

Attention Mr Stefan Falk
Chief Executive Officer
Retort Charcoal Producers

ECC-118-588-LET-01-A
17 December 2024

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Signature: _____

Date: / /

Dear Mr Falk,

Test pumping analysis of five (5) boreholes on Farm Gai Kaisa, no. 159, Otjozondjupa Region

Environmental Compliance Consultancy (Pty) Ltd (ECC) was appointed to undertake test pumping analysis of five boreholes drilled on Farm Gai Kaisa no. 159 near Grootfontein, Otjozondjupa Region (Figure 1). The boreholes all target sediments of the Damara Super Group, Swakop Group (Karibib marble formation and undifferentiated sediments of the Swakop Group).



Figure 1 – Map of borehole locations on Farm Gai Kaisa no. 159

Table 1 provides an overview of the various tests undertaken at the five (5) boreholes. As analytical solutions for karstic aquifers are not readily available, a combination of unconfined Theis (1935) and Neumann (1974) solutions were applied to determine the aquifer parameters for the karstic aquifer. The aquifer thickness was

conservatively assumed to be 120 m for all boreholes. Analysis for aquifer parameters and forward solution modelling of long term drawdown values was undertaken in Aqtesolv software developed by HydroSolve Inc., while FC programme was used to evaluate derivative curves and subjective information regarding boundaries and flow regimes. Parameter estimation was undertaken for periods of radial flow where possible. All analyses were carried out with conservative available drawdown values to protect main water strikes intersected during drilling (similarly for recommended pump installation depths). All drilling information is contained in the associated drillers reports prepared by Africa Drilling cc. No storage estimates are available due to a lack of observation borehole data during individual pumping tests (minimum of three required). Water quality samples were collected for analysis, with hand held meters indicating neutral pH values, low Electrical Conductivity and low metals; the water quality is anticipated to be classified as good and acceptable for potable use once tested.

Forward solution modelling of drawdown was undertaken based on 2 years of continuous pumping with an assumed zero (0) recharge to the aquifer. All boreholes are recommended to pump at least 6 days a week, allowing up to 24 hours for recovery and evaluation of dynamic water levels and borehole performances. All results indicate constant head or recharge boundaries to be present, decreasing drawdown and resulting in rapid recovery and deviation from solution type curves, particularly at late time.

Table 1 – Borehole and test pumping details

BH ID	BH Name	Lat	Long	BH Depth (m)	Rest water level (mbgl)	Test Yield (m ³ /hr)					CDT Duration (min)	Final Drawdown (m)
						Step1	Step2	Step3	Step4	CDT		
BH1	Land I	-19.89001	17.82349	105	11.86	30	50	80	100	100	1440	5.99
BH2	Land II	-19.8875	17.82782	129	10.73	20	30	50	70	40	1440	15.02
BH3	Site Water Feed	-19.8952	17.83057	45	8.8	30	50	70	100	100	1440	3.98
BH4	Site Workers Camp	-19.8997	17.82729	51	7.4	30	60	80	112	110	1440	1.4
BH5	House	-19.8956	17.83204	105	7.98	30	60	90	113	105	1440	2.5

Borehole 1 – Land I

BH1 – Land I underwent a stepped discharge test on 23/09/2024 comprising four (4) one hour long discharge steps, followed by recovery monitoring for 240 minutes until the water level recovered to 100% of the rest level measured prior to testing. Table 1 provides a summary of the borehole construction and testing details. Figure 2 provides an overview of elapsed time since start of pumping versus drawdown of water level recorded during the step test. Step 4 (100 m³/hr) was cut short for unknown reasons.

The Constant Rate Discharge Test (CDT) was undertaken for 24 hours (1440 minutes) on 24/09/2024 at a rate of 100 m³/h. Figure 3 shows the time versus drawdown during the constant rate discharge test and recovery monitoring. The borehole is high yielding, with limited drawdown and shows rapid recovery after cessation of pumping.

Applying a combination of the Theis (1935) and Neumann (1974) analytical solutions (Figure 4), a Transmissivity value of 379 m²/d was determined. The recommended yield of 65 m³/hr is determined based on subjective information related to flow boundaries, a two year forward modelling of drawdown and the assumption of zero recharge entering the system. It is recommended that the borehole be allowed to recover for at least 24 hours per week. A summary of results and recommendations is provided in Table 2. Abstraction rates (weekly), volumes (weekly and collated monthly) and groundwater levels (twice daily) are recommended to be monitored at the borehole, allowing a revision (upward or downward) of the recommended yield after 6 months of operation.

