11 April 2022

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The Registrar
PLANNING AND ENVIRONMENT COURT

## HOFFMAN v GOLD COAST CITY COUNCIL & ORS
## P&E COURT APPEAL No 137 of 2020
## GROUNDWATER MODELLING REPORT

## 1 INTRODUCTION

1 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.

2 By Decision Notice dated 12 December 2019, Council refused the development application, citing a number of reasons for refusal, including several relating to groundwater hydrology. The applicant has subsequently appealed this refusal in the Planning and Environment Court (No 137 of 2020).

3 Council and the Co-Respondents by Election allege that the potential environmental effects of the proposed groundwater extraction have not been suitably considered and accurately determined in the technical information submitted in support of the application. Relevant matters which could be affected by the extraction include the ecology of the local area (more specifically any flora which may be groundwater dependent) and surface flows within the two water supply catchments in the area, namely the Nerang River and Little Nerang Creek.

4 In particular, Dr Matthew Currell (groundwater expert for the Australian Rainforest Conservation Society) has stated that the project will have unacceptable adverse impacts on groundwater in the region, relating specifically to the likelihood that groundwater conditions on site will be anisotropic (ie effectively that the extraction of groundwater will have greater impacts in the west-east direction than in the south-north direction).

5 Consequently, Hoffmann has nominated Dr Trevor Johnson to provide relevant advice in respect of this matter to assist the Court in its consideration of potential groundwater impacts that would result from approval of the development.

6 I state that I am a civil engineer with over 44 years of experience in the fields of urban development, hydraulics, water quality and engineering infrastructure. I hold the degrees of Bachelor of Engineering (Honours), Master of Engineering Science and Doctor of Philosophy, all in civil engineering from the University of Queensland. I am a Fellow of the Institution of Engineers Australia as well as a Registered Professional Engineer Queensland (RPEQ) and an Adjunct Associate Professor in the School of Civil Engineering at the University of Queensland. My Curriculum Vitae has previously been provided to the Court in respect of this matter.

7 This document responds to a request from Counsel in January 2022 for me to consider what numerical modelling might be available to consider the potential occurrence of anisotropy within the aquifer present below the Hoffmann site. Based on this request, I caused SLR Consulting to undertake an investigation into this matter.

## 2 BACKGROUND

8 On-site monitoring of groundwater conditions has been undertaken by Mr Iain Hair of Australian Groundwater Consult Pty Ltd and reported in *Additional Hydrogeological Assessment of the Hobwee Basalt Aquifer at 263 Repeater Station Road, Springbrook, SE Queensland. January 2022*.

9 That report presents:

- locations of 10 boreholes on Lot 36 RP139816 (4.125 ha) [Bore 01 through to Bore 10];
- measurements of groundwater levels in six boreholes [Bore 01, Bore 02, Bore 04, Bore 05, Bore 06 and Bore 07] from January to December 2021;
- measurements of groundwater drawdown in six boreholes due to pumping Bore 05 and Bore 06 for 7 days in February 2021 (a wet period); and
- measurements of groundwater drawdown in six boreholes due to pumping Bore 05 and Bore 06 for 7 days in July 2021 (a dry period).

10 Driller bore logs are available for all 10 bores constructed by Hoffmann Drilling from 15 January 2016 [Bore 01] to 6 May 2020 [Bore 10]. The logs indicate the interception of several basalt strata with perched groundwater and a regional water table within deeper basalt above rhyolite bedrock. At each bore, perched water is free to descend to the water table via an annular gravel pack that links a number of slotted intervals in each hole.

11 Figure 1 shows that the subject property is located on the eastern limb of a prominent topographic ridge of approximate elevation 920 m AHD aligned with Repeater Station Road. Groundwater is observed to discharge as springs at and below 830 m AHD on the property. The surficial geology is basalt at elevations greater than approximately 800 m AHD, below which rhyolite bedrock becomes outcrop.

12 The groundwater hydrographs for 2021 are reproduced in Figure 2 and transects of key attributes are shown in Figure 3. Key observations from Figure 2 are:

1. Each hydrograph shows a well-defined “rest” level, or low level, in drier months.
2. The rest levels range from 813 to 858 mAHD over a distance of 130 m.
3. There are distinct wet (November-March) and dry (April-October) seasons.
4. Rainfall is very high at Springbrook, with about 3,700 mm recorded in 2021 (long-term average 2,831 mm/a).
5. Five of the six bores respond to strong rainfall events with different magnitudes of rise and different rates of decay.

13 Points 2 and 5 indicate that the basalt aquifer is not uniform in its transmissive and porous properties.

14 Key observations from Figure 3 are:

1. The rhyolite bedrock level beneath the topographic ridge is irregular, varying from about 815 to 845 m AHD. The highest levels are at Bore 05 (846 m AHD) and at Bore 03 (838 m AHD). Bore 10, only 7 m from Bore 03, has bedrock reported at approximately 823 m AHD.

2. Groundwater mounds are evident beneath Bore 05 and Bore 06, the two production bores.

3. The dry-period minimum saturated thickness is about 10 m at most bores, but at some sites it is negligible (e.g. Bore 01, Bore 02, Bore 07).

4. The short-term wet-period maximum saturated thickness exceeds 10 m at all bores except Bore 07, the greatest thickness being approximately 35 m at Bore 05.

5. The dry-period hydraulic gradient from Bore 05 to Bore 01 is 50% .

6. The two 7-day pumping tests reduced the water table to similar profiles (except near Bore 06 where the saturated thickness was exhausted in the dry period). In the wet period, the maximum drawdown (near the pumping bores) was about 10 m, with slightly less at Bore 05 and more at Bore 06.

15 The extreme gradient at Point 5 indicates that the basalt aquifer is not uniform in its transmissive property, and there is likely to be compartmentalisation separating zones of higher water levels from zones of lower water levels. The basalt aquifer is likely to be anisotropic, with the direction of higher permeability perpendicular to Repeater Station Road, as marked on Figure 1.

