Expert Report on Hydrology and Groundwater Issues

Hoffmann Drilling Pty Ltd Superannuation Fund v Gold Coast Council & Ors (P&E No. 137 of 2020)

22 December 2021

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CONTENTS

1	INTRODUCTION	4
1.1	General	4
1.2	Statement to the Court	4
2	GENERAL HYDROGEOLOGICAL PRINCIPLES	5
2.1	Introduction	5
2.2	An Aquifer	6
2.3	The Water Table	6
2.4	Potentiometric Surface Patterns	7
2.5	Vadose Zone	7
2.6	Area of Influence	8
2.7	Cone of Depression	8
2.8	Zone of Contribution	8
2.9	Groundwater Mass Balance	8
2.10	Aquitard	8
2.11	Recharge rate	9
2.12	The Effect of Groundwater Extraction on the Availability of Groundwater	9
2.13	Groundwater Flow Direction	9
2.14	The Effect of Drawdown of the Water Table on Surrounding Environments and the Vadose Zone in particular	9
3	NATURE OF THE SITE AND UNDERLYING AQUIFERS	10
4	DATA COLLECTION/ANALYTICAL PROCESS	11
4.1	Douglas Partners (2017)	11
4.2	Douglas Partners (2018)	12
4.3	Peter J. Ramsay (2014)	12
4.4	Peter J. Ramsay (2015)	13
4.5	Peter J Ramsay (2017)	13
4.6	‘Hair Report’ (undated, assumed 2021)	13
4.7	Summary	14
5	MODELLING CONSIDERATIONS	17
5.1	Available Models	17
5.2	AWBM Method (General)	17
5.3	Application of the AWBM Model to the Subject Site	19

6 RECOMMENDED ASSESSMENTS TO DETERMINE SUSTAINABLE YIELD FROM 263 REPEATER STATION ROAD 34
7 DRAFT CONDITIONS OF APPROVAL PROPOSED BY THE APPELLANT 36
8 PROPOSED DEVELOPMENT'S COMPLIANCE (OR NONCOMPLIANCE) WITH RELEVANT ASSESSMENT BENCHMARKS 37
9 SUMMARY/CONCLUSIONS 41
10 DECLARATION 42

APPENDICES

Appendix A Curriculum Vitae of Tony McAlister

LIST OF FIGURES

Figure 2-1 Groundwater Conceptual Diagram 5
Figure 2-2 Groundwater Impact Illustration 7
Figure 3-1 Overall Area Geology (Source – Queensland Department of Mines and Energy) 10
Figure 4-1 Extract from Douglas Partners 2018 16
Figure 5-1 Structure of the AWBM Rainfall-Runoff Model 18
Figure 5-2 Catchment Representation from South East 21
Figure 5-3 Catchment Representation from South East (zoomed in) 22
Figure 5-4 Catchment Representation from North East 23
Figure 5-5 Catchment Representation from North East (zoomed in) 24
Figure 5-6 Catchment Representation from South West 25
Figure 5-7 Catchment Representation from South West (zoomed in) 26
Figure 5-8 Illustration of Poor Flow Prediction of SLR AWBM Modelling of Regular Flows 27
Figure 5-9 Site Long Section Locations 28
Figure 5-10 Site Long Sections 29
Figure 5-11 830 m AHD Coverage 30
Figure 5-12 Site Visit Photograph Locations (note the contour interval is 5m) 31
Figure 5-13 Site Image 5821 32
Figure 5-14 Site Image 5823 33

1 INTRODUCTION

1.1 General

1. This statement of evidence provides background and relevant detail to guide and inform the Court and justify how I have formed my opinion in regard to this matter. In this report, I provide my advice and opinion on the following:
   - General hydrogeological principles (Section 2);
   - The nature of the site, waterways and underlying aquifers (Section 3);
   - Discussion on relevant bore extraction data collection and analysis procedures (Section 4);
   - Discussion in regard to modelling work that has been conducted by the project proponent and my analysis and commentary on issues related to the catchment areas proximate to the site (Section 5);
   - An overview of the assessments that I recommend as being required to determine the sustainable groundwater yield from 263 Repeater Station Road (Section 6);
   - My comments on the draft conditions of approval proposed by the Appellant (Section 7);
   - My comments on the proposed Development's compliance (or noncompliance) with relevant assessment benchmarks (Section 8); and
   - Relevant summary statements and conclusions (Section 9).

1.2 Statement to the Court

2. In preparing this Statement of Evidence, I confirm that:
   - The factual matters stated in this Statement of Evidence are, as far as I know, true;
   - I have made all enquiries considered appropriate;
   - The opinions stated in this Statement of Evidence are genuinely held by me;
   - This Statement of Evidence contains reference to all matters I consider significant;
   - I understand the expert's duty to the court and have complied with the duty; and
   - I have not received or accepted instructions to adopt or reject a particular opinion in relation to any issue in dispute in the proceedings.
3. My qualifications and experience are contained in the Curriculum Vitae provided in Appendix A.

2 GENERAL HYDROGEOLOGICAL PRINCIPLES

2.1 Introduction

4. Geoscience Australia[1] provides the following useful explanation of groundwater …

   When rain falls, some of it flows across the surface of the land and accumulates in rivers, lakes, and eventually the ocean. But some of the water seeps into the ground and accumulates within cracks or pores in the rocks (aquifers), forming groundwater resources, which in turn also eventually flow into rivers, lakes or the ocean.

5. Encyclopedia Britannica [2] also provides the useful Figure 2-1 to illustrate the above description.

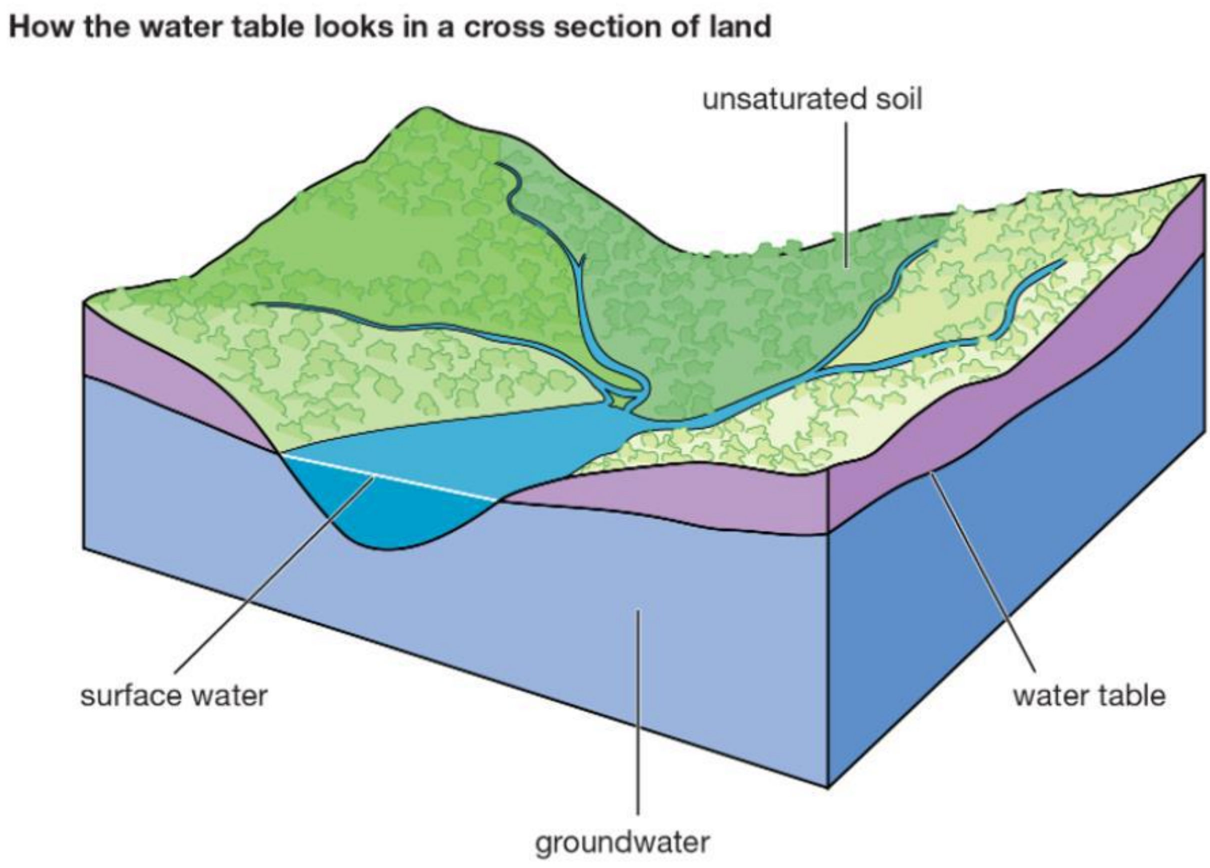


Figure 2-1 Groundwater Conceptual Diagram

6. Most groundwater comes from rainfall. Rainfall infiltrates below the ground surface into the soil zone. When the soil zone becomes saturated, water percolates downward. A zone of saturation occurs where all gaps in the soil are filled with water. There is also a zone of aeration where these gaps are occupied partially by water and partially by air. Groundwater continues to descend until, at some depth, it merges into a zone of dense rock. Water is contained in the pores of such rocks, but the pores are not connected, and water will not migrate. The process of rainfall replenishing the groundwater supply is known as

[1] https://www.ga.gov.au/scientific-topics/water/groundwater/basics/what-is-groundwater

[2] https://www.britannica.com/science/groundwater

recharge. In general, recharge occurs only during the rainy season in tropical climates or during winter in temperate climates. Typically, 10 to 20 percent of the precipitation that falls to the Earth enters water-bearing strata, which are known as aquifers.

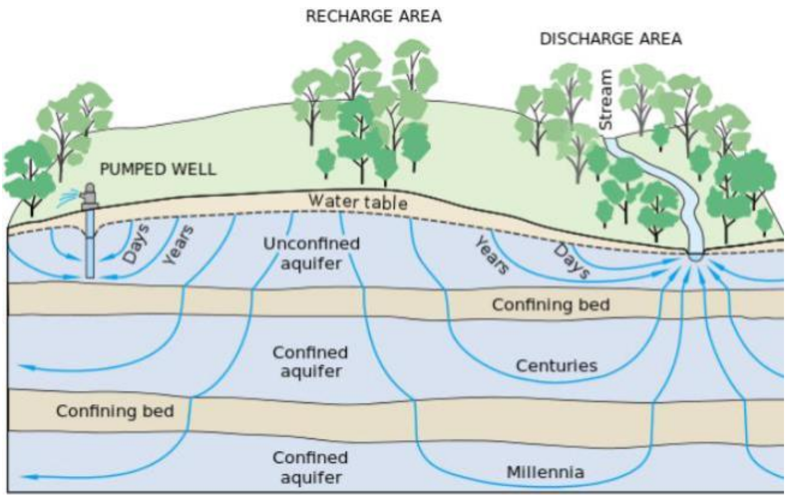
7. Groundwater is constantly in motion. Compared to surface water, it moves very slowly, with the actual rate of movement being dependent on the transmissivity and storage capacity of the aquifer. Natural outflows of groundwater take place through springs and riverbeds when the groundwater pressure is higher than the atmospheric pressure in the vicinity of the ground surface. Internal circulation is not easily determined, but near the water table the average cycling time of water may be a year or less, while in deep aquifers it may be as long as thousands of years.

