Hoffmann Drilling Pty Ltd Superannuation Fund v Gold Coast City Council & Ors

Planning and Environment Court Appeal No 137 of 2020

Third Joint Expert Report on groundwater issues between the following:

1. **Dr Trevor Johnson (TJ) of SLR Consulting, acting for Hoffmann Drilling on groundwater**
2. **Tony McAlister (TM) of Water Technology acting for Gold Coast City Council on groundwater**
3. **Professor Matthew Currell (MC) of RMIT acting for the Australian Rainforest Conservation Society on groundwater**

STATEMENT TO COURT

We, the undersigned, hereby acknowledge that we have been instructed on an expert's duty to assist the Court and that, that duty overrides any obligation we may have to any party to the proceedings or to any person who is liable for our fees or expenses.

We furthermore state that no instructions were given or accepted to adopt or reject any particular opinion in preparing this report.

BACKGROUND

On 24 April 2018, Michel Group acting on behalf of Graeme Hoffmann and Chuda Kaewmongkhon as trustee for the Hoffmann Drilling Pty Ltd Superannuation Fund [**Hoffmann**] made application to Gold Coast City Council [**Council**] for a Development Permit for Material Change of Use for Extractive Industry (Commercial groundwater extraction) on land located at 263 Repeater Station Road, Springbrook. The land is described more particularly as Lot 36 on SP 139816.

By Decision Notice dated the 12th of December 2019, Council refused the development application, citing inter alia a number of reasons for refusal relating to groundwater and ecological issues. Thynne Macartney Lawyers, acting on behalf of Hoffmann, lodged a Notice of Appeal with the Planning & Environment Court on the 17th of January 2020 (No 137 of 2020), seeking the refusal to be overturned.

Subsequently, the nominated groundwater and ecology experts met separately to prepare relevant Joint Experts Reports which were completed in October 2020.

On 27 May 2021, Council lodged Revised Reasons for Refusal with the Court, as follows:

> ***Groundwater***
>
> a. ***Suitable geological characterisation, groundwater testing and modelling investigations have not been undertaken for the site and surrounding areas to demonstrate that the proposed use is acceptable;***
>
> b. ***It has not been demonstrated that the proposed extraction will not cause unacceptable environmental impacts, including when considering the cumulative impacts of the proposed extraction with other groundwater extraction operations and climate change.***

Two previous JERs on groundwater issues have been completed on this matter. The first was completed by the groundwater experts on the 23rd of October 2020. A second JER, completed in conjunction with the ecological experts in this matter, was concluded on the 3rd of August 2021.

The Court has subsequently ordered that a third JER be prepared to consider additional information provided by consultants acting on behalf of Hoffman.

FURTHER INFORMATION

Subsequent to the combined JER, additional technical information was provided by the Appellant. This information was as follows:

1. The results of 'dry season' pump testing conducted in July 2021 and referred to herein as the 'Hair Affidavit' of the 11th of February 2022;
2. The bore logs associated with the various drilling activities conducted on the site by the Appellant (provided to Council and the Correspondent by Election on the 2nd of March 2022); and
3. The results of groundwater modelling conducted by SLR and referred to herein as the 'SLR Report' (provided by Hoffman's solicitors to the other parties on the 19th of April 2022).

PREAMBLE

1. As an introduction to this JER, we wish to provide the Court with a summary of the fundamental processes underpinning this matter. The key issue in question here is whether the pumped extraction of 16 ML/year (0.51 L/s) from the nominated site will have unacceptable impacts on groundwater or surface water resources in the immediate vicinity of the site, or further afield.
2. A portion of the rainfall falling on the catchment of the area of interest will infiltrate into the soil and become groundwater, with the rest running off the site and becoming surface water. The aquifer stores water. Where the aquifer intersects with the ground surface, some of the stored water 'leaks' out and becomes spring-fed surface flow.
3. The aquifer in this case is composed of basalt rock, which contains variable amounts of open space, due to fracturing and weathering. The recently provided bore logs for the ten bores constructed on the site show the basalt aquifer composition beneath the site is not uniform, and both the thickness and amount of weathering is highly variable. This means that there may be multiple aquifer units within the overall aquifer, which may be connected to a greater or lesser degree. The basalt aquifer sits above another volcanic rock type – rhyolite, which has little or no capacity to store and transmit groundwater (i.e., it does not act as an aquifer). Groundwater percolating vertically to the boundary between the basalt and rhyolite will flow horizontally along the boundary between these rock units to appear as springs.
4. When pumped extraction of water occurs, water is drawn from the aquifer. Depending on the rate of pumping and the amount of rainfall, the level of water in the aquifer may be drawn down, particularly during periods of dry weather. The amount (that is, the vertical distance) of this drawdown is greatest at the site of pumping, and reduces with distance from the bore because it takes time for water to flow horizontally to the pump location. Differences in composition (e.g., amount of fracturing or extent of permeable zones) will also affect the amount of drawdown. If pumping rates are too large, or there is insufficient rainfall, the area of drawdown of water levels in the aquifer can extend for considerable distances from the pumping site, and then affect other areas away from the site where water is used by the environment or other water users.
5. The use of pump tests and other technical investigations at the site is intended to allow the existing aquifer to be adequately described and modelled.

POINTS OF AGREEMENT

6. It is agreed that the relevant question to examine here is whether the development will have an unacceptable adverse impact on environmental conditions dependent on groundwater, particularly external to the site. In terms of groundwater, 'impacts external to the site' might be measured as changes to groundwater levels (which the appellant has attempted to estimate using pumping tests and modelling), or changes in the amounts of discharge of groundwater to surface water bodies (e.g. springs and groundwater-fed streams on and downstream of the site). Whether such changes in groundwater levels and flows to the surface result in unacceptable impacts, can only partly be assessed by the groundwater experts, as this depends primarily upon the ecological, cultural and environmental values that are supported by the groundwater (topics for other experts).

7. TJ notes that the standard test of impact which water engineers apply in the Planning & Environment Court is whether the development will cause actionable nuisance external to the site on which the development is located. Put another way, the correct test is to determine whether the development will have an unacceptable adverse impact on conditions external to the site. He concurs with the view that this impact depends upon all of the natural and anthropogenic features of the environment.

8. It is agreed that this view is in line with the analysis contained in a Groundwater Investigation of Tamborine Mountain, undertaken by Andrew Todd from the Queensland University of Technology and reported upon in June 2011 (Todd, 2011). The following are relevant extracts from that report:

> ***5.6 Environmental Flows***
>
> Environmental flow is groundwater that discharges to the surface where it maintains permanent water systems such as springs, streams and wetlands. The ecosystems that characterise these environments are typically dependent on a continuous or semi continuous supply of water. The term environmental flow is often used synonymously with base-flow in streams.
>
> Small decreases in water table height, or aquifer surface level, can result in a significant reduction in water supply to these groundwater dependent ecosystems (GDEs). Flow can cease over a disproportionately large area depending on surface slope and geology.
>
> This project has confirmed that groundwater discharges continuously to all streams draining off the Tamborine plateau, and to streams originating around the plateau escarpment. SWL measurements suggest that groundwater discharge is approximately equal to recharge over the long term. The ecosystems that have developed on and around Tamborine Mountain over many thousands of years, and which are now somewhat modified, are founded on this groundwater supply.
>
> The question is: ***How much groundwater is required to sustain a level of health in these ecosystems which is acceptable to the Tamborine community?***
>
> Various values are used for the allocation of groundwater to the environment. For example a study of a very similar basalt terrain on the Astonville Plateau in Northern NSW (Brodie and Green, 2002) used 80% of groundwater recharge as an appropriate allocation to the environment, due to the high level of interaction between groundwater and GDEs mapped in this area. A similar level of interaction may exist on Tamborine, however Brodie and Green (2002) assumed a relatively low rate of recharge (8% of annual rainfall) compared to that estimated for Tamborine.

> The NSW State Groundwater Dependent Ecosystems Policy (Dept of Land and Water Conservation, 2002) recommends site specific studies to determine appropriate allocations to the environment, but in the absence of such studies recommends 30% of average annual recharge be allocated to the environment. There is no current policy developed for Queensland, but site specific studies are undertaken for priority groundwater management areas.

> The water balance illustrates that the estimated volume of groundwater extracted, even in a worst case scenario, is less than 3% of average annual recharge. It follows that the proportion of average annual groundwater recharge that is available to the environment is at least 95% for the entire system. Even accounting for a high groundwater requirement for local ecosystems, it can be concluded that current levels of extraction are sustainable over the long term.
>
> Analysis of stream flow during 2010 indicates that about 50% of groundwater recharge flows laterally and discharges to streams draining the plateau as base-flow. Most groundwater extracted on Tamborine Mt is from Unit C and below, which can safely be assumed to be below the level of surface streams on the plateau. It follows that most extraction is from the 50% of average annual groundwater recharge that moves to these lower levels. Groundwater extraction is still less than 5-6% of recharge.
>
> It is also noted, however, that high demand for groundwater during extended dry periods, will exacerbate the natural decline in aquifer levels. A small drop in the water table can have a disproportionately large effect on stream flow as the water table drops below the stream bed over large areas. For example Cedar Ck was observed to run dry for several weeks in late 2009, upstream of the State High School. It is important to consider these localised and temporary impacts on groundwater dependent ecosystems when managing the Tamborine resource.

9. It is agreed that Todd has determined 'impact' not by specific change in groundwater levels or discharge, but on whether environmental flows (i.e. that level of groundwater discharge which is needed to adequately sustain natural environmental values, particularly in the context of vegetation) have been maintained to an acceptable level or not.

POINTS OF DISAGREEMENT

11. MC and TM contend that it has not been demonstrated that the proposed 16 ML/year rate of extraction from the aquifer will not have unacceptable adverse impacts on ground and surface water resources. They believe that such impacts are likely, primarily in the vicinity of the site (including adjacent properties), and to a lesser degree, the wider Springbrook Area.

12. TJ states that it can be noted that the researchers on Mt Tamborine (Todd, 2011) have accepted that extraction rates which represent less than 5 to 10% of the average recharge are sustainable, and unlikely to damage the environment in the long run. TJ says that this would appear to be a reasonable criterion for determining impact at the Springbrook site. TJ further states that on this basis, he believes that sufficient assessment has been completed to demonstrate that the proposed extraction at 263 Repeater Station Road, both in its own right as well as cumulatively with all other extraction operations, will not have an unacceptable adverse impact on the natural environment.

13. MC and TM disagree, and believe that this way of defining the level of impact is:

    a) Too narrow and not necessarily appropriate for protecting the environment, and that instead a thorough understanding of the relationship between extraction rates, groundwater levels and groundwater discharge to the surface must be obtained **prior** to determining the appropriate extraction volume (which could be determined as a percentage of local groundwater recharge, or as a volume that supports minimum threshold groundwater elevations and/or discharge rates to surface water at key sites)

    b) Unable to be demonstrated as consistent with the proposed extraction volume, as the groundwater recharge rate is not established, and the appropriate spatial scale to assess this rate against the extraction rate is not agreed.

14. TJ says that MC and TM seemingly contend that there is no safe rate of extraction from the aquifer which would not have an unacceptable adverse impact on both ground and surface water resources in the Springbrook Area. However, this appears to be in conflict with TM's statement to the Court of 27 December 2021 (paragraph 52, 53 and 54) which appeared to support the view that an extraction yield of between 9.9 and 12.0 ML per annum for 133 Repeater Station Road was sustainable. A similar view is expressed at paragraph 64 of that report where a sustainable extraction rate of between 7.0 and 10.0 ML was mentioned.

15. TM disagrees with TJ. He maintains his opinion that **some** rate of extraction from the site is possible, that being the **<u>sustainable yield</u>**. He also maintains that based on previous studies in the area (e.g. those at 133 Repeater Station Road), the Hair pump tests and TJ's modelling that none of these sources demonstrate that 16 ML/year is sustainable. MC also disagrees with TJ, and believes that further field studies are required – particularly, to understand the relationships between groundwater, surface water and ecology, in order to determine if there is a sustainable yield for the site (and what rate of extraction this might be). TM and MC believe that to approve the proposed extraction in the absence of such studies would place the groundwater and environmental values it supports at risk.

16. Based on the **Hair Affidavit and the borelog data**, TM and MC provide the following commentary. Comments made by TJ are interspersed with this commentary as individual numbered paragraphs, commencing with "TJ says".

17. TM and MC note that the project proponent has conducted a pumping test under 'dry season' conditions, as per their previous recommendations, with results reported in the Hair Affidavit of the 11th of February 2022. This pump test showed that there were adverse effects on groundwater levels at the northern property boundary, which would have extended beyond the property hence causing 'actionable nuisance external to the site on which the development is located' as outlined by TJ in Paragraph 7. Further details on this matter are provided below:

- Figure **1** shows the two bores from which water was extracted in the July test (Bores 5 and 6 - see also Bullet Point 4 below) and the four key monitoring bores (Bores 1, 2, 4 and 7);
- Figure **2** shows the **actual** water level data recorded in each bore, which are different in vertical scale due to the specific details of the bores, where loggers are located, and what layers of the site aquifer(s) are intersected;
- Figure **3** shows the **change** in water level which occurs in each bore. This figure conclusively shows that after 7 days of pumping, water levels in Bore 2 (located midway between the extraction bores) reduced by 1.4m, water levels in Bore 4 (located midway between the extraction bores and the northern site boundary) reduced by 0.9m, and water levels in Bore 1 (located near the northern site boundary) reduced by 0.3m. Importantly, all three records were trending downwards, meaning that if the pumping had continued (as would be expected if year-round pumping at the proposed rate of 16 ML/year is permitted), greater reductions in water level would have occurred; and
- These results show that pumping of groundwater at the rate proposed will lead to drawdown extending beyond (and potentially significantly beyond) the boundary of the property, thereby causing actionable nuisance external to the site on which the development is located.