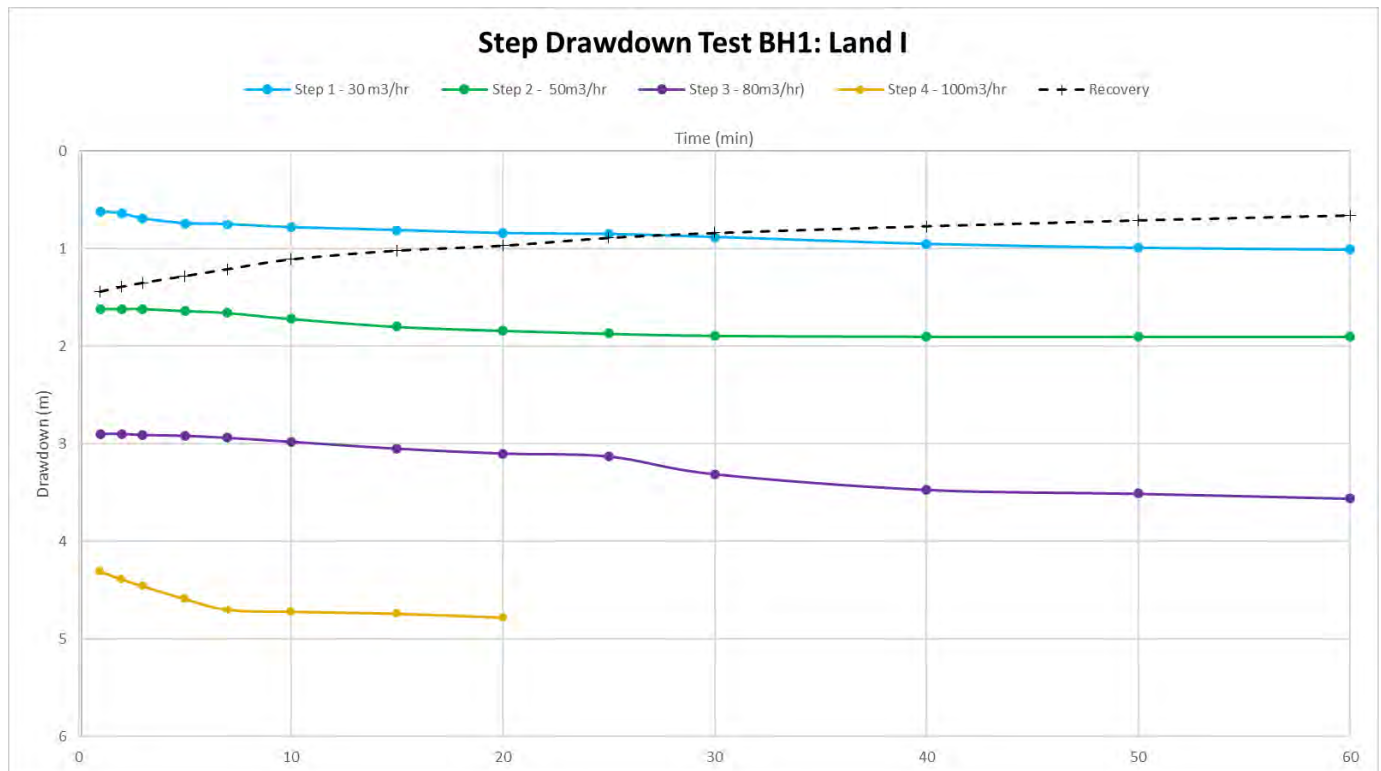


Figure 2 – Step test at BH1 – Land I

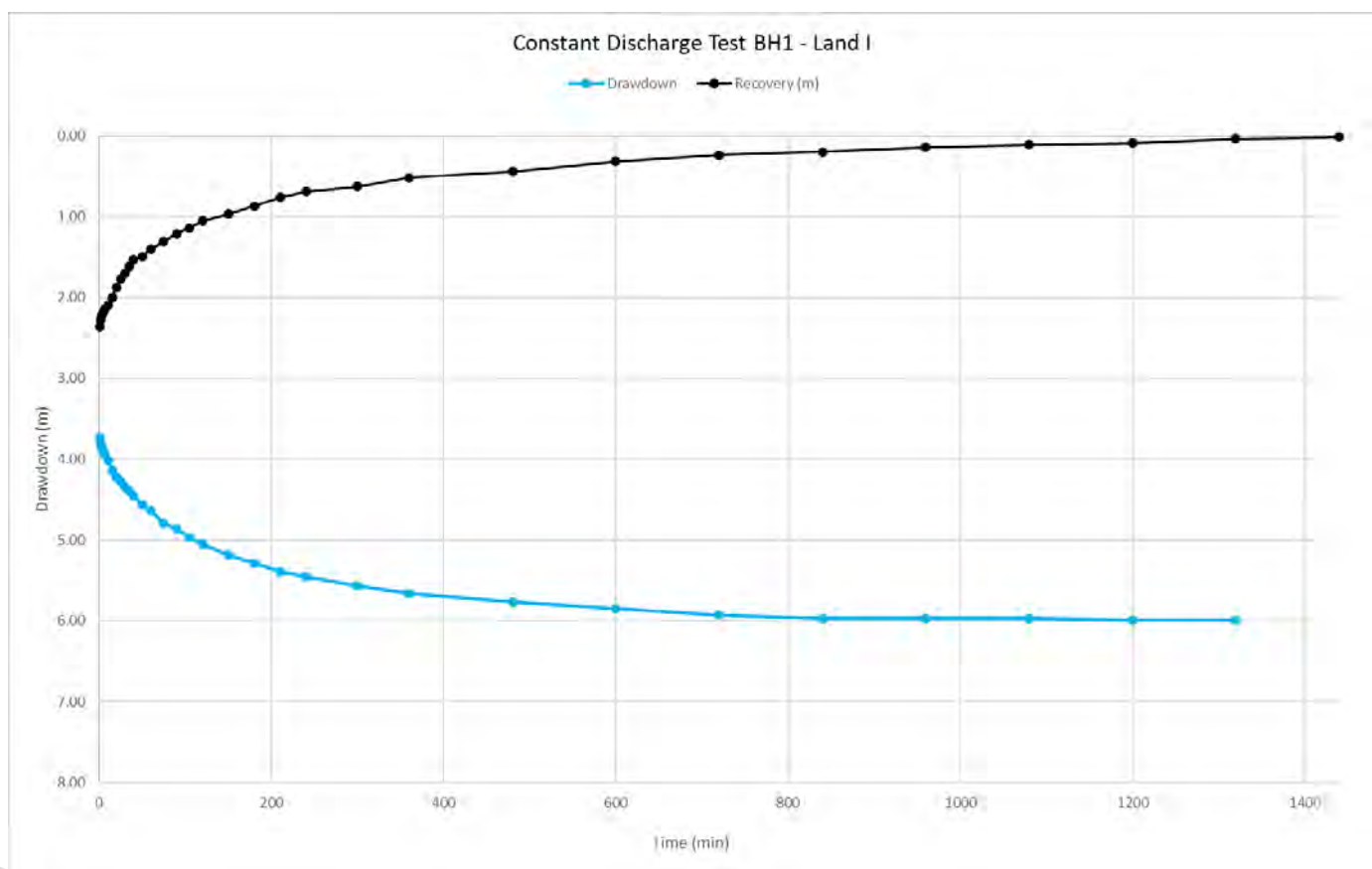


Figure 3 – CDT at BH1 – Land I at a rate of 100 m³/h for 24 hours

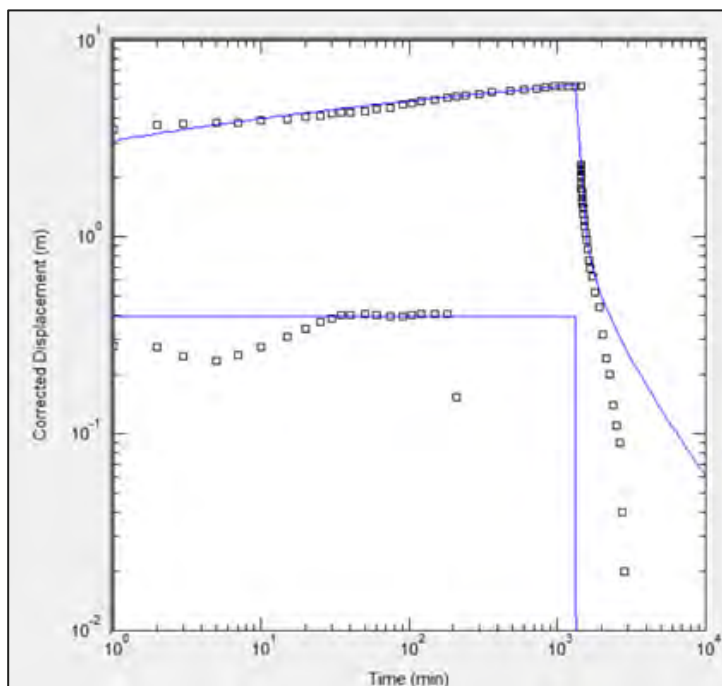


Figure 4 – Curve matching drawdown vs time and derivative data with the Theis (1934) solution for aquifer parameter estimation

Borehole 2 – Land II

BH2 – Land II underwent a stepped discharge test on 17/10/2024 comprising four (4) one hour long discharge steps, followed by recovery monitoring for 480 minutes until the water level recovered to 100% of the rest level measured prior to testing. Table 1 provides a summary of the borehole construction and testing details. Figure 5 provides an overview of elapsed time since start of pumping versus drawdown of water level recorded during the step test. Step 4 (70 m³/hr) could not be maintained for a full hour before the available drawdown was exhausted.