8. In the various joint expert reports (JER) and other documentation that will be with the Court on this matter, a wide range of technical jargon and 'common knowledge' assumptions are used. The following descriptions may assist in interpretation and understanding these matters:

2.2 An Aquifer

9. An aquifer is an underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt).

10. Groundwater from aquifers can be extracted using a water well. The study of water flow in aquifers and the characterisation of aquifers is called hydrogeology. Related terms include aquitard, which is a bed of low permeability along an aquifer, and aquiclude (or aquifuge), which is a solid, impermeable area underlying or overlying an aquifer, the pressure of which could create a confined aquifer.



11. An unconfined aquifer is one in which the water table is its upper boundary. Because the aquifer is not under pressure, the water level in a well is the same as the water table outside the well. An unconfined aquifer is near to the surface – causing it to be easily recharged as well as easily contaminated.

12. A confined aquifer is an aquifer that is located between layers of relatively impermeable materials and is consequently under pressure, also known as an artesian aquifer.

13. The aquifer beneath 263 Repeater Station Road is unconfined in nature.

2.3 The Water Table

14. The water table is the boundary between the unsaturated zone and the saturated zone underground. Below the water table, groundwater fills any spaces between sediments and within rock.

15. At 263 Repeater Station Road, the water table (Douglas Partners 2017) is relatively deep, being 55 to 66.4 metres below the ground level at various bores. If the ground level of these bores is around 900m AHD (this being somewhat less than the levels along the higher western boundary (925m AHD) of the site reported in SLR 2020), then the relevant level of the groundwater table is of the order of 834.6 to 845m AHD.

16. SLR have used 830m AHD in their assessments, which may be somewhat lower than the data indicates, and which would see them over represent the zone of contribution (and under estimate potential impacts) at 263 Repeater Station Road (see my analysis in Section 5).

2.4 Potentiometric Surface Patterns

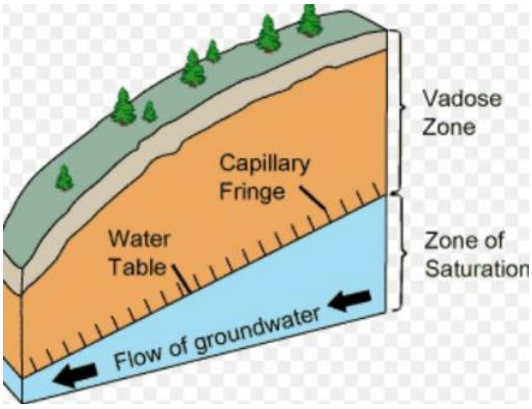
17. For groundwater, “potentiometric surface” is a synonym of “piezometric surface”, which is an imaginary surface that defines the level to which water in a confined aquifer would rise were it completely pierced with wells. If the potentiometric surface lies above the ground surface, a flowing artesian well would result. Contour maps and profiles of the potentiometric surface can be prepared from well data.

18. As the aquifer below 263 Repeater Station Road is unconfined in nature, the potentiometric surface is the same as the water table.

2.5 Vadose Zone

19. The vadose zone, also termed the unsaturated zone, extends from the ground surface to the water table.

20. In the case of 263 Repeater Station Road, this zone extends some 55 to 66.4 metres below the ground level (Table 1 of Douglas Partners 2017) to where the static water level in the various boreholes will establish.



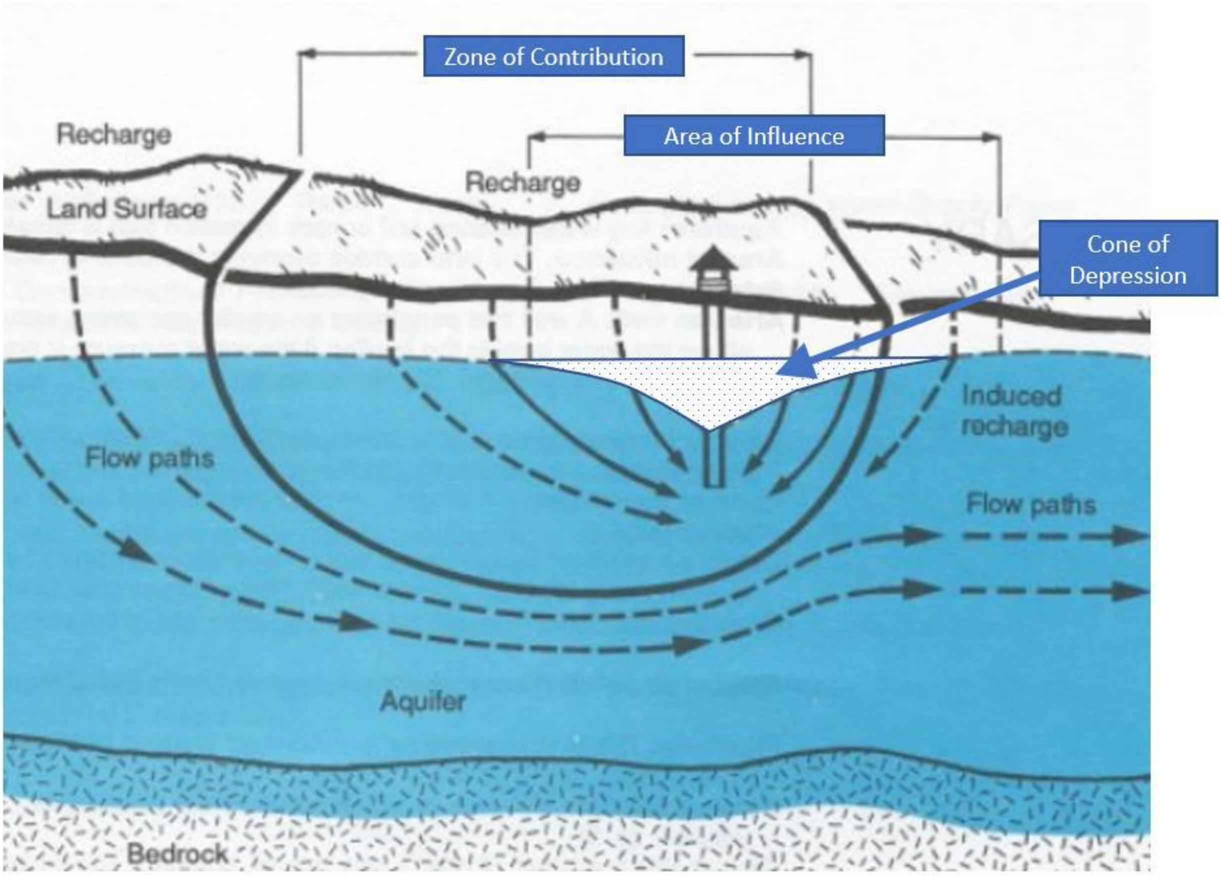


Figure 2-2 Groundwater Impact Illustration

2.6 Area of Influence

21. The area of influence (Figure 2-2) is the area of groundwater which is affected by the pumping of a well. The faster the pumping rate - the larger the area. The area of influence is the area of land above the cone of depression.

22. At 263 Repeater Station Road, Douglas Partners (2018) applied an analytical technique to define the theoretical area of influence. This technique implies that that there will be 1.5 m of drawdown for a 'circle' with a radius of 270m from the pumping site, or a potential area of just under 23 Ha. It also implies that there will be up to 1.0 m of drawdown at a radius of 1,000 m (or 1 km) from the site, or a potential area of 314 Ha, or 3.1 km^2. This analysis assumes a homogeneous and extensive aquifer, which is not the case for this site. Other than this analysis which does not fit with the site characteristics, the proponent has not been able to quantify what the area of influence of site operations will actually be.

2.7 Cone of Depression

23. The cone of depression (Figure 2-2) is the depression in the groundwater table or potentiometric surface that has the shape of an inverted cone, and which develops around a well from which water is being withdrawn. The slopes of the cone become increasingly steep the closer they are to the well. Its trace (perimeter) on the land surface defines the area of influence of a well.

24. As stated above, for 263 Repeater Station Road the analytical technique applied by Douglas Partners (2018) shows a cone of depression (their Drawing 3) with a maximum drawdown depth of 4.5 m extending for over 1 km from the site. This analysis assumes a homogeneous and extensive aquifer, which is not the case for this site. Of note, Douglas Partners (2017) conducted a one-day pump test (not one year as was the case for their analytical analysis) and this pump test measured 4.5 m of drawdown in **one day**.

2.8 Zone of Contribution

25. The zone of contribution (Figure 2-2) is the area surrounding a well or spring that encompasses all areas or features that supply groundwater recharge to a well.

26. The largest potential zone of contribution for 263 Repeater Station Road is the surface area of the surrounding catchment that is greater than 834.6 to 845m AHD, this being the groundwater table level inferred by myself from Douglas Partners 2017 (depth to groundwater) and SLR 2020 (surface level). This zone is evaluated further in Section 5 of this report.

2.9 Groundwater Mass Balance

27. A groundwater mass balance is simply a statement of water accounting, that for a given control volume, aside from sources or sinks, mass cannot be created or destroyed. The conservation of mass states that, for a given increment in time, the difference between the mass flowing in across the boundaries, the mass flowing out across the boundaries, and the sources within the volume, is the change in storage.

28. Groundwater mass balance issues at Repeater Station Road are discussed further in Section 5 of this report.

2.10 Aquitard

29. An aquitard is a saturated, but poorly permeable, formation that does not yield water freely to a well or a spring. An aquitard may transmit appreciable water to or from adjacent aquifers.

30. At 263 Repeater Station Road, there have been no suitable studies to define whether there are any areas beneath the site that could be defined as an aquitard in nature.

2.11 Recharge rate

31. The recharge rate is the volume of water that replenishes underground water via infiltration or percolation of water to an aquifer, generally expressed in terms of mm (of rainfall) per year.
32. Recharge rate issues at 263 Repeater Station Road are discussed further in Section 5 of this report.

2.12 The Effect of Groundwater Extraction on the Availability of Groundwater

33. If the rate at which groundwater is extracted exceeds the rate at which it is recharged, the cone of depression increases, and the area of influence also increases. This may affect other groundwater supplies. Also, streams and rivers connected to the groundwater source can have their supply/flow diminished.

2.13 Groundwater Flow Direction

34. Groundwater typically flows from higher to lower elevations.
35. In the case of 263 Repeater Station Road, this would imply that groundwater flows from the West-South-West to the East-North-East.

2.14 The Effect of Drawdown of the Water Table on Surrounding Environments and the Vadose Zone in particular

36. Surface water and groundwater are strongly connected – particularly alluvial aquifers adjacent to rivers and aquifers that support lakes. Many rivers flow long after rainfall has ceased and runoff from tributaries has receded, because flow is maintained from groundwater discharge. A good indicator that a river is maintained by groundwater discharge is that it flows throughout the year. Of note, the waterways downstream of 263 Repeater Station Road flow continuously throughout the year, highlighting that these flows come from groundwater discharge for much of the year.
37. The connections between groundwater and rivers mean that the use of one resource can have negative impacts on the other. Rivers can be termed as 'gaining', 'losing', 'disconnected' or 'through flowing', depending on the interactions between groundwater and the river. In a gaining river reach, groundwater pumping may eventually reduce river flows by the amount pumped, because this water would have otherwise discharged to the river. In a losing river reach, groundwater pumping can draw down the water table and induce additional recharge from the river. When groundwater and rivers are managed as separate resources these interactions are neglected, leading to overestimates of the amount of water that can be used – a problem known as double accounting. Of note, the waterways downstream of 263 Repeater Station Road are 'gaining' in nature.
38. The low gradients and low flow rates through aquifers can cause considerable time lags before the consequences of pumping are realised. For example, the effects of expansions of groundwater use in many alluvial aquifers will not be experienced for several decades in some cases.