18. TJ says that the impact of pumping at the northern boundary was minor for dry season pump tests. The dry season result shows a reduction in groundwater level in Bore 1 of 0.3 m. It is difficult to understand how MC and TM can reasonably classify this change as in any way significant, since it is clearly well within the range of natural variation.

19. MC and TM do not agree that the drawdown observed during the dry season is unlikely to have adverse impacts (considering it would occur during the periods when groundwater levels are already low due to low rainfall), and believe it is a matter for the ecology experts to determine if such drawdown may lead to adverse impacts on vegetation or other ecological values. MC and TM also note that the observed drawdown was from a 7 day pump test conducted immediately after a period of heavy rainfall (see Figure **7**) and that they expect far greater drawdowns would result from protracted pumping under real dry conditions.

20. TJ does not agree that the monitoring shows a downward trend. In his opinion, two of the bores mentioned by MC and TM have effectively stabilised and are not continuing to fall.

21. TM and MC disagree with TJ, they are of the opinion that all dry season data records are clearly trending downwards, which is significant particularly when considering the reduction in extraction rates due to Bore 6 running dry in the second half of the test.

22. The data accompanying the pump test results also reported nearly 30 mm of rain midway through the test (noting that the reliability of the rainfall data reported is in TM and MC's opinions questionable, see further discussion under **51** below). This indicates to TM and MC that the proposed rate of extraction of groundwater is likely to be unsustainable, due to the observation that extended drawdown occurs when extracting during periods of limited rainfall (noting that the environmental effects of such drawdown are unclear and is a matter for the ecology and other experts). As discussed below, periods of low rainfall (and/or negligible groundwater recharge) lasting weeks or months are not uncommon at Springbrook.

23. TJ says that the use of a single thick blue line to represent rainfall in Figures 3 and 4 is significantly misleading and inaccurate. Rainfall should be shown as an hyetograph with each bar representing the rainfall which actually occurred on each day, as per the charts produced by Ian Hair. The actual rainfall which fell during the monitoring period at the Wunburra Gauge was 19.2 mm on 24 July, and zero on the other days. It is noted that low rainfall totals generally do not reflect in any measurable change in groundwater level. For Tamborine Mountain, the QUT researchers found that rainfall events up to 30 – 40 mm or less did not translate into any recharge to groundwater. A similar type of behaviour is likely to occur in the Springbrook area. If this is the case, then the rain falling during the monitoring period is unlikely to have had any measurable effect on groundwater levels.

24. MC and TM believe that the use of the arrow is appropriate to indicate when the rainfall event in question occurred.

25. TM and MC agree that rain events below 30 mm are unlikely to result in any significant recharge to groundwater (as discussed under **90**), and believe that the downward dry season pumping test water level trend (accounting for periods of reduced extraction when one of the bores was pumped dry) in itself supports the view that pumping at the proposed rate in the dry season is unlikely to be sustainable, regardless of the whether the rain event in question influenced groundwater levels during the test.

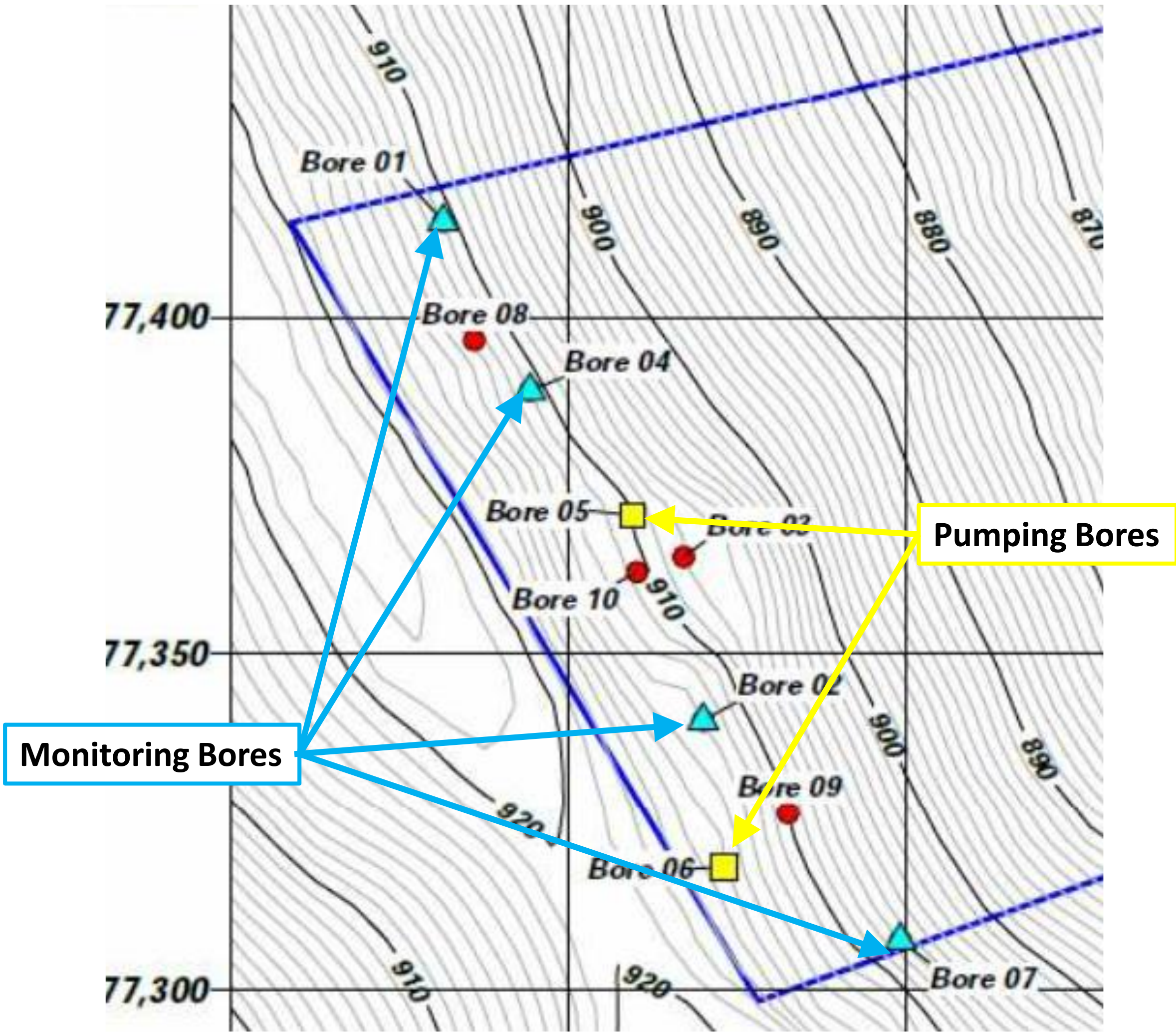


Figure 1 Site Bore Locations

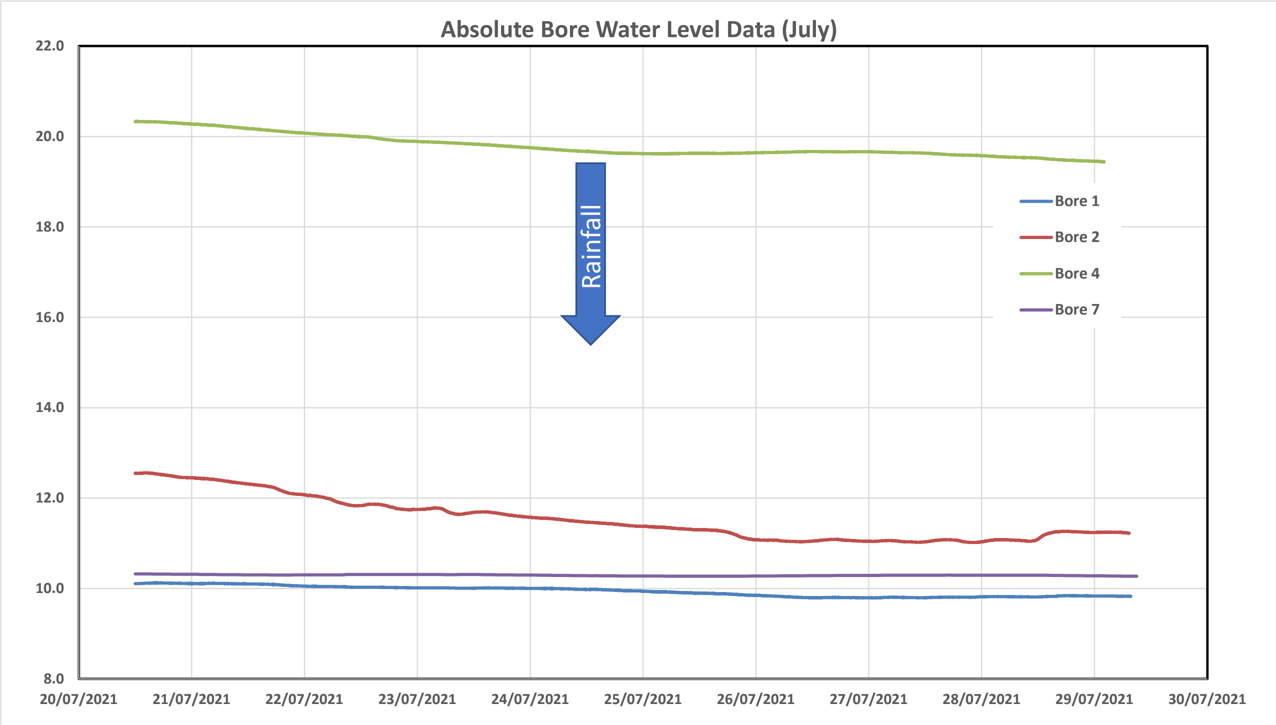


Figure 2 Absolute Bore Water Level Data for July

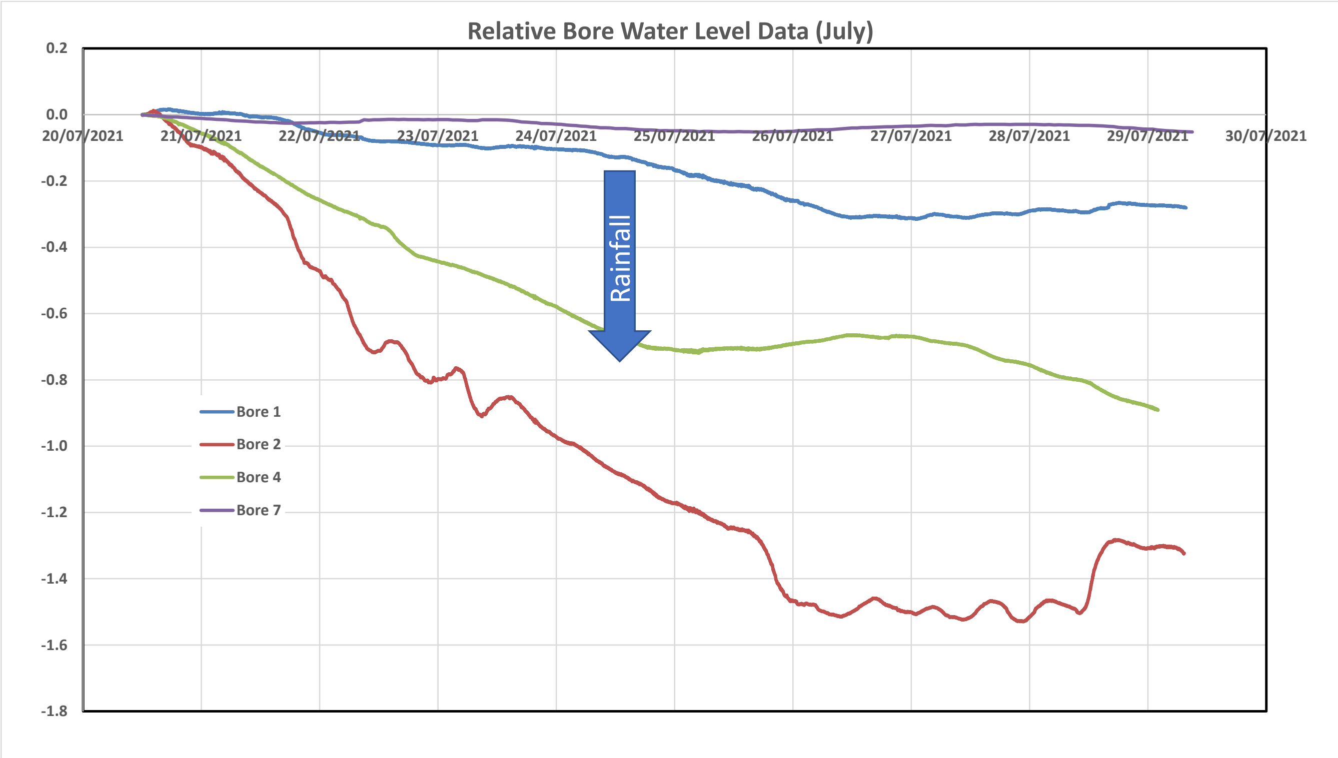


Figure 3 Relative Bore Water Level Data for July

26. As stated above, TM and MC note that the new pumping test was conducted in a month (July) that often exhibits 'dry season' characteristics, but in this instance was not conducted under **protracted** dry weather conditions. This fact is discussed below:

- Figure **4** shows daily rainfall data for 2021 for the BOM Wunburra gauge on the Springbrook Plateau while Figure **5**Figure 5 shows similar daily rainfall for June and July 2021. It is apparent from these figures that there was considerable rainfall in the weeks leading up to the pump test, and as stated earlier, during the period when the test occurred, which will mean that impacts of groundwater extraction during extended dry periods (which are not uncommon) are likely to be underestimated by the testing;
- Table 1 presents **monthly** rainfall percentage statistics for the more than 60 years of rainfall data from the BOM Wunburra gauge. Monthly rainfall in June 2021 was 19.8 mm, while in July 2021 it was 64.9 mm. That is, June was a 10th percentile rainfall month, which can be considered dry, while July, when the test was conducted, was a 40th percentile rainfall month, only slightly lower than an average rainfall month for the entire rainfall record. That is, almost 5 months each year on average will typically have less rainfall than that which occurred during the period preceding the 'dry season' pump test.