The Constant Rate Discharge Test (CDT) was undertaken for 24 hours (1440 minutes) on 18/10/2024 at a rate of 40 m³/h. Figure 6 shows the time versus drawdown during the constant rate discharge test and recovery monitoring. The borehole is moderately high yielding, and shows rapid recovery after cessation of pumping.

Applying a combination of the Theis (1935) and Neumann (1974) analytical solutions (Figure 7), a Transmissivity value of 93 m²/d was determined. The recommended yield of 25 m³/hr is determined based on subjective information related to flow boundaries, a two year forward modelling of drawdown and the assumption of zero recharge entering the system. It is recommended that the borehole be allowed to recover for at least 24 hours per week. A summary of results and recommendations is provided in Table 2.

Abstraction rates (weekly), volumes (weekly and collated monthly) and groundwater levels (twice daily) are recommended to be monitored at the borehole, allowing a revision (upward or downward) of the recommended yield after 6 months of operation.

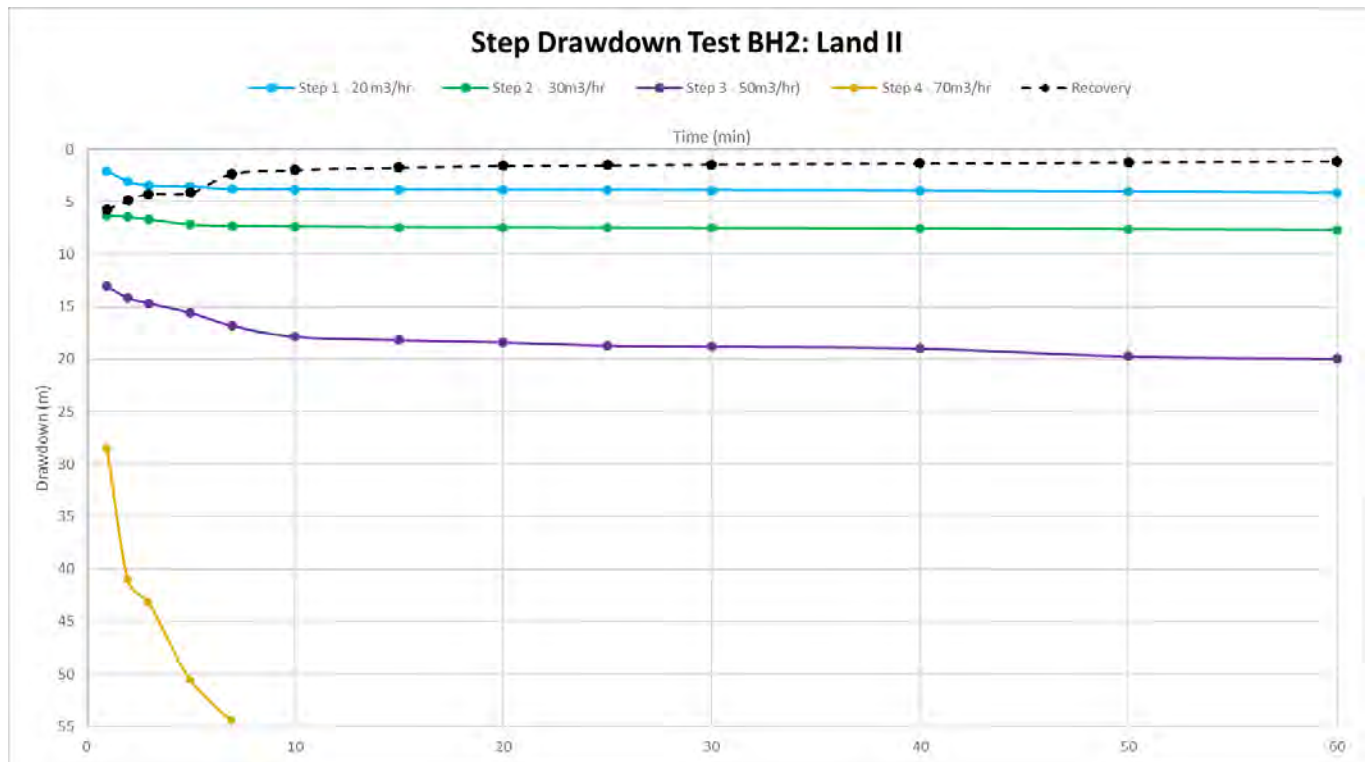


Figure 5 - Step test at BH2 – Land II

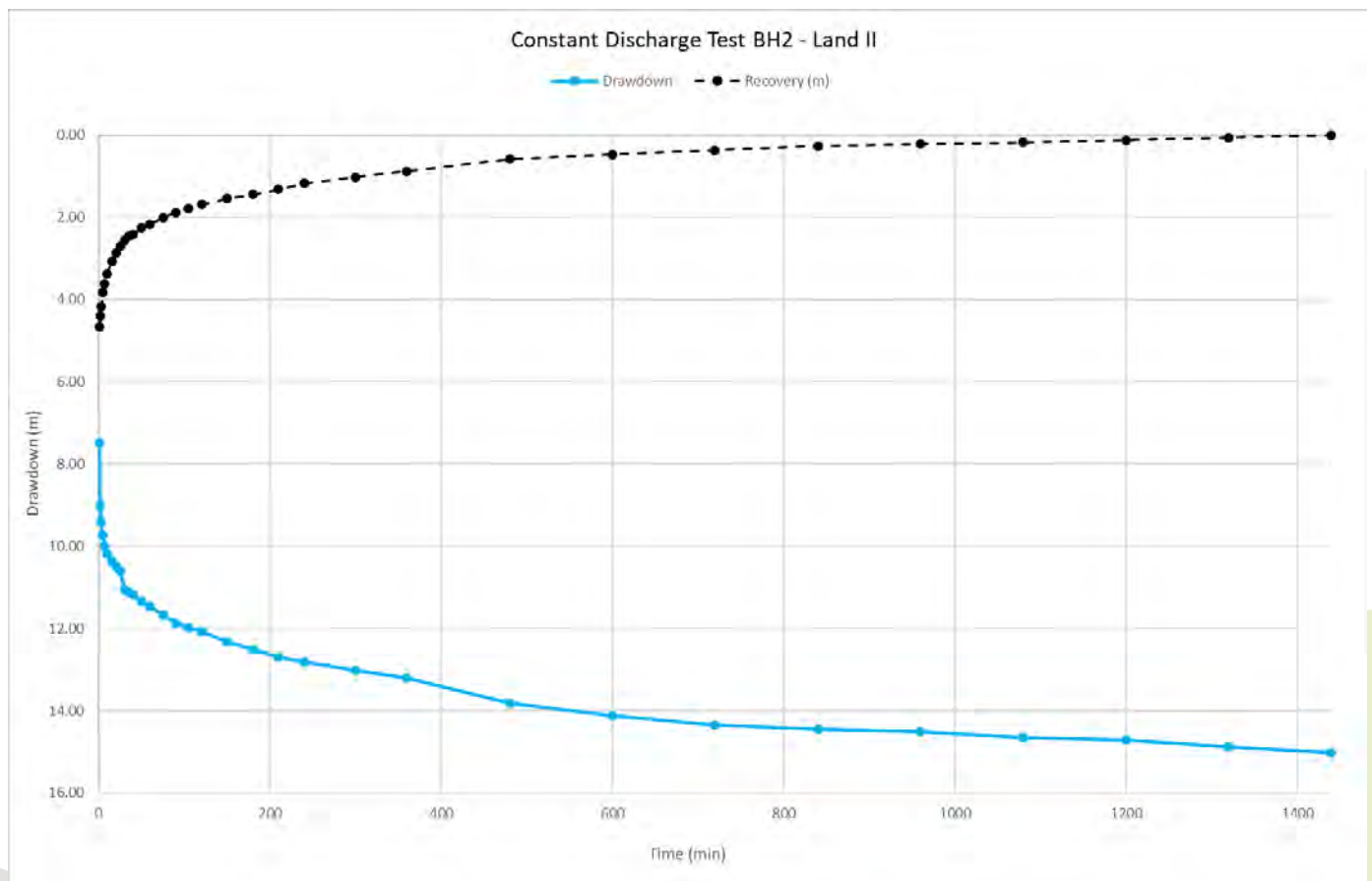


Figure 6 – CDT at BH2 – Land II at a rate of 40 m³/h for 24 hours

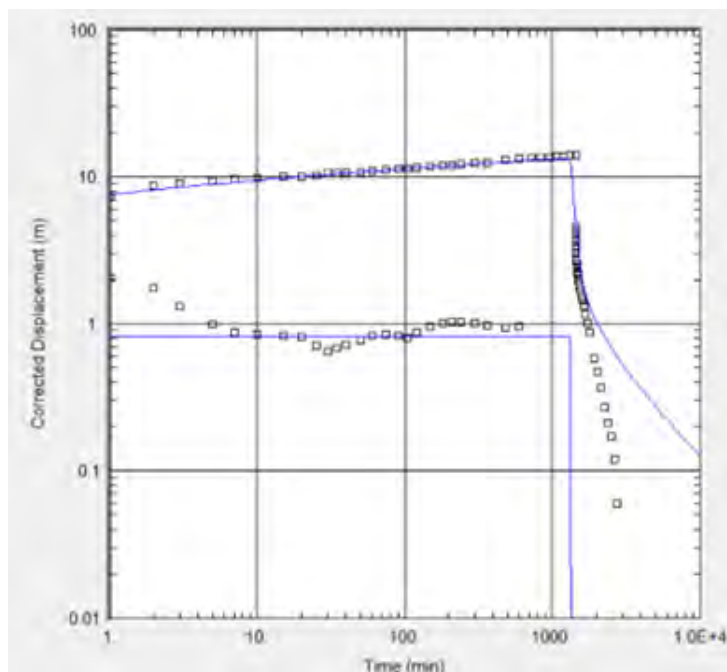


Figure 7 - Curve matching drawdown vs time and derivative data with the Theis (1934) solution for aquifer parameter estimation

Borehole 3 – Site Water Feed