3 NATURE OF THE SITE AND UNDERLYING AQUIFERS

39. The site is underlain by the Hobwee Basalt layer, which forms part of the Lamington Basalt Complex. According to Douglas Partners (2017), bores constructed on the site intersected a sequence of hard basalts and fractured vesicular basalts. I note that vesicular means containing vesicles, and that a vesicle is a small cavity in the mineral or rock. As such, the fractured vesicular zones contain the groundwater resource that is located beneath the property. Douglas Partners (2018) note that the basalt aquifer is unconfined.

40. According to Springbrook Region Conservation Reserves Management Plan (Gold Coast City Council 2009[3]), the Springbrook plateau is on a radial spur of the now heavily-eroded rim of the ancient Tweed shield volcano, which was originally 2,000 metres high and centred on Mount Warning in Northern New South Wales. Since its last eruption 23 million years ago, water driven processes have eroded the landscape into the striking escarpments, waterfalls, rock pools and valleys that characterise the Springbrook landscape today. The caldera is the best preserved of its kind and size in the world. The higher parts of the Springbrook and Purlingbrook Conservation Areas are dominated by lavas from the Tweed shield volcano, including ridge lines of Binna Burra rhyolite in between layers of Beechmont and Albert basalts (Figure 3-1).

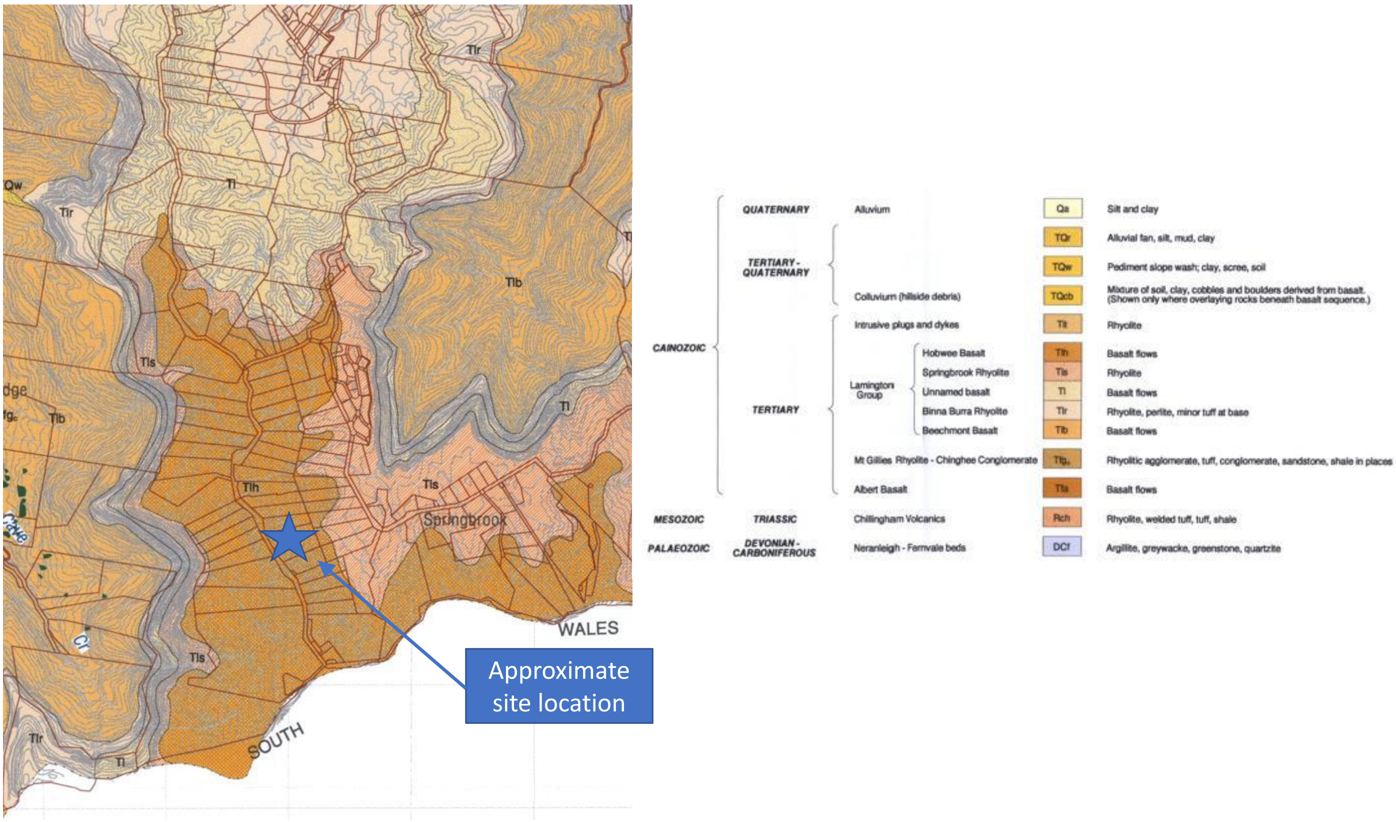


Figure 3-1 Overall Area Geology (Source – Queensland Department of Mines and Energy)

[3] https://ws-07-8bdxkw.goldcoast.qld.gov.au/documents/bf/springbrook-conservation-plan.pdf

4 DATA COLLECTION/ANALYTICAL PROCESS

41. A number of sources of data collection and groundwater behaviour analysis investigations have been presented or drawn upon in regard to this matter by the project proponent to attempt to justify why the 16 ML/year groundwater extraction rate is acceptable. I have summarised these investigations, and other relevant sources of information on this matter below, presenting my commentary on their relevance and then making a relevant set of conclusions.

42. In many of these summaries, I refer to the **sustainable yield** of the local groundwater system. The sustainable yield is **the average rate of pumping that can be maintained without endangering the aquifer and associated environments by excessively drawing down water levels**. If continued pumping occurs at a rate that is greater than the sustainable yield, then at various (often critical) times for a local groundwater resource (e.g. typically under lower rainfall and/or drought conditions) there may be excessive drawdown of the water level in an aquifer. This drawdown can affect the aquifer's long-term viability as a supply source, and may also have unacceptable off-site effects through starving vegetation of groundwater and affecting downstream spring-based water sources.

4.1 Douglas Partners (2017)

43. This investigation reported the results of a **1-day** pump test conducted in August 2017 at 263 Repeater Station Road. This test saw the extraction of 0.7 L/sec of groundwater from the site, from which Douglas Partners conclude that 0.4-0.5 L/sec (12.6-15.8 ML/yr) can be reliably and sustainably extracted from the site on a long-term basis, with no off-site impacts. This test did not use any external observation bore, but relied upon water level data collected within the bore itself. The data from this test (Drawing No 2 of the report) showed that bore water levels has not reached steady state after 1 day.

44. In my opinion, a 1-day pump test is not sufficient to determine the sustainable yield of groundwater from what is in fact a relatively constrained area of an unconfined aquifer with a small zone of contribution. I note that AS 2368-1990 Test Pumping of Water Wells[4] would have required that pumping tests comprise a constant rate of extraction for a period of between 24 hours (1 day) and 160 hours (almost 7 days), with longer testing for intensive extraction bores. I consider the case at 263 Repeater Station Road is 'intensive' in nature given the large rate of pumping when compared with the small zone of contribution to the site. I provide further justification in regard to this opinion in Section 6 of this report.

45. As well as using guidance that would have been provided by AS 2368-1990, I have considered the requirements that would have been associated with AS 2368 with material presented in the book 'Analysis and Evaluation of Pumping Test Data' by Kruseman and de Ridder (Second Edition) (2000). This is a benchmark publication that is accepted around the world as a key guidance document in regard to groundwater pump tests. I consider this text a foundational publication and have used it to guide and inform my opinions.

46. I note that Kruseman and de Ridder state that '...in an unconfined aquifer, because the cone of depression expands slowly, a longer period (than 24 hours) is required'. I also note that Kruseman and de Ridder state that 'better and more reliable data are obtained if pumping continues until steady or pseudo steady flow has been attained'. They also state that 'in some tests, steady state… conditions occur a few hours after the start of pumping; in others they occur within a few days or weeks; in yet others they never occur….'. They also state that 'it is good practice to strive for a steady state, especially if accurate

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[4] I note that AS 2368 has been 'withdrawn'. In regard to this matter, the Standards Australia website states as follows:

The withdrawn status indicates that the standard is no longer relevant. Standards Australia will not undertake further work to maintain or update a withdrawn standard.
It is still possible for a withdrawn standard to be used within an industry or reference by a government if they choose to do so. One reason for this may be because there are no replacement technical documents readily available.

I also note that no 'replacement technical documents' are available.

information on the aquifer characteristics is desired'. By steady state, these descriptions refer to a state wherein the groundwater level in an observation bore change negligibly over a specified time while pumping is occurring, if they change at all.

47. I also note that the long-term extraction rate proposed by the Appellant is at the upper bound of the range of findings of the Douglas Partners report (0.4 L/s to 0.5 L/s), without justification as to why this higher rate was chosen.

4.2 Douglas Partners (2018)

48. This investigation saw no new data collection or fieldwork being conducted. Rather, this work was the application of the 'Theis Non-Equilibrium Equation' to assess the extent of drawdown in groundwater levels that may occur around a production bore on the 263 Repeater Station Road property. If I am to accept this analysis, the modelled area of influence due to 1 year of site operations predicted by this investigation is reproduced in Figure 4-1, with the red circle showing the extent of the 1.5 m groundwater drawdown contour. This indicates potential off-site impacts due to the proposed groundwater extraction. As stated earlier in this report, the 1 m drawdown contour (if shown) would extend to a radius of almost 1 km from the site, highlighting even further potential off site impacts.

49. I note, however, that this analysis is based on the following:
    - No rainfall in the 12-month period.
        - This is highly unlikely in an area such as Springbrook. For example at the Bureau of Meteorology rainfall station at Wunburra on the Springbrook Plateau which has data extending back to 1953, the lowest annual rainfall was 575 mm, the median annual rainfall was 1,698 mm and the highest annual rainfall was 3,759 mm.
    - The aquifer has an infinite areal extent.
        - This is not the case as shown in Figure 3-1.
    - The aquifer is homogenous and of uniform thickness.
        - The subsequent 'Hair Report' shows this is not the case - as explained in Paragraph 60.

50. As such, no reliability can be assigned to this analysis. In my opinion, this analysis cannot be used to determine the sustainable yield of groundwater from the site as the assumptions which underpin it are not met. I provide further justification in regard to this opinion in Section 6 of this report.

4.3 Peter J. Ramsay (2014)

51. This thorough investigation (I note that this report was not produced for the Appellant for this case) was conducted in regard to groundwater extraction works at 133 Repeater Station Road, which is some distance down slope (the site has an approximate RL of 819 m AHD) and away from the subject site. Salient points from this work are as follows:
    - The report identified correctly that pumping tests only evaluate short-term groundwater impacts, and that longer term impact assessments require monitoring and appropriate site-based water balance modelling;
    - The report saw the performance of a **5-day** pump test[5] which was far more appropriate than the limited period of pumping associated with the Douglas Partners (2017) investigation at 263 Repeater Station Road, having consideration of AS 2368 – 1990 (Test pumping of water wells) and matches

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[5] Attachment 1 of the Peter J Ramsay report shows that water levels in the separate monitoring bore used by this test had reached quasi-steady state conditions within this 5-day period.

with the recommendations of Kruseman and de Ridder (2000). The testing was also conducted in October 2014, following several months with rainfall that was lower than the long-term average;

- Water level testing was conducted in the extraction well and in a separate disused extraction well; and
- The report concluded that extraction at a rate of 9.9 ML/yr is highly unlikely to cause any short-term impact to existing groundwater users and nearby ecosystems. It also recommended that if greater extraction rates are proposed, that further pump tests should be conducted.

