone is approximately 800 m wide (ie. 400 m on both sides from PB13-3, which is installed in the centre of the fault, along the line of fault 'push ups').

The Theis equation was used to predict the 1 m drawdown contour along and across the fault/fracture zones as a result of pumping from bore PB13-3. Figure 1.2 shows the modelled predicted 1 m drawdown contour extending up to 2 km along the fault/fracture zone, and extending approximately 500 m perpendicular to the fault, assuming the fractured zone is approximately 800 m wide (i.e. 400 m both sides of PB13-3), as was reported in the H2 assessment. In addition, Figure 1.2 shows the 1 m drawdown contour assuming the aquifer has infinite areal extent (i.e. not having aquifer barrier boundaries), which is unlikely at PB13-3 (as there is a barrier boundary evident from the test pumping data).

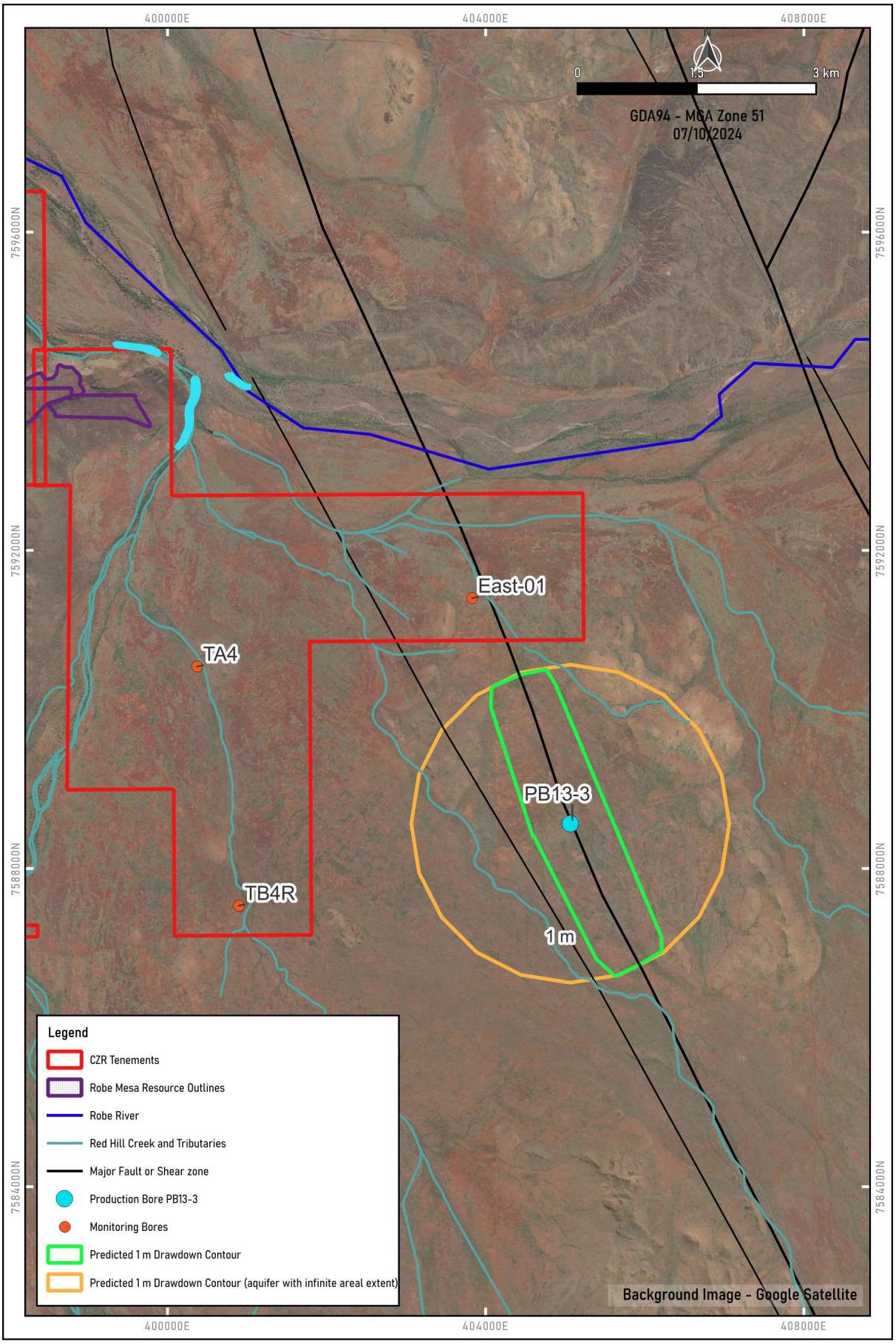

Figure 1.2 Predicted 1 m Drawdown Contour in the Bedrock Aquifer (Fractured and Unfractured) Due to Pumping from PB13-3 at 17 L/s for 7 Years

1.3 DWER Comment 3

"Discussion of the geological analysis of why pumping from the production bore will not affect flows in nearby ephemeral creeks (i.e. closer than the identified pools, or any pools on these creeks)."

AQ2 Response:

As outlined in the H2 Assessment report, creeks in the vicinity of water supply bore PB13-3 are ephemeral with runoff responding to sporadic significant rainfall events.

The local Quaternary age transported unconsolidated sediments and valley fill material sediments (clay, silt, sand and gravel in various proportions) when saturated (i.e. below the water table) can form a localised aquifer. Typically, the saturated Quaternary sediments are associated with the drainage lines, which are directly recharged by rainfall infiltration during the wet season. There are relatively large surface water runoff volumes from the Mungarathoona Creek (formerly known as the Red Hill Creek) and Warramboo Creek Catchments expected to occur in the Project area.

The PB13-3 lithological log shows that red brown sand and gravel was intersected from the surface to 5 mbgl, which is associated with the Quaternary age transported material. This material is unsaturated, with the depth to water at PB13-3 being around 12 to 14 mbgl (i.e. 101 to 103 mAHD). In addition, Figure 1.3 shows a simple east-west elevation profile (using Google Earth) between the closest creek (~1.2 km to the west) and bore PB13-3. The creek bed elevation is at approximately 111 mAHD and the groundwater level is at approximately 101 to 103 mAHD, which is about 8 to 10 m below the creek bed elevation. This indicates that local groundwater and surface water systems are not in direct hydraulic connection (the water table is below the base of the local creek beds). As such, under normal conditions, while the local valley-fill aquifer may be recharged by vertical leakage from the creek during its flowing periods, there will be no groundwater baseflow to the creek during or after the wet season. Therefore, any unidentified pools on this creek are highly likely to be totally dependent upon surface water flows alone.

It is noted that it might be possible for groundwater levels to rise closer to the surface in low lying areas during and following extreme rainfall events (e.g. cyclones), due to higher than normal recharge. However, at such times, flow within the local creeks would be dominated by surface water runoff, with a minimal contribution from the groundwater.

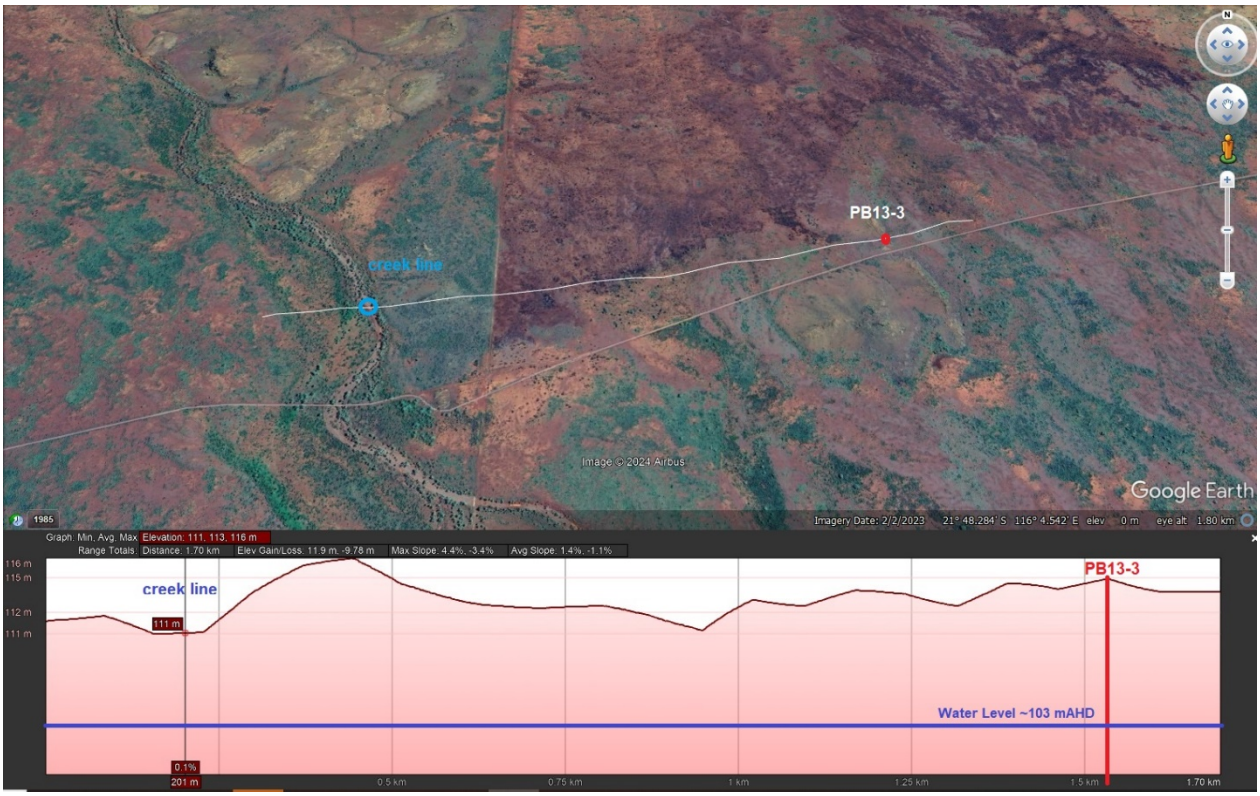

Figure 1.3 Simple Ground Level Elevation Profile between the Nearest Creek Line and PB13-3

1.4 DWER Comment 4

"This area of the Pilbara is currently experiencing the driest three-year period in the last four decades. Please confirm that the pumping test analysis in Attachment C is based on zero recharge. If possible, it is the department's preference Zanthus runs the SRO analysis in Attachment B with no recharge to see if any different predictions arise which increase the risk."

AQ2 Response:

The pumping test analysis as presented in Attachment C of the H2 Assessment report are based on zero recharge. The current drawdown predictions (refer to Section 6 in the same report) also conservatively assume that there is no rainfall recharge.