16 Rainfall (R) of 688 mm fell on 22-24 March 2021. The water level rise (dh) at each bore can be used to estimate the specific yield (Sy), or drainable porosity, local to each bore from this formula:

$$Sy = f R / dh$$

where f is the fraction of rainfall that infiltrates to the water table ($f < 1$).

17 The calculations shown in Table 1 give a median Sy of 1% to 10%, at most, for infiltration rates in the range of 10% to 100%.

**Table 1: Estimates of specific yield (drainable porosity)**

| | | | | Mar-21 | | |
|---|---|---|---|---|---|---|
| BORE ID | TOPO | BASALT | BASALT | dh | Max Sy | Min Sy |
| | | THICKNESS | FLOOR | | (f=1) | (f=0.1) |
| | [mAHD] | [m] | [mAHD] | [m] | 1 | 0.1 |
| | | | | | | |
| 01 | 911 | 79 | 832 | 12 | 0.06 | 0.006 |
| 02 | 914 | 90 | 824 | 6 | 0.11 | 0.011 |
| 03 | 910 | 72 | 838 | | | |
| 04 | 911 | 78 | 833 | 7 | 0.10 | 0.010 |
| 05 | 910 | 64 | 846 | 24 | 0.03 | 0.003 |
| 06 | 915 | 96 | 819 | | | |
| 07 | 907 | 92 | 815 | 2 | 0.34 | 0.034 |
| | | | | | | |
| | | | | MEDIAN | 10% | 1% |

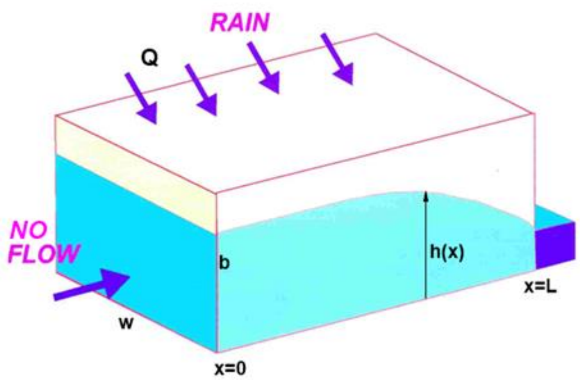
# 3 CONCEPTUAL MODEL

18 A conceptual model graphic is shown at Figure 4, based on an almost symmetric topographic profile marked A-A' on Figure 1. The profile passes through Bore 05, one of the production bores, beneath which the rhyolite bedrock is domed. A conceptual model is a simplified representation of the hydrogeology of a site, including the dominant recharge processes (e.g. rainfall infiltration) and discharge processes (e.g. spring discharge, evapotranspiration [ET], and pumping) acting on a groundwater system.

19 Dry-period and wet-period water tables are sketched to show a nonlinear (parabolic) shape, with discharge to springs at approximately 830 mAHD on either side of the ridge. When pumping occurs, the water table is drawn down symmetrically into a cone of depression which radiates outwards towards the springs. When Bore 05 is pumping, the discharge to the springs will be reduced in the same proportion as the reduction in the hydraulic gradient at the spring outlet.

20 Without pumping, a vertical line directly beneath the ridge denotes a no-flow zone, which means groundwater would not cross that line from one side to the other. Particles of water along that line would move either west or east away from a groundwater mound beneath the ridge.

21 For a situation with a no-flow boundary separated from a constant-head boundary (e.g. a spring), with intervening steady rainfall infiltration, such as in the conceptual diagram below, the elevation of the water table follows a simple quadratic formula that defines parabolic curvature.




22 The formula for the analytical model is:

$$h(x) = h(L) + \frac{(L^2 - x^2)Q^*}{2LKA} \qquad (1)$$

where: h(x) is the groundwater elevation at any distance x;

L is the length of flowpath;

$Q^*$ is the rate of discharge at the spring, equal to the rainfall recharge rate at steady-state;

$Q = Q^*/L$ is the recharge rate per metre of length along the flowpath;

A is the cross-sectional area of flow at the spring outlet equal to width w times aquifer thickness b; and

K is the permeability (hydraulic conductivity) of the aquifer.

23 For a section between the ridge adjacent to Bore 05 and the eastern spring at 830 m AHD, the adopted values are:

L = 205 m

h(0) = 858 m AHD; h(L) = 830 m AHD

A = 400 m2 (w = 40 m; b = 10 m)

24 For 2,500 mm/annum rainfall:

Rain infiltration volume: f x 2500 mm/yr x 205 m x 40 m = f x 56.2 m3/day

This suggests a spring discharge rate of 0.07 to 0.7 L/sec (*f*: 0.1 to 1) but does not account for extra groundwater inputs from north and south.

K: 0.43 m/day max (f=1) to 0.043 m/day min (f=0.1)

25 The hydraulic gradient will be quite flat near the bore (when inactive) and gradually increase as extra rainwater percolates to the water table. The discharge to the spring is determined by the hydraulic conductivity of the aquifer and the hydraulic gradient immediately uphill from the spring.

26 Use of this formula allows estimation of likely groundwater elevations along a line connecting Bore 05 to the spring, thereby supplementing the measurements obtained at the installed monitoring bores.

# 4 GROUNDWATER MODELLING

27 When pumping is active in an anisotropic aquifer, the cones of depression will be elliptical rather than radial. An estimate can be obtained for the drawdown (dd) at any position (x,y) at any time t after pumping commences at a steady rate Q, using this formula (Reed, 1980) :

$$dd = \frac{Q\,W(u)}{4\,\pi\,\sqrt{[T_x T_y]}} \qquad (2)$$

where:

$$u = \frac{S_y\,[T_x y^2 + T_y x^2]}{4\,t\,T_x T_y} \qquad (3)$$

and: $T_x$ is transmissivity in the *x*-direction
$T_y$ is transmissivity in the *y*-direction
$S_y$ is specific yield.