Table 1 Monthly Rainfall Statistics at the BOM Wunburra gauge

Percentile	Monthly Rainfall (mm)
10	16
20	31
30	48
40	69
50	90
60	123
70	164
80	210
90	332

- Further, Table 2 presents rainfall percentage statistics for the more than 60 years of rainfall data from the BOM Wunburra gauge. Annual rainfall in 2020 was 1,737mm and in 2021 was 1,867 mm. That is, 2020 was a 60th percentile rainfall year, (wetter than average), while 2021 was almost a 70th percentile rainfall year (far wetter than average). The degree of drawdown that would have been measured by this pump test if it was conducted in, for example, a 10th percentile rainfall year would have been considerably larger.

- Climate modelling also predicts that the frequency of such low rainfall periods, and their severity will increase in the coming years (as was noted in the Climate Change JER), further increasing the likelihood of greater levels of groundwater drawdown when pumping occurs during such periods.

Table 2 Annual Rainfall Statistics at the BOM Wunburra gauge

Percentile	Annual Rainfall (mm)
10	1049
20	1222
30	1355
40	1478
50	1704
60	1759
70	1912
80	2239
90	2474

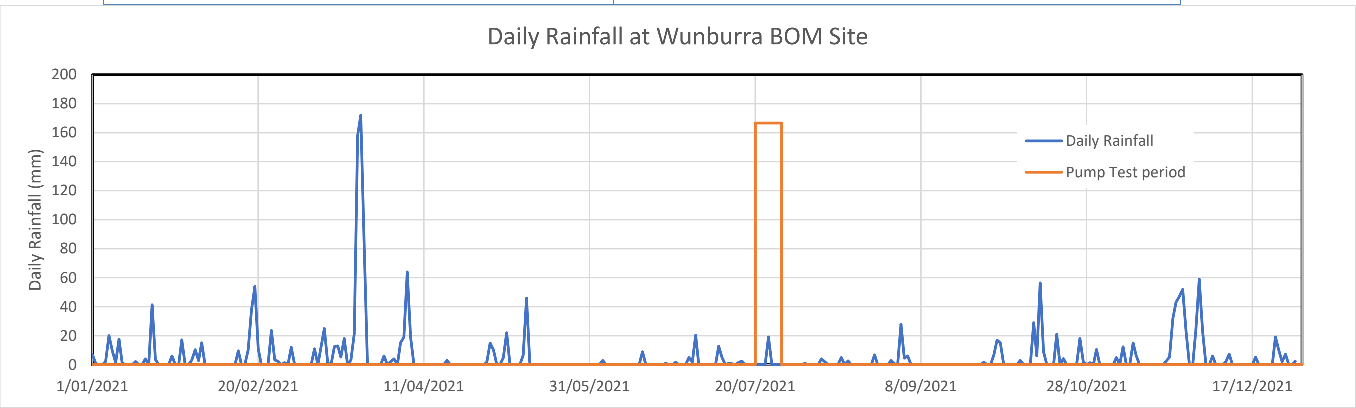


Figure 4 Rainfall data for 2021, indicating timing of pump test

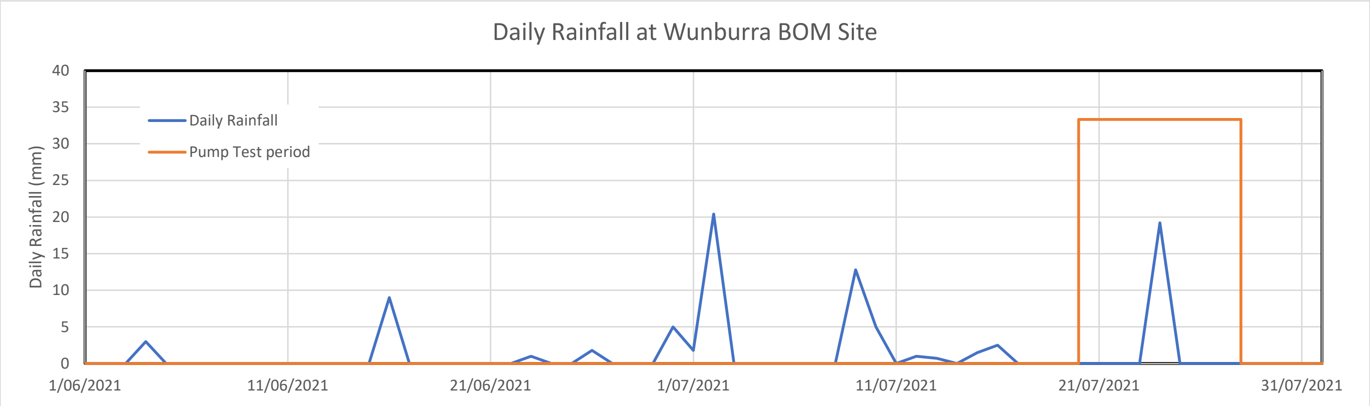


Figure 5 June-July 2021 Rainfall data

27. TJ says that the Wunburra gauge significantly underestimates the depth of rainfall which falls on the catchment above 830 m AHD. The Wunburra station has an elevation of only 566 m, and reliance on the statistics for that gauge may lead to erroneous and misleading findings. TJ accepts that 2020 and 2021 were wetter years than average, and that drawdown might be greater in a drier year. However, we can only deal with the information that we have in my opinion. In that respect, the data collected by Hair has been used to calibrate the analytical groundwater model, and it is the results of that modelling which are considered pertinent here.

28. TM and MC note that the Wunburra data was presented because this site has the longest data record (some 60 years). They also present Table 3 which is the analysis of some 37 years of rainfall data for the nearby Springbrook Road gauge (elevation 697m) and Figure **6** and Figure **7** which show daily rainfall data for 2021 for the BOM Springbrook Road gauge on the Springbrook Plateau and similar daily rainfall for June and July 2021. These data confirm their comments regarding 2020 and 2021 being wetter years than average based on the Wunburra data. Figure **7** actually shows that there was **even more rainfall** in the weeks leading up to the 'dry' season pump test at these sites than was the case using the Wunburra data - making it even less representative of dry season conditions.

29. TJ says that it remains the fact that rainfalls at Wunburra are not a reasonable indicator of the volume of rain falling above 830 m AHD.

Table 3 Annual Rainfall Statistics at the BOM Springbrook Road gauge

Percentile	Annual Rainfall (mm)
10	1347
20	1569
30	1770
40	1866
50	1957
60	2075
70	2379
80	2630
90	2773

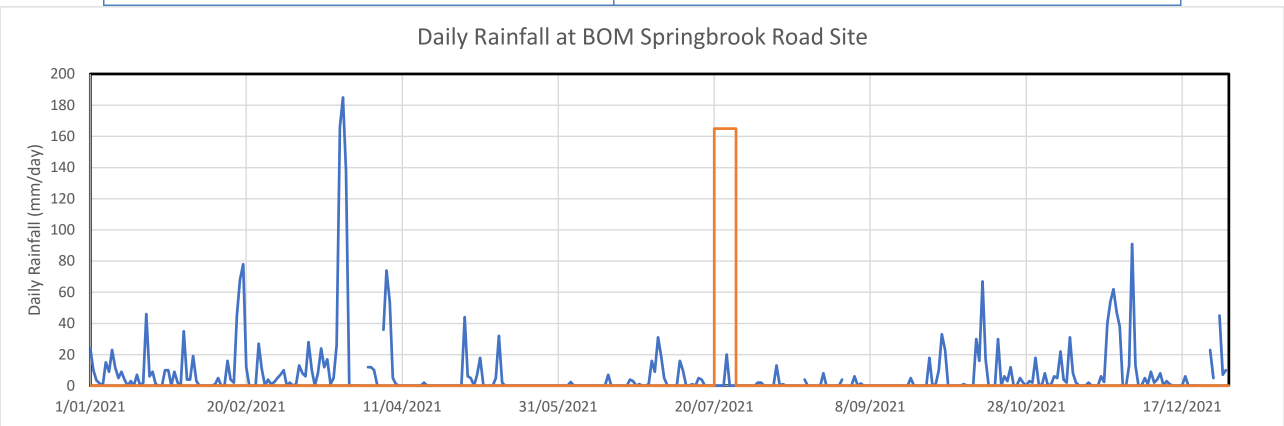


Figure 6 Rainfall data for 2021 at Springbrook Road gauge, indicating timing of pump test

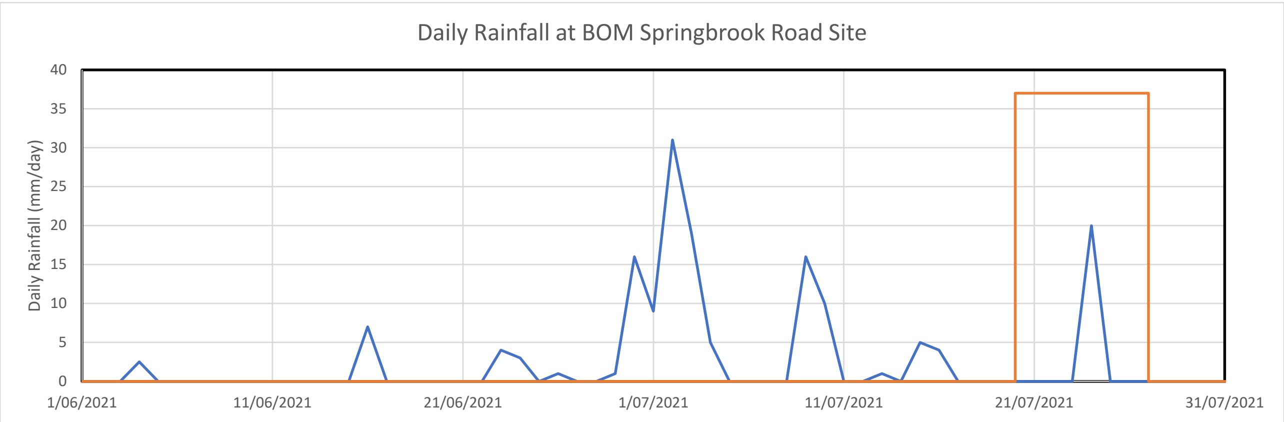


Figure 7 June-July 2021 Rainfall data at Springbrook Road gauge

30. TM and MC note that groundwater monitoring during the ‘dry season’ test was unable to accurately determine drawdown impacts to the south, east and west of the extraction bores (due to a lack of appropriate monitoring bores in these directions). That there was no apparent drawdown in water levels in the bore at the southern boundary of the site (Bore 7) reflects the fact that this bore was actually recording data from the rhyolite layer beneath the fractured basalt (i.e., not the same aquifer as the water extraction). The rock unit in which Bore 7 is constructed is likely to be an ‘aquitard’ (the hydrogeology term for a rock layer with low permeability for water flow), with limited hydraulic connection with the fractured basalt layer from which the water was pumped (other than possible vertical leakage within the bore itself, due to its inappropriate construction – see paragraph **0**).

    - This is evident from Figure **2**, Figure **3**, Figure **8** and Figure **9** with the data from Bore 7 showing little, if any, water level variation, either due to pumping or from rainfall recharge.
    - The lithology log from Bore 7, provided by the appellant on the 2nd of March 2022, shows that the bore intersects basalt from its surface elevation (906.64 m AHD) to 78 m below ground (828.6 m AHD). Below this depth, the bore intersects volcanic ash within Rhyolite (to a depth of 814.6 m AHD) and then pure Rhyolite from a depth of 814.6 to 810.6 m AHD. The water levels recorded in Figure 2 of the Hair affidavit (reproduced as Figure **8** below) were between 813 and 814.5 m AHD throughout 2021, and therefore completely within the Rhyolite (not the basalt aquifer, from which the groundwater extraction took place).