In should be noted that Attachment B of the H2 Assessment report presents the RPS (2011) unpublished PB13-3 bore completion report, with 24-hour test pumping results and the SRO analysis (to estimate a recommended safe pumping yield).

AQ2 did not use the RPS (2011) SRO analysis in the H2 Assessment to estimate the bore maximum pumping levels and the recommended pumping yield for PB13-3. As outlined in Section 6.1 of the H2 report, extrapolation of the 7-day test pumping late-time drawdown data at PB13-3 (H2 report Figure 6.1) indicated that the required pumping rate of 17 L/s is sustainable in the long-term, i.e. the groundwater level over the 7-year mine life water demand period will drop to approximately 20 mbgl (i.e. 6.2 m drawdown), which is well above the pump depth set at 72 mbgl, assuming that no further boundaries are intersected or there is no major fracture set dewatering (with a consequently increase in the drawdown rate).

Additional SRO analysis was run by AQ2 using the hydrogeological information gathered during drilling and the recent test pumping and the results are shown in Figure 1.4 below. No recharge was applied in this assessment (i.e. it was assumed that the period between recharge events was 7 years (2,555 days)). This recent SRO calculation confirmed that the required pumping rate of 17 L/s is sustainable in the long-term.

Source Reliable Output Calculations **Bore No:** 385E

Notes:
Calculates SRO and expected pumping water levels for newly constructed bores
Pumping Test Analysis must have been undertaken first
Pumping water levels calculated from assumed average conditions - as seen during drilling
Assumes transient radial flow conditions prevail (eg Theis Equation)

Data Input

Rest Water Level = 14 mbgl Top of Aquifer/Max PWL = 72 mbgl

Step Test Data

Enter parameters of step test equation $s=BQ+CQ^2$

B =	9.04E-04	
C =	2.60E-07	
valid time	100	mins

Constant Rate Test Data

Enter parameters from constant rate analysis

T =	230	m^2/d	(transmissivity)
s =	5.00E-02		(storativity)
r =	0.155	m	(radius of bore)

Enter Operational Data

Assumed period between recharge events t2 = 2555 days
Range of discharges to be considered Are there interference effects (Y/N) N

Q1	691.2	m^3/d	8 L/s	Dist to first bore	m
Q2	1469	m^3/d	17 L/s	pumping rate	m^3/d
Q3	2160	m^3/d	25 L/s	Dist to second bore	m
Q4	2592	m^3/d	30 L/s	pumping rate	m^3/d

Calculations of Drawdown

Discharge	Short Term Drawdown	Long Term Drawdown	Interference Effects	Total Drawdown	Pumping Water Level
691.2	0.75	2.51	0.00	3.26	17.26
1468.8	1.89	5.34	0.00	7.23	21.23
2160	3.17	7.85	0.00	11.01	25.01
2592	4.09	9.42	0.00	13.51	27.51

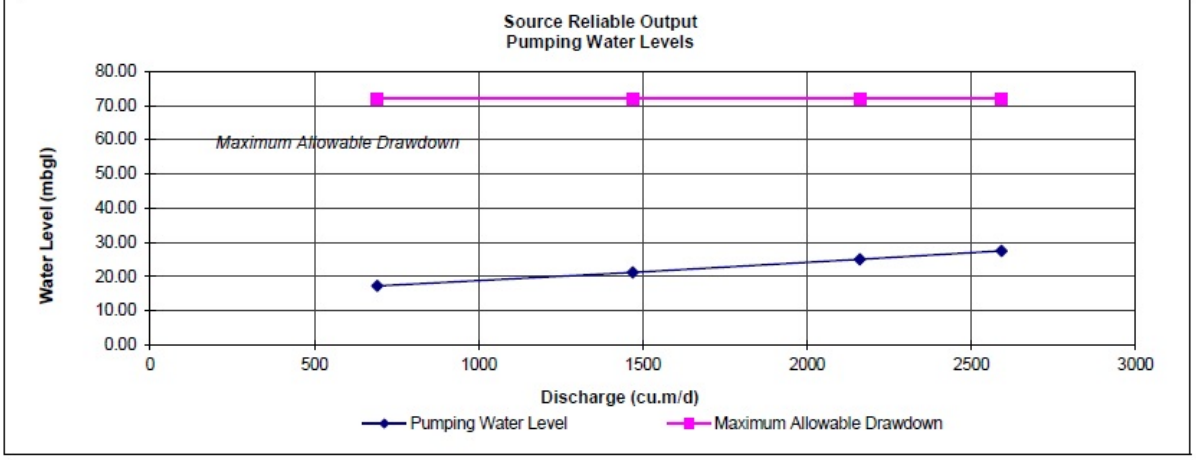

Figure 1.4 Source Reliable Output (SRO) Calculations

Hopefully this has answered your queries. Please let us know if you need any further information on this.

Regards,

Basia Kozikowska *Alastair Hoare*

Consulting Hydrogeologist Consulting Hydrogeologist

Author: BDK (07/10/24)
Checked: AGH (08/10/24)
Reviewed: AGH (08/10/24)

Attached:

Attachment A RPS, 2011, PB14-8 Bore Completion Report
Attachment B RPS, 2011, PB11-5 Bore Completion Report
Attachment C RPS, 2011, MB13-1 Bore Lithological Log

ATTACHMENT A

RPS, 2011, PB14-8 Bore Completion Report

RPS Aquaterra

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MEMORANDUM

COMPANY:	API Management		
ATTENTION:	Phil Davidson/Kimberley Flowerdew		
FROM:	Jon Shudra/Armelle Bonneton		
DATE:	26 September 2011	JOB NO: 898C	DOC NO: 042a
SUBJECT:	PB11-5 Bore Completion Report		

In 2010, API Management Pty Ltd appointed RPS Aquaterra to undertake a groundwater supply investigation for a proposed rail line in Western Pilbara. This bore completion report provides a brief factual summary of the drilling, bore construction, pump testing and hydrogeological information which was recorded during the installation of Production bore PB11-5.

Production Bore PB11-5

Production bore PB11-5 is situated approximately 10km south of the Robe River at rail chainage CH213. The grid reference for the bore location is 0404219 Easting, 7581653 Northing (MGA94, Zone 50) and is shown in Figure 1. A summary of the drilling details are shown in Table 1 along with a summary of the pump testing in Table 2 and Table 3.

The bore was drilled and constructed by Welldrill, with hydrogeological support from RPS Aquaterra personnel from 20/11/10 to 23/11/10. A 12.5" hole was drilled to 6 meters followed by the installation and cementing of a (8") 255mm ND steel surface casing to 6mbgl. The exploration hole was drilled with a 6" diameter drill bit to a total depth of 80m by Conventional air hammer drilling. With a sufficient airlift yield recorded, the exploration hole was reamed out using a 10" drill bit to 80m to equip the hole as a production bore. A 155mm PVC casing was used to construct the production bore to a depth of 66m by installing blank casing from 66m to 60m, slotted casing from 60m to 6m and blank casing from 6m to surface. The annulus was backfilled with 3.2 to 6.4mm graded quartz gravel pack from 66m to surface with fallback from 66m to 80m. The bore headworks were completed with a 1m x 1m x 0.2m concrete block and a lockable steel post protecting the capped PVC casing. Prior to the completion of PB11-5 a monitoring bore MB11-5 was drilled approximately 9m away and was used as a monitoring bore during the pump testing of PB11-5.

Geology/Hydrogeology

The drilling lithology for PB11-5 exposed a succession of sand, gravel, dry powder, banded iron formation (BIF) in the top 3m. Underlying this was brownish grey clay to 30m (first water strike at 12m). Underlying was detritals, sand, chert, sub-rounded to rounded, resembling river bedding with BIF, orange bits and fractures present throughout to 42m. The underlying weathered basalt (basement) presents angular to sub-angular chips, quartz with orange bits and fractures throughout to 80m with hard drilling from 55m to 80m. A final airlift yield of 20L/s was recorded with a predominant water zone between 18m and 55m.

Table 1: Drilling and Bore Construction Details PB11-5

Bore	Easting	Northing	Max Yield (L/S)	Final EC (mS/cm)	PH	Depth Drilled (mbgl)	Static water Level (mbgl)	Bore Construction (155mm PVC)

Bore	Easting	Northing	Max Yield (L /S)	Final EC (mS/cm)	PH	Depth Drilled (mbgl)	Static water Level (mbgl)	Bore Construction (155mm PVC)
PB11-5	0404219	7581653	20.0	1.42	7.88	80	8.35	Blank= 0m to 6m Screen= 6m to 60m Sump= 60m to 66m

Aquifer Testing

The test pumping was undertaken on PB11-5 comprised of three 60min multi-rate step tests and a 24 hour constant rate pumping test. The constant rate test was followed by a two hour recovery test. Aquifer Testing was undertaken by Welldrill between the 17th and 19th of August 2011.

Step Tests

Table 2: Summary of PB11-5 Step Test Analysis

Bore	Step Number	Discharge Rate (L/s)	Initial Static Water (mbtoc)	Pump depth (mbtoc)	Corrected Drawdown (m)	Apparent Well Efficiency (%)
PB11-5	1	4.55	7.04	43	0.91	7.05
	2	5.30		43	1.11	67.2
	3	6.82		43	1.57	61.5

(mbtoc) meters below top of casing

The step test was designed to pump the bore at three different rates for 60 min, respectively. The pump was set in the production bore at a depth of approximate 43mbtoc. The initial discharge rate was 4.55L/s, resulting in a pumping water level of 7.95m and a drawdown of 0.91m. The bore was then pumped at 5.3L/S and 6.82L/S with a final pumping water level of 8.63m and a total drawdown of 1.59m.

Constant Rate Test

A 24 hour constant rate test was conducted on August 19th, 2011 which was followed by a two hour water level recovery period once pumping had ceased. Based on the results of the step test data and being restricted to a 4" pump, the constant rate discharge was undertaken at 6.06L/s. The drawdown of the water level was recorded in both the pumping bore (PB11-5) and the observation bore (MB11-5) which was located approximately 9m from PB11-5. Pumping water level in PB11-5 reached 8.77m with a drawdown of 1.73m while a drawdown of 1.08m was recorded in the observation bore (MB11-5). Evaluating the mid to late time pumping data using the Cooper-Jacob method and the mid to late time recovery data using Theis-Recovery analysis resulted in a transmissivity of 368m2/d to 733m2/d. A conservative value of 368m2/d was adopted as signs of a barrier boundary start to be visible at the end of the test. Estimates of bulk aquifer permeability and storativity derived from the data collected from observation bore MB11-5 were taken into consideration.

A storativity of 2.49E-5 was adopted from the observation bore based on Cooper-Jacob analysis from mid to late time pumping recovery data. The adopted storage value was chosen based on pumping data and hydrogeological considerations. An aquifer with a barrier boundary may seriously affect the bores yield potential hence a transmissivity value of 368m2/d has been used to calculate sustainable pumping yields.