52. In my opinion, this is the type of analysis required to be conducted at 263 Repeater Station Road in order to robustly determine what the sustainable yield from the site will be. That is, it was a longer-term pump test conducted under predominantly dry weather conditions. Importantly, this analysis indicated a sustainable yield from the 133 Repeater Station Road site of **9.9 ML/yr**, a site that has a greater potential zone of contribution to the groundwater table than 263 Repeater Station Road. To me, this indicates that the sustainable yield from 263 Repeater Station Road will be less than that at 133 Repeater Station Road.

4.4 Peter J. Ramsay (2015)

53. This investigation (I note that this report was not produced for the Appellant for this case) again relates to 133 Repeater Station Road. No further field tests were conducted, rather analysis was undertaken of long-term (12 months) groundwater level monitoring data, in association with ongoing water extraction operations from the site. This investigation supported an extraction rate of 12 ML/yr over the long-term, though they did conclude that monitoring during periods of lower rainfall is required.

54. This analysis indicated a sustainable yield from 133 Repeater Station Road of **12ML/yr** from a location which has a much greater potential zone of contribution to the groundwater table than 263 Repeater Station Road. This indicates that the sustainable yield from 263 Repeater Station Road will be less than 12 ML/yr.

4.5 Peter J Ramsay (2017)

55. Again, this work relates to 133 Repeater Station Road, and again no further field-based pump tests were conducted, but an analysis of 2 years of long-term groundwater level monitoring data was undertaken. I note that this report was not produced for the Appellant for this case. This investigation concluded that groundwater extraction at rates of 7.4 ML/yr (for 2015-2016) and 10.14 ML/yr (for 2016-2017) are sustainable. The annual average rainfall at Springbrook Road (BOM Site 40607) is 1,997.7 mm, and the annual rainfall for 2015-2016 was 1,618.5 mm and for 2016-2017 was 2,395.4 mm.

56. This analysis indicated a sustainable yield from 133 Repeater Station Road of as low as **7.4 ML/yr** from a location which has a much greater potential zone of contribution to the groundwater table than 263 Repeater Station Road. This indicates that the sustainable yield from 263 Repeater Station Road will be less than 7.4 ML/yr.

4.6 'Hair Report' (undated, assumed 2021)

57. This investigation related to works conducted at 263 Repeater Station Road. Salient points from this work are as follows.

58. A 7-day pump test was conducted, using an extraction rate of 0.5 L/s (15.8 ML/yr) and with water levels being measured in the pumping bores and in observation bores.

59. This pump test was conducted in the wettest period of the year (February) and there was heavy rainfall midway through the test. I note that Kruseman and de Ridder (2000) state as follows in regard to this situation:

    In general, the water levels measured during a pumping test cannot be corrected for unique fluctuations due, say, to heavy rain or the sudden rise or fall of a nearby river or canal that is in hydraulic connection with the aquifer. In certain favourable circumstances, allowance can be made for such fluctuations by extrapolating the data from a control piezometer outside the zone of influence of the well. But, in general, the data of the test become worthless, and the test has to be repeated when the situation has returned to normal.

60. The investigation also showed that the aquifer beneath the site is highly compartmentalised and is not 'uniform' as quite different changes in water level were measured from the various boreholes across the property used in the testing.

61. Significantly, when water level data collected at the northern and southern boundaries of 263 Repeater Station Road (Figure 4 of the Hair Report) during the pump test are compared, the southern data collection point showed little change in water level during testing, whereas the northern data collection point showed an almost 10 m increase in groundwater level.

62. Any extrapolation of these data to derive or recommend long-term sustainable rates of water extraction from the site and the prediction of associated changes in water levels within the site or at adjacent sensitive receptors is highly problematic. The data indicates that the aquifer beneath the site is not homogenous due to the significant difference in water level drawdown and recovery between various boreholes, and all analytical techniques that have been applied have assumed a far more homogeneous system.

4.7 Summary

63. When I consider all of the investigations outlined above, the conclusions I reach are presented below.

64. Of the analysis sets which are available for the two sites (133 and 263 Repeater Station Road), the only one which I consider to be comprehensive (that is which would have complied with AS 2368 – 1990 (Test pumping of water wells), is appropriate given the recommendations of Kruseman and de Ridder (2000) and which also has an operational data set covering some three years with varying rainfall conditions) relates to 133 Repeater Station Road. Quite thorough, lengthy (multiple year) and comprehensive analyses at this site have conclusively shown that groundwater extraction rates of the order of **7 – 10 ML/yr** are sustainable for that site.

65. For 263 Repeater Station Road, there have only been two short term data collection exercises. The first was for 1 day under dry conditions and the second was for 7 days under wet conditions, neither of which would have complied with AS 2368 or meet with the recommendations of Kruseman and de Ridder (2000), or are sufficient to assess long-term groundwater behaviour at the site. A separate analytical investigation was conducted, however, as highlighted above and discussed further below, the assumptions underpinning that analytical investigation are incorrect, meaning the conclusions from that analytical investigation are also incorrect. As such, this analysis/dataset is of insufficient quality/duration and does not fit with the site characteristics (in the case of the analytical investigation) to reliably be able to inform an opinion of the sustainable pumping yield from 263 Repeater Station Road. My justification of this opinion is based on the following:

    - The first pumping test was of insufficient duration (**1 day**) and spatial extent (water level monitoring only occurred within the pump bore and not in a separate observation bore) to reliably assess the sustainable yield of the groundwater system as steady state conditions did not develop in the pumped well;
    - The subsequent (analytical) investigation which was undertaken shows (if it were correct) impacts that extend well beyond the property boundary. However, due to its fundamental assumption of a

uniform aquifer (which is incorrect as demonstrated by the second pumping test, see below) the results of this analysis cannot be relied upon; and

- The second test, while of a more suitable duration (**7 days**), is flawed by:
  - Being during the wetter period of the year;
  - Having a major rainfall event occur midway through the test (which Kruseman and de Ridder claim means that '*the data of the test become worthless')*; and
  - Showing quite different water level results from the boreholes placed across the property, indicating that the aquifer beneath the site is highly fragmented and non-homogenous and also steady state conditions did not develop.

For all of the above reasons, any extrapolation of this test to derive a long-term sustainable yield cannot be relied upon.

66. When I review all of the above, my opinion is that sufficient work has been done at 133 Repeater Station Road to demonstrate that **7 – 10 ML/yr** is a sustainable yield from that site. This is due to the relationship between the site location and the zone of contribution that is providing water to the groundwater table at this site. Given the location of 263 Repeater Station Road is significantly upslope of 133 Repeater Station Road, and hence with a far smaller zone of contribution, the sustainable pumped groundwater yield from the 263 Repeater Station Road site will be less than the 7 – 10 ML/yr value derived by Peter J. Ramsay for the 2015 – 2017 period. Extraction of 16 ML/yr from 263 Repeater Station Road will have unacceptable impacts on the groundwater table in the area.
67. I also note that the Appellant has not demonstrated what level of extraction is sustainable from 263 Repeater Station Road.

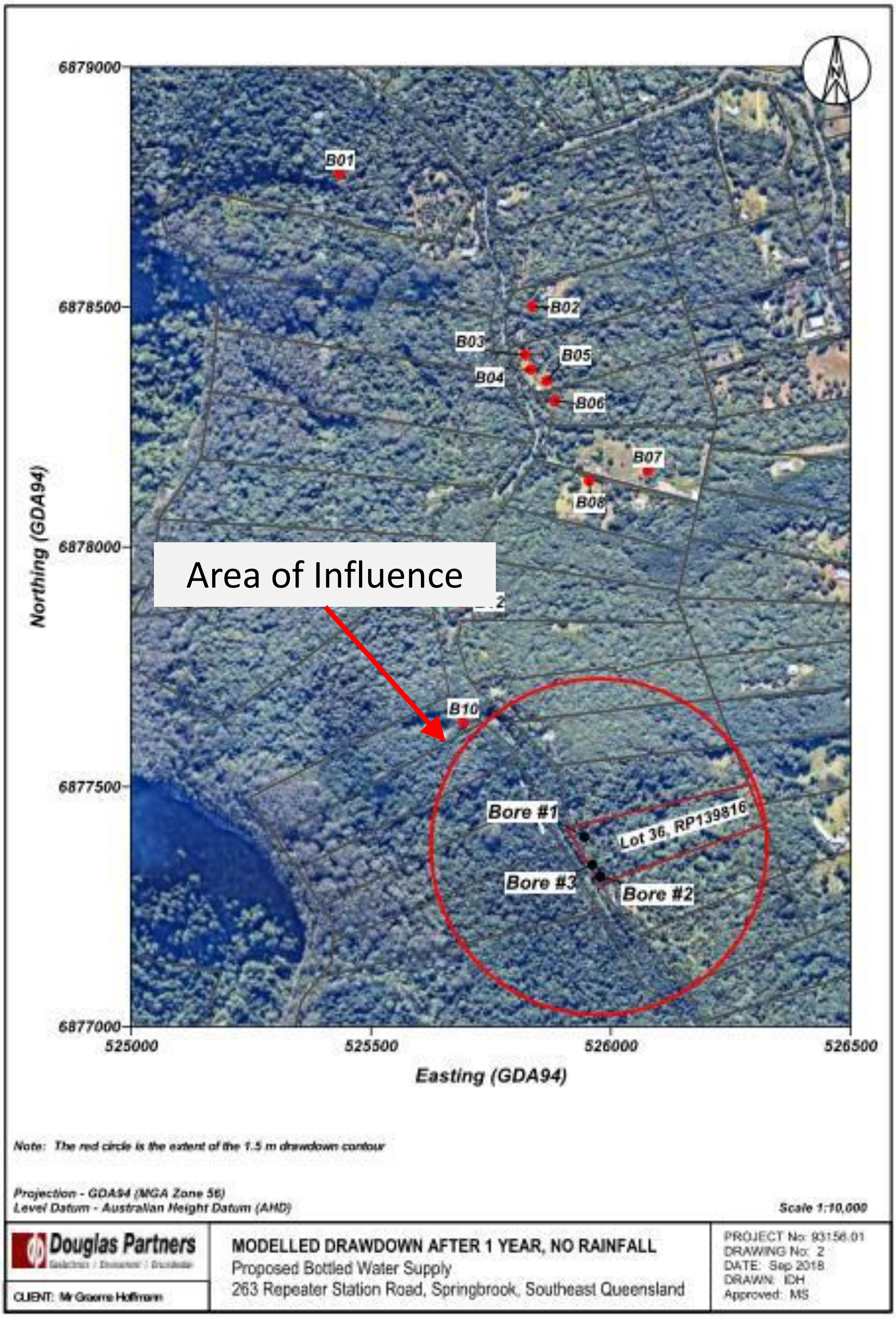

Figure 4-1 Extract from Douglas Partners 2018

5 MODELLING CONSIDERATIONS

5.1 Available Models

68. Two modelling investigations have been used by the proponent of the project at 263 Repeater Station Road to attempt to justify the proposed groundwater extraction rate of 16 ML/year. The simple, analytical solution of the 'Theis Non-Equilibrium Equation' used by Douglas Partners (2018) has been discussed in Section 4.2 of this report. In my opinion, that approach does not comply with the characteristics of this site. The remainder of this section of the report addresses the other modelling approach applied, which is the work conducted by SLR. In this section, I describe why this modelling also is inappropriate to assess the impact of groundwater extraction works at 263 Repeater Station Road.