BH3 – Site Water Feed underwent a stepped discharge test on 12/11/2024 comprising four (4) one hour long discharge steps, followed by recovery monitoring for 120 minutes until the water level recovered to 100% of the rest level measured prior to testing. Table 1 provides a summary of the borehole construction and testing details. Figure 8 provides an overview of elapsed time since start of pumping versus drawdown of water level recorded during the step test.

The Constant Rate Discharge Test (CDT) was undertaken for 24 hours (1440 minutes) on 13/11/2024 at a rate of 100 m³/h. Figure 9 shows the time versus drawdown during the constant rate discharging test and recovery monitoring. The borehole is high yielding, and shows rapid recovery after cessation of pumping.

Applying a combination of the Theis (1935) and Neumann (1974) analytical solutions (Figure 11), a Transmissivity value of 3250 m²/d was determined. The recommended yield of 80 m³/hr is determined based on subjective information related to flow boundaries, a two year forward modelling of drawdown and the assumption of zero recharge entering the system. It is recommended that the borehole be allowed to recover for at least 24 hours per week. A summary of results and recommendations is provided in Table 2.

Abstraction rates (weekly), volumes (weekly and collated monthly) and groundwater levels (twice daily) are recommended to be monitored at the borehole, allowing a revision (upward or downward) of the recommended yield after 6 months of operation. This borehole is ~160 m west of BH 5 – House and should be monitored to ensure no hydraulic connection (borehole interference) exists between the two boreholes if pumped simultaneously.