28 The well function W(u) is an exponential integral that can be calculated readily by a series expansion.

29 Computer code (FORTRAN) has been written to compute drawdown fields associated with Bore 05 and Bore 06 separately, then combined using the Principle of Superposition. The x-direction is defined as 16 degrees anticlockwise from east, as indicated by the dashed line on Figure 1 linking Bore 05 to the spring.

30 A calibration process was undertaken on the wet-period 7-day pumping test, in order to gain a reasonable agreement with the drawdowns observed at each monitoring bore. The pumping rates were 0.27 L/sec at Bore 05 and 0.23 L/sec at Bore 06. Optimal parameters are:

- Near Bore05, K ~ 0.3 m/day; anisotropy ratio ~5; Sy ~ 0.01
- Near Bore06, K ~ 0.3 m/day; anisotropy ratio ~10; Sy ~ 0.1

31 The simulated drawdown pattern at the end of the 7-day pumping test is shown in Figure 5. This matches the maximum drawdown at each bore reasonably well, and importantly gives a small drawdown at the most northerly Bore 01 and zero drawdown at the most southerly Bore 07.

32 A drawdown of 0.1 m is anticipated at a distance of 120 m from Bore 05 towards the spring at 170 m for the 7 day analysis.

33 The model can be used only as an indicator of potential drawdown extent for pumping of a longer duration. The model cannot account for diffuse rainfall recharge, which would tend to counteract the drawdown caused by pumping, as demonstrated during the February 2021 pumping test. The model does not account for compartmentalisation, which means that the model may overestimate drawdowns. The available bore level information shows that there is strong evidence of compartmentalisation in the south-north direction. If similar compartmentalisation is present in the west-east direction (as seems probable or even likely), drawdowns at the spring location will be much less than predicated, and commensurately greater near the production bores.

34 An indication of worst-case potential drawdown is illustrated in Figure 6 where pumping is assumed to be continuous for 90 days, at rates 0.27 L/sec at Bore 05 and 0.23 L/sec at Bore 06. A critical assumption is that zero rain would occur in this period. For this unlikely situation, the model estimates a drawdown of 1.3 m at the spring at 830 m AHD. As groundwater discharge is likely to be occurring between 820 and 830 m AHD before water is channelled along Little Nerang Creek, there would be only partial loss of flow to the spring. In all likelihood, actual rainfall recharge is expected to offset this potential loss, given the very high rainfall record at the site.

35 In my opinion, a drawdown in the order of 1.0 m is likely to be inconsequential for the following reasons. Spring discharge likely occurs over a 10 m range from 830 to 820 m AHD, and this is no different from what is occurring naturally on a seasonal basis. If the normal seepage face is from 830 to 820 m AHD over a distance of 40 m, then a 1 m reduction would give a seepage face from 829 to 820 m AHD, which means the seepage face would shorten by 4 m (that is, 10%). This oscillation in seepage face length is occurring naturally under existing conditions, and flora ought to be accustomed to these changes. Under this conditions, there will also be increased flow to the spring from northern and southern sides which would tend to offset any reduction in spring flow coming from the west.

36 The likelihood of zero rainfall for 90 days has been assessed by examining SILO daily rainfall from 1900 to 2020. The rainfall statistics are summarised in Table 2. The 5th percentile (P5) rainfall of 138 mm is one quarter of the median rainfall of 552 mm. Steady rainfall at the P5 rate would reduce natural spring flow by about 78% according to the analytical model discussed above. The statistical analysis indicates that 70 mm of rain will fall in the 90 day period corresponding to the 1% Annual Exceedance Probability (AEP) event. That is, in the driest period in 100 years, at least 70 mm would still be available for spring flow.

**Table 2. Statistics for accumulated rainfall over a continuous 90-day period**

| Stats | 90DayRain | SpringFlow | | Reduction |
|---|---|---|---|---|
| | (mm) | (m3/d) | (L/s) | from base 2500mm/a |
| **MIN** | 3.8 | 0.35 | 0.004 | -99% |
| **P5** | 138 | 12.6 | 0.15 | -78% |
| **P10** | 197 | 17.9 | 0.21 | -68% |
| **P25** | 324 | 29.5 | 0.34 | -47% |
| **P50** | 552 | 50.3 | 0.58 | -10% |
| **P75** | 923 | 84.1 | 0.97 | 50% |
| **P90** | 1394 | 127.0 | 1.5 | 126% |
| **P95** | 1761 | 160.4 | 1.9 | 186% |
| **MAX** | 3809 | 347.0 | 4.0 | 518% |

37 It can reasonably be concluded that the absence of significant rainfall over any 90 day period is highly unlikely. For example, there is only a 5% chance in any year that the rainfall in the worst 90 day period will be less than 138 mm. Even allowing for the analytical model's overestimation of drawdown extent to the north, it is clear that the proposed project will not interfere with groundwater levels at the Come by Chance and Coca Cola Amatil operations much farther north (approximately 1 km and 2 km, respectively).

38 The other issue to consider here is that the discharge from the spring on the subject land is actually not particularly significant. For the median rainfall condition, the spring would flow at a rate of 0.58 L/s, which is equivalent to an annual discharge of about 18.2 ML. In comparison, the median yearly inflow into Little Nerang Dam is more than 14,000 ML. The total discharge from the spring represents less than 0.13% of the dam inflow.

## 5 POST-DEVELOPMENT MONITORING AND CONCLUSIONS

39 It will be critical to monitor groundwater level fluctuations close to the spring in order to demonstrate that the extraction will not have an unacceptable adverse impact on existing groundwater conditions. It is recommended that a shallow borehole, approximately 10 m deep be drilled between the 835 m AHD and 845 m AHD topographic contours, as indicated on Figure 7 and Figure 8. Approximate coordinates are listed in Table 3, along with depths of water estimated from the parabolic head profile discussed in Section 3.