69. SLR used a lumped surface water balance model, not a groundwater analysis or groundwater model. A groundwater model is based on groundwater flow equations, which are differential equations (which are mathematical equations which explain how groundwater flows) that can often be solved only by approximate methods using a numerical analysis. An example of a groundwater model is MODFLOW. Mathematical models, such as MODFLOW, are based on the real physics that the groundwater flow follows. Therefore, the lumped surface water balance model does not accurately predict groundwater flows, because it is focused on surface water flows and baseflow in a stream/river network. For clarity, baseflow is not groundwater flow, for the reasons explained at paragraph 77.

70. Given the highly heterogeneous nature of the aquifer beneath the 263 Repeater Station Road site, groundwater modelling would be extremely difficult, if not impossible, and would require a major drilling and data collection program to provide sufficient data to inform the model. Where a groundwater model is not practicable, it is not appropriate to use a lumped surface water model in its place, because such models do not accurately reflect the physical processes occurring onsite (as explained at paragraph 69). Instead, where a groundwater model is not practicable, (appropriate) pump testing programs are the usually preferred way of assessing the behaviour of groundwater. In my opinion, the minimum requirements for an appropriate pump testing program are identified at paragraph 87, including in particular that it must be of sufficient duration and undertaken in drier conditions. The pump testing program that I recommend should be carried out **prior** to lodging a development application, as it will inform the nature of the development that is being assessed.

71. I outline my concerns in more detail below regarding the suitability of the AWBM model for assessing the water balance at the site and how groundwater extraction may relate to this water balance.

5.2 AWBM Method (General)

72. SLR used a lumped surface water balance model to infer the rate of recharge of groundwater beneath the 263 Repeater Station Road site. The model they have applied is the Australian Water Balance Model, or AWBM. This model simulates the entire 68 km² catchment upstream of the Numinbah Valley streamflow gauge via 5 'buckets', as illustrated in Figure 5-1 (noting that this figure was sourced from the following location:

    https://wiki.ewater.org.au/display/SD45/Australian+Water+Balance+Model+%28AWBM%29+-+SRG).

73. On the eWater website, which hosts a version of the AWBM model, the following description is given of this particular analytical tool.

    AWBM is a catchment water balance model that relates daily rainfall and evaporation to run-off, and calculates losses from rainfall or flood hydrograph modelling. The model contains five stores; three surface stores to simulate partial areas of run-off, a base flow store and a surface run-off routing store.

74. In 'Boughton, W.J. (2004) The Australian water balance model, Environmental Modelling & Software, vol. 19, pp. 943-956.; the original publication that introduced the AWBM model, the following description is provided:

> *The Australian water balance model (AWBM) is a catchment water balance model that calculates runoff from rainfall at daily or hourly time increments. The daily version is used for water yield and water management studies; the hourly version is used for design flood estimation.*

75. Neither of these descriptions mention groundwater stores.

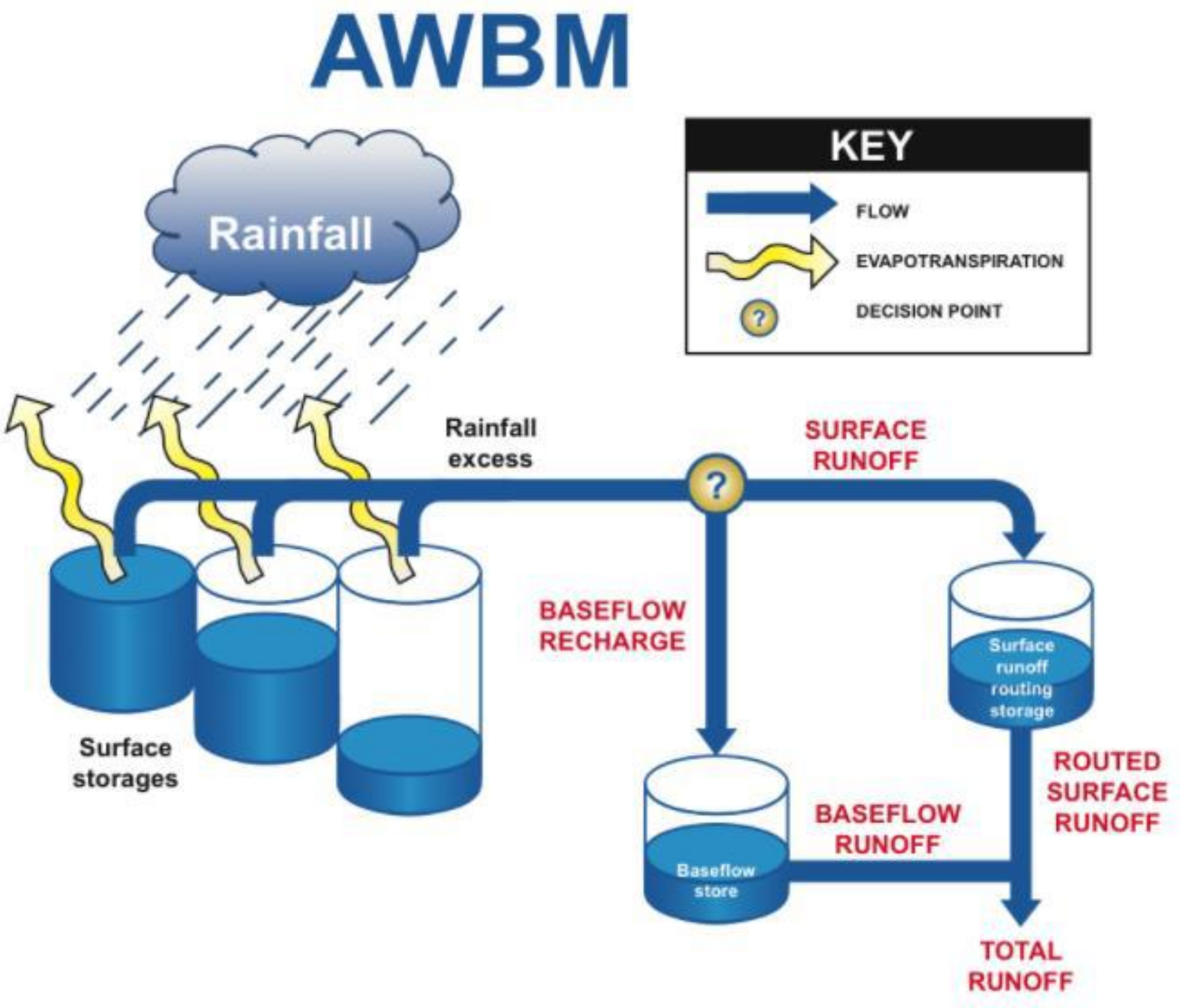

Figure 5-1 Structure of the AWBM Rainfall-Runoff Model

76. AWBM aggregates the behaviour of an entire catchment into five stores or buckets. That is, a 68 km^2 catchment with varying slopes, soil types, vegetation coverage, rainfall and evaporation patterns is aggregated into 5 buckets. Hence, all one can really tell from such an approach is how an entire catchment behaves, not how a particular site within a catchment (which will have its own unique slopes, soil types, vegetation coverage, rainfall and evaporation patterns) will behave. This aggregation approach means that the model does not explicitly simulate the following key processes;

- Spatial patterns of rainfall, land use, evaporation, et cetera across a catchment;

- Changes in slope and hence rates of run-off and infiltration across a catchment;
- Variations in soil types and underlying geology across a catchment (which in this case are considerable); and
- Flow processes within streams within a catchment, wherein some areas flow may pass from groundwater into a stream, while in other areas the reverse may occur.

77. I also note that the baseflow store shown in Figure 5-1 is not representative of deep fractured vesicular basaltic groundwater systems as per the aquifer underneath the 263 Repeater Station Road site.

5.3 Application of the AWBM Model to the Subject Site

78. For all these reasons, use of the model developed by SLR which is calibrated for flow data at the Numinbah gauge (catchment area 68 km²) to then extrapolate groundwater recharge at the 263 Repeater Station Road site, with a far smaller and totally different catchment and climate pattern, is incorrect. This analysis takes no consideration of the individual characteristics (slope, catchment area, incident rainfall, et cetera) of the 263 Repeater Station Road site itself, nor of the nature of the geology and aquifer characteristics beneath the site. My concerns in this regard are illustrated in the images of Figure 5-2 to Figure 5-7 which show how the catchment upstream of the Numinbah gauge is markedly different to the catchment upstream of 263 Repeater Station Road.

79. As well as my overarching concerns as outlined above regarding the suitability of the AWBM model in general, I have the following further issues with how SLR has actually applied the model in this particular instance.

80. The 'excellent representation of the recorded flows, particularly for the lower flow rates' cited in the SLR report is not apparent in their Figure 6, which would appear to overpredict the influences of regular rainfall events. This is illustrated in the highlighted boxes shown in Figure 5-8.

81. The model is 'calibrated' to data collected on the Nerang River at Numinbah, a site located a significant distance 'downgradient' from the edge of the Springbrook escarpment. As shown in Figure 5-9 and Figure 5-10, the longitudinal slope of the river by the time it reaches Numinbah is quite different to that in the vicinity of the area of interest, and hence there will be different relationships between flows at this site, the catchment and floodplain at Numinbah to those at 263 Repeater Station Road which is steeper, wetter, has different soil types and has no floodplain. As such, model results at this downstream location are not transferable to the upstream part of the catchment.

82. In my opinion, SLR have used too large a catchment area in their analysis. They state that 'the catchment area draining to the 830m AHD contour was estimated to be 309 Ha'. In my opinion SLR have used an unrealistically large catchment, as their analysis as presented in the Groundwater JER would imply that rainfall falling on the Springbrook region some 2km distance from the 263 Repeater Station Road site will flow a substantial distance west and then north before being extracted from the site, all based on there being 'no offsite' impacts associated with the project. When I undertake additional inspections, see Figure 5-11, taking into account more local (though still potentially too large) patterns of potential groundwater recharge, I derive a catchment of 137 Ha that may see water recharge the 830 m AHD contour (realising that such a catchment can have surface flow passing both to the east and west of the drainage divide). This would mean that extracting 16 ML/year from the site with an annual recharge rate of (say) 30% and an annual rainfall of 2,000 mm/yr would see the extraction remove 2% of the volume of water otherwise recharging the underlying aquifer in an average year. Being even more conservative, the area of the 263 Repeater Station Road site is 4.2 ha and if I assume that all other external areas recharge the aquifer in other directions, extraction will remove 63% of the volume of water otherwise recharging the aquifer in an average year. This shows that the catchment area used in the analysis significantly affects the percentage of water available for recharge. As such, this will mean that SLR will be underpredicting the potential impact of the groundwater extraction via their analysis.