Sustainable Pumping Yield and Recommendations

The safe pumping yield in PB11-5 estimates a recommended maximum average discharge rate without exceeding an acceptable water level draw down in the bore. A maximum allowable pumping water level of 31mbgl has been selected for the SRO assessment, which sets the drawdown limit to roughly the 50% of the screened bore interval. During the constant rate test, water levels were drawn down to 8.77mbgl without any detrimental effects on bore performance.

The assessment is based on the hydrogeological information that was gathered during drilling and test pumping. For PB11-5, the SRO calculation indicates a safe pumping yield of 32L/s (2,765m3/d) with a recommended pump setting situated 40m below top of casing (btoc) based on a pumping time frame of 60 days. The SRO estimates should only be regarded as indicative this yield might vary when considering different factors like transmissivity variations, pumping time or interference effects due to surrounding bores.

Table 3: Summary of Safe Pumping Yield and Pump Setting for Bore PB11-5

Bore	SWL (mbgl)	ND (mm)	Material	Slotted Intervals (mbgl)	Total Depth (mbgl)	Recommended Pumping Rate(L/S)	Max. Allowable Pumping WL (mbgl)	Pump Setting (mbgl)
PB11-5	6.58	150mm	PVC	6 - 60	66	32.0	31	40

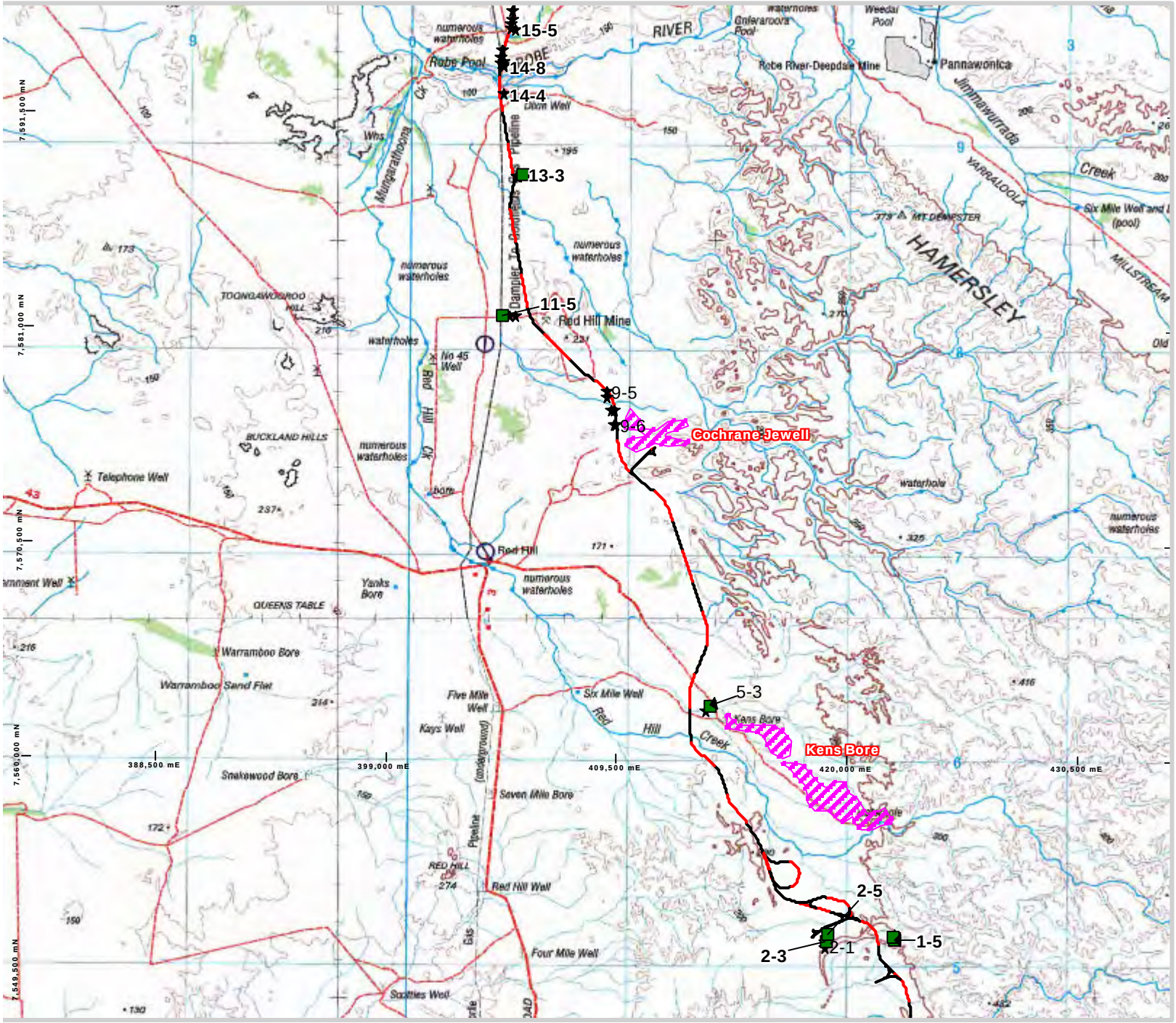
Yours sincerely,
RPS Aquaterra

Jon

Jon Shudra
Hydrogeologist

Armelle

Armelle Bonneton
Project Hydrogeologist



LOCATION MAP

LEGEND

- Exploration Bore
- Monitoring Bore
- Production Bore
- Groundwater Target
- Railway Line

Data Source:
1:100,000 Scale State Topographic Map

N

4 0 4

Kilometers

Scale: 1:250,000 @A4

MGA 1994 Zone 50

RPS Aquaterra

FIGURE 1 WSA1- 15

BORE LOCATION MAP

AUTHOR:	KO	REPORT NO:	NA
DRAWN:	KO	REVISION:	b
DATE:	23/03/2011	JOB NO:	898C

ocation: F:\Jobs\898C\C2\BoreCompletionReports\Fig1WSA1_WSA15

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COMPOSITE WELL LOG

Well No: PB11-5

Client: API Management **Project:** WPIOP, chainage 213

Commenced:	20/11/10	**Method:**	Conventional Hammer	**Area:**	West Pilbara
Completed:	23/11/10	**Fluid:**	Air	**East:**	404219
Drilled:	Welldrill	**Bit Record:**	0-6m: 12 1/2"	**North:**	7581653
Logged By:	JS		6-80m: 10"	**Projection:**	GDA94 Z50

Static Water Level: 8.35m BTOC **Date:** 30/11/10

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion: Diagram	Well Completion: Notes
0			SAND: Red orange with gravel and BIF, dry powder.			0-6m: 255mm steel surface casing
			CLAY: Brownish grey and dry.			0-6m: blank 150mm PVC casing
10				12m: First water strike		
20						1-80m: 3.2-6.4mm Gravel pack
30			DETRITAL: Brownish grey, sub rounded to rounded with sand, chert looking river bedding, BIF and Orange bits. Presence of fractures.	Water zone between 18 and 55m		
40						6-60m: slotted 150mm PVC casing
			Basalt: Grey and black, angular to sub angular and weathered with fractures, quartz and orange bits.			
50				55m: Drilling gets harder		
60						60-66m: blank 150mm PVC casing
70						66-80m : Fallback
				Field readings: Airlift yield: 20L/s, EC: 1.42 mS/cm, pH: 7.88		
80						EOH: 80m

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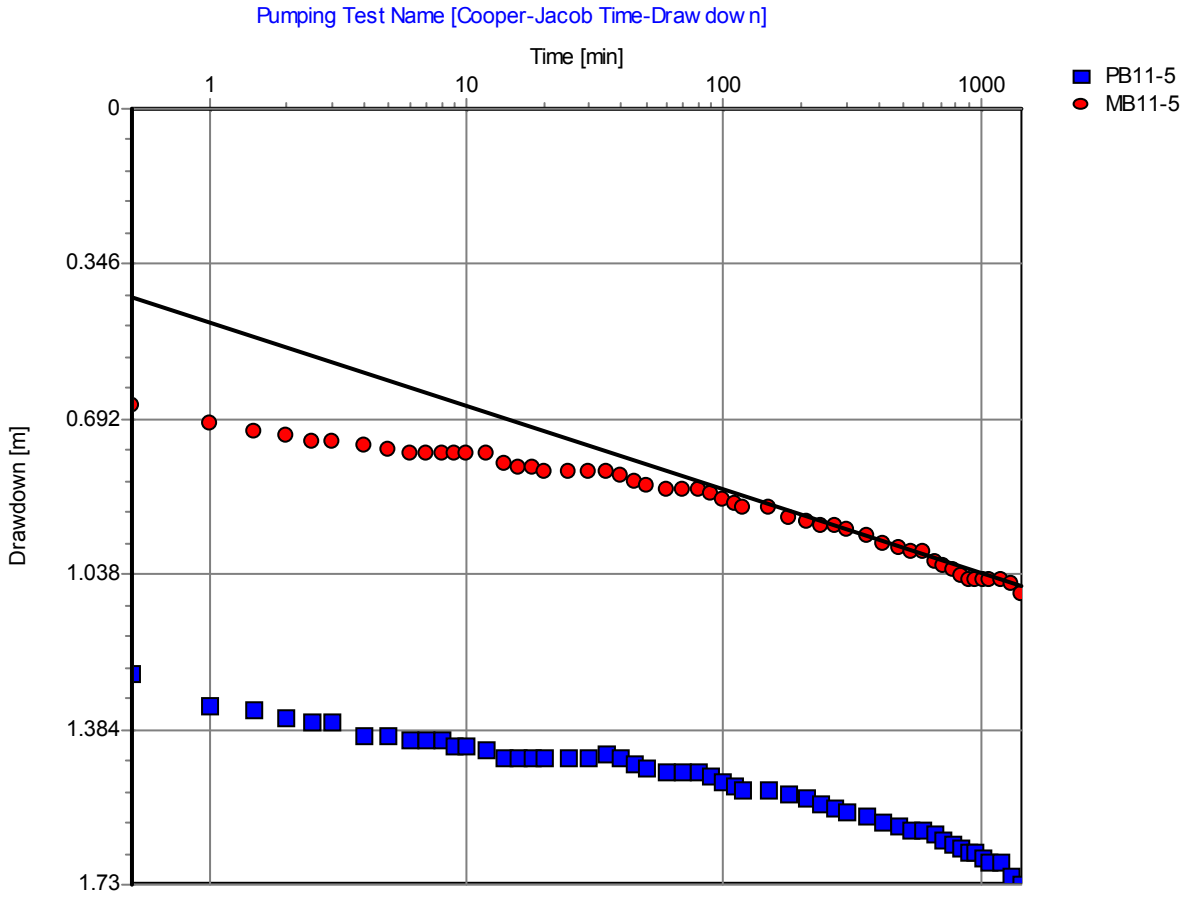
Pumping Test Analysis Report