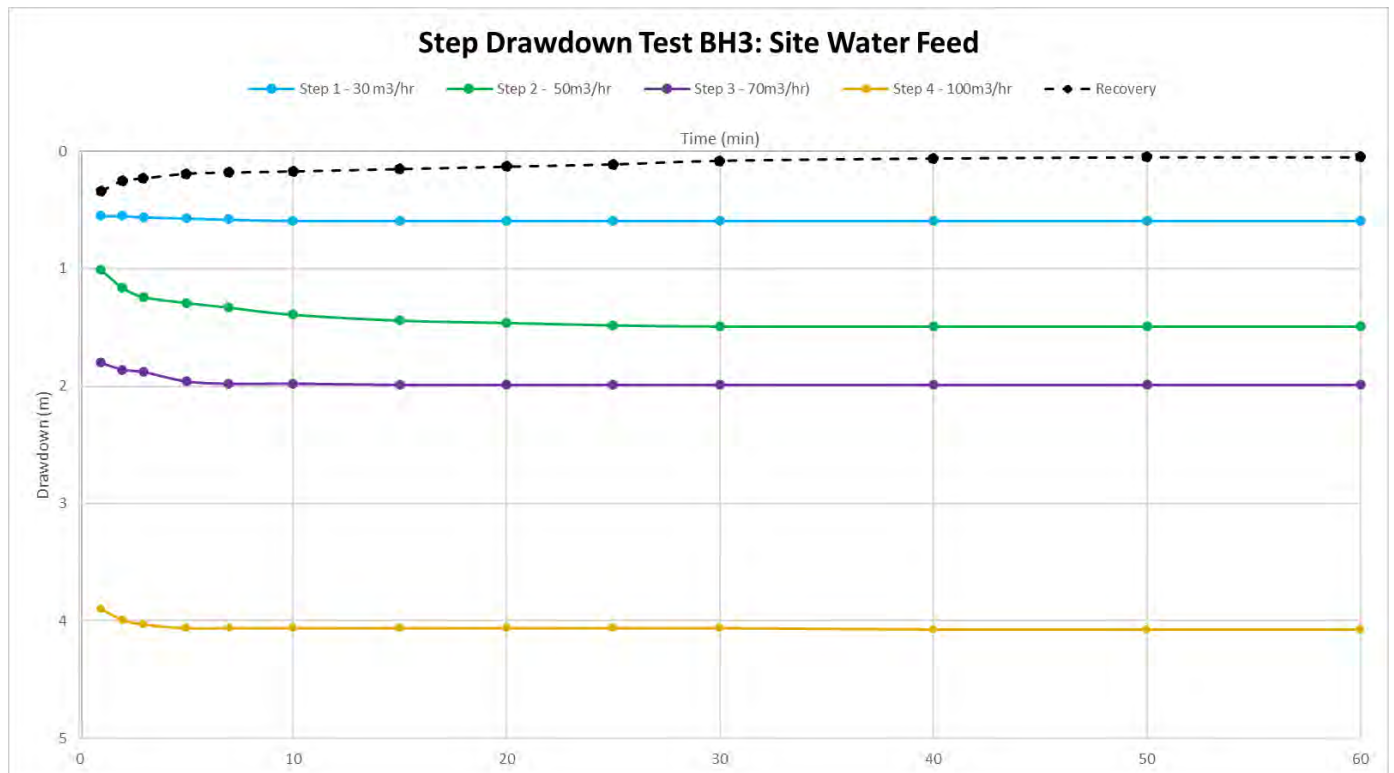


Figure 8 - Step test at BH3 - Site Water Feed

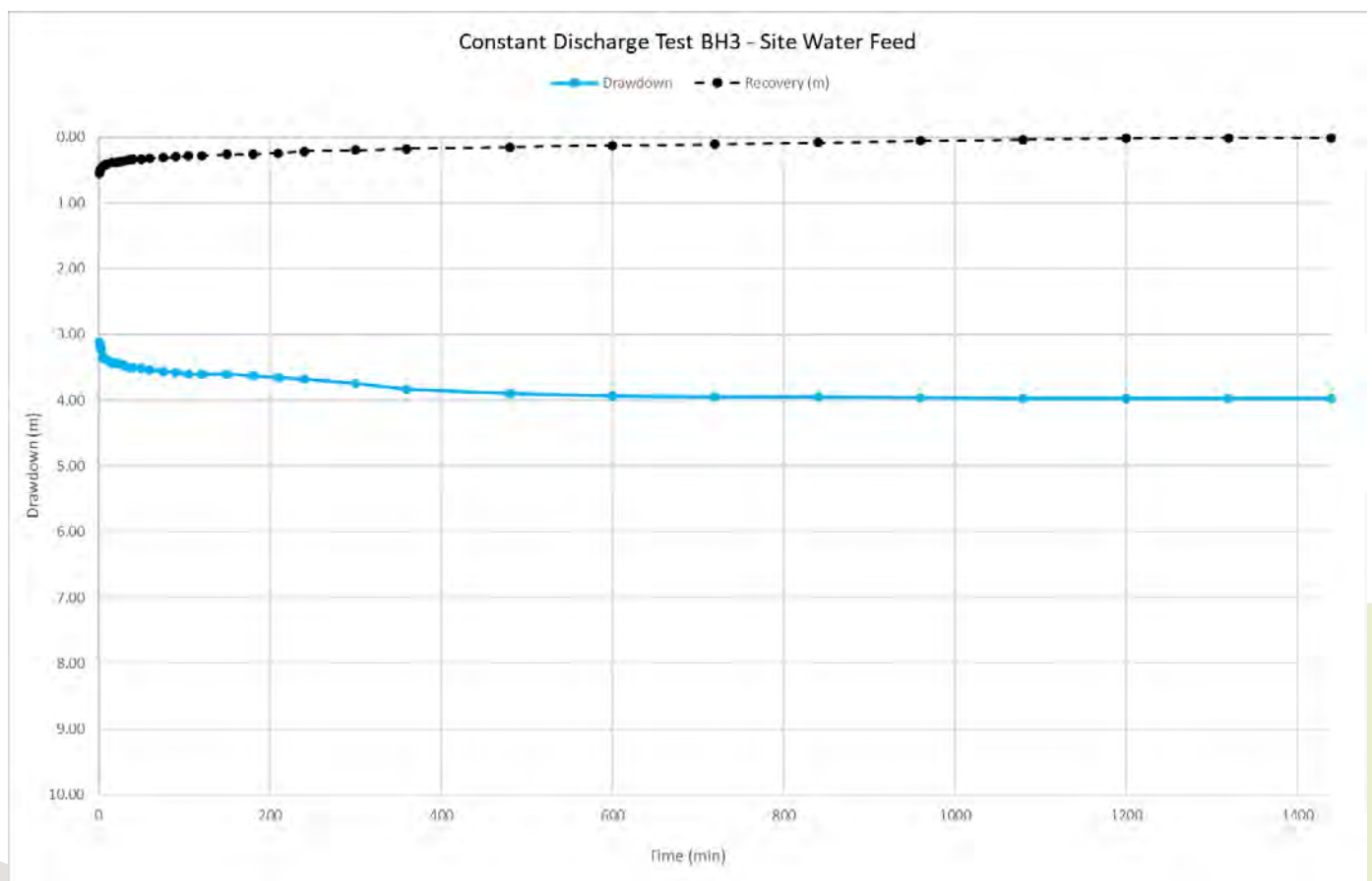


Figure 9 - CDT at BH3 - Site Water Feed at a rate of 100 m³/h for 24 hours

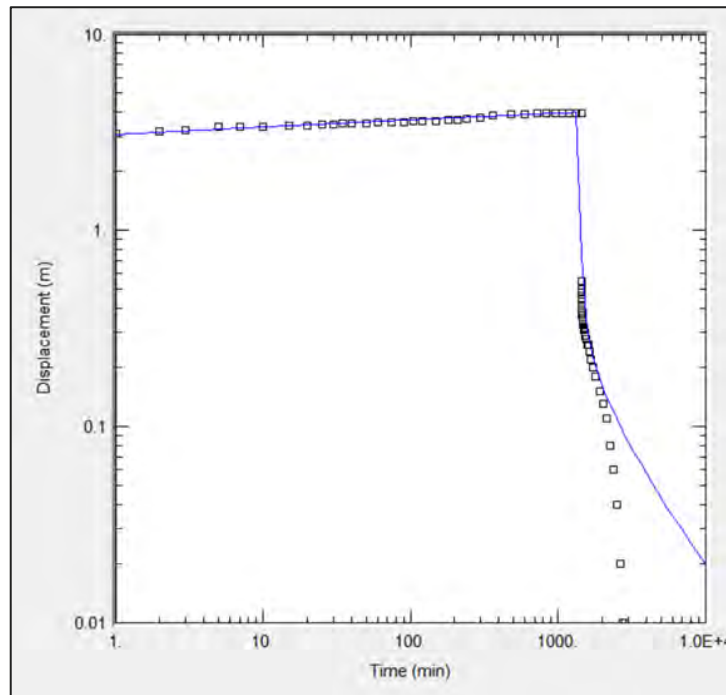


Figure 10 - Curve matching drawdown vs time and derivative data with the Theis (1934) solution for aquifer parameter estimation

Borehole 4 – Site Workers Camp

BH4 – Site Workers Camp underwent a stepped discharge test on 15/11/2024 comprising four (4) one hour long discharge steps, followed by recovery monitoring for 300 minutes until the water level recovered to 100% of the rest level measured prior to testing. Table 1 provides a summary of the borehole construction and testing details. Figure 11 provides an overview of elapsed time since start of pumping versus drawdown of water level recorded during the step test.

The Constant Rate Discharge Test (CDT) was undertaken for 24 hours (1440 minutes) on 16/11/2024 at a rate of 110 m³/h. Figure 12 shows the time versus drawdown during the constant rate discharge test and recovery monitoring. The borehole is high yielding, and shows rapid recovery after cessation of pumping.