83. This opinion was confirmed when I visited the site on the 8th of December 2021. The two most upstream sites that I inspected which were just below where surface water springs begin to occur on the site (see Figure 5-12 for the locations visited and Figure 5-13 and Figure 5-14 showing the two sites, also highlighted via red stars in Figure 5-12) were located in close vicinity to the 830m AHD contour, the indicative level of the groundwater table in this area. This supports my earlier derivation of this as being the groundwater table level for much of the time below the site and indicates where the fractured basaltic layer 'daylights' and water can escape as surface water runoff. When Figure 5-11 is viewed in light of these observations, I believe that this indicates that there is no way that the catchment area of SLR can be realistic, and in fact even my estimate of 137 Ha may be too large.

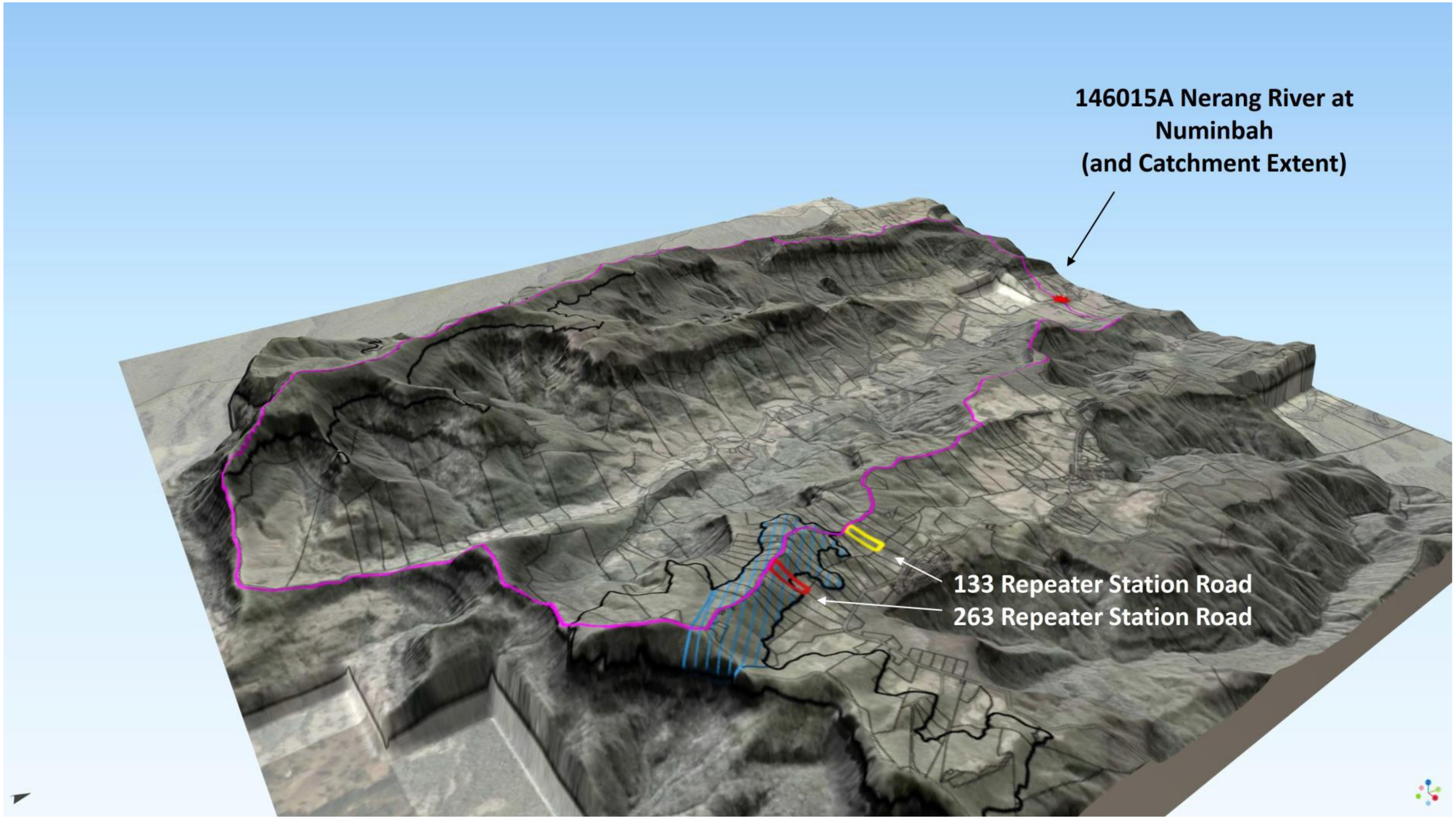

Figure 5-2 Catchment Representation from South East

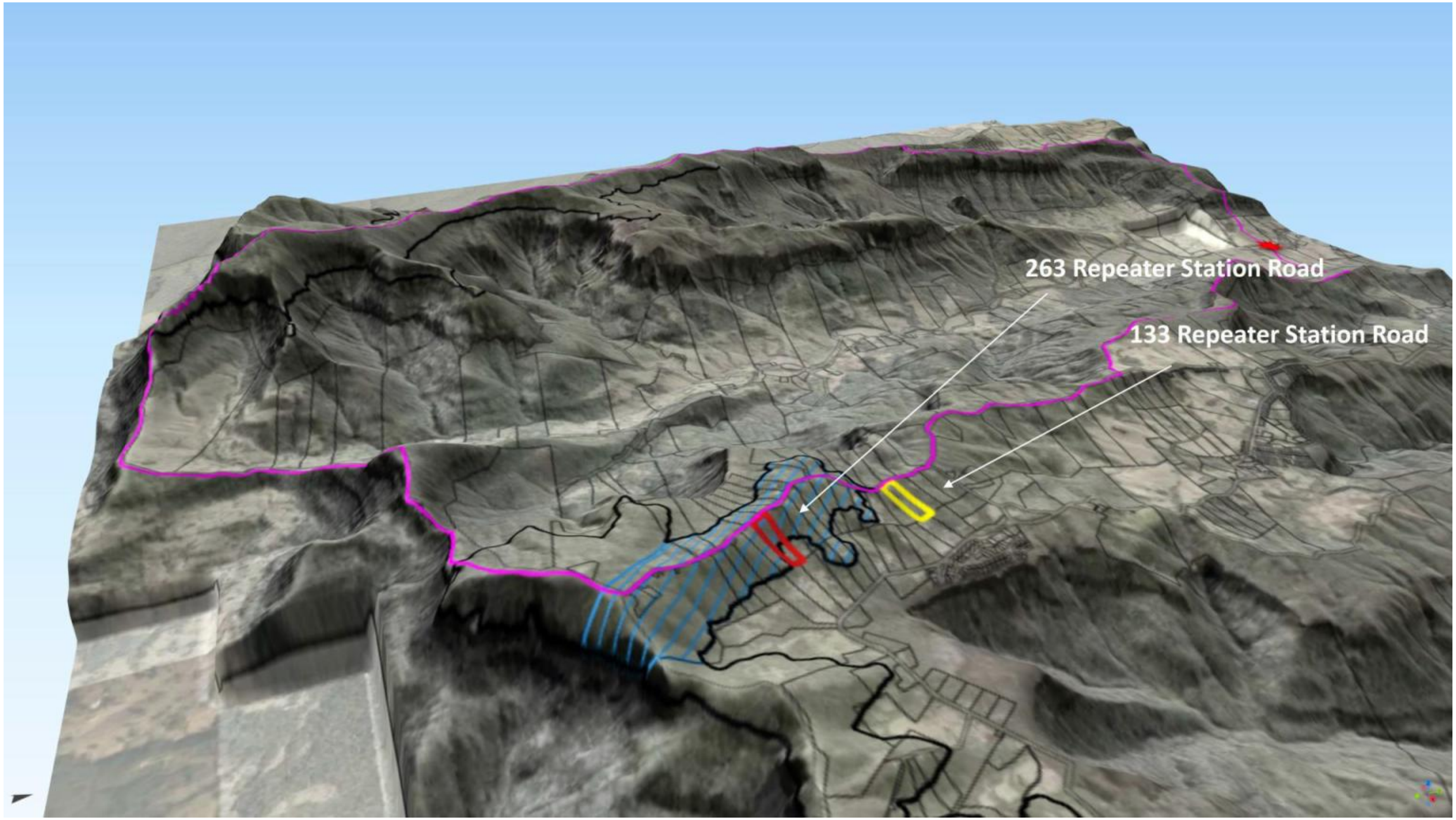

Figure 5-3 Catchment Representation from South East (zoomed in)