Project:	WPIOP (PB11-5)
Number:	898C
Client:	API Management



Pumping Test: **Pumping Test Name**

Analysis Method: **Cooper-Jacob Time-Drawdown**

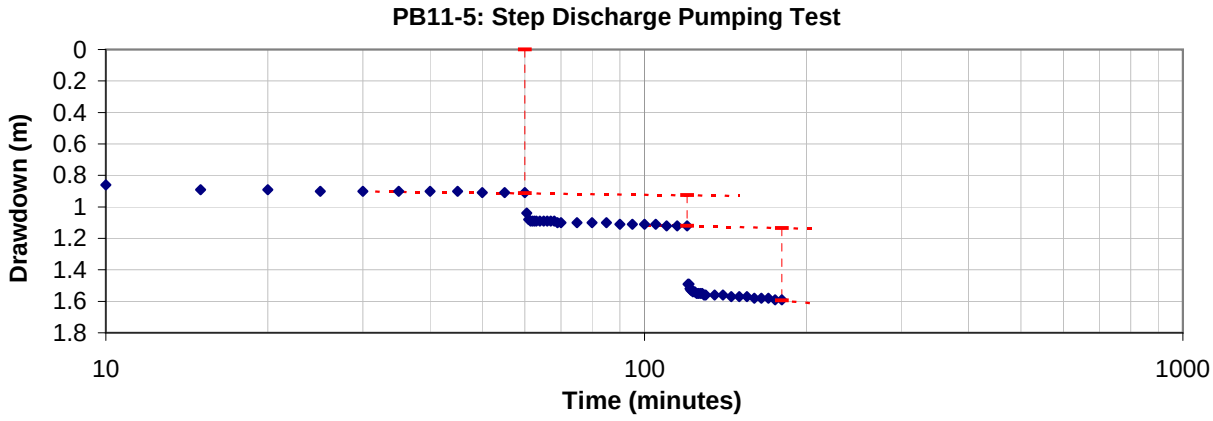
Analysis Results:				
	Transmissivity:	5.18E+2 [m²/d]	Conductivity:	9.60E+0 [m/d]
	Storativity:	2.49E-5		

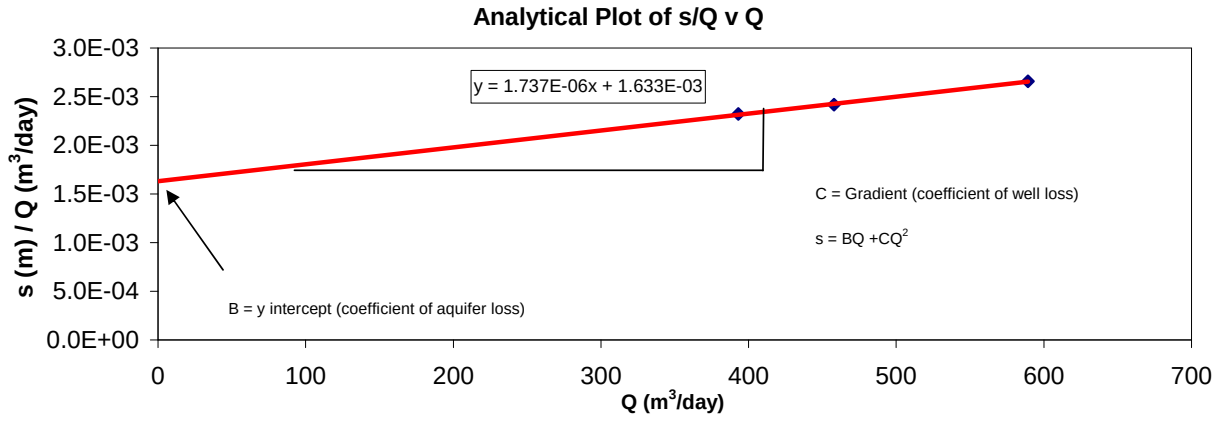
Test parameters:				
	Pumping Well:	PB11-5	Aquifer Thickness:	54 [m]
	Casing radius:	0.075 [m]	Confined Aquifer	
	Screen length:	54 [m]		
	Boring radius:	0.127 [m]		
	Discharge Rate:	6.06 [l/s]		

Comments:

Evaluated by: AB

Evaluation Date: 21/09/2011





$s_{w(n)} = BQ_n + CQ_n^P$ (Rorabaugh's equation)

Where: B = Intercept with y axis (coefficient of aquifer loss or laminar flow)
C = Gradient (coefficient of turbulent flow loss or apparent well loss)
s = Drawdown in the borehole
P = Value determined using Rorabaugh's method of superposition

Components of Jacob's (1947) equation BQ and CQ^2 are termed the aquifer loss and apparent well loss respectively. They give an indication of the proportion of total drawdown caused by laminar and turbulent flow.

Please note:
1. In thin or fissured aquifers large components of well loss are due to high flow velocities in the aquifer rather than inefficient bore design. Therefore, the term "apparent well loss" is better than well loss.
2. In aquifers where the flow horizons are vertically anisotropic, changes in bore performance often relate to changes in the rest water level with respect to the primary aquifer horizons.

$Ew = (BQ/(BQ + CQ^P)) \times 100$

Ew or Well Efficiency represents the proportion of drawdown caused by laminar flow

From plot of s/Q v Q (trend line equation):

Intercept (B) 1.633E-03
Gradient (C) 1.737E-06

ANALYSIS TABLE

Calculation of well efficiency and comparison of observed and predicted drawdowns

Step (60 minute duration)	Discharge (l/s)	Discharge (Q) (m^3/d)	Measured Incremental Drawdown (metres)	Corrected Drawdown (metres)	Predicted Drawdown (metres)	s/Q	Apparent Efficiency (Ew) %
1	4.6	393	0.91	0.91	0.91	2.32E-03	70.5
2	5.3	458	0.19	1.11	1.11	2.42E-03	67.2
3	6.8	589	0.46	1.57	1.57	2.66E-03	61.5
4							

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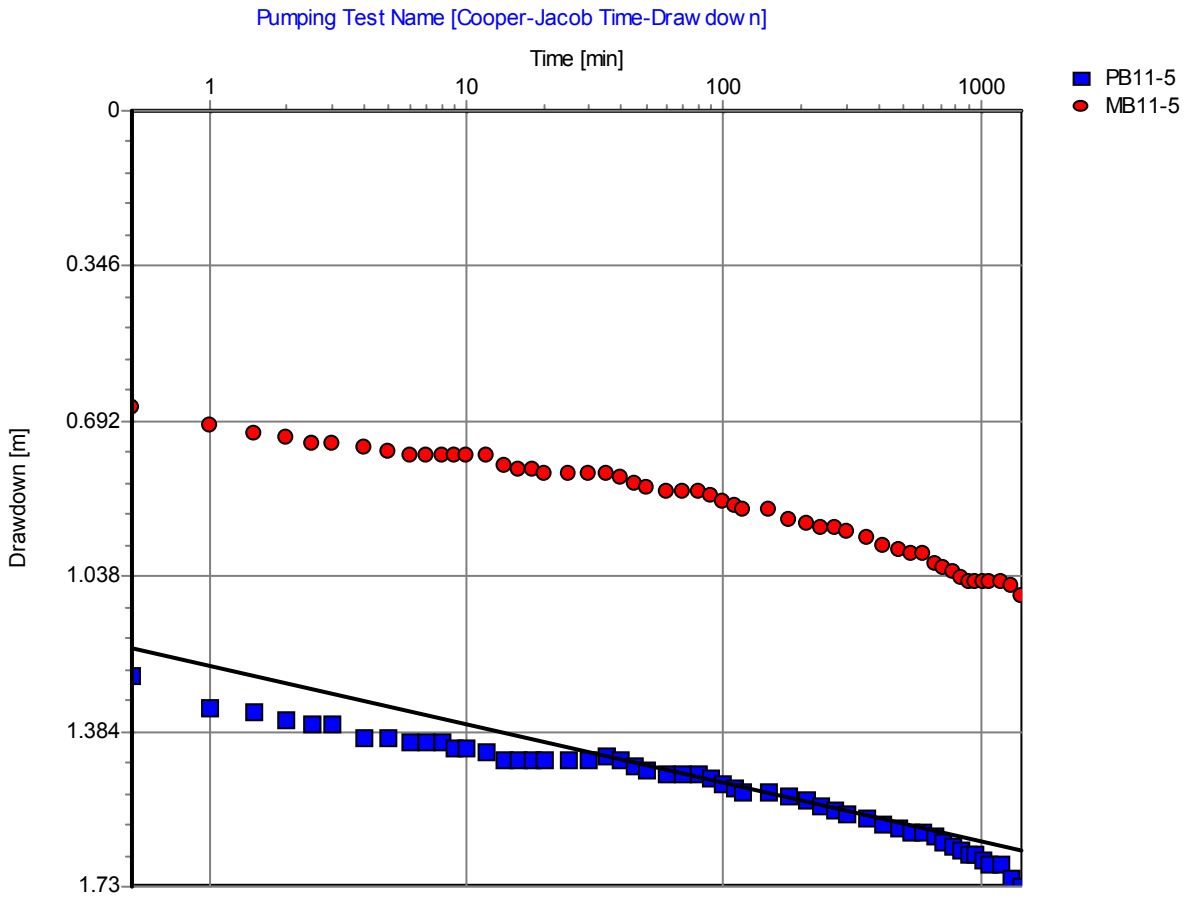
Pumping Test Analysis Report

Project:	WPIOP (PB11-5)
Number:	898C
Client:	API Management



Pumping Test: **Pumping Test Name**

Analysis Method: **Cooper-Jacob Time-Drawdown**

Analysis Results:				
	Transmissivity:	7.33E+2 [m²/d]	Conductivity:	1.36E+1 [m/d]

Test parameters:				
	Pumping Well:	PB11-5	Aquifer Thickness:	54 [m]
	Casing radius:	0.075 [m]	Confined Aquifer	
	Screen length:	54 [m]		
	Boring radius:	0.127 [m]		
	Discharge Rate:	6.06 [l/s]		

Comments:

Evaluated by: MW

Evaluation Date: 21/09/2011

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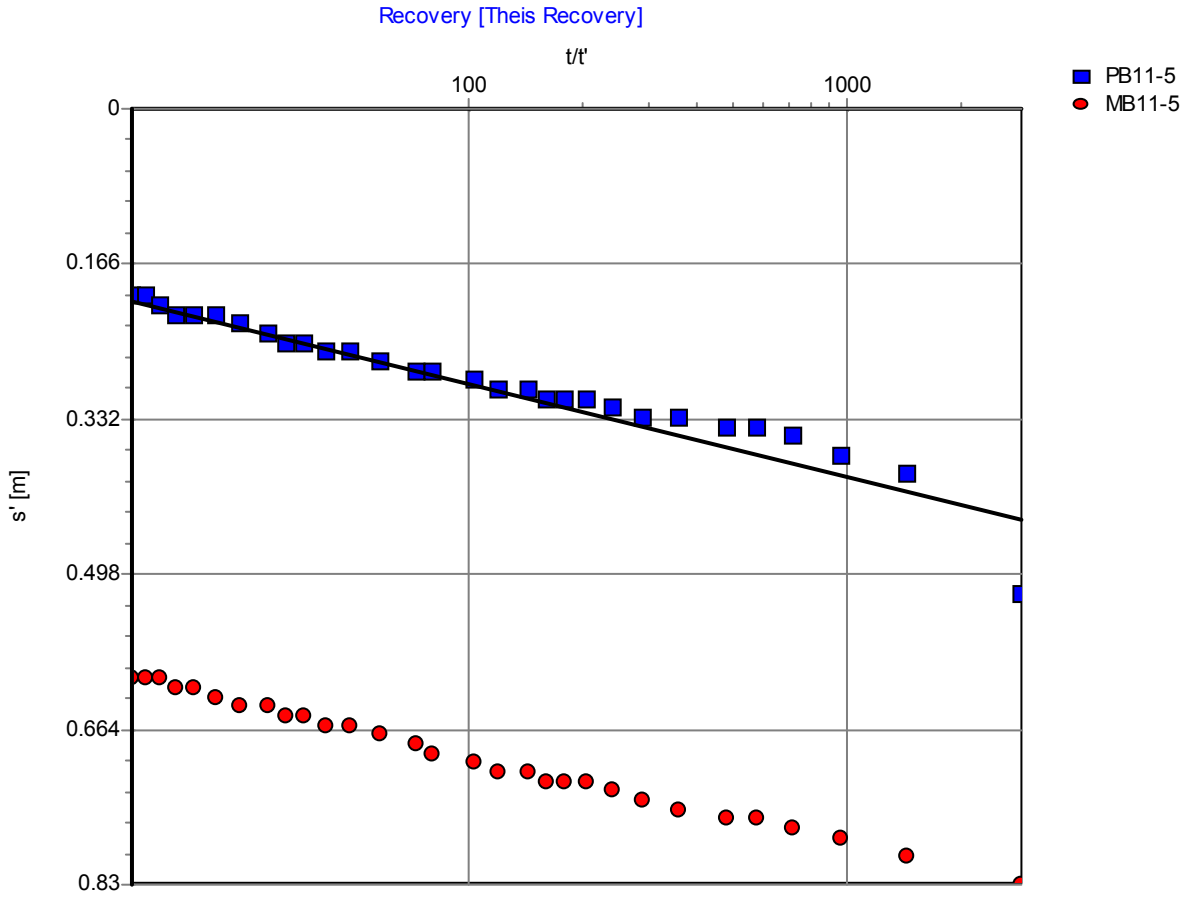
Pumping Test Analysis Report

Project:	WPIOP (PB11-5)
Number:	898C
Client:	API Management



Pumping Test: **Recovery**

Analysis Method: **Theis Recovery**

Analysis Results: Transmissivity: 9.58E+2 [m²/d]

Test parameters:

Pumping Well:	PB11-5	Aquifer Thickness:
Casing radius:	0.075 [m]	Confined Aquifer
Screen length:	54 [m]	
Boring radius:	0.127 [m]	
Discharge Rate:	6.06 [l/s]	
Pumping Time	1440 [min]	

Comments:

Evaluated by: AB

Evaluation Date: 21/09/2011

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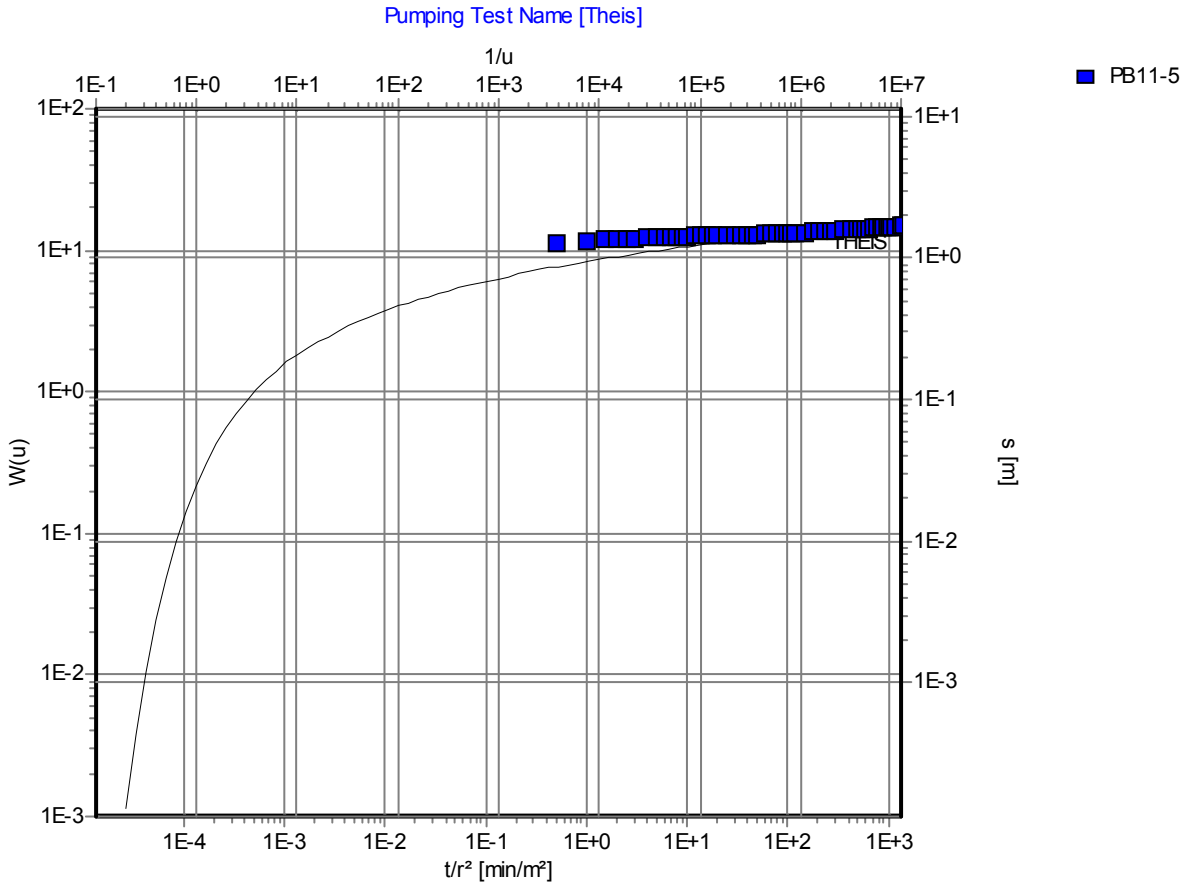
Pumping Test Analysis Report

Project:	WPIOP (PB11-5)
Number:	898C
Client:	API Management



Pumping Test: **Pumping Test Name**

Analysis Method: **Theis**

Analysis Results:	Transmissivity:	3.68E+2 [m²/d]	Conductivity:	6.81E+0 [m/d]
	Storativity:	1.38E-4		

Test parameters:	Pumping Well:	PB11-5	Aquifer Thickness:	54 [m]
	Casing radius:	0.075 [m]	Confined Aquifer	
	Screen length:	54 [m]		
	Boring radius:	0.127 [m]		
	Discharge Rate:	6.06 [l/s]		

Comments:

Evaluated by: AB

Evaluation Date: 21/09/2011

Source Reliable Output Calculations **Bore No:** PB11-5

Notes:
Calculates SRO and expected pumping water levels for newly constructed bores
Pumping Test Analysis must have been undertaken first
Pumping water levels calculated from assumed average conditions - as seen during drilling
Assumes transient radial flow conditions prevail (eg Theis Equation)

Data Input

Rest Water Level = 8.16 mbgl Top of Aquifer/Max PWL = 31 mbgl

Step Test Data

Enter parameters of step test equation $s=BQ+CQ^2$

B =	1.63E-03	
C =	1.74E-06	
valid time	60	mins

Constant Rate Test Data

Enter parameters from constant rate analysis

T =	368	m^2/d	(transmissivity)
s =	2.49E-05		(storativity)
r =	0.127	m	(radius of bore)

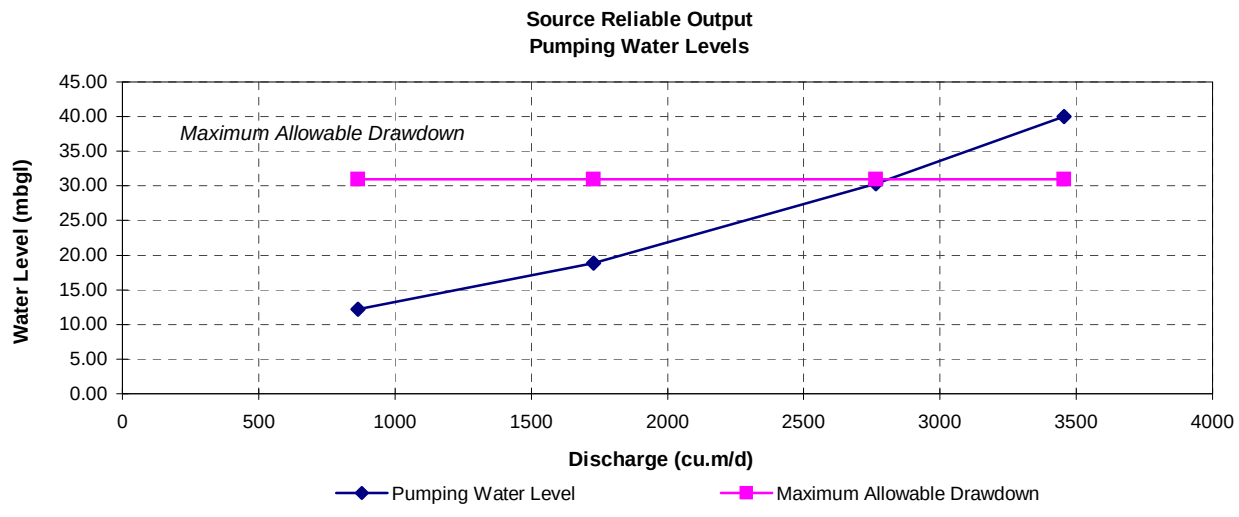
Enter Operational Data

Assumed period between recharge events t2 = 60 days
Range of discharges to be considered Are there interference effects (Y/N) N

Q1	864	m^3/d	10	Dist to first bore	m
Q2	1728	m^3/d	20	pumping rate	m^3/d
Q3	2764.8	m^3/d	32	Dist to second bore	m
Q4	3456	m^3/d	40	pumping rate	m^3/d

Calculations of Drawdown

Discharge	Short Term Drawdown	Long Term Drawdown	Interference Effects	Total Drawdown	Pumping Water Level
864	2.71	1.36	0.00	4.06	12.22
1728	8.01	2.71	0.00	10.72	18.88
2764.8	17.79	4.34	0.00	22.14	30.30
3456	26.39	5.43	0.00	31.82	39.98



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ATTACHMENT B

RPS, 2011, PB11-5 Bore Completion Report

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MEMORANDUM

COMPANY:	API Management		
ATTENTION:	Phil Davidson		
FROM:	Jon Shudra / Kevin O'Connell		
DATE:	2 e tember 2011	JOB NO: 898C	DOC NO: 089b
SUBJECT:	PB14-8 Bore Completion Report		

In 2010, API Management Pty Ltd appointed RPS Aquaterra to undertake a groundwater supply investigation for the construction of a proposed rail line in the Western Pilbara. This bore completion report provides a brief factual summary of the drilling, bore construction, pump testing and hydrogeological information that was recorded during the installation of production bore PB14-8.