Applying a combination of the Theis (1935) and Neumann (1974) analytical solutions (Figure 13), a Transmissivity value of 2700 m²/d was determined. The recommended yield of 90 m³/hr is determined based on subjective information related to flow boundaries, a two year forward modelling of drawdown and the assumption of zero recharge entering the system. It is recommended that the borehole be allowed to recover for at least 24 hours per week. A summary of results and recommendations is provided in Table 2.

Abstraction rates (weekly), volumes (weekly and collated monthly) and groundwater levels (twice daily) are recommended to be monitored at the borehole, allowing a revision (upward or downward) of the recommended yield after 6 months of operation.

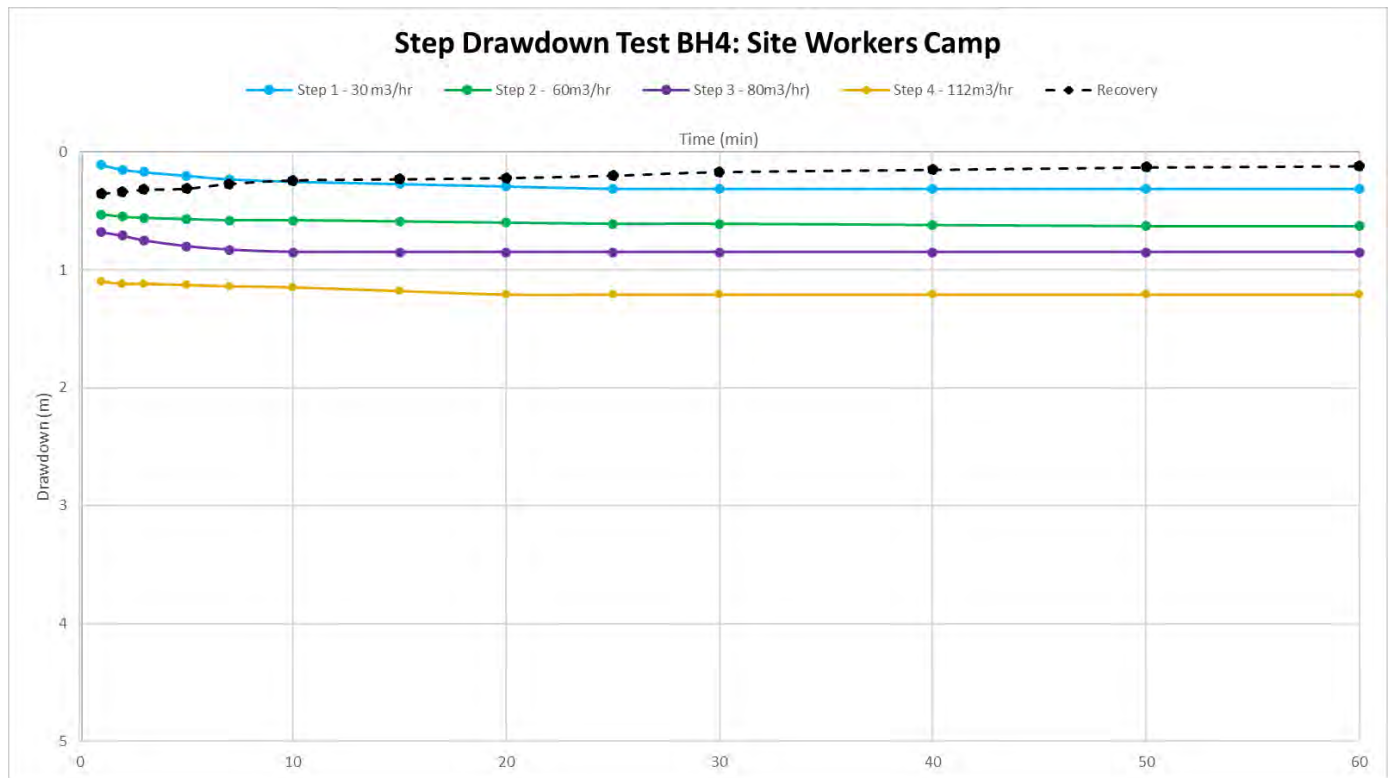


Figure 11 - Step test at BH4 – Site Workers Camp

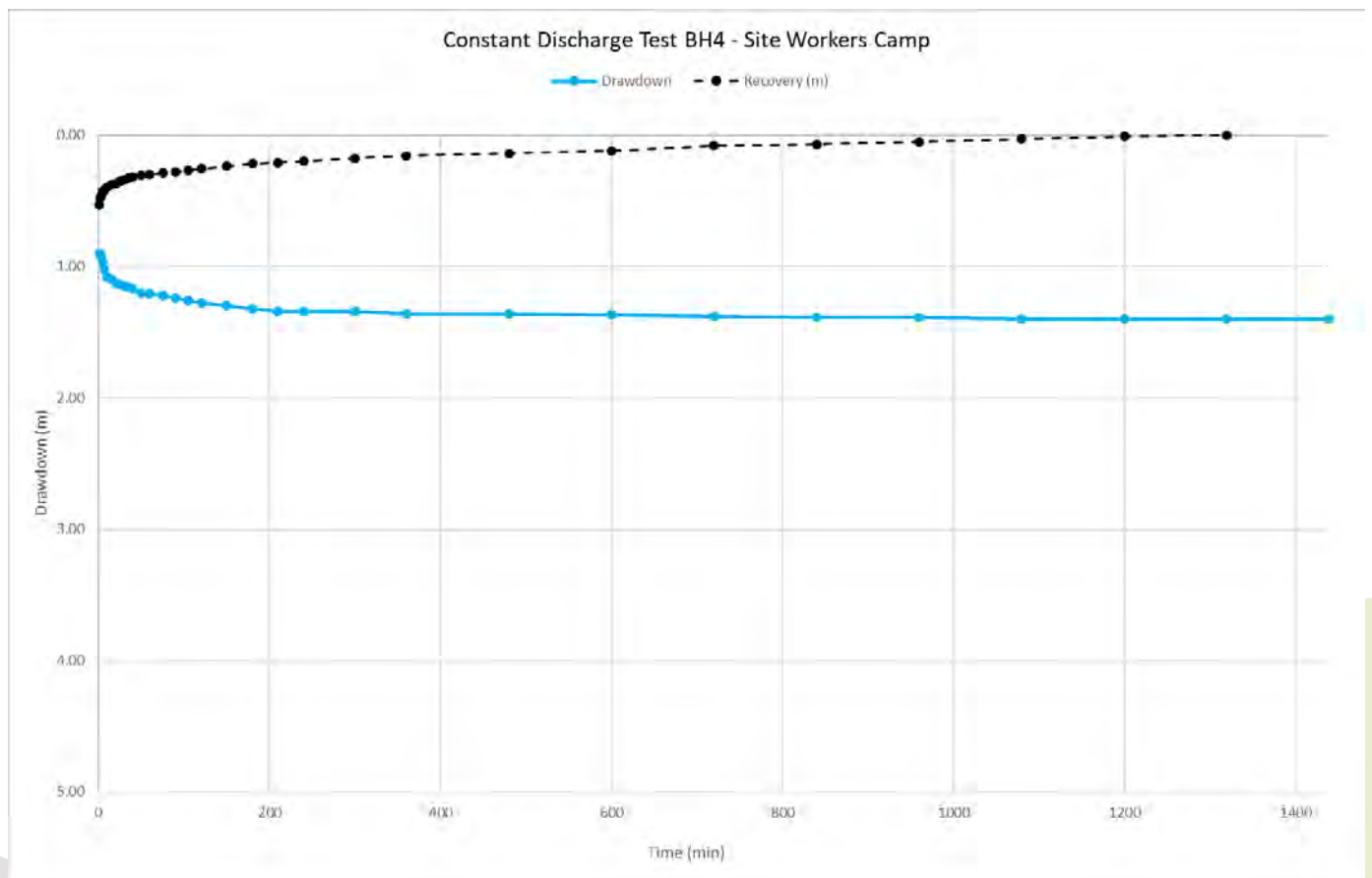


Figure 12 - CDT at BH4 – Site Workers Camp at a rate of 110 m³/h for 24 hours

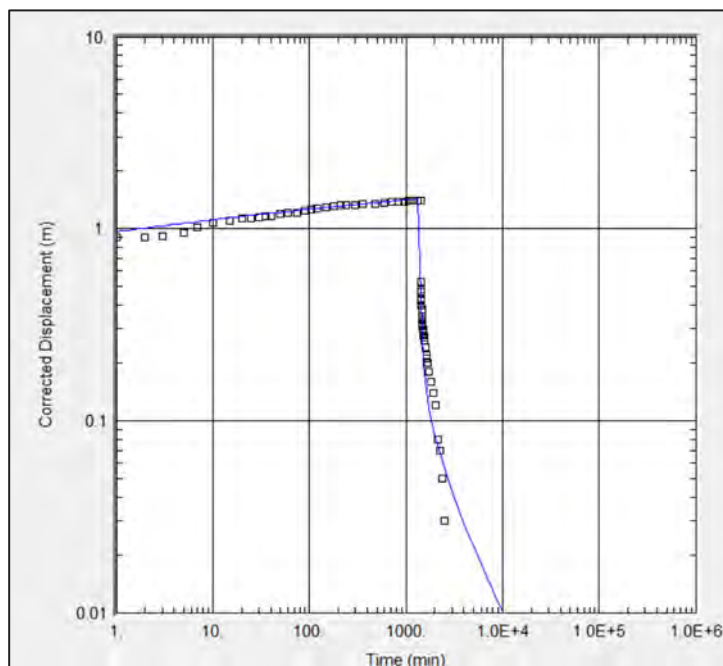


Figure 13 - Curve matching drawdown vs time and derivative data with the Theis (1934) solution for aquifer parameter estimation

Borehole 5 – House

BH5 – House underwent a stepped discharge test on 18/11/2024 comprising four (4) one hour long discharge steps, followed by recovery monitoring for 180 minutes until the water level recovered to 100% of the rest level measured prior to testing. Table 1 provides a summary of the borehole construction and testing details. Figure 14 provides an overview of elapsed time since start of pumping versus drawdown of water level recorded during the step test.