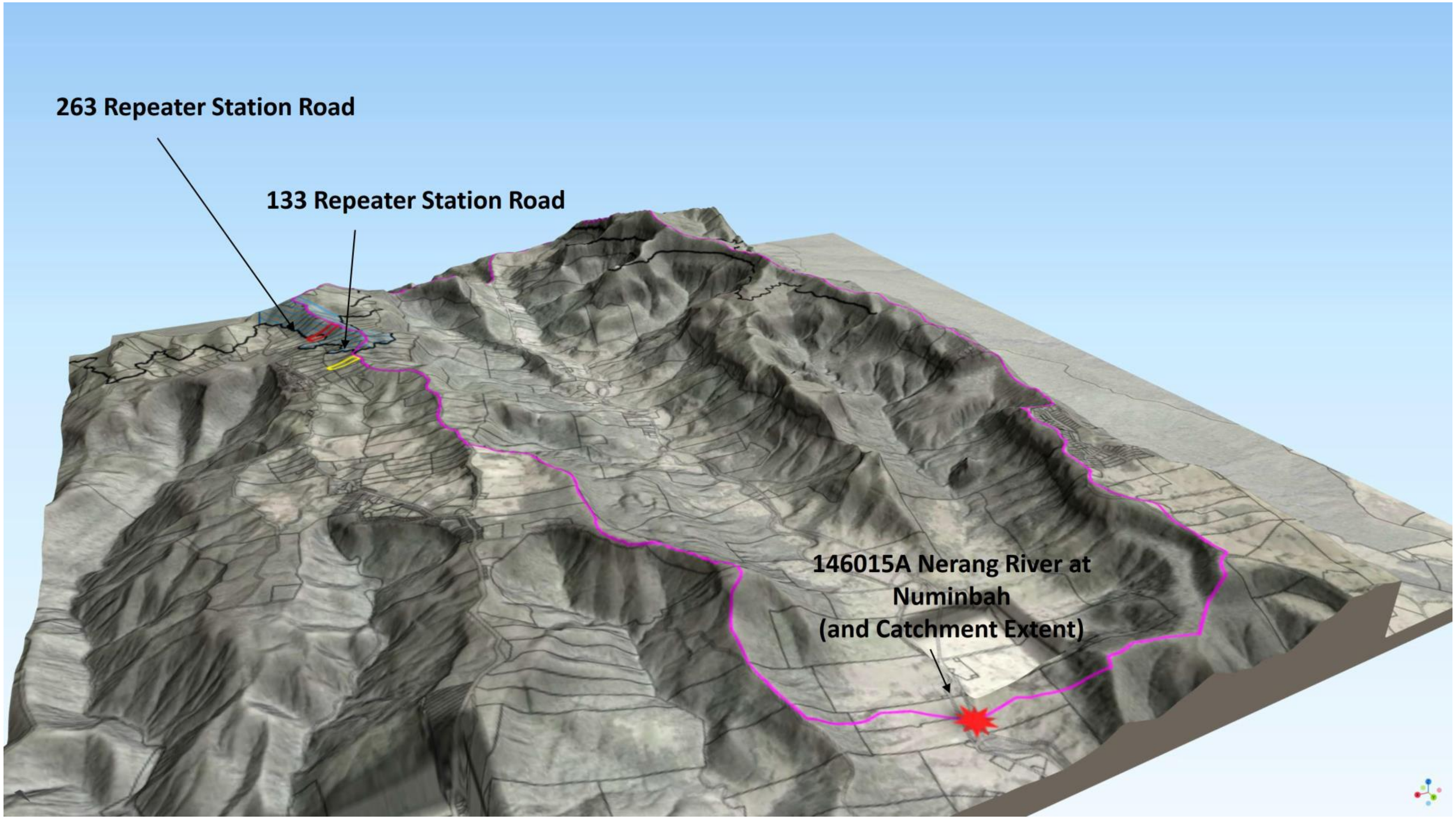

Figure 5-4 Catchment Representation from North East

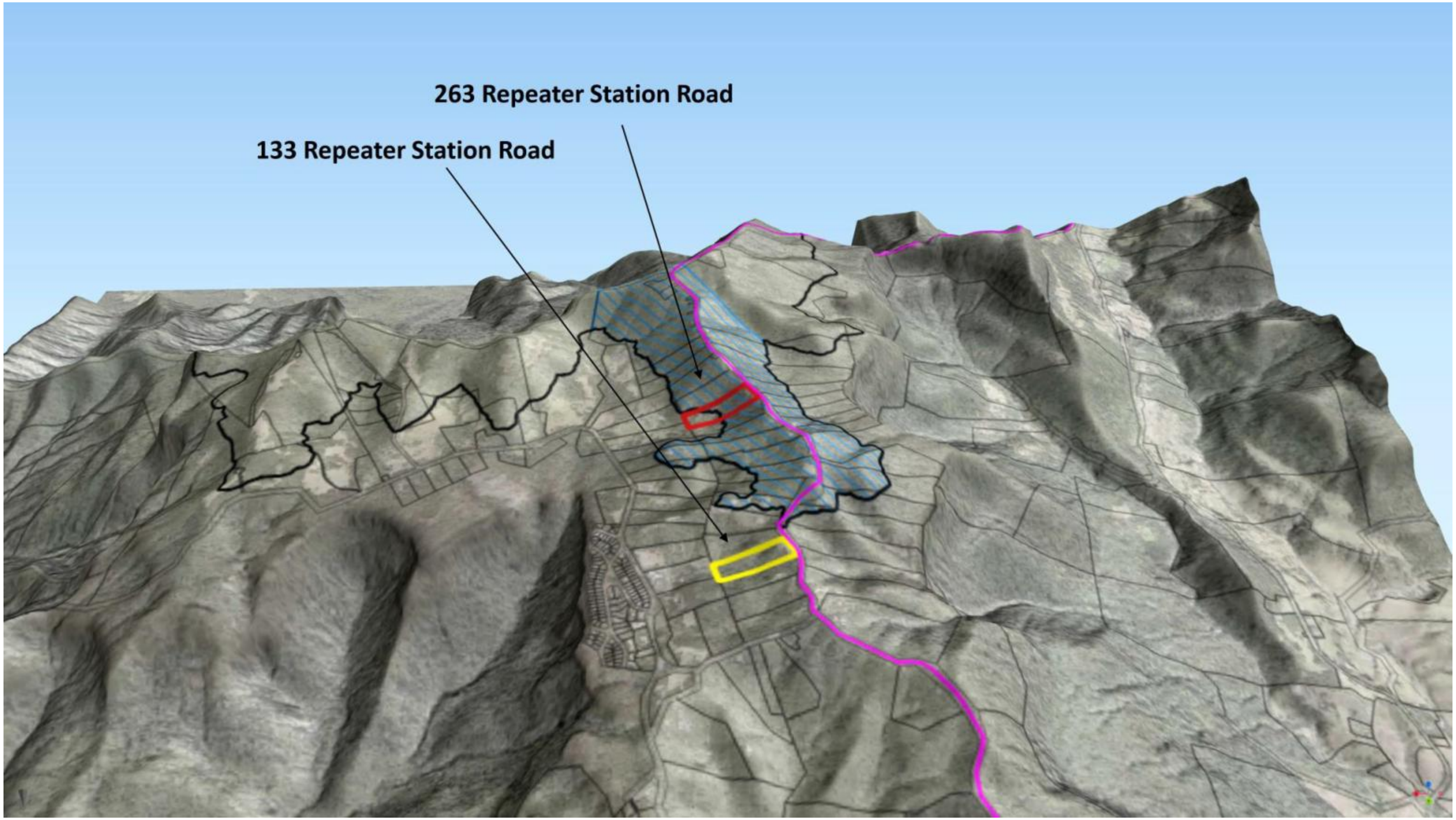

Figure 5-5 Catchment Representation from North East (zoomed in)

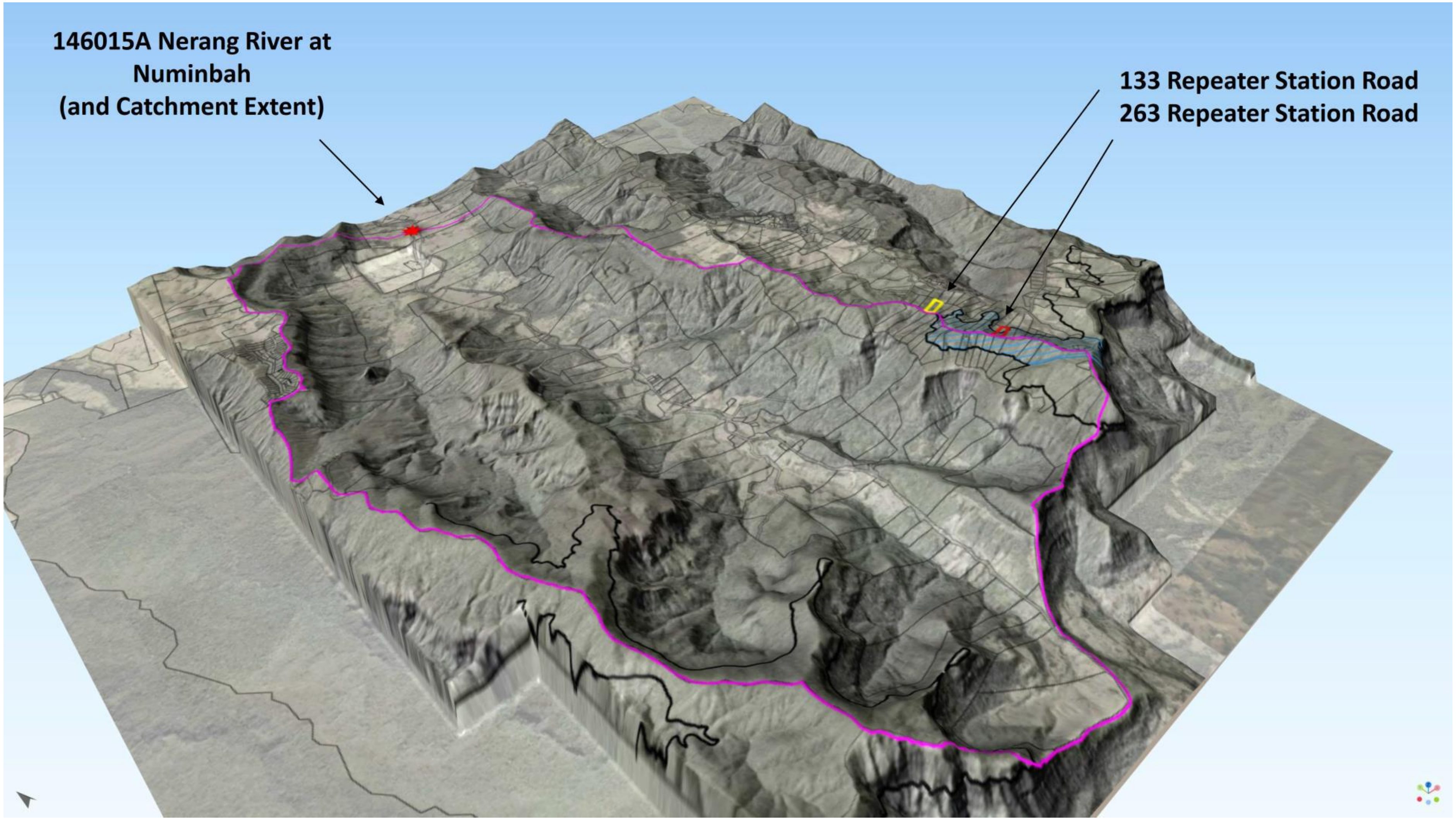

Figure 5-6 Catchment Representation from South West

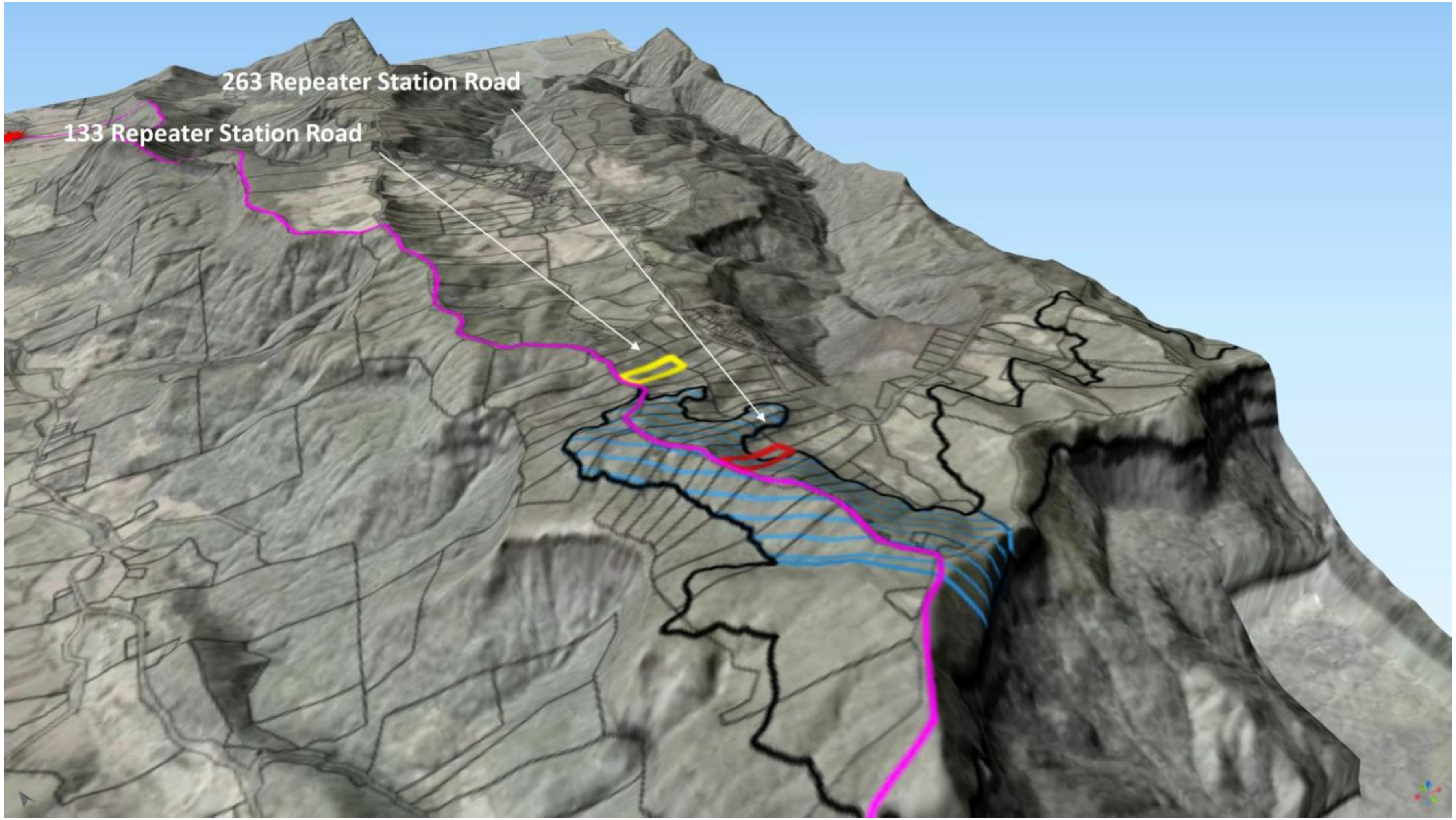

Figure 5-7 Catchment Representation from South West (zoomed in)