31. TJ says that Bore 7 is connected to the aquifer system via the gravel pack and multiple screened intervals. In his opinion, It is nonsensical to contend that the water level in Bore 7 somehow represents a water level in an impermeable layer of rhyolite. Rather, the fact that Bore 7 recorded no major change in water level during the pumping test is more likely to be represent the fact that the pumping has had no measurable impact on the various aquifer layers which it passes through. In fact, Figure 7 shows that Bore 7 does respond slightly to rainfall, which tends to obviate the argument made by MC and TM. MC and TM appear to disregard any evidence, correct or not, which does not suit their arguments in this matter. All data is relevant in some way, and the level changes in Bore 7 support my view that there is unlikely to be any impact of pumping on areas north and south of the subject site.

32. TM and MC disagree with TJ’s opinions above and maintain that Bore 7, the only bore located south of the two extraction bores, does not reflect the groundwater levels or extent of drawdown in the basalt aquifer (the relevant aquifer in question) during the period of the pumping tests and monitoring shown in Figure 2 of the Hair affidavit, as the water level is within the rhyolite for the whole period. This is supported by relevant statements in the Minimum Construction Requirements for Water Bores in Australia, (2020) – as further discussed in paragraph **0**. The minor changes in water levels in Bore 7 referred to by TJ may reflect some minor groundwater recharge to this low-permeability layer (the rhyolite – aquitards are not necessarily fully impermeable at TJ implies, or free from groundwater recharge), or more likely, some leakage of water via the bore itself (rather than through the geology), due to the bore’s inappropriate construction with multiple screened intervals. The location of the groundwater level within the screened interval in the rhyolite (rather than basalt) means that it is not appropriate to monitor drawdown in the target aquifer.

33. As such, TM and MC believe there are no reliable data to indicate how far drawdown travels towards the southern property boundary during the groundwater extraction. Similarly, no monitoring of drawdown has been conducted to the east or west of the extraction bores. Springs and seeps that are fed by outflows from the basalt aquifer(s) between elevations of approximately 830 and 835 m AHD (documented in the affidavit of Elanor Fenge) are located to the east and west of these bores. Documentation of both the amount of drawdown occurring in these directions, and the change in volumetric rate of flow from springs during extraction, are needed to understand the extent to which the proposed extraction would impact on these water sources. As discussed from Paragraph **46** onwards of this JER, the modelling conducted by SLR does not address this need, in TM and MC's view.

34. TJ says that the reliance on observations made by a third party who is neither a hydraulic engineer nor a hydrogeologist is questionable. TJ says that, in his opinion, there is every reason to believe that seepage occurs generally above the rhyolite layer from 820 m AHD up to the recorded water table level in the extraction bore of about 830 m AHD (which also corresponds to the upper level of spring activity on the site). There is nothing in the geology of the site which would affect such a conclusion. This is clearly illustrated on the following Figure **8** in respect of bores 2 and 7.

35. MC disagrees, and believes the observations taken in the Fenge affidavit are well documented (with clear, accompanying photographs) and scientifically robust. He believes these are the best available evidence to determine where groundwater discharge occurs at the site. Considering these observations and his own site visit conducted in January 2021, the opinion groundwater discharge could be occurring over a seepage face of 10 meters vertical distance (made in the modelling outlined in in SLR, 2022 and discussed by TJ in paragraph 34) is completely inconsistent with field observations at the site. MC himself (a Professor of Environmental Engineering with over 15 years' experience as a hydrogeologist) inspected the site in January 2021, and all his observations were consistent with those outlined in Ms Fenge's affidavit – that is, there were very limited observable points of groundwater discharge to the surface, and these were all at a similar elevation (not a thick and extensive seepage face, as modelled by SLR, 2022).

36. TJ says that Ms Fenge undertook no accurate measurement of levels on the western side of the ridge, and her observations are at best those of a person without technical expertise in either hydrogeology or hydraulic engineering.

37. In relation to springs on the western side of Repeater Station Road, TJ notes that the consultants for Hoffmann did not have the benefit of carrying out inspections in those areas. Access to these areas was apparently restricted to the ARCS experts.

38. TJ finally notes that if the development application is approved, he accepts that a necessary condition of approval will be a requirement to install a monitoring bore downslope (east) of the extraction site.

39. MC and TM believe that this would be inadequate to monitor the impacts, and that appropriate baseline data showing groundwater levels and spring-flow rates would need to be collected and incorporated into further modelling and impact analysis in order to properly assess the likely impact of the extraction **before** the development application is approved, or it would risk causing adverse impacts to groundwater and the environmental values it supports.

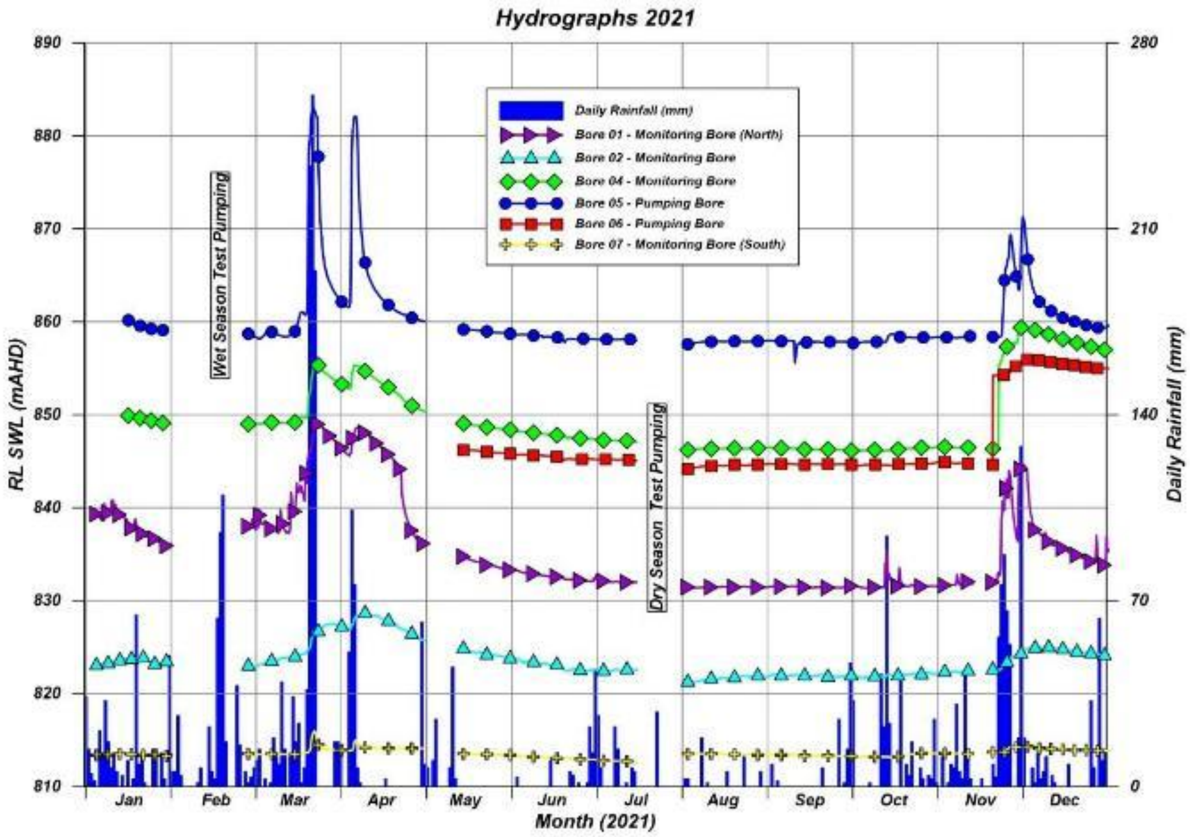


Figure 8 Daily Rainfall and Recorded Groundwater Levels – 2021

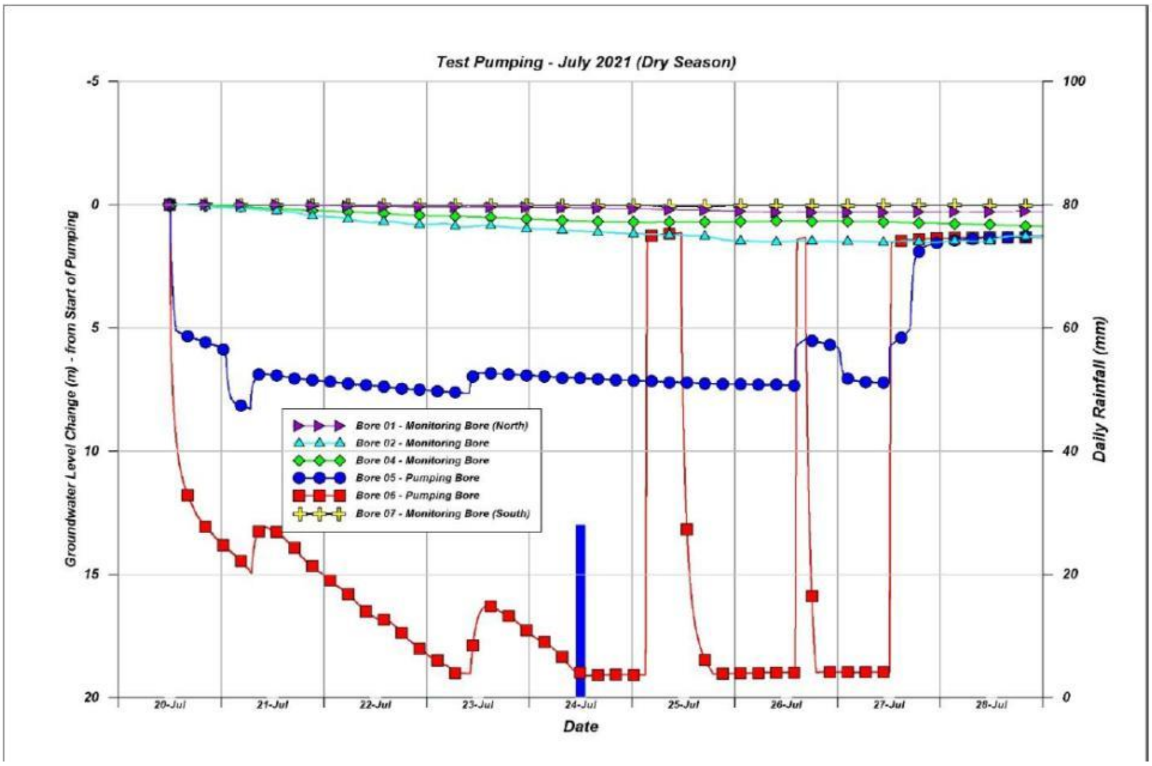


Figure 9 Water level changes during July pumping test

40. TM and MC note that upon reviewing the bore logs provided on the 2nd of March 2022, it is apparent that the bores have been constructed in an inappropriate manner to correctly understand individual aquifer water level and flow behaviour. All boreholes have been constructed with the upper zone (to depths of the order of 10 to 20 m) being sealed with cement or bentonite and then with all subsequent depths having a slotted PVC pipe located inside a surrounding envelope of 5 mm 'pea' gravel. While this may be suitable for optimising water extraction (the goal of the Appellant for this project), it does not enable studies of individual aquifer layers, and the water level trends within these aquifers during pumping at different rates (or in response to rainfall) to be conducted. When TM and MC review the 'Minimum Construction Requirements for Water Bores in Australia' (sourced from Business Queensland: https://www.business.qld.gov.au/industries/mining-energy-water/water/bores-and-groundwater/construction-standards), they note that this document - intended to guide the appropriate construction of bores in Queensland (and nationally) states as follows:

- 'Bores drilled to intersect multiple aquifers will disturb the aquifers by providing a vertical connection between aquifers if not sealed correctly, and a connection can mix different groundwater heads and qualities';
- 'The bore design should take into account the protection of the groundwater resource. Bores drilled to intersect an aquifer will disturb that aquifer and can provide a vertical connection between aquifers of different heads or ground water qualities'; and
- 'Where multiple aquifers are encountered, the key element of the bore design for aquifer protection is to ensure that waters in different aquifers do not mix, either in the bore casing or in the annulus between the casing and the borehole. Sometimes multiple aquifers may be penetrated before the targeted aquifer. In these instances, it is often easier to ensure there is no possible mixing of waters by grouting the annulus from the production aquifer to the surface.

41. TJ says that the bores on the Hoffmann site have not been constructed "inappropriately". In the real world, people construct bores of this type for water extraction purposes, not to provide information about the theoretical behaviour of those aquifers. The only consideration which Hoffmann had in constructing the bores was to achieve the desired rate of water extraction. Once again, the data is simply what it is based on the available bores.

42. TM and MC note that as a result of the fact that the design of the bores does not align with the principles of the minimum bore construction requirements (as outlined above):

- The data produced from these bores for monitoring purposes is not of high quality – e.g., it does not allow for full understanding of key hydrogeological characteristics, such as the number of aquifers within the basalt, their response to rainfall and pumping, and connectivity between different aquifers or aquifer zones; and
- The bores have created a potential future risk of increasing inter-aquifer mixing of water and any potential pollutants between zones that may have otherwise been separated, due to variations in geology.