1. PRODUCTION BORE PB14-8

Production bore PB18-8 is situated on the north bank of the Robe River at rail chainage CH200. The grid reference for the bore location is 0404212 Easting, 7593883 Northing (MGA94, Zone 50) and is shown in Figure 1. A summary of the drilling details are shown in Table 1 along with a summary of the pump testing in Table 2 and Table 3.

The bore was drilled and constructed by Welldrill, with hydrogeological support from RPS Aquaterra personnel from 04/04/11 to 11/04/11. A 17.5" hole was drilled to 18m, followed by the installation and cementing of a (14") 350mm ND steel surface casing to 17m. The exploration hole was drilled by 6" diameter drill bit to a total depth of 71m by mud rotary drilling. The exploration hole was reamed out using a 12 ¼" drill bit to 71m to equip the hole as a production bore. 205mm steel casing was used to construct the production bore to a depth of 69.5m by installing slotted casing from 69.5m to 33.5m and blank casing from 33.5m to surface. The annulus was backfilled with 3.2 to 6.4mm graded quartz gravel pack from 71m to surface. The bore headworks were completed with a 1m x 1m x 0.2m concrete block and a lockable steel post protecting the capped steel casing. Monitoring bore MB14-8 was drilled approximately 20m away and was used as a monitoring bore during the pump testing of PB14-8.

1.1 Geology/Hydrogeology

The drilling of PB14-8 exposed a succession of detritals comprised of coarse gravel, banded iron formation (BIF) cobbles, chert and shale in the top 14m (first water strike at 6m). Underlying this was a soft and plastic clay with minor sand and gravel to 39m. Underlying this was sand and clay with cobbles and boulders, quartz, chert and shale with BIF gravels to 63m. The bottom section of the production hole comprised of fine- grained and widely laminated shale bedrock to 71m. A fracture zone approximately 24m thick from 39m to 63m provided most of the water inflow, and a final airlift yield of 22L/s was recorded.

Table 1: Drilling and Bore Construction Details

Bore	Easting	Northing	Max Yield (L /s)	Final EC (mS/cm)	pH	Depth Drilled (mbgl)	Static Water Level (mbgl)	Bore Construction (205mm Steel)
PB14-8	0404212	7593883	22.0	0.715	8.03	71	4.90	Blank= 0m to 33.5m Screen= 33.5m to 69.5m

1.2 Aquifer Testing

The test pumping undertaken on PB14-8 comprised of both multi-rate step tests and a 24 hour constant rate pumping test. The constant rate test was followed by a 30 minute recovery test. Aquifer testing was undertaken by Welldrill between the 11th and 13th of May 2011.

1.2.1 Step Tests

Table 2: Summary of PB14-8 Step Test Analysis

Bore	Step Number	Discharge Rate (L/s)	Initial Static Water (mbtoc)	Pump depth (mbtoc)	Corrected Drawdown (m)	Apparent Well Efficiency (%)
PB14-8	1	21	5.17	45	11.67	48.4
	2	25		45	16.16	44.0
	3	29		45	19.35	40.4

(mbtoc) meters below top of casing

The step test was designed to pump the bore at three different rates for 60 minutes each. The pump was set in the production bore at a depth of approximately 45mbtoc. The initial discharge rate was 21L/s, resulting in a drawdown of 11.52m. The bore was then pumped at 25L/s and 29L/s, with a final drawdown of 20.68m and a pumping water level of 25.85mbtoc.

1.2.2 Constant Rate Test

A 24 hour constant rate test was conducted on May 12th, 2011 which was followed by a 30 minute water level recovery period once pumping had ceased. Based on the results of the step test data, the constant rate discharge was initially set at 22L/s for the first 60 minutes, then immediately increased and undertaken at 28L/s until the end of the test. The drawdown of the water level was recorded in both the pumping bore (PB14-8) and the observation bore (MB14-8), which was located approximately 20m from PB14-8. Drawdown in PB14-8 reached 21.59mbtoc, while a drawdown of 7.58m was recorded in the observation bore. Evaluating the early and late time pumping data using the Cooper-Jacob method and the mid to late time recovery data using Theis-Recovery analysis resulted in a transmissivity of 174m2/d. With the bore location in close proximity to the Robe River, the pump bore data set shows a significant yield which is most likely due to a very leaky semi- confined aquifer. Estimates of bulk aquifer permeability and storativity derived from the data collected from observation bore MB14-8 were taken into consideration.

A storativity of 1.28E-4 was adopted from the observation bore based on Theis and Cooper-Jacob analysis from early to mid time pumping data, and the mid to late time recovery data. The adopted storage value was chosen based on pumping data and hydrogeological considerations. A leaky aquifer with a recharge may seriously affect the bore's yield potential hence a transmissivity value of 174m2/d has been used to calculate sustainable pumping yields.

1.3 SUSTAINABLE PUMPING YIELD AND RECOMMENDATIONS

The safe pumping yield in PB14-8 estimates a recommended maximum average discharge rate without exceeding an acceptable water level draw down in the bore. A maximum allowable pumping water level of 35mbgl has been selected for the SRO assessment, which sets the drawdown limit to roughly the top of the screened bore interval. During the constant rate test, water levels were drawn down to 26.76mbgl without any detrimental effects on bore performance.

The assessment is based on the hydrogeological information that was gathered during drilling and aquifer pump testing. For PB14-8, the SRO calculation indicates a safe pumping yield of 30L/s (2,592m3/d) with a recommended pump setting situated 45m below top of casing (mbtoc), based on a pumping time frame of 90 days. The SRO estimates should only be regarded as indicative this yield might vary when considering different factors like transmissivity variations, pumping time or interference effects due to surrounding bores.

Table 3: Summary of Safe Pumping Yield and Pump Setting for Bore PB14-8

Bore	SWL (mbgl)	ID (mm)	Material	Slotted Intervals (mbgl)	Total Depth (mbgl)	Recommended Pumping Rate(L/s)	Max. Allowable Pumping WL (mbgl)	Pump Setting (mbtoc)
PB14-8	5.17	205mm	Steel	33.5 – 69.6	71	30.0	35	45

Yours sincerely,
RPS Aquaterra

Jon

Jon Shudra
Hydrogeologist

Kevin

Kevin O'Connell
Senior Hydrogeologist

APPENDIX A: BORE CONSTRUCTION DETAILS

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COMPOSITE WELL LOG

Well No: PB14-8

Client: API Management

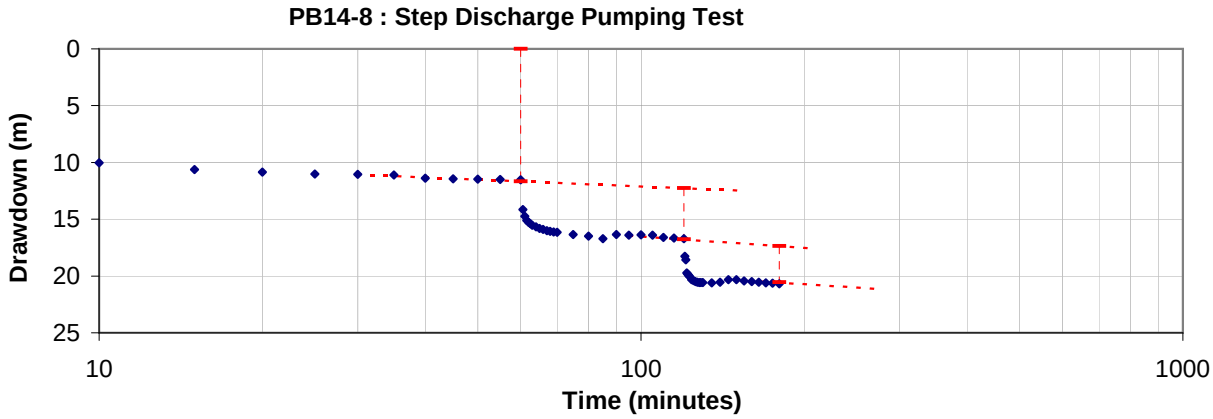
Project: WPIOP, Chainage 200

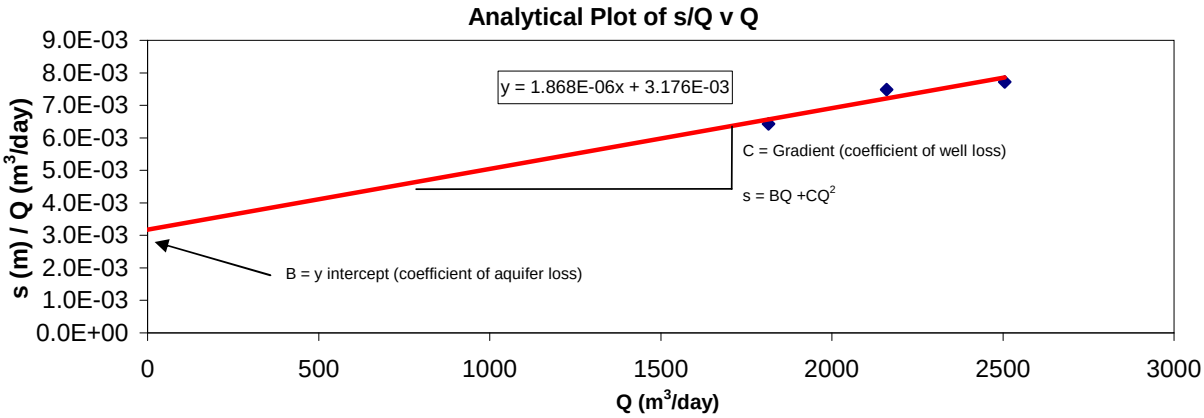
Commenced:	04/04/11	**Method:**	Mud Rotary	**Area:**	West Pilbara
Completed:	11/04/11	**Fluid:**	Mud	**East:**	404212
Drilled:	Welldrill	**Bit Record:**	0-16m: 17"	**North:**	7593883
Logged By:	TV		16-71m: 12"	**Projection:**	MGA94 Z50