The Constant Rate Discharge Test (CDT) was undertaken for 24 hours (1440 minutes) on 19/11/2024 at a rate of 105 m³/h. Figure 15 shows the time versus drawdown during the constant rate discharge test and recovery monitoring. The borehole is high yielding, and shows rapid recovery after cessation of pumping.

Applying a combination of the Theis (1935) and Neumann (1974) analytical solutions (Figure 16), a Transmissivity value of 1440 m²/d was determined. The recommended yield of 90 m³/hr is determined based on subjective information related to flow boundaries, a two year forward modelling of drawdown and the assumption of zero recharge entering the system. It is recommended that the borehole be allowed to recover for at least 24 hours per week. A summary of results and recommendations is provided in Table 2.

Abstraction rates (weekly), volumes (weekly and collated monthly) and groundwater levels (twice daily) are recommended to be monitored at the borehole, allowing a revision (upward or downward) of the recommended yield after 6 months of operation. BH 5 is nearest BH3 (~160m) and while it is unknown if the same karstic feature is targeted, it is recommended that groundwater level monitoring be undertaken during separate and combine pumping to evaluate borehole interference and compounding of drawdown effects. All recommendations do however account for the possibility of interference / hydraulic connection between boreholes and recommended yields are anticipated to provide protection to main water strikes and pump infrastructure.