43. TJ says that the issues raised by MC and TM about bore construction are irrelevant. There is no requirement for the bores to have been constructed in the manner proposed. There is no reason why the nominated bores cannot be used for water extraction. This is not an academic exercise. It is a practical and cost effective solution to allow water to be extracted from a series of aquifers. Are MC and TM really contending that there is likely to be some contamination in upper perched aquifers which will affect regional water quality. It is clear from the monitoring and drilling data records that perched aquifers exist. The proposed pumping can only affect the regional water table, and that is what is monitored by the deepest screened interval, supplemented by some water cascading down the gravel pack. It is pointless monitoring perched aquifers, as they will not respond to a pumping test or give any idea of the groundwater resource.

44. TM and MC note that the proponent claims that the second (July) pumping test (Hair affidavit) was 'conservative' in its estimation of drawdown due to extraction, because water was pumped at a greater rate than the desired amount (reportedly 0.6 L/second was pumped compared with the proposed long-term extraction rate of 0.5 L/second). TM and MC note that this is incorrect, as the monitoring data for Bore 6 (Figure 9) shows that it was 'pumped dry' a number of times (first on the 23rd of July 2021 and then again for long periods on the subsequent four days). The actual average rate of extraction over the 7-day period, encompassing these periods in which Bore 6 was dry, was almost the same as the desired extraction rate (i.e., ~0.5 L/s). The fact that the bore went dry after a relatively short period of pumping is further evidence that extraction at the proposed rate will deplete the groundwater in the aquifer during relatively dry periods.

45. TJ has stated in numerous affidavits to the Court that he has placed no reliance on the text in the Hair reports. TJ accepts that Bore 6 probably does not connect to a large groundwater resource, and that it would be preferable to use Bore 5 as one of the production bores. Perhaps Bore 6 may only be useable during wetter months. MC believes that the uncertainty about connectivity between Bore 6 and a 'large groundwater resource' which TJ refers to, further shows the need for monitoring bores that are constructed according to the Minimum Construction Requirements, to properly establish the number of aquifer units and their connectivity.

46. Based on the **SLR report (of the 11th of April, 2022)**, TM and MC have the following commentary:

47. TM and MC note that data from Borehole 7 was included in the SLR analysis which is incorrect when it is clearly different to all other boreholes, monitoring groundwater in the rhyolite, not basalt aquifer. TM and MC believe that data from this bore should be excluded from the analysis (see Paragraph 30 above). Because the groundwater level in the bore was in the Rhyolite prior to the test (below the basalt), it would not be able to be drawn down by pumping in the over-lying basalt aquifer(s) unless there was significant inter-aquifer connectivity (which is considered highly unlikely – see paragraph **3**).

48. TJ says that he does not agree. It is clear that the monitored level in Bore 7 has validity due to its connectivity with the overlying basalt through the gravel pack. In that regard, it is identical to the other bores which MC and TM accept as valid. Compartmentalisation is a valid and reasonable explanation for the lack of observed drawdown at the southern boundary.

49. TM and MC note the use of incorrect (or highly questionable) rainfall data in the analysis at SLR Report Paragraph 16. Bureau of Meteorology (BOM) rainfall gauges showed 521.4 mm at Lower Springbrook Alert and 489 mm at Springbrook Road, an average of 505 mm over the three days mentioned, as compared to the 688 mm used in the SLR analysis.

50. TJ says that the rainfall used in the analysis was based on actual recorded rainfall at the site, which is likely to be a much more realistic estimate of the rain falling above 830 m AHD than any of the stations nominated by MC and TM. The rainfall used was accurate, and certainly not incorrect. Hair in his 2022 report states

> The property is in one of the highest rainfall areas on Springbrook Plateau and in Southeast Queensland. During 2021, the property received more than 3,700 mm of rainfall with almost 70% occurring in the Wet Season months of January, February and March, November and December. Daily rainfall totals are plotted as a bar chart on Figure 2. The highest rainfall days occurred during 22 March to 24 March inclusive, when daily totals of 234 mm, 260 mm and 194 mm were recorded. Rainfall over

51. TM and MC believe it is not proven that the rainfall data quoted are accurate, and state that they place much greater trust in calibrated and carefully operated BOM rainfall gauges than they do in data collected on site by the proponent. They note that the Springbrook Road gauge is at an elevation of 697m and hence is actually 130m lower than the 263 Repeater Station Road site, not 'hundreds of metres' as overstated by TJ in paragraph 53. MC has further inspected the data from the Springbrook Forestry station (another BOM station with data available on the government's SILO database), located at an elevation of 806 m and only 1.5 km away from the site. The total rainfall over the three-day period of March 22nd to 24th at this gauge was 403.2 mm – more than 200 mm less than the data collected by the proponent. The significantly lower rainfall totals at **multiple** Bureau of Meteorology gauges in the area compared to the rainfall data collected by the appellant calls into question the validity of the latter rainfall data.

52. TM and MC note that the estimation of specific yield (S_y) values is an important part of the drawdown modelling, and they believe that the S_y values presented in Table 1 of the SLR report have been over-estimated. A low S_y value means that a greater amount of drawdown will be experienced for a given volume of water pumping compared to an aquifer with a greater S_y. Over-estimation of S_y (as seems apparent to TM and MC) therefore underestimates drawdown. As a general point, the large water level rises observed following rain events at the site indicate limited porosity and therefore low specific yield.

53. TJ says that the derived S_y value is correct and theoretically supportable on the basis of the rainfalls recorded at the site (688 mm) rather than the much lower values relied on by MC and TM which were recorded at significantly lower levels. The groundwater expressing at the site is clearly proportional to the rainfall recorded above the level of 830 m AHD rather than the rainfalls recorded at sites hundreds of metres lower in the Mountain. It is agreed that the water level rises do indicate limited porosity and low specific yield. However, this is no reason to question the S_y values derived correctly from the data by SLR Consulting.

54. TM and MC maintain that the rainfall data mentioned by TJ is unreliable, and inconsistent with the best available data from the Bureau of Meteorology and SILO database. Further that there are other assumptions apart from the choice of rainfall data (outlined below) which make the S_y estimates in SLR, 2022 unreliable, and probably significantly over-estimated.

55. TM and MC note that Table 1 of the SLR report includes Borehole 7 (which does not provide reliable groundwater level data from the aquifer in question, as explained in paragraphs **30**, **0** and **47)** and uses inappropriate rainfall data. When Borehole 7 (which has a water level in rhyolite and thus does not monitor the basalt aquifer effectively) is excluded, and when the more appropriate rainfall (see Paragraph 51 above) is used, S_y estimates from the event in question range from 7% to 0.7%, not 10% to 1% as proposed by SLR.

- TM and MC further note that the S_y value of 7% is associated with an f = 1 value, which means that 100% of rainfall infiltrates to the water table, which is extremely unlikely, if not impossible. A significant proportion of rainfall is likely to become surface runoff, and some is also likely to be rapidly consumed by vegetation before reaching the water table. At a national scale, the conversion of rainfall to recharge is typically between 1% and 10% of rainfall over the majority of Australia (excluding the tropics), which corresponds to f values of 0.01 to 0.1 (Crosbie et al., 2010[1]; CSIRO, 2011[2]), i.e., ten times lower than the range of f values used in SLR, 2022.
- TM and MC feel that an f = 0.1 value is more realistic, with an absolute upper maximum value of 0.3 (i.e., 30% of rainfall is converted to groundwater recharge). The CSIRO's national scale review of recharge rates for Australia showed that in Queensland, measured recharge ranged from rates of less than 1% of rainfall converted to recharge (in the Qld Murray Darling Basin) to a maximum of 33%, in the wet tropics (Crosbie et al., 2010), which would be expected to have higher conversion of rainfall to recharge than Springbrook. Based on the above analysis, the S_y value should be of the order of 0.7% (0.007) to 2.1% (0.021).
- TM and MC note that using the next significant rain event (April 5th to 7th, 2021) where approximately 164 mm of rainfall occurred (according to the data from the Springbrook Rd BOM station), and between 2 and 20 m of water table rise was observed in bores 1, 4 and 5, assuming an f of 0.1 to 0.3 (a generous assumption), the S_y values would be approximately 0.8 to 2.5%.
- TM and MC believe that using these lower (more realistic) S_y values in the modelling would result in greater drawdown values than have been presented in the SLR report.

56. TJ says that the SLR Consulting analysis did not use an f factor of 1. It was simply presented in a range of possible values. TJ agrees that the use of such a factor would mean that all rain falling on the catchment would be converted to infiltration, and that this outcome is highly unlikely, albeit not impossible as contended by MC and TM. TJ agrees that an appropriate f value range of between 0.1 and 0.3 is likely, and that based on the measured rainfall of 688 mm, this would produce an S_y value of between 0.01 to 0.03 (that is 0.01 to 0.3%). TJ also believes there is an error in the third dot point above, where the value of 0.08% should probably be 0.8%.

57. MC disagrees and maintains that the calculation of S_y, according to the method outlined in SLR, (2022) and using the values quoted above (paragraph 55, dot point 2) result in S_y in the range of 0.082 to 2.46%. In the modelling documented in SLR, (2022) the range of 'optimised' parameters for the model is reported as Sy values of 1 to 10% (0.01 to 0.1). Hence, according to the analysis above (paragraph 0 and 56), these values over-estimate the likely specific yield, resulting in under-estimation of drawdown (see paragraph **52**).

[1] Crosbie, R et al. 2010. Review of Australian Groundwater Recharge Studies. CSIRO National Research Flagships: Water for a Healthy Country.
[2] CSIRO, 2011. Water: Science and Solutions for Australia. CSIRO Publishing, 192pp.

58. TJ says that in any case, the MC and TM estimates are biased towards the lower values since their rainfall totals are incorrect. Rather than the correct and measured value of 688 mm, they rely on lower (and hence incorrect) rainfall totals from stations significantly downslope of the site.

59. MC and TM contest this and believe the rainfall data quoted by TJ to be unreliable, as per Paragraph 51.

60. TJ confirms that he supports the results of the SLR Consulting model.

61. TJ also notes that excluding bore 7 from the analysis does not affect either the calculated median f value, or the range of 10% to 1% for S_y. However, the principal issue with the MC analysis is that it uses significantly lower rainfall values. There can be no argument that the value of 688 mm recorded at the site is much more relevant than values taken from sites kilometres away and hundreds of metres lower.

62. TM and MC disagree, as outlined in Paragraphs 49 and 51, and maintain that the rainfall data utilised, and the assumed conversion of rainfall to recharge in SLR, 2022, are unreliable. Further, they believe that additional assumptions that are questionable (i.e., not just the disagreement about rainfall totals) are responsible for the over-estimation of Sy values in SLR, 2022. These include the selection of only one rain event (whereas the analysis of other rainfall events and water level rises results in lower estimates of Sy, as outlined in paragraph 0).

63. A further issue with the modelling noted by TM and MC is the assumption of uniform and constant S_y values. The analysis in Table 1 of the SLR report assumes a linear relationship between rainfall event size and recharge, and constant S_y values in space and time. These assumptions are rarely true, as explained by Healy and Cook (2002)[3] and Healy (2010)[4]. It is much more likely that the fraction of rainfall converted to recharge will change depending on the size of the rain event and the pre-existing water table level. During periods of relatively low total rainfall, in which both the overall rainfall and individual rain event size are small (as is common during the July to October dry season at Springbrook), it is likely that effective recharge will be negligible (i.e., f values are likely to be well below 0.1 and may be zero), as most rainfall will be rapidly consumed by vegetation as evapotranspiration. This is important in the later analysis of the potential 'worst case scenario' modelling discussed later in the report.

64. TJ says S_y is a physical property of the aquifer, and is not affected by rainfall events. While rainfall and water level changes are used to calculate S_y, it remains a parameter which is defined solely by aquifer conditions. While TJ accepts that S_y may vary in space, there is no reason to consider that it would vary in the conditions found on this site. In that respect, the water level drawdowns measured on site and used to calibrate the groundwater model are the best available to allow accurate determination of performance under changed rainfall conditions. TJ also notes that the drawdown modelling assumes a period of no rain, effectively adopting an f value of zero for the analysis.