**Table 3. Potential sites for an additional monitoring bore**

| SITE | EASTING | NORTHING | DEPTH to WATER (m) |
|---|---|---|---|
| **P830** | 526128 | 6877417 | 0 |
| **P835** | 526115 | 6877414 | 2 |
| **P840** | 526101 | 6877410 | 3 |
| **P845** | 526090 | 6877407 | 5 |

40 If mitigation should prove necessary, optional measures include the following:

- Pumping at lower steady rates.
- Pumping for shorter durations in line with the seasons.
- Construction of recharge beds close to the western property boundary to increase the rate of rainfall recharge.

41 In that regard, an analysis has also been completed based on pumping at constant rate equivalent to an extraction rate of 12 ML/annum (in comparison to the 16 ML/annum contained within the application). It was determined that for this condition, the drawdown in water level at the spring location would be approximately 1.0 m based on no rainfall for 90 days. This result is shown on Figure 9 below.

42 For both conditions modelled (Figure 6 - 16 ML/annum and Figure 9 - 12 ML/annum), there is only marginal impact on groundwater levels beyond the eastern boundary of the property. The reduction in mean groundwater level at the property boundary is approximately than 0.2 m for both cases. Such a change is considered insignificant. It can reasonably be concluded that the proposed extraction of groundwater at this site will have no impact on aquifer conditions external to the site itself.

DR TREVOR JOHNSON
Technical Director

April 2022

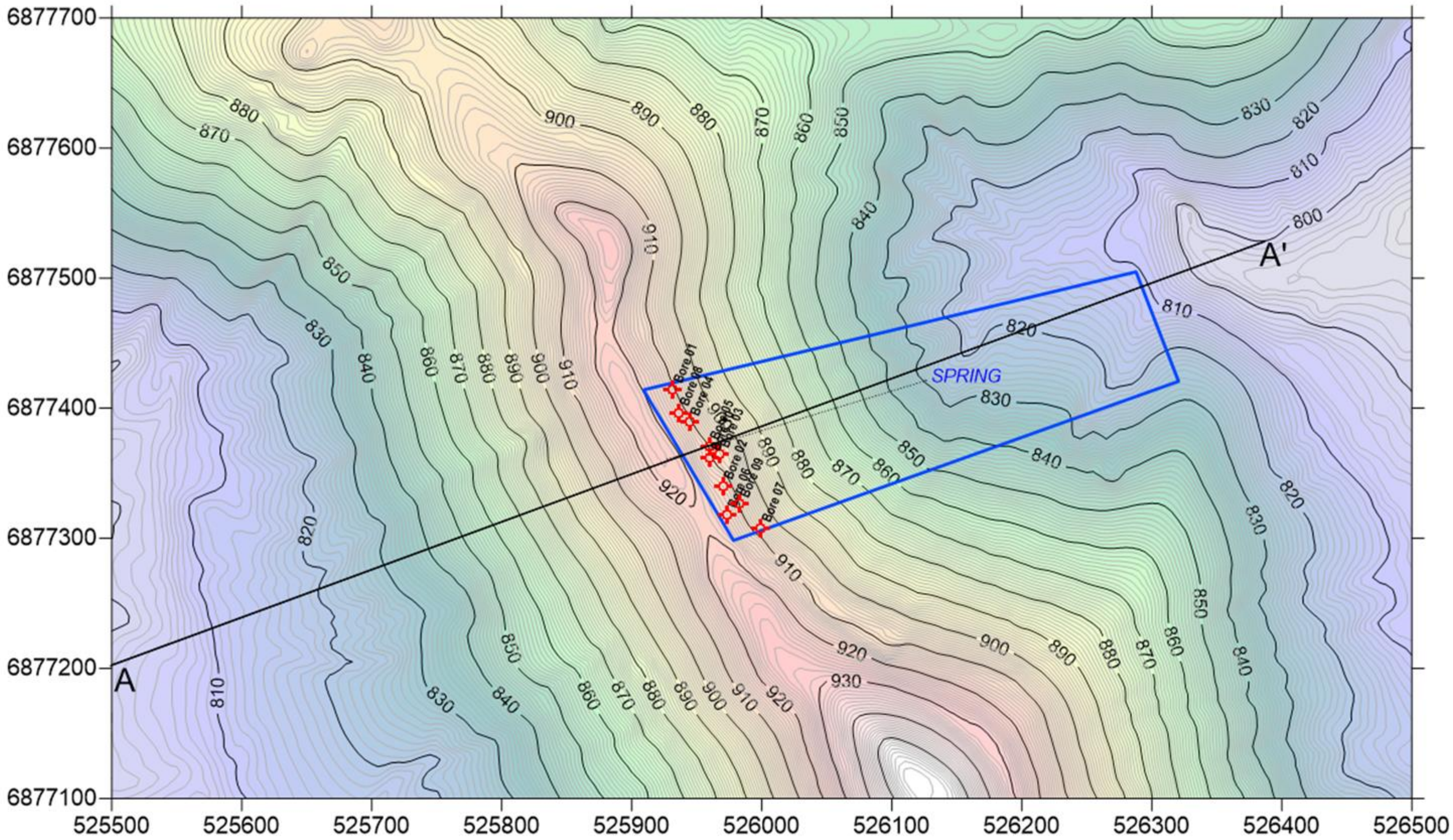



Figure 1. Topography (m AHD) and bores located on Lot 36, 263 Repeater Station Road, Springbrook [Dashed line is the assumed major anisotropy axis]