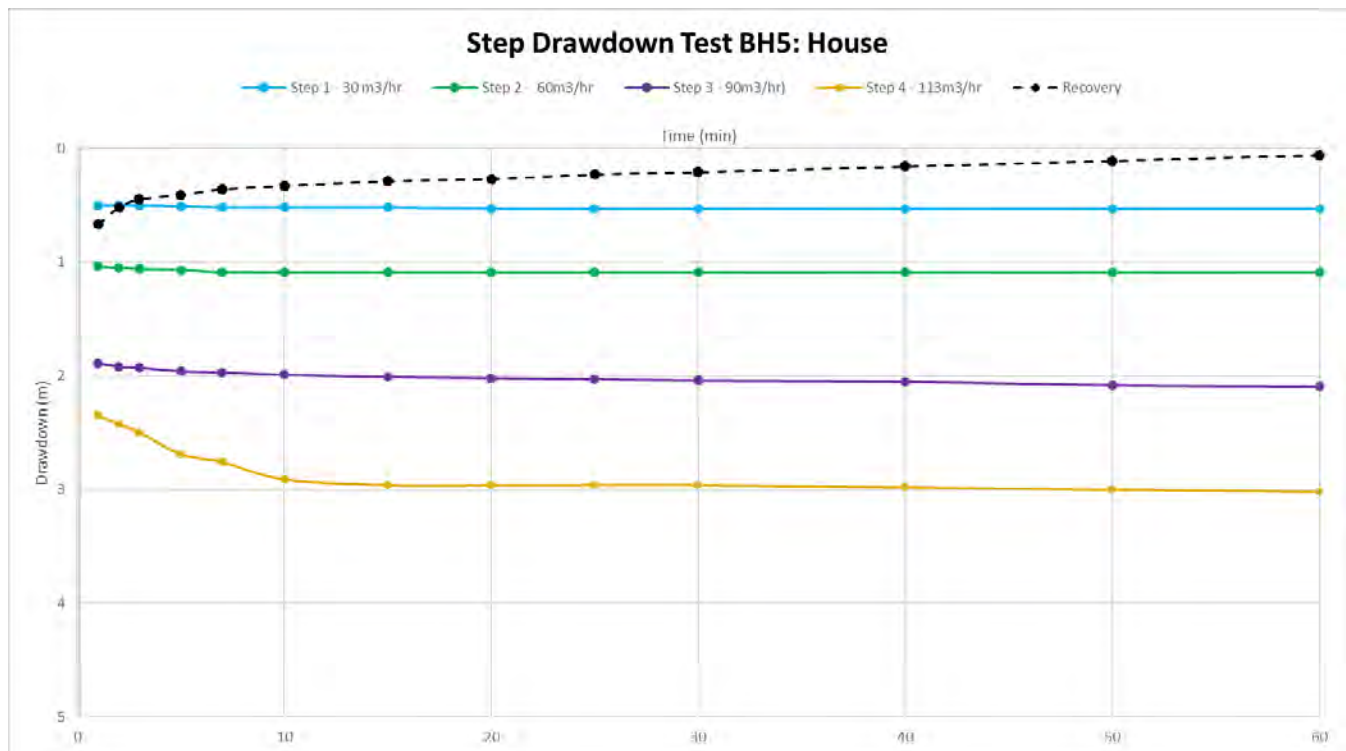


Figure 14 - Step test at BH5 – House

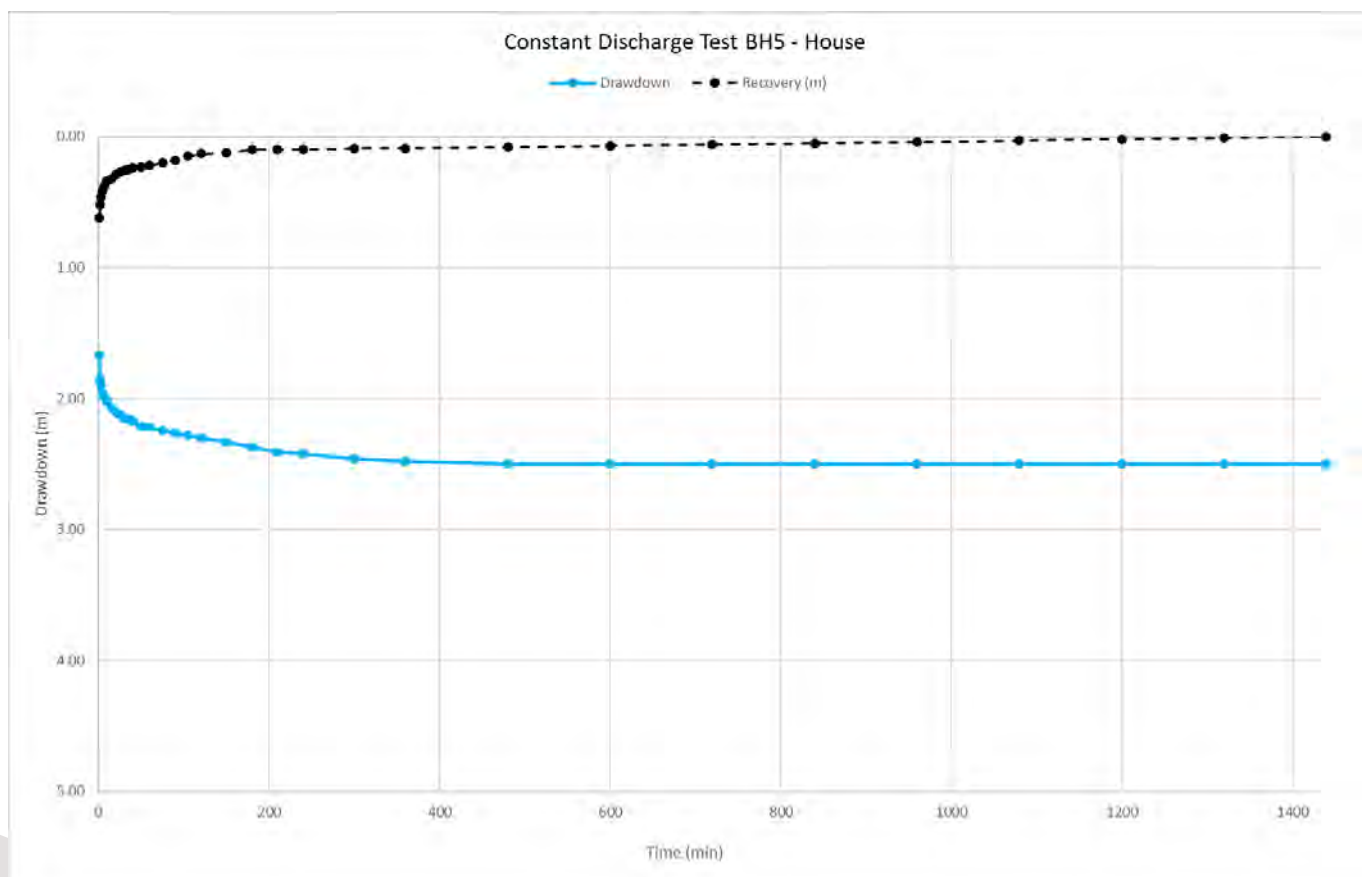


Figure 15 - CDT at BH5 – House at a rate of 105 m³/h for 24 hours

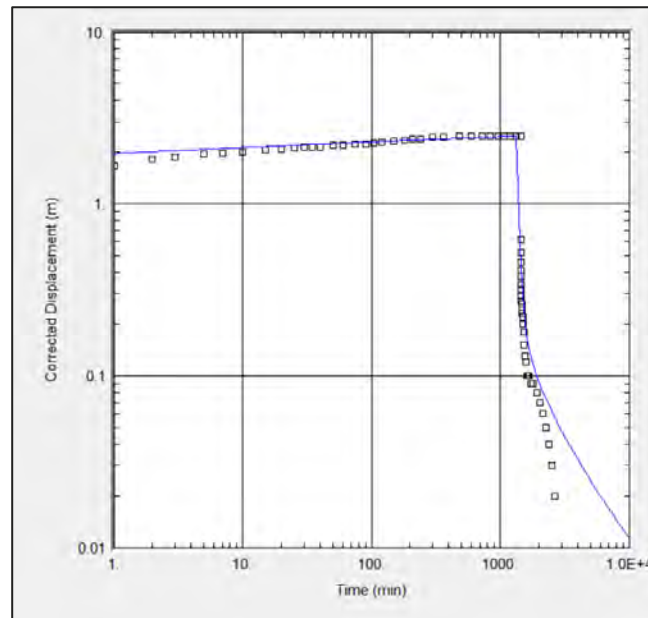


Figure 16 - Curve matching drawdown vs time and derivative data with the Theis (1934) solution for aquifer parameter estimation

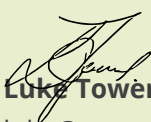
All boreholes drilled targeted the karstic aquifer and are resultantly high yielding. It is recommended that bi-annual sampling of groundwater be included in the water level and volumetric monitoring prescribed per borehole. The analysis undertaken and results obtained (Table 2) may be used in support of an abstraction licence application to the Department of Water Affairs, for a volume of ~2.625 million cubic metres per annum.

Table 2 – Summary table of results and recommendations

BH ID	T (m ² /d) (Theis)	K (m/d)	Recommended Pump Installation Depth (mbgl)	Available Drawdown based on pump	Recommended Yield (m ³ /hr)	Pumping regime (hrs/month)	Yield per month (m ³)	Yield per annum (m ³ /a)	Aquifer Type	Modelled Drawdown after 2 years, zero recharge
BH1 - Land I	379	3.00	30	18	65	625	40625	487500	Karstic	9
BH2 - Land II	93	0.8	30	20	25	625	15625	187500	Karstic	10
BH3 - Site Water Feed	1450	12	30	21	80	625	50000	600000	Karstic	4
BH4 - Site worker Camp	3250	27	30	22	90	625	56250	675000	Karstic	2
BH5	2700	22	30	22	90	625	56250	675000	Karstic	2.5
Total					350	625	218750	2625000		

Yours sincerely,


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