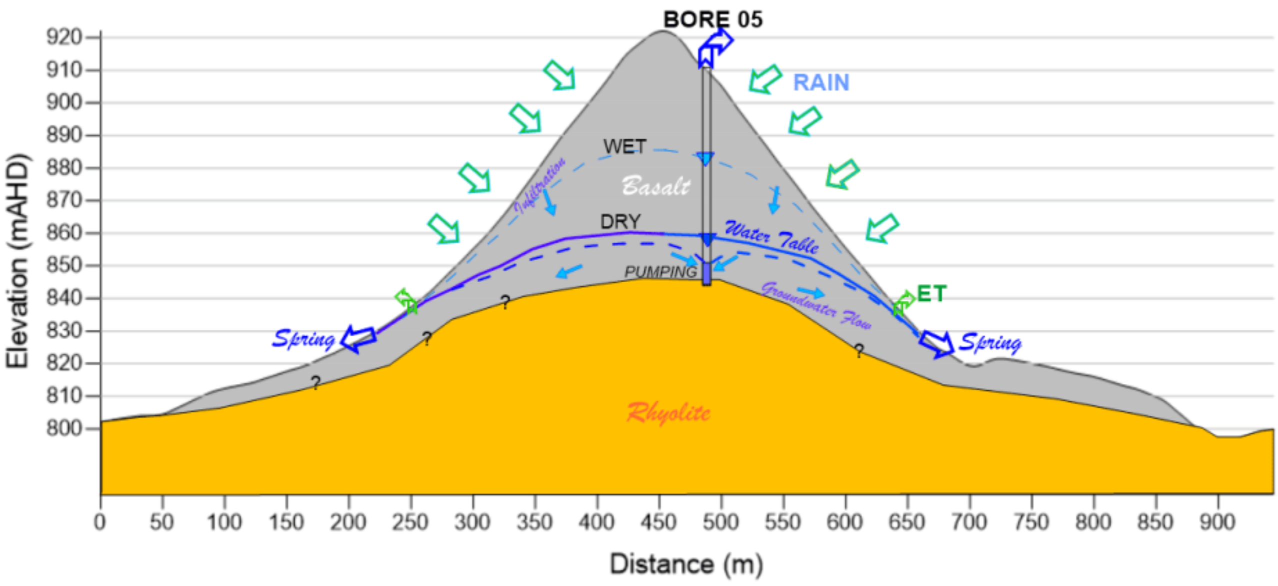
[3] Healy, R.W., Cook, P.G., 2002. Using groundwater levels to estimate recharge. Hydrogeology Journal 10: 91-109
[4] Healy, R.W. 2010. Estimating groundwater recharge. Cambridge University Press.

65. MC disagrees, noting that the treatment of S_y as a fixed aquifer parameter, independent of time, does not account for the time required for drainage of water from the soil and rock as outlined by Healy and Cook (two eminent global experts in groundwater recharge):

> "Specific yield is [often] treated as a storage term, independent of time, that in theory accounts for the instantaneous release of water from storage. In reality, the release of water is not instantaneous. Rather, the release can take an exceptionally long time, especially for fine-grained sediments. King (1899) determined S_y to be 0.20 for a fine sand; however, it took two and a half years of drainage to obtain that value. The limitations of this definition are noted by Meinzer (1923), who also points out that it does not account for temperature and chemical effects." (Healy and Cook, 2002).

Healy and Cook further outline the impact of non-linear behaviour of soil moisture curves during wetting vs. drying periods. This supports the fact that S_y values are typically time-variable as well as spatially variable.

66. TJ says that what may be theoretically correct is not always amenable to approximate numeric modelling techniques. The intent of the modelling here was to establish the values for key parameters in an approximate range, ie "in the ballpark". All natural environment models are inherently incorrect to some degree since the mathematics of the solution, ie the "algorithm" in today's language, is only an approximate description of the physical process. A strong aphorism is that all models are wrong, some are useful. The key is knowing what information to take from the model, and how to use that information in drawing conclusions. TJ notes that he relies on the following conceptual groundwater model in considering how extraction might affect downstream areas.



. **Conceptual model of groundwater processes during dry, wet and pumping conditions**

Figure 10 – SLR Conceptual Groundwater Model

67. TM and MC note that in Para 24 of the SLR report, the K value should be 0.043 m/day (assuming f=0.1) and cannot be as high as 0.43, which would imply 100% rainfall is converted to recharge. An absolute maximum based on this method of estimation would be 0.13 (based on a maximum f value of 0.3, see above). TM and MC note that this method of estimation is also flawed for the setting in question (see below).

68. TJ says that the aim of the analysis was to determine a realistic range for S_y, and he considers that the SLR Consulting work achieves this. TJ accepts that the work is obviously approximate. However, it was fit for purpose, which was to estimate maximum drawdown which might occur along the west-east axis on the site. MC is putting theoretical objections forward which do not affect the merit of the SLR Consulting work.

69. MC disagrees and maintains that these objections are not merely theoretical, but critically important limitations and/or errors in the modelling work which require resolution to properly characterise the likely level of impact of the proposed extraction.

70. In regard to the modelling conducted by SLR, TM and MC have the following further concerns and questions;

    - TM and MC question why the model was calibrated to data collected in a wet period. At the very least, TM and MC believe that **both** dry and wet season model calibrations should have been conducted and the degree of fit assessed for both sets of conditions.
    - Alternatively, TM and MC state that if the model was calibrated to wet condition data, it should have been validated to dry period data.
    - TM and MC note that the model calibration by SLR has produced K values of 0.3 m/day, which is too high, as highlighted at Paragraph 67 above. Also, the S_y values do not match the data presented in the early SLR analysis. Specifically:
        - The 'calibration' K value of 0.3 m/day compares with the more appropriate estimate of 0.043 m/day (with a maximum of 0.13 m/day) – see Paragraph 67; and
        - The 'calibration' S_y values of 0.01 and 0.1 compare with the more appropriate estimate of 0.007 to 0.021 – see second dot point in Paragraph 55.
    - TM and MC do not accept the modelling, as a result of these potential parameter estimation errors, and the uncertainty associated with the applicability of the selected equations to a system that is clearly not uniform - i.e., the geology is heterogeneous, as acknowledged in Paragraphs 14 and 15 of the SLR 2022 report, yet a model that applies uniform aquifer parameters and geometry is applied to estimate the drawdown. They note Para 19 of the SLR report contradicts Para 15 which states that the T is not uniform, and the aquifer may be 'compartmentalised'. Modelling a radially symmetrical cone of depression in this context is misleading and likely to be inaccurate.
    - TM and MC note that the 'long-term simulation' uses model coefficients calibrated based on wet period data and takes no direct account of rainfall recharge. This has to be addressed. At the very least, the model should have been calibrated to dry period data such that any long-term simulations have a realistic basis of fact and model constituents are derived from a period when there was little rainfall.

71. TJ says that the aim of the calibration was to infer K_x, K_y and S_y. In that respect, there was never an intent to include rainfall in the modelling exercise, which would have made the model much more complex. The intent was to consider the worst-case scenario, where there was no recharge of the aquifer by rain falling on the catchment. In that respect, the analysis does achieve its aim, which was simply to determine the likely maximum drawdown which could reasonably occur in the aquifer. In fact, since the analysis does not include rainfall, the difference between wet and dry datasets is simply the adopted starting water level. Further, the use of wet weather data for this purpose will produce greater drawdowns than for a corresponding dry weather analysis. TJ reiterates that this is a real world exercise where the data available is limited. Notwithstanding the limitations on this data, it is sufficient in his opinion to support the conclusion that the proposed extraction of water from this aquifer will have no unacceptable impacts, if only because the predicted changes are well within the range of levels which will exist under natural (i.e. no extraction) conditions.TM and MC disagree that the modelling represents a 'worst-case' scenario and maintain that inappropriate assumptions in the modelling (e.g. paragraph 62 and 70) have likely led to under-estimation of the extent of drawdown, even under the assumption of 90 days of no rainfall (this is further discussed under paragraph 90 and 0).

72. TJ says that MC and TM attempt to portray the information used in the SLR Consulting analysis as "erroneous". In fact, the analysis adopts reasonable estimates for analysis purposes in TJ's opinion, and those of the hydrogeologists who set up the model. MC and TM may argue about the reasonableness of the assumptions, but the results are not erroneous. There is no high ground of absolute right in this assessment, there is only informed judgement based on experience and expertise. While MC and TM are critical of the modelling, they offer no viable alternatives. Lastly, TJ notes that MC and TM state that the SLR Consulting model has used uniform aquifer parameters and geometry. This is clearly not the case. The model adopts anisotropy as its starting position, and also notes that likely west-east compartmentalisation would result in lower predicted drawdowns.

73. TM and MC strongly disagree with the above opinions (Paragraphs 71 and 72), pointing to major flaws in the model's assumptions that do not reflect the reality of the site – for example the use of a highly simplified, homogeneous aquifer geometry and flat water table (when the field data clearly show this is not true), the assumption of a 10 m-thick seepage face (which contradicts the observations from site visits – see paragraph **0** and **35**035) and aquifer parameters (S_y and K) that have been calculated using questionable methods and unreliable data (paragraph **67** and **70**). While TM and MC agree that groundwater modelling can never perfectly replicate the behaviour of an aquifer system in every regard, they believe that the modelling presented is definitely not fit-for the purpose at hand, as it is too far from reflecting the reality of the site, and based on incomplete and questionable field data. They believe (contrary to TJ's portrayal of their opinion in paragraph 72) there are indeed viable alternative approaches to the modelling reported in SLR, (2022) including:

    a) A more data-driven, field-based approach to the problem, which carefully monitors groundwater levels over a wider area (including to the east and west of the pumping bores), using properly constructed monitoring bores, and which also maps the locations of groundwater seepages, measures groundwater discharges from springs, and records the changes over time in these flow rates under different climate conditions and pumping rates. Combining these measurements with determination of ecological relationships between groundwater and biota (as outlined by Todd, 2011 in the paragraphs quoted in the Points of Agreement), working in conjunction with suitably qualified ecologists.

    b) The development of a finite-difference or finite-element numerical groundwater model, populated with appropriate aquifer parameters (K and S_y) groundwater recharge and discharge rates, and aquifer geology and geometry that are determined using appropriate field techniques (such as those outlined in paragraphs 3e, 4b, 6b of the first groundwater JER).

74. A combination of these two approaches would be the ideal solution to properly understand the likely impacts of the proposed extraction on groundwater and associated environmental values.

75. TJ notes that MC and TM do not attempt to put a cost on the level of investigation which they say is necessary to resolve the question of what impact will occur as a consequence of the proposed extraction. It is not necessary to collect reams of data at multiple sites over several years to come to the conclusion that the extraction of 16 ML of water from the Springbrook Aquifer is unlikely to have any impact external to the site. It just needs common sense to start from the position that the removal of 16 ML of groundwater from a catchment (only down to the 830 m AHD level) which receives over 9,270 ML of rainfall per annum on average is unlikely to be problematic, particularly on the basis that changes in the order of 5 to 10% are likely to be well within the range of normal variation.

76. TM and MC strongly disagree with this over-simplified analysis of the issue, and with TJ's estimate of 9,270 ML/yr as an appropriate figure to compare with the proposed extraction, as explained by TM in the first JER. They believe this is a gross overstatement which analyses the water budget at far too large a scale.

77. TJ says that the modelling which was undertaken is likely to be conservative in that it will overestimate the maximum drawdown likely to occur. The modelling is clearly not radially symmetric, but elliptical, with increased impacts in the west-east direction compared to the south-north direction. This represents the likely shape of the drawdown cone and is not misleading in any way. TM and MC disagree, as outlined in paragraphs **70** and **0**).

78. TM and MC state that (further to their opinions regarding the inappropriateness of the model's assumptions outlined in paragraph 70), there is no data presented to confirm that the spring discharge is a constant head boundary. The water table in the vicinity of the spring (and the discharge rate from the spring) is likely to vary considerably, invalidating this assumption in the model. The lack of water table or spring flow modelling in the area of the springs means that it cannot be properly verified. Estimation of K using the method outlined in Para 22 of the SLR Report in this context is not reliable.

79. TJ says that MC has consistently argued that any change in groundwater level at the point of the spring as a result of extraction would be highly problematic, in that it would signal a reduction in surface flow rate, which was somehow important for downstream conditions. TJ has never agreed with this position since it seems obvious that the flow from one or even several springs is unlikely to be important in the overall context of the quantum of the downstream flow. However, it appears that MC now accepts that there will be significant variation in the spring level under natural conditions which must mean that natural flow rates are also highly variable. TJ believes the adoption of a constant head boundary at the spring is considered to be an effective modelling tool which simplifies the analysis without having any significant impact on the results. Lastly, TJ notes that estimation of K in the manner undertaken is perfectly reasonable in a context where an approximate range of values is required to be calculated.

80. MC and TM disagree (as outlined in paragraph **70** and elsewhere).

81. MC believes that paragraph 80 is a mis-representation of his opinion. He indeed believes that the water table and spring flow rates are likely to vary through time (he has never stated otherwise) and that what is important is the likely **additional** reduction of groundwater levels and spring discharge caused by the proposed extraction. According to the data contained in the Hair affidavit, this may be considerable. He believes that reduction in current minimum seasonal groundwater levels will likely cause spring flows to drop below current minimum levels (as described in the first paragraph of Todd, 2011, quoted in paragraph **8**) and they could potentially cease to flow completely during low rainfall periods due to the proposed extraction.

82. TM and MC note that SLR Para 25 (flat hydraulic gradient near the bore) contradicts Para 14 which proposes the hydraulic gradient in dry times to be 50% (which TM and MC note is an extremely large gradient).

83. TJ says that there is no inconsistency here. The context of paragraph 25 relates to a cross-section across the site in a west-east direction, with a flat gradient near the bore. The context of paragraph 14 is in respect of a north-south section parallel to the ridge. Both conditions can occur simultaneously without conflict.

84. MC believes there are no field data to support this assumption and it remains questionable.

85. TM and MC note that drawdown of the water table, and reduction of groundwater discharge to the surface are also almost certain to occur on the western side of the bores, and to the west of Repeater Station Rd, outside the property boundary. This contradicts the opinion in SLR (2022) that 'It can be reasonably concluded that the proposed extraction of groundwater at this site will have no impact on aquifer conditions external to the site itself' (paragraph 42 of SLR, 2022).