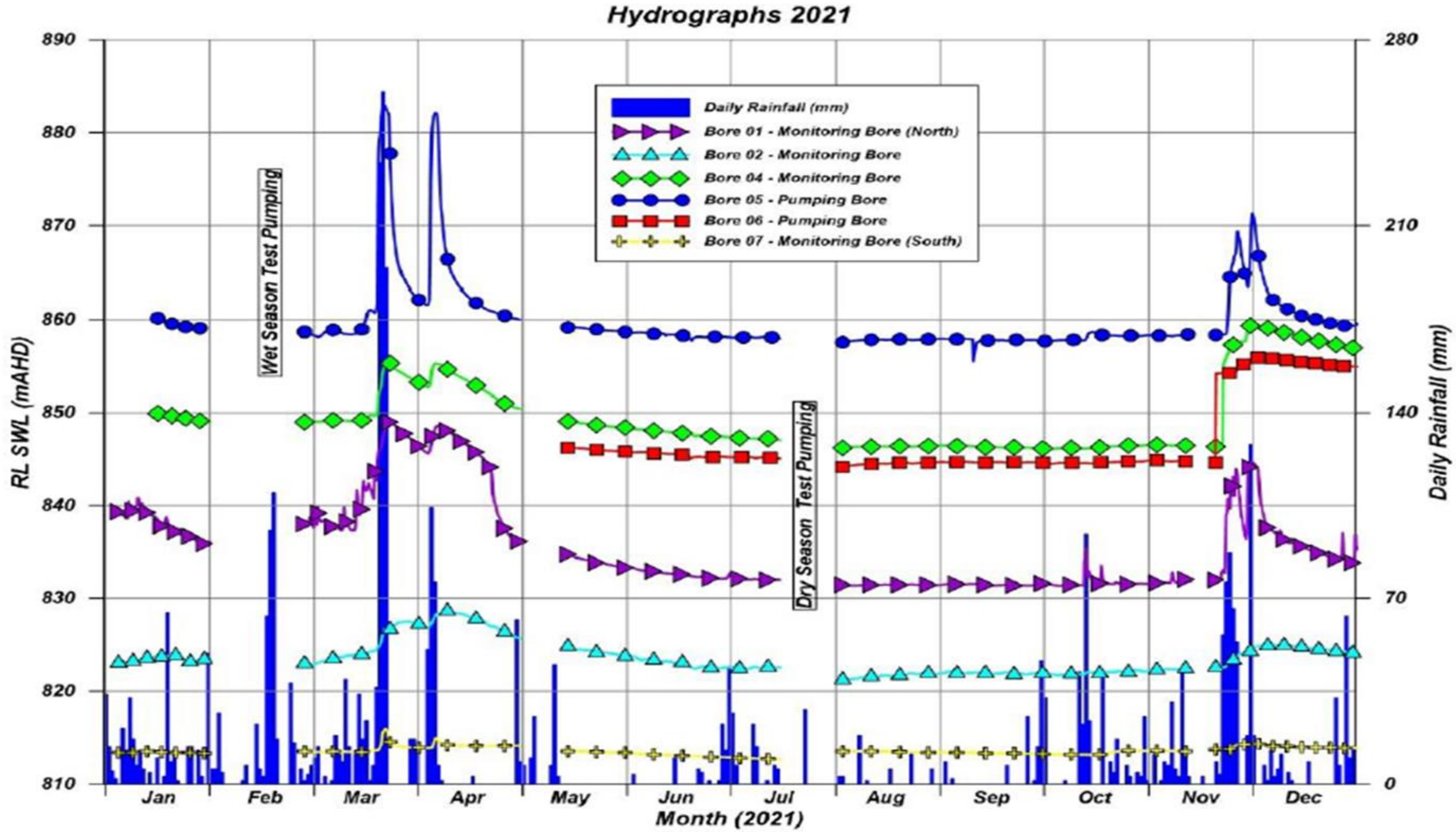



**Figure 2. Groundwater levels and daily rainfall in 2021 [from Hair, 2022]**

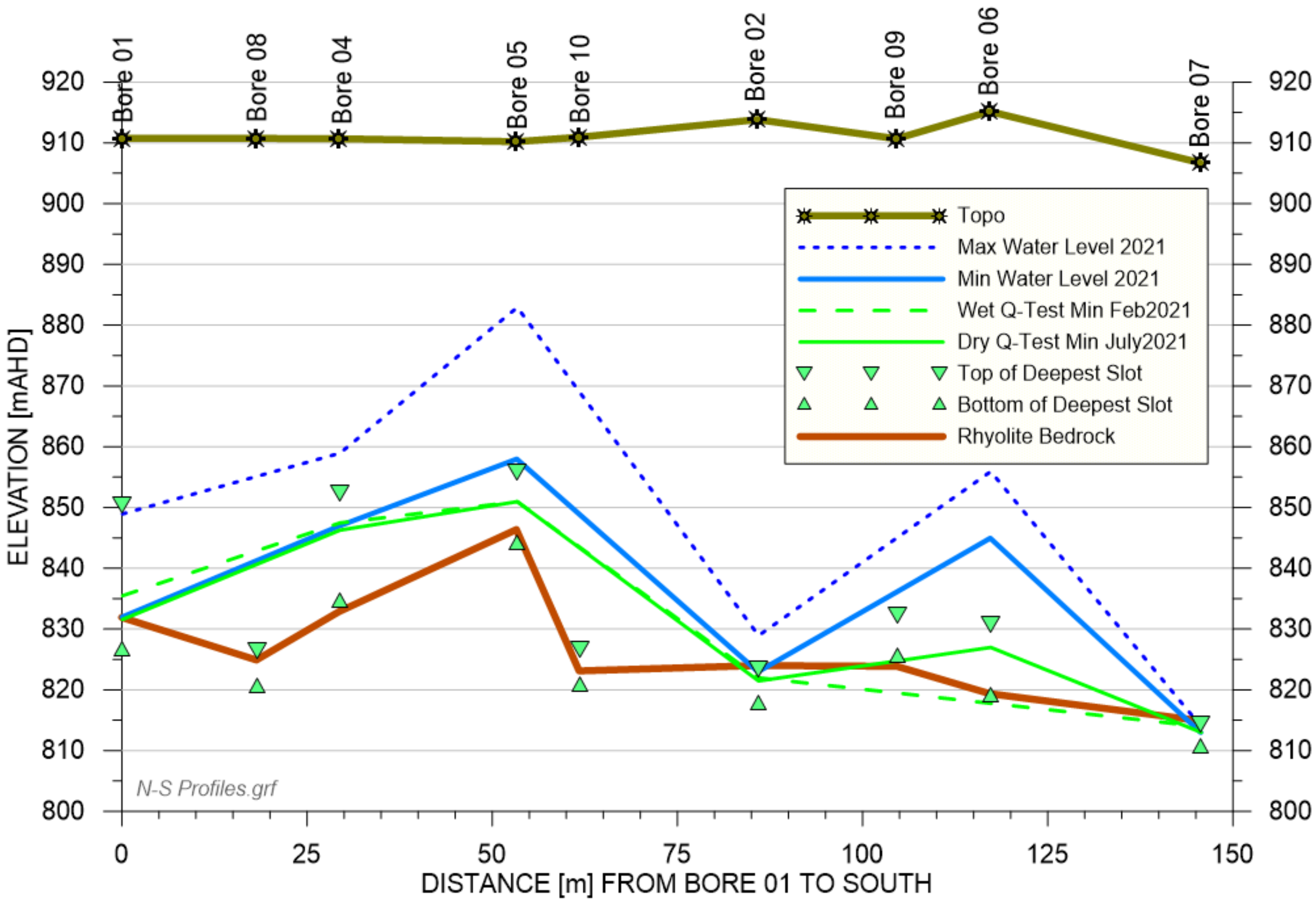



**Figure 3. Summary of data measured in 2021 along a profile parallel to Repeater Station Road, Springbrook**

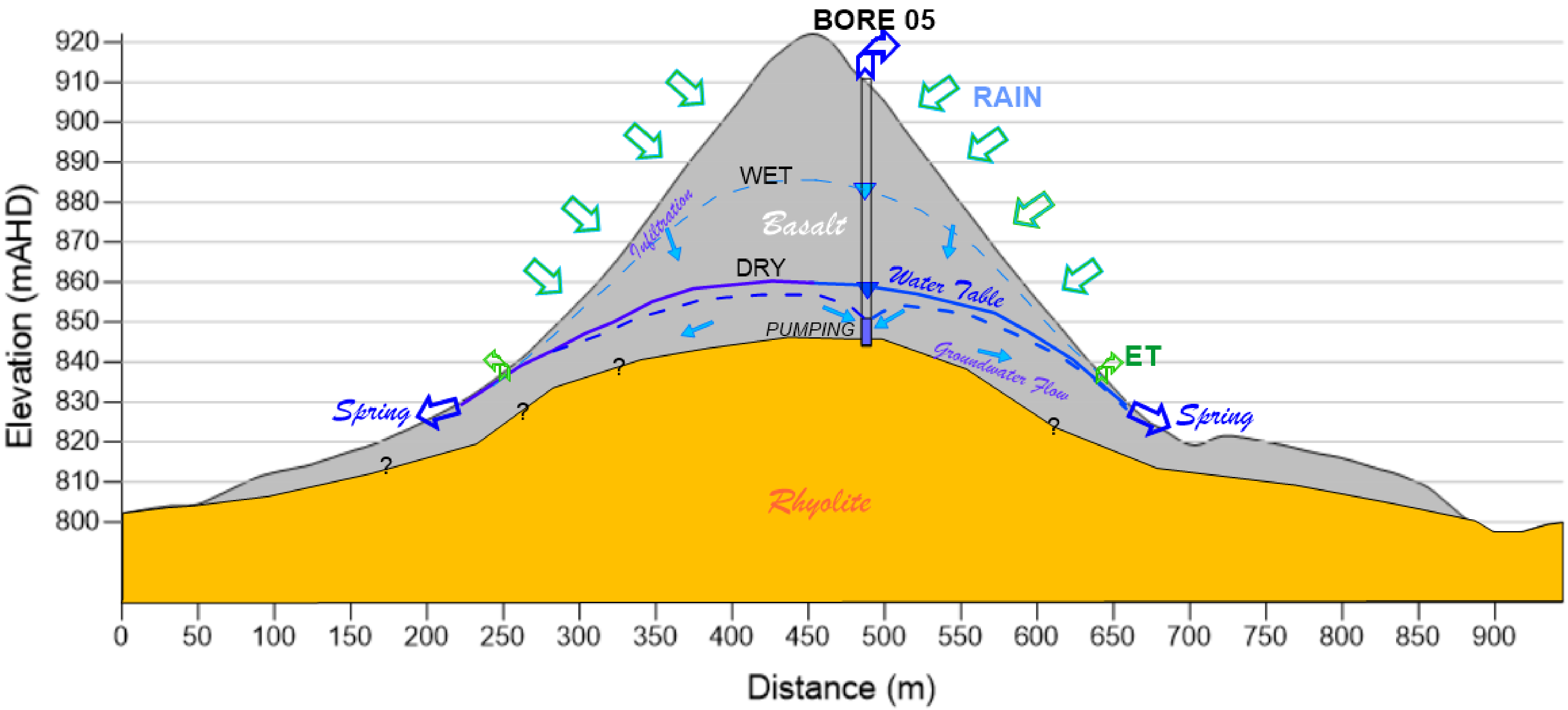