Static Water Level: 4.90 MBTOC **Date:** 16/04/11

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion: Diagram	Well Completion: Notes
0			GRAVEL AND SAND: Red brown, rounded and flattered (typical of rive gravels), coarse grained gravels and cobbles of BIF, chert, quartzite and shale. Minor sands, negligible clay.			0-17m: blank 350mm steel surface casing
10						0-17m: cement
			CLAY: Blue grey, fine grained, soft and plastic sticky clay with minor (40%) clastic components (sand and gravel).			
20						0-33.5m: 205 mm steel casing
30						0-71m: 3.2-6.4mm Gravel pack
40			SAND AND CLAY: Pale grey clayey sands (clay 20-30%). Sand very angular (probably broken up) with cobbles and boulders. Mainly quartz (ex BIF), chert, iron-ore, BIF and shale.			
50				Good fractures, water zone between 39 and 63m		33.5-69.5m: slotted 205mm steel casing
			CLAY AND GRAVEL: Green grey, soft, plastic clay with 20% contained gravels and sands. Mainly angular quartz with chert, shale and BIF.			
60				Field readings: Airlift yield: 21L/s, EC: 0.715mS/cm, pH: 8.03		
			SHALE: Blue grey, fine grained, widely laminated shale bedrock.			
70						EOH: 71m

APPENDIX B: TEST PUMPING RESULTS





$s_{w(n)} = BQ_n + CQ_n^P$ (Rorabaugh's equation)

Where: B = Intercept with y axis (coefficient of aquifer loss or laminar flow)
C = Gradient (coefficient of turbulent flow loss or apparent well loss)
s = Drawdown in the borehole
P = Value determined using Rorabaugh's method of superposition

Components of Jacob's (1947) equation BQ and CQ^2 are termed the aquifer loss and apparent well loss respectively. They give an indication of the proportion of total drawdown caused by laminar and turbulent flow.

Please note:
1. In thin or fissured aquifers large components of well loss are due to high flow velocities in the aquifer rather than inefficient bore design. Therefore, the term "apparent well loss" is better than well loss.
2. In aquifers where the flow horizons are vertically anisotropic, changes in bore performance often relate to changes in the rest water level with respect to the primary aquifer horizons.

$Ew = (BQ/(BQ + CQ^P)) \times 100$

Ew or Well Efficiency represents the proportion of drawdown caused by laminar flow

From plot of s/Q v Q (trend line equation):

Intercept (B) 3.176E-03
Gradient (C) 1.868E-06

ANALYSIS TABLE

Calculation of well efficiency and comparison of observed and predicted drawdowns

Step (60 minute duration)	Discharge (l/s)	Discharge (Q) (m^3/d)	Measured Incremental Drawdown (metres)	Corrected Drawdown (metres)	Predicted Drawdown (metres)	s/Q	Apparent Efficiency (Ew) %
1	21.0	1814	11.67	11.67	11.91	6.43E-03	48.4
2	25.0	2160	4.50	16.16	15.58	7.48E-03	44.0
3	29.0	2506	3.18	19.35	19.69	7.72E-03	40.4

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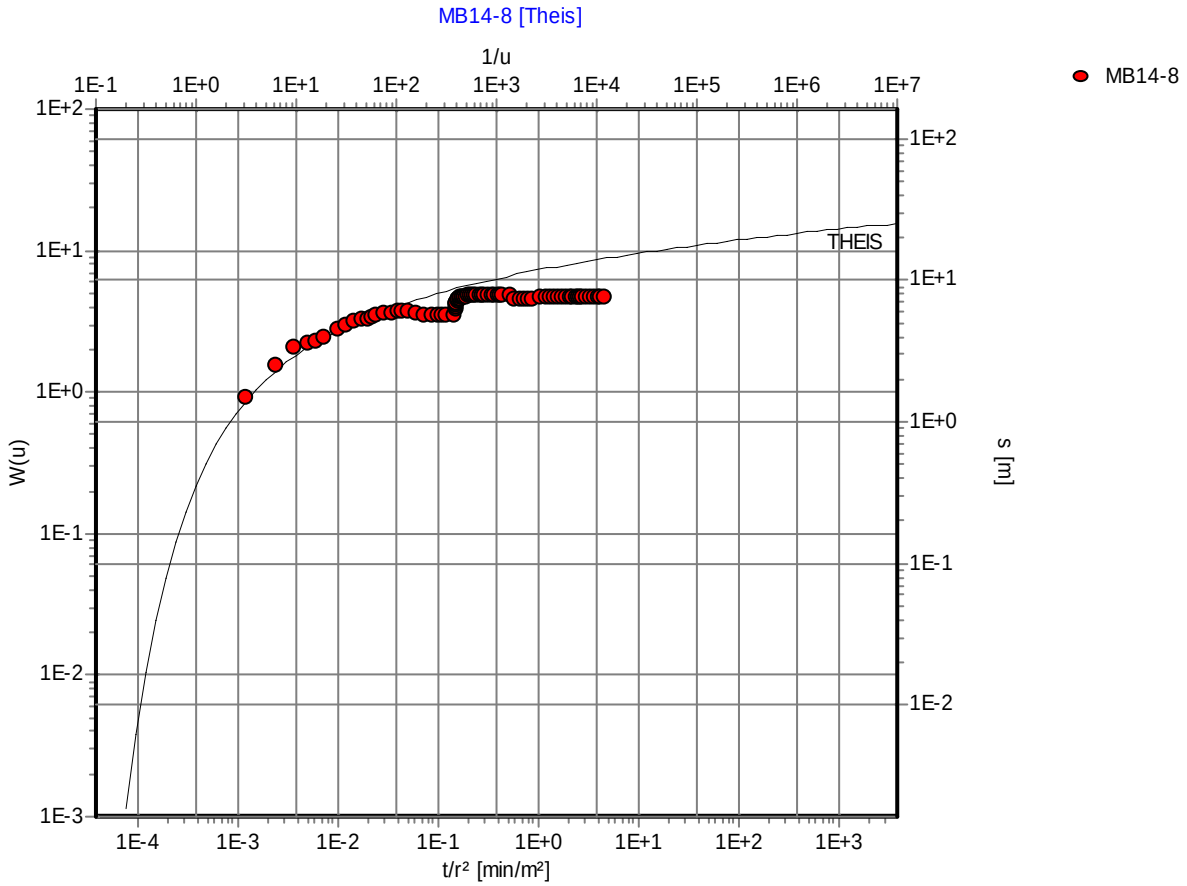
180 Columbia St. Unit 1104
Waterloo, Ontario, Canada
Phone 519 746-1798

Pumping Test Analysis Report

Project: WPIOP (PB14-8)

Number: 898C

Client: API Management



Pumping Test: **MB14-8**

Analysis Method: **Theis**

Analysis Results:	Transmissivity:	1,18E+2 [m²/d]	Conductivity:	2,24E+0 [m/d]
	Storativity:	1,28E-4		

Test parameters:	Pumping Well:	PB14-8	Aquifer Thickness:	52,86 [m]
	Casing radius:	0,1025 [m]	Confined Aquifer	
	Screen length:	36 [m]		
	Boring radius:	0,1625 [m]		
	Discharge Rate:	28 [l/s]		

Comments:

Evaluated by: Jon Shudra

Evaluation Date: 14/07/2011

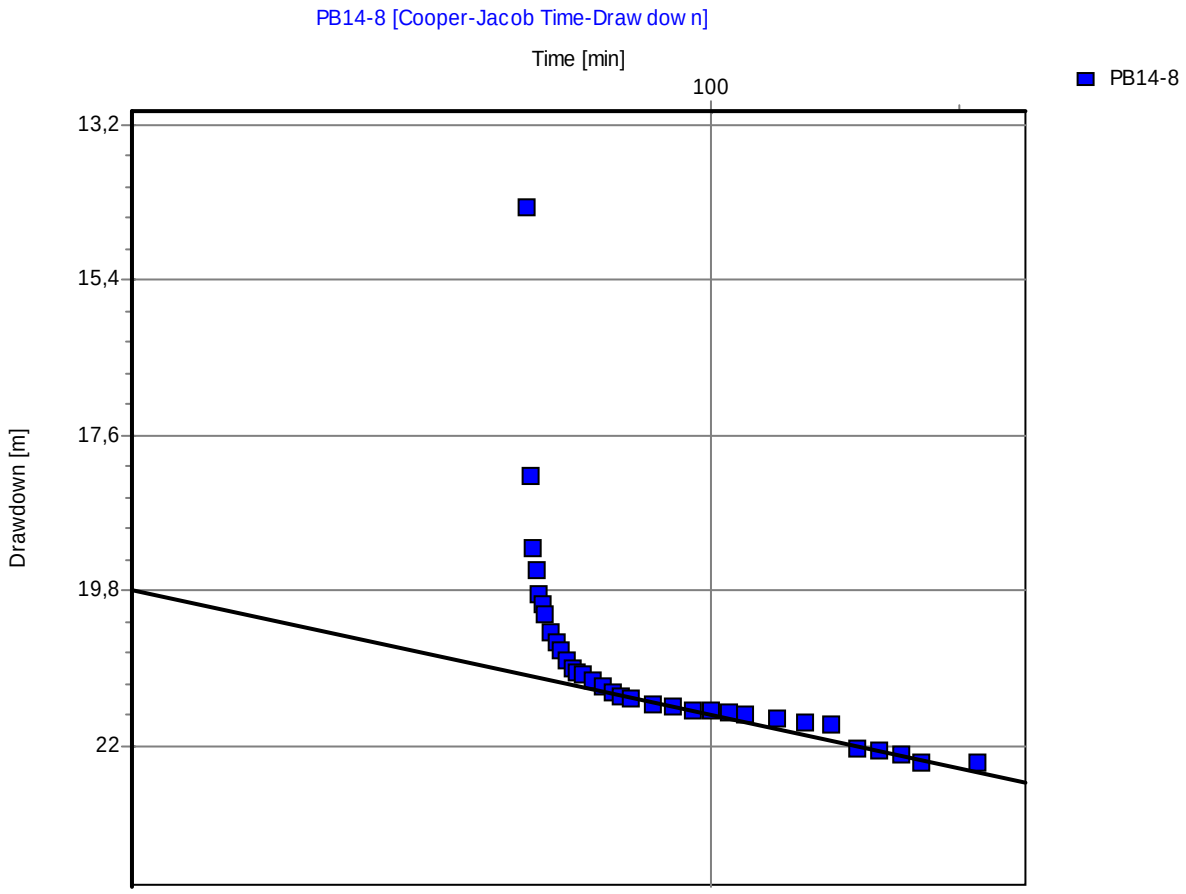
Waterloo Hydrogeologic Inc.
180 Columbia St. Unit 1104
Waterloo, Ontario, Canada
Phone 519 746-1798