86. TJ says that the groundwater model shows insignificant drawdown at both the western and eastern boundaries of the site. MC and TM ignore the fact that the extraction point is located somewhat downslope from and east of the ridge. It is simple matter of geography that the elliptical drawdown surface is therefore greater on the east than the west.

87. TM and MC note that the modelled drawdown shown in Figure 6 of SLR, (2022) (reproduced below) clearly extends well beyond the western boundary of the property, in direct contradiction of TJ's opinion:

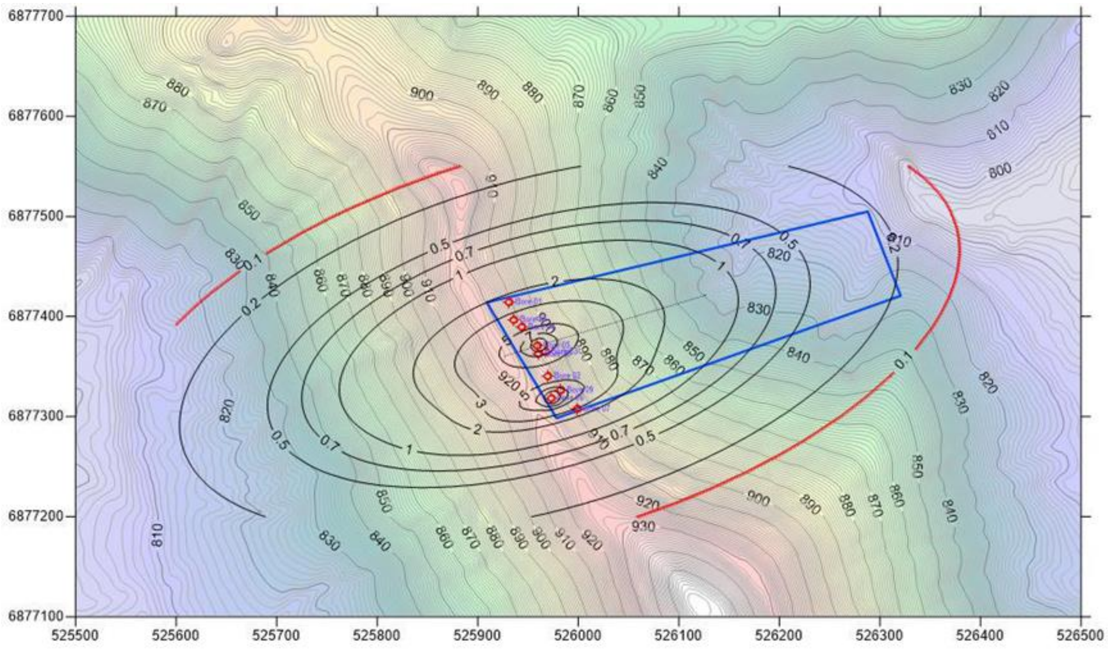


Figure 11 – Modelled drawdown under no-rainfall scenario (reproduced from SLR, 2022).

88. TJ accepts that there are water table level impacts on the western side of the ridgeline, but that these impacts are unlikely to be unacceptable for the same reasons that the eastern impacts are not unacceptable.

89. In addition to the above points raised by both TM and MC, MC has the following concerns

90. In Paragraphs 34 to 37 of the SLR Report, the report claims that a 'worst case scenario' has been modelled, and that the impact of groundwater extraction under this scenario is 'inconsequential'. MC does not agree with this assessment for the following reasons:

   - While it is true there is unlikely to be zero rainfall occurring for 90-day periods at Springbrook, there are multiple periods in the past when rainfall has been very low for a period of more than 90 days. For example, the period 1st July to 1st October 2017 recorded only 46.4 mm (at Springbrook Road BOM station), while 10th July to 10th October 2019 recorded 68.5 mm total. Lower rainfall totals were recorded during these 3-month intervals at the Springbrook Forestry rainfall monitoring station (data available on SILO). The largest individual daily rain event in the 2017 dry period was 13 mm, while in the 2019 dry period it was 28 mm. During such periods, it is likely that there will have been effectively no (or negligible) groundwater recharge taking place to the aquifer, as the vadose zone would be dry, and plants would consume any rainwater as evapotranspiration before it reaches the water table. This opinion is supported by Todd, (2011), who noted that effective aquifer recharge to the Tambourine Mountain aquifer - which has the same or a very similar geological setting, probably only takes place following rain events of over 30 mm:

     > "Rainfall events of 30-40 mm or less do not usually result in recharge to groundwater, due to evapotranspiration losses, unless they follow soon after a prior event[5]."

   - As such, simulating a 90-day period of no rainfall is not (from the perspective of aquifer recharge) an absolute 'worst case scenario', but rather something likely to occur relatively frequently into the future. This also considers the best available climate modelling, which indicates that the frequency of severe and extreme drought and the duration of droughts, are all likely to become more frequent and severe on the Springbrook Plateau in the coming decades (see Groundwater JER paragraph 21a).

91. TJ says the table of statistics on 90-day rainfalls presented in the SLR Consulting report is correct and shows that the events discussed by MC in the first dot point above are currently both much less than the 5th percentile, i.e. very rare. MC then suggests that climate change will make such events much more common. This may or may not be the case. Climate change predictions are based on global climate change models which may or may not be shown to be accurate in the future. Unfortunately, there is no opportunity for commerce or the world generally to simply shut down in the face of whatever climate change occurs. If the climate at Springbrook does become significantly drier in the future, then this proposed operation may become non-viable. However, that is not a reason to do nothing. If the use is determined in the future to be non-viable, then it will cease in accordance with the likely conditions of approval.

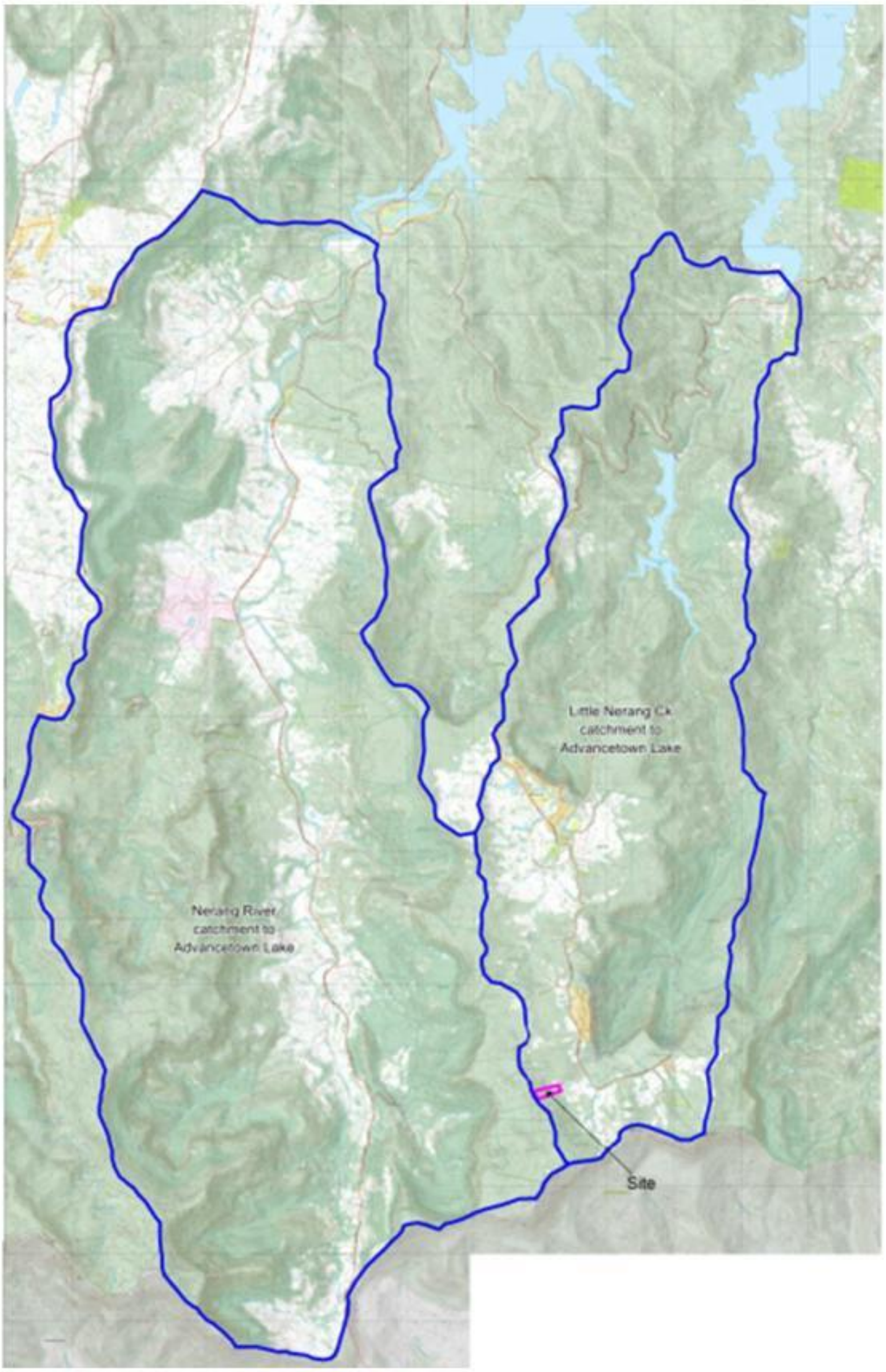
[5] Todd, A. 2011. Groundwater Investigation Tamborine Mountain, SE Queensland. Queensland University of Technology technical report to South East Queensland Catchments Ltd.

92. MC notes that Para 35 of the SLR report states that ‘Spring discharge occurs between 820 and 830 m AHD’ which is not correct. While the modelling conducted to predict drawdown during such periods of no recharge is speculative and makes assumptions that are unsupported by field data (see above), it indicates that drawdown in excess of 1 m is likely to occur during these dry periods at the elevation of springs mapped on the property. The spring referred to in the SLR report is one of a number of groundwater discharge features on both the east and west of the site between elevations of approximately 830 and 835 m AHD. These features are mapped in the affidavit of Elanor Fenge (see Document 1 of the Affidavit and accompanying photos). MC notes that during his site inspection, which occurred towards the end of the 2021 dry season, these groundwater discharge features were flowing, but at relatively low rates. These features would be expected to experience drawdown impacts as a result of the proposed groundwater extraction, based on the extent of drawdown observed during the dry season pumping test, as well as a reduction in water flow from the ridgeline where the bores are located, as this water is ‘captured’ by the extraction bores before it can reach the location of the springs. See first groundwater JER paragraph 8 which indicates that all experts agree the water that would be extracted by the bores would ‘otherwise flow, via groundwater discharge from seeps and springs to surface water sites at lower elevations, including any existing GDEs, as well as Twin Falls and Cave Creek, which are sites of considerable environmental and regional tourism significance.’

93. TJ states that MC and TM prefer the word “error” to misrepresent the analysis, when it is clear that the adoption of certain parameters in the analysis is not an error but a matter of judgement. A review of Google Earth images overlain with contours supports the view that the springs generally operate around the site in the range from 820 to 830 m AHD. In any case, TJ believes this argument about the level of springs is largely moot. The only issue here is whether the extraction of water from the aquifer is likely to deprive the natural environment downstream of the site of sustaining flows.

94. MC disagrees that the issue of the Springs is ‘moot’. The springs are located at the top of the local catchment and the water from them sustains surface water bodies downstream. Reduction in these flows thus will result in a reduction in surface water flows downstream (see, for example, paragraph 100). He further points out that the accuracy of Google Earth images to determine the elevation of spring flows is a highly approximate method, and that the field evidence (as discussed in paragraph 0 and 35) contradicts TJ’s analysis of the springs’ elevation (upon which the SLR, 2022 modelling is based). The opinion that there is likely to be 10 m of available drawdown before the springs cease to flow (Paragraph 35 of SLR, 2022) is unfounded – as the saturated thickness of the aquifer and water table height at the springs has not been determined - and it is not consistent with the field evidence. He points out that it is not known how much drawdown the spring referred to in Paragraph 34 of the SLR report and other springs and seeps mapped to the east and west of the bores can tolerate before ceasing to flow completely. In the dry season, the additional drawdown caused by the extraction (the subject of the modelling) may be the difference between springs flowing with water, and ceasing to flow entirely.

95. TJ believes that the extraction clearly does not capture all of the seepage water between the extraction point and spring, even on this property alone. It is only common sense to conclude that the volume of water extracted from one small site (16 ML) can have no measurable effect on the overall functioning of the downstream ecosystem which covers many thousands of hectares. In his report of 24 December 2021 which has been submitted to the Court, TJ presented the following map which shows just how insignificant this site is in the context of the overall catchment.