**Figure 4. Conceptual model of groundwater processes during dry, wet and pumping conditions**

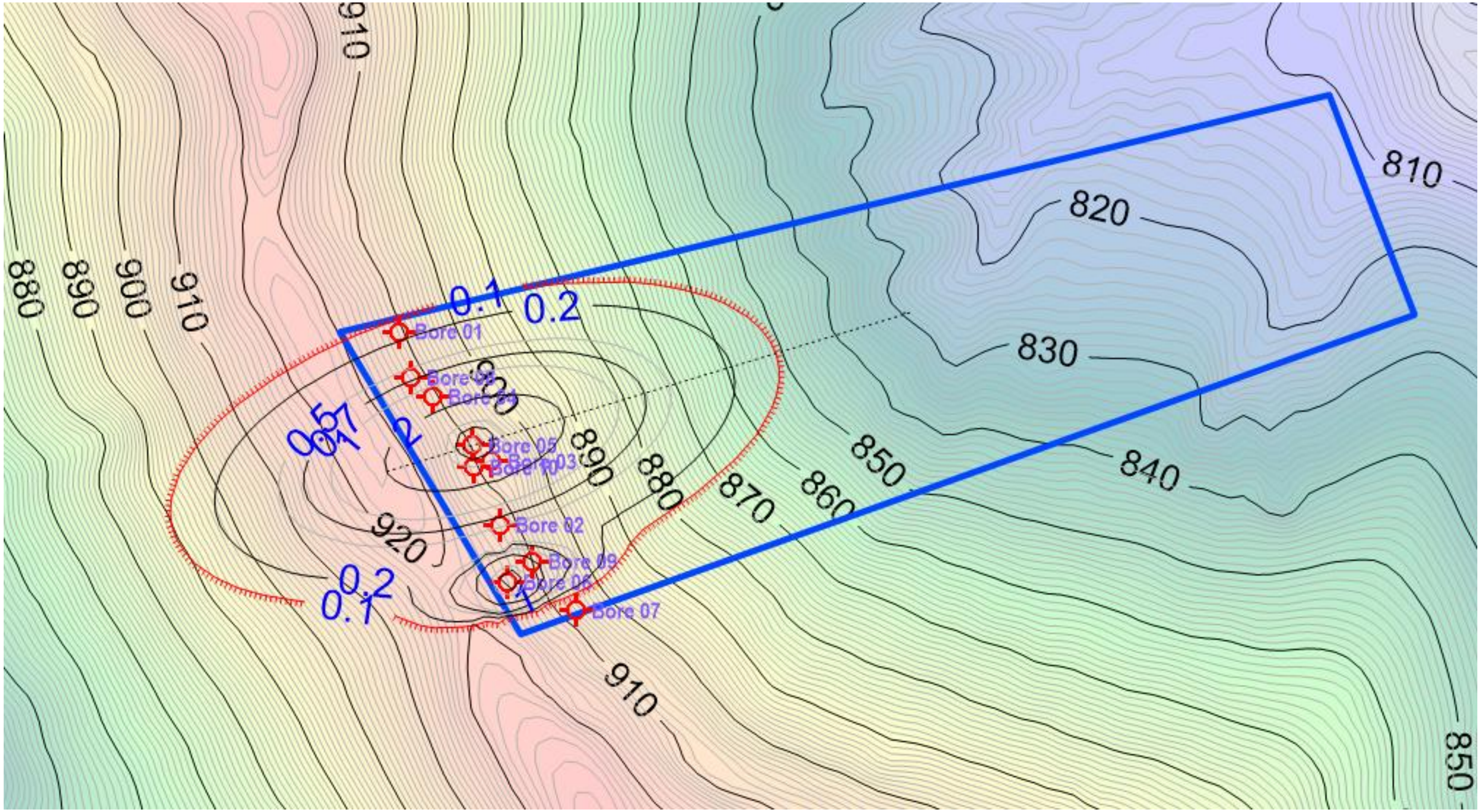



**Figure 5. Simulated drawdown (m) after 7 days pumping at Bore 05 and Bore 06**

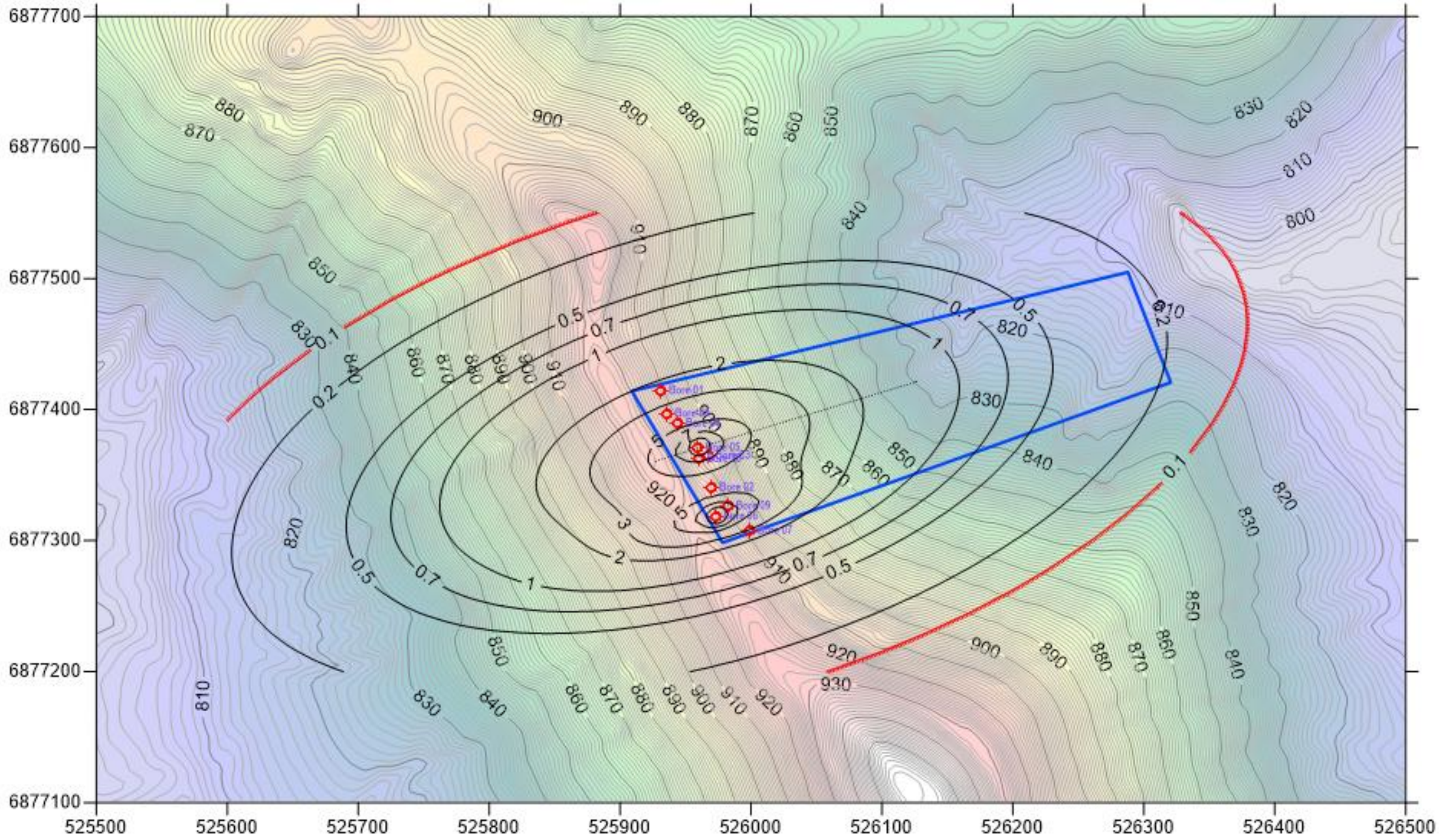