Pumping Test Analysis Report

Project: WPIOP (PB14-8)

Number: 898C

Client: API Management



Pumping Test: **PB14-8**

Analysis Method: **Cooper-Jacob Time-Drawdown**

Analysis Results:				
	Transmissivity:	1,74E+2 [m²/d]	Conductivity:	2,70E+0 [m/d]

Test parameters:				
	Pumping Well:	PB14-8	Aquifer Thickness:	64,33 [m]
	Casing radius:	0,1025 [m]	Confined Aquifer	
	Screen length:	36 [m]		
	Boring radius:	0,1625 [m]		
	Discharge Rate:	28 [l/s]		

Comments:

Evaluated by: Jon Shudra

Evaluation Date: 14/07/2011

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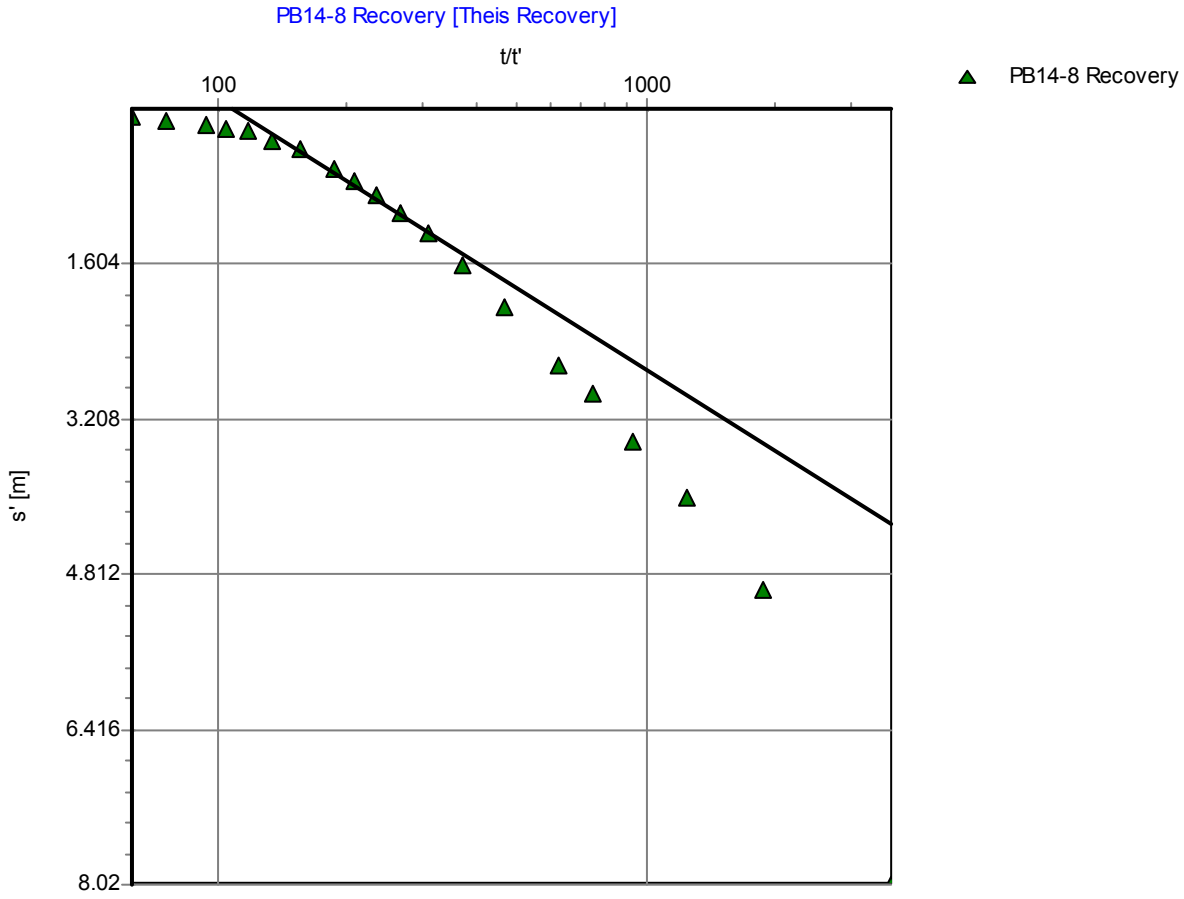
Pumping Test Analysis Report

Project:	WPIOP (PB14-8)
Number:	898C
Client:	API Management



Pumping Test: **PB14-8 Recovery**

Analysis Method: **Theis Recovery**

Analysis Results:				
	Transmissivity:	1.59E+2 [m²/d]	Conductivity:	2.47E+0 [m/d]

Test parameters:				
	Pumping Well:	PB14-8 Recovery	Aquifer Thickness:	64.33 [m]
	Casing radius:	0.1025 [m]	Confined Aquifer	
	Screen length:	36 [m]		
	Boring radius:	0.1625 [m]		
	Discharge Rate:	28 [l/s]		
	Pumping Time	1860 [min]		

Comments:

Evaluated by: Jon Shudra

Evaluation Date: 11/07/2011

Source Reliable Output Calculations **Bore No:** PB14-8

Notes:
Calculates SRO and expected pumping water levels for newly constructed bores
Pumping Test Analysis must have been undertaken first
Pumping water levels calculated from assumed average conditions - as seen during drilling
Assumes transient radial flow conditions prevail (eg Theis Equation)

Data Input

Rest Water Level = 5,17 mbgl Top of Aquifer/Max PWL = 35 mbgl

Step Test Data

Enter parameters of step test equation $s=BQ+CQ^2$

B =	3,18E-03	
C =	1,87E-06	
valid time	60	mins

Constant Rate Test Data

Enter parameters from constant rate analysis

T =	174	m^2/d	(transmissivity)
s =	1,28E-04		(storativity)
r =	0,155	m	(radius of bore)

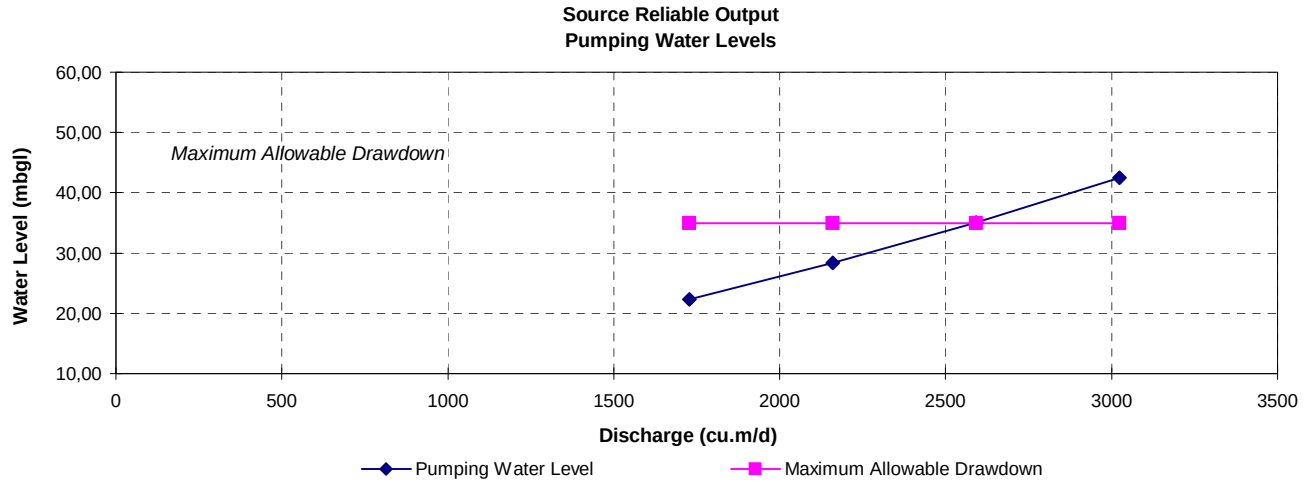
Enter Operational Data

Assumed period between recharge events t2 = 90 days
Range of discharges to be considered Are there interference effects (Y/N) N

Q1	1728	m^3/d	20	Dist to first bore	m
Q2	2160	m^3/d	25	pumping rate	m^3/d
Q3	2592	m^3/d	30	Dist to second bore	m
Q4	3024	m^3/d	35	pumping rate	m^3/d

Calculations of Drawdown

Discharge	Short Term Drawdown	Long Term Drawdown	Interference Effects	Total Drawdown	Pumping Water Level
1728	11,07	6,06	0,00	17,13	22,30
2160	15,58	7,58	0,00	23,15	28,32
2592	20,78	9,09	0,00	29,87	35,04
3024	26,69	10,61	0,00	37,29	42,46



RPS Aquaterra

ATTACHMENT C

RPS, 2011, MB13-1 Bore Lithological Log

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COMPOSITE WELL LOG

Well No: 13-1

Client: API Management **Project:** WPIOP, chainage 205

Commenced:	28/11/10	**Method:**	Conventional Hammer	**Area:**	West Pilbara
Completed:	29/11/10	**Fluid:**	Air	**East:**	404791
Drilled:	Welldrill	**Bit Record:**	0-6m: 10 1/2"	**North:**	7588450
Logged By:	JC		6-114m: 6 1/2"	**Projection:**	GDA94 Z50

Static Water Level: TBD **Date:** TBD

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion: Diagram	Well Completion: Notes
0			SANDY GRAVEL: Red, poorly sorted and subangular with BIF.			
			Silty Sand: Cream brown, moderatly sorted, sub angular and highly oxided with gravel and BIF.			
10			Silty Sand: Cream grey, well sorted, increased clay content at 24m and 26m.			
20				17m: First water strike		
			Clayey Sand: Grey brown, moderatly sorted with some gravels. Increased clay content from 35-36m.			
30						Backfill
			SANDY GRAVEL: Brown with BIF. Grades into weathered basalt from 46-51m.			
40						
50			Basalt: Grey black with quartz. Increased in yield from 108-114m.	Field readings: Airlift yield: 3.39L/s, EC: 0.842mS/cm, PH: 8.46		
60						
70						
80						
90						
100						
110						