96. MC believes that groundwater and associated spring flows observed on the site and surrounding properties, as well as World Heritage sites such as Twin Falls (see paragraph 100), depend on water flows from a much smaller catchment area than is shown in the above figure, and that the proposed 16 ML of extraction is likely to be significant when analysing these impacts at a smaller scale, as is appropriate for assessing impacts according to the definition outlined in Paragraph 7. Viewing the site at a very large scale shown in the above map does not allow for a proper analysis of the primary question of interest (as agreed in paragraph 7) – i.e., whether the proposed extraction is likely to cause an adverse impact **external to the site**. This definition encompasses areas much closer to the site than can be appropriately analysed the large scale of the above map.

97. MC considers that a likely scenario is that the spring (and other groundwater discharge points directly east and west of the bores) require the water table to be constantly above a threshold elevation of approximately 830 m AHD, where fracturing in the basalt geology allows groundwater to flow (through the aquifer as per the analogy in the preamble) to the surface. If the elevation of this fracturing is near the seasonal water table minimum - as the restricted elevation of discharge observed in the field appears to indicate, any additional drawdown caused by the pumping bores will cause complete drying of the spring(s) and seeps. This view is consistent with the conclusion of Todd (2011) for the Tamborine Mountain aquifer system (which is agreed by all the experts to be a highly similar setting to Springbrook):

> "Small decreases in water table height, or aquifer surface level, can result in a significant reduction in water supply to these groundwater dependent ecosystems (GDEs). Flow can cease over a disproportionally large area depending on surface slope and geology"

98. If this scenario were to be true at the site, then it would cause (in line with the agreed definition of an 'impact' in paragraph 7) 'actionable nuisance external to the site' by depriving nearby downstream sites of this source of water (see paragraph 100).

99. TJ says that Todd concluded that the extraction of water from the Tamborine Mountain aquifer was "sustainable over the long term" even considering the point that he made about individual impacts at particular locations.

100. MC notes that loss of spring flow as described above would reduce flows not just on the site itself, but also to Twin Falls to the east of the bores (fed by the tributary to Boy Ull creek, which begins at the spring and which has a much smaller catchment area than shown in the map TJ provides above). The photograph below (Plate 1) shows that during dry periods (e.g. following the 2017 dry spell) Twin Falls is sustained by a very small amount of baseflow, and as such the loss of spring discharge from the site may reduce water flowing to the falls by a high proportion at such times.

Twin Falls, Springbrook National Park, in full flow Photo: Andras Deak

Twin Falls, Springbrook National Park, September 2017 Photo: Catherine Ash

Plate 1: Twin Falls during different periods of climate. The image on the right shows that the falls are sustained by limited amounts of baseflow (likely including groundwater discharge from the spring to the east of the extraction bores), and are thus vulnerable to further flow reduction as a result of the proposed extraction.

101. TJ says that the flows to the waterfall shown above come from a catchment which is many times larger than the site itself. Changes at the extraction site will have no discernible effect on the rate of flow at the falls. TJ says that this information is irrelevant to the argument, and is simply another way of presenting MC's opinion that a change in groundwater conditions is unacceptable. Waterfalls make pretty pictures, but the issue here is whether the extraction of a small volume of groundwater (in comparison to volumes of both rainfall and groundwater recharge) will cause unacceptable adverse impact. The natural variation which MC highlights in this photo comparison is the very reason why the proposed extraction is unlikely to cause any detectable change in downstream conditions.

102. MC points out that he has never stated that 'no change in groundwater conditions is acceptable' and maintains that a loss of flow from one or more springs on the appellant's property due to the groundwater extraction (a plausible scenario based on current data) may cause a significant material difference in the flow of water to Twin Falls during extended low rainfall periods. He believes that a combination of water table monitoring near the springs, improved characterisation of the thickness and porosity of the aquifer in this region, and gauging of the rate of flow from springs at different water table levels are essential to fully understand the level of risk to the springs and other groundwater seeps (which may cease to flow during periods of groundwater extraction by the bores). This work is required to understand the level of risk and impact from the proposed groundwater extraction.

103. MC believes that in addition to the likely impacts on surface water flows to the east of the bores noted above, flow of groundwater to Cave Creek (to the west of the site) may also be impacted, as it crosses the 830 m contour to the southwest of the bores (albeit at a greater distance than the spring which ultimately feeds Twin Falls to the east). This creek sustains flows to Natural Arch, another site of high cultural significance. The springs and seeps to the west of Repeater Station Rd that were documented in the affidavit of Elanor Fenge also likely provide important environmental water; for example, a crayfish was identified in the small spring mapped to the west of the bores (site W2 in the affidavit) at elevation of approximately 831 m AHD (Plate 2 below).

104. TJ says that along the axis downdip from the site, Cave Creek crosses the 795 m AHD contour. The 835 m AHD crossing is a substantial distance from this point.

105. TJ does not understand how a photo of a crayfish at a site somewhere on the Mountain is in any way relevant to the matter being considered by the groundwater experts. TJ is not an expert in astacology (the study of crayfish), and can make no meaningful response to these photographs.

Location W2

Location W2

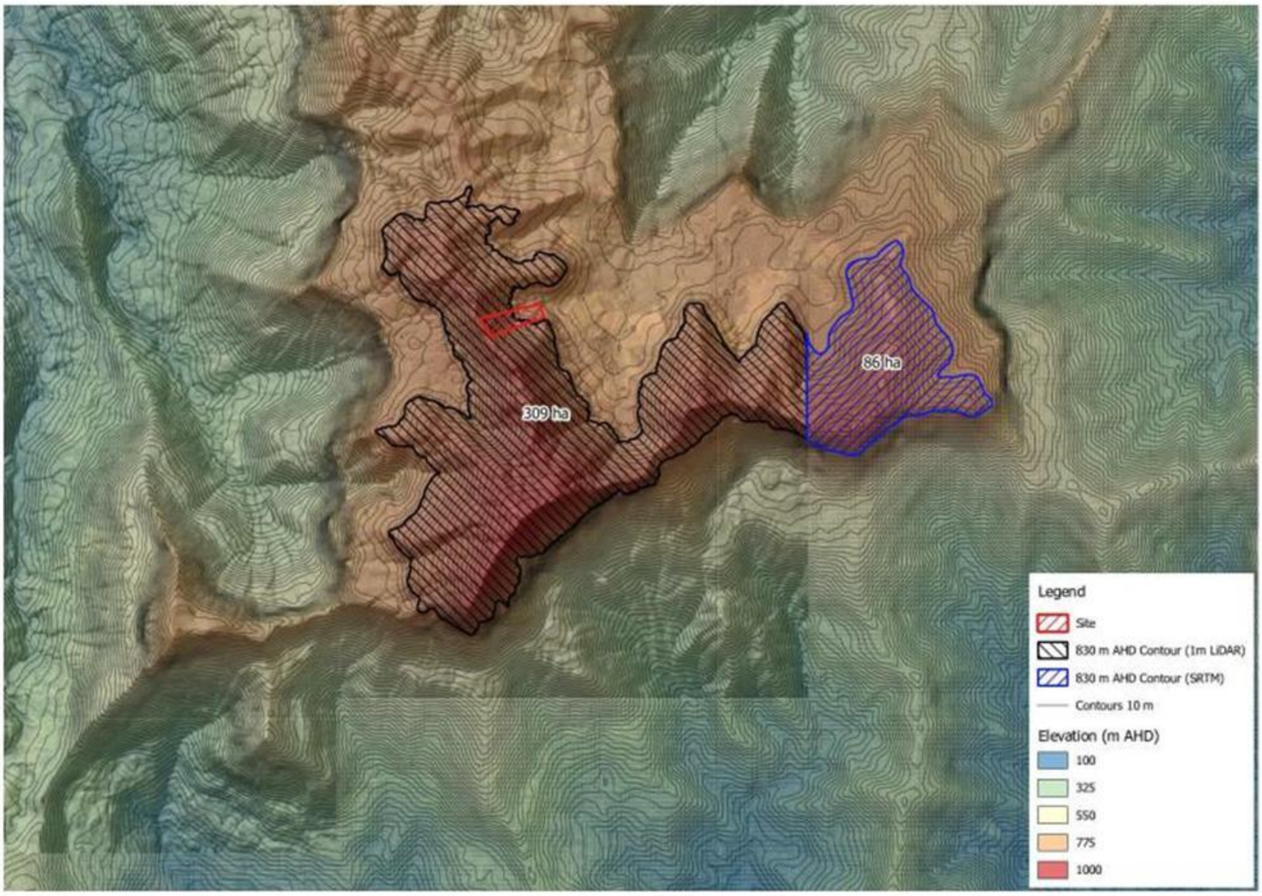
Plate 2: Small groundwater spring to the west of the extraction bores (outside the property boundary) which occurs at elevation of approximately 831 m AHD, which provides habitat for crayfish.

106. The overall **conclusions** that TM and MC draw from the above points raised are as follows:

107. Modelling of the kind conducted in SLR, 2022 can be useful, when it aligns with field observations. In this case, there are many field observations that are either missing, or which contradict the assumptions made in the modelling presented. So, the conclusion after this analysis is that the modelling is flawed and needs considerable work. Hence, TM and MC return to the fundamental argument that the Hair Affidavit dry weather pump test showed drawdown of 0.3m at the northern boundary of the site after seven days of pumping, and the groundwater level data was continuing to trend downwards, which would in turn demonstrates **unquestionably** that the project will cause **actionable nuisance** external to the site on which the development is located. Until the SLR modelling can reproduce this behaviour, and align with other field observations, TM and MC have little, if any, faith in its relevance and would have to then draw upon the field data as the **primary source** of evidence. The field evidence indicates that, for protracted periods of pumping with low rainfall conditions, significant off-site impacts to groundwater levels are likely to occur. The field data also appear to indicate a substantial risk that springs and seeps at the site are in danger of drying up/ceasing to flow during periods of extended low rainfall, which are in fact relatively common in the historical rainfall data for Springbrook.

108. TJ notes simply that this is a misrepresentation of the information which has been used in the numeric analysis. He notes for example that the downward groundwater trend occurred for only one bore rather than for all bores.

109. TJ says that the only question which needs to be addressed here is whether the extraction of a relatively small volume of water from one insignificantly small site in Springbrook is likely to have any adverse impact on environmental values downstream of the site. Previous analyses which I have completed (see the first JER on this matter) have determined that the catchment area of the Springbrook range above 830 m AHD (see below) is at least 309 ha. The recorded average annual rainfall from the Springbrook Forestry Gauge, which is highest local gauge available, is over 3,000 mm per annum. Todd determined that the recharge rate at Mt Tamborine was an average of 32% of rainfall. Adopting a conservative infiltration rate of 20% of rainfall (the monitoring information would indicate that a significantly higher rate is likely), the total volume of water flowing to the Springbrook aquifer above the 830 m AHD contour is approximately 1,854 ML per annum. The proposed 16 ML/annum take by Hoffmann represents only 0.9% of the inflow. If we assume that Hoffmann represents 10% of the total extraction from the aquifer, the total loss of water from the aquifer to anthropogenic extraction still represents only 8.6% of the volume of water which flows to the aquifer each year. I have previously noted in this report (paragraph 5) that the researchers at Mount Tamborine considered that extraction rates of up to 10% would have no adverse impact on the natural environment. That is, they determined that the range of natural variation was such that environmental flows could be adequately sustained so long as 90% of the volume of water flowing to the aquifer each year was maintained.



110. TJ says that he believes that it is clear that the amount of water which Hoffmann proposes to extract from the Springbrook aquifer will have no adverse impact on wider environmental values within the catchment. There will be impacts since all development creates changes in existing conditions. However, there will be no unacceptable adverse impacts since the rate of change from the existing status quo is so low. Further, it is my opinion that adequate controls and safeguards can be placed over the operation by conditions of approval to ensure that this outcome is achieved.

111. TM and MC disagree with TJ's above conclusions, and (as outlined in the first JER) do not believe that the above analysis of the recharge rate is:

a) Supported by the data (for example, note the point by TM in paragraph 1c of the first JER, that the catchment area used in the above analysis is not correct).

b) Relevant to the assessment of the primary question outlined in the Points of Agreement i.e., whether the extraction at the proposed rate is likely to have unacceptable adverse impacts outside the site.

112. TM and MC believe that the scale over which recharge is being estimated in the above calculations is overly large, and obscures what could be a substantial impact within the areas immediately on and surrounding the property itself and which will cause **actionable nuisance** external to the site on which the development is located. A more appropriate comparison would be the rate of extraction versus the recharge that occurs directly on the site and/or which passes through the aquifer within the zone likely to be impacted by the extraction bores (i.e., the capture zone for the extraction bores). Without robust estimates of groundwater recharge for the site (which MC and TM believe are yet to be determined), and additional hydrological and geological investigations, a proper analysis of the sustainability of the proposed extraction cannot be achieved, and in line with Council's grounds for refusal, it has not been demonstrated that the proposed extraction will not cause unacceptable environmental impacts.

113. TJ says that MC and TM still confuse actionable nuisance with change in the water table level. On their reasoning, a reduction in water table level of 0.3 is unacceptable. However, the measurements taken on site, as well as common sense, would indicate that the natural variation in water table level over months, seasons and years is much greater than the 0.3 m change.

Trevor Johnson
BE, MEngSc, PhD, CPEng, FIEAust, RPEQ, GAICD

Tony McAlister
BE(Hons), MEngSc, CPEng, FIE Aust. RPEQ, GAICD

Matthew Currell
PhD, BSc(Hons), BA

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