**Figure 6. Simulated drawdown (m) after 90 days pumping at Bore 05 and Bore 06, with no rainfall**


**Figure 7. Google-Earth image of key existing bores and potential sites for an additional monitoring bore, looking north.**

**Figure 8. Google-Earth image of potential sites for an additional monitoring bore, looking west.**

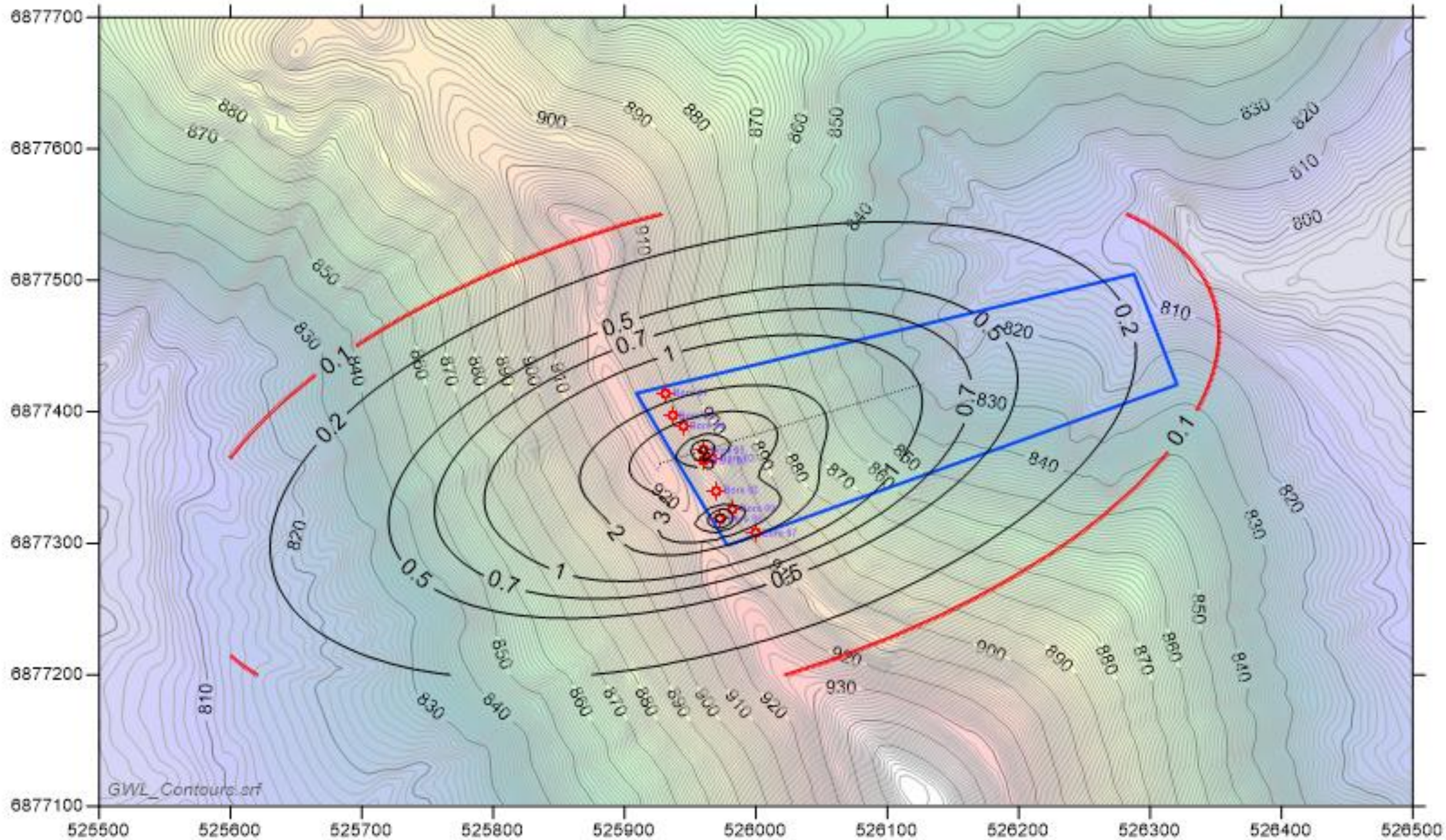



**Figure 9. Simulated drawdown (m) after 90 days pumping at Bore 05 and Bore 06, with no rainfall**

Pumping rates: 0.20 L/s (Bore 05), 0.18 L/s (Bore 06). Total 12.0 ML/year if continuous.