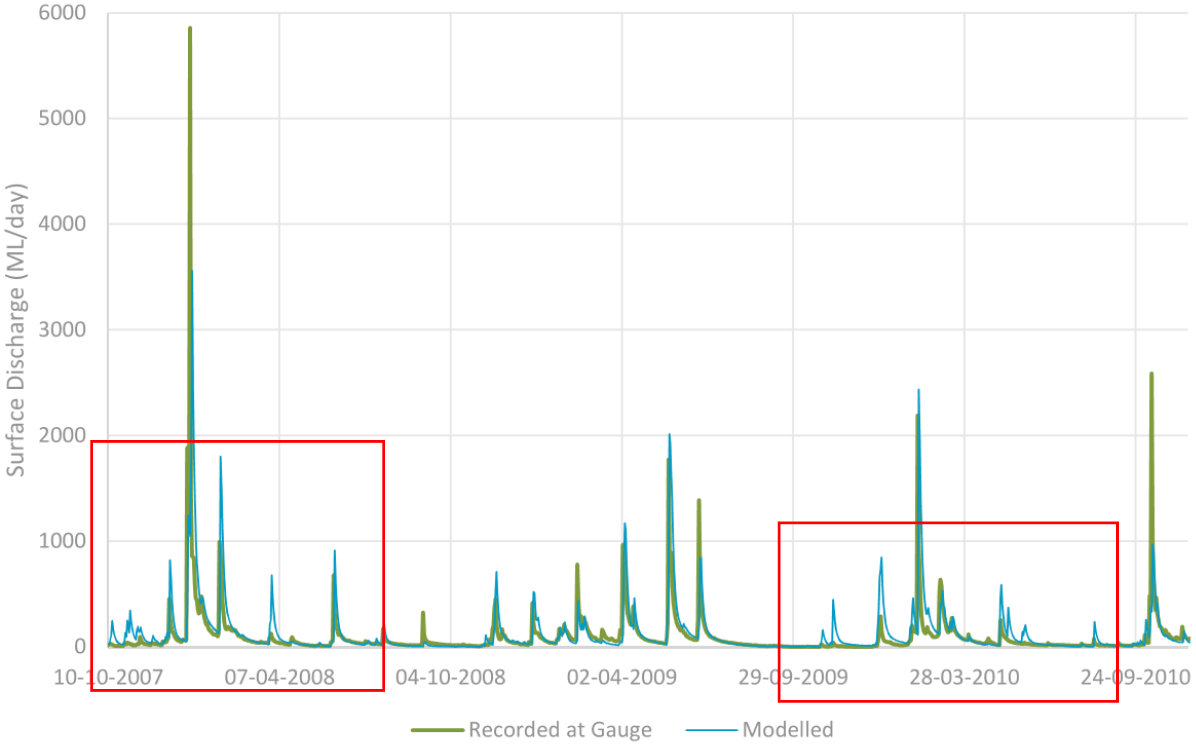

Figure 5-8 Illustration of Poor Flow Prediction of SLR AWBM Modelling of Regular Flows

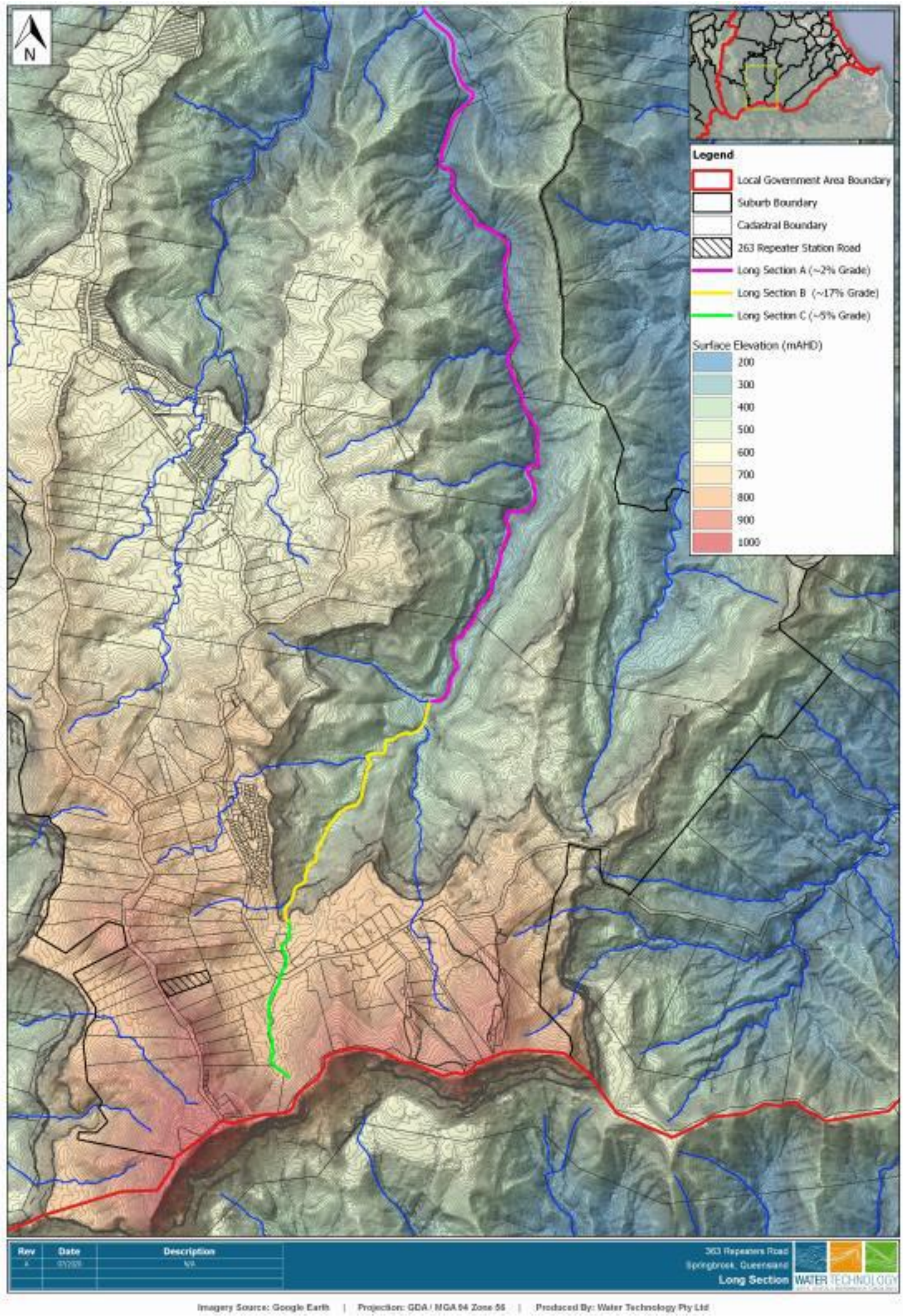

Figure 5-9 Site Long Section Locations

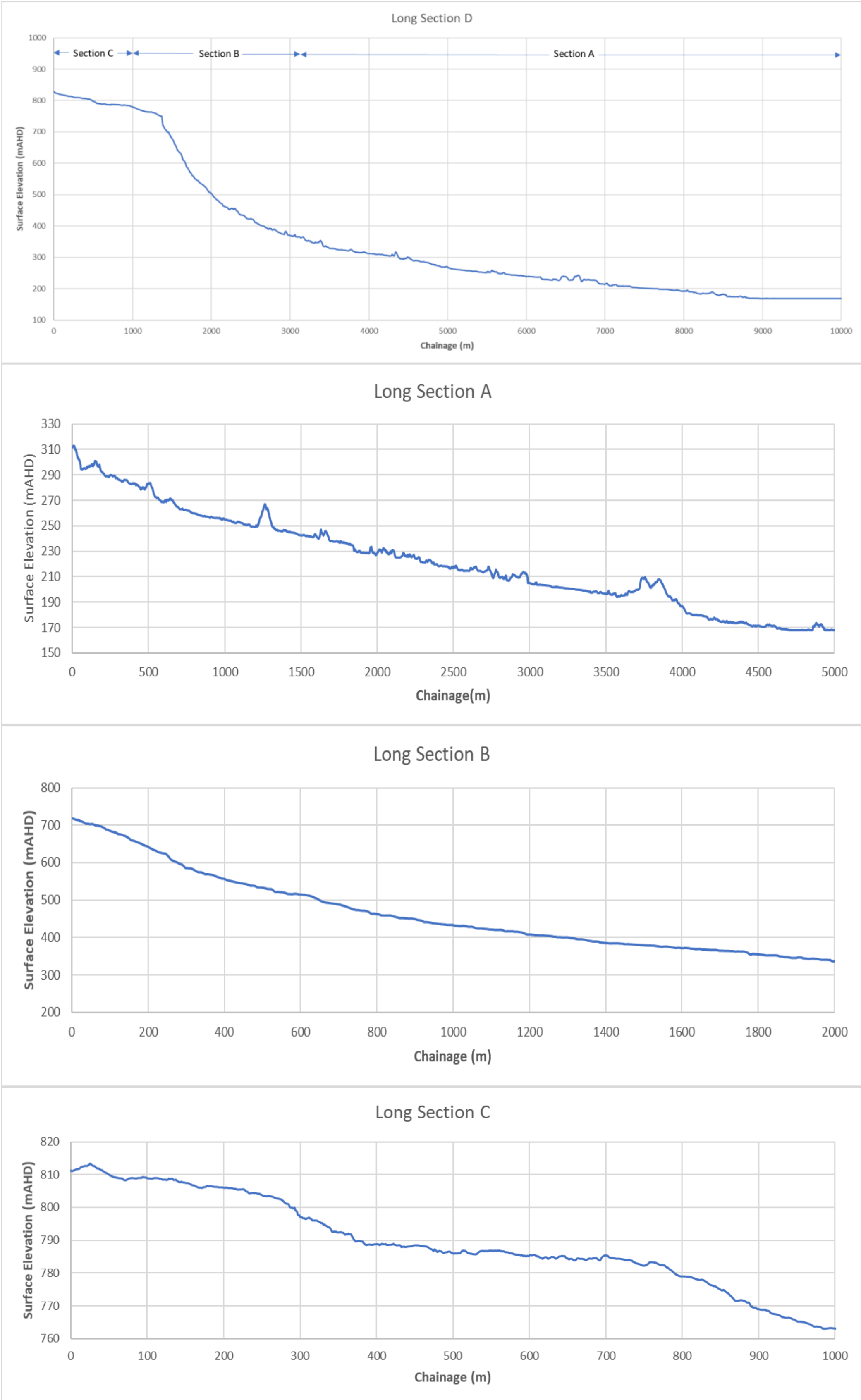

Figure 5-10 Site Long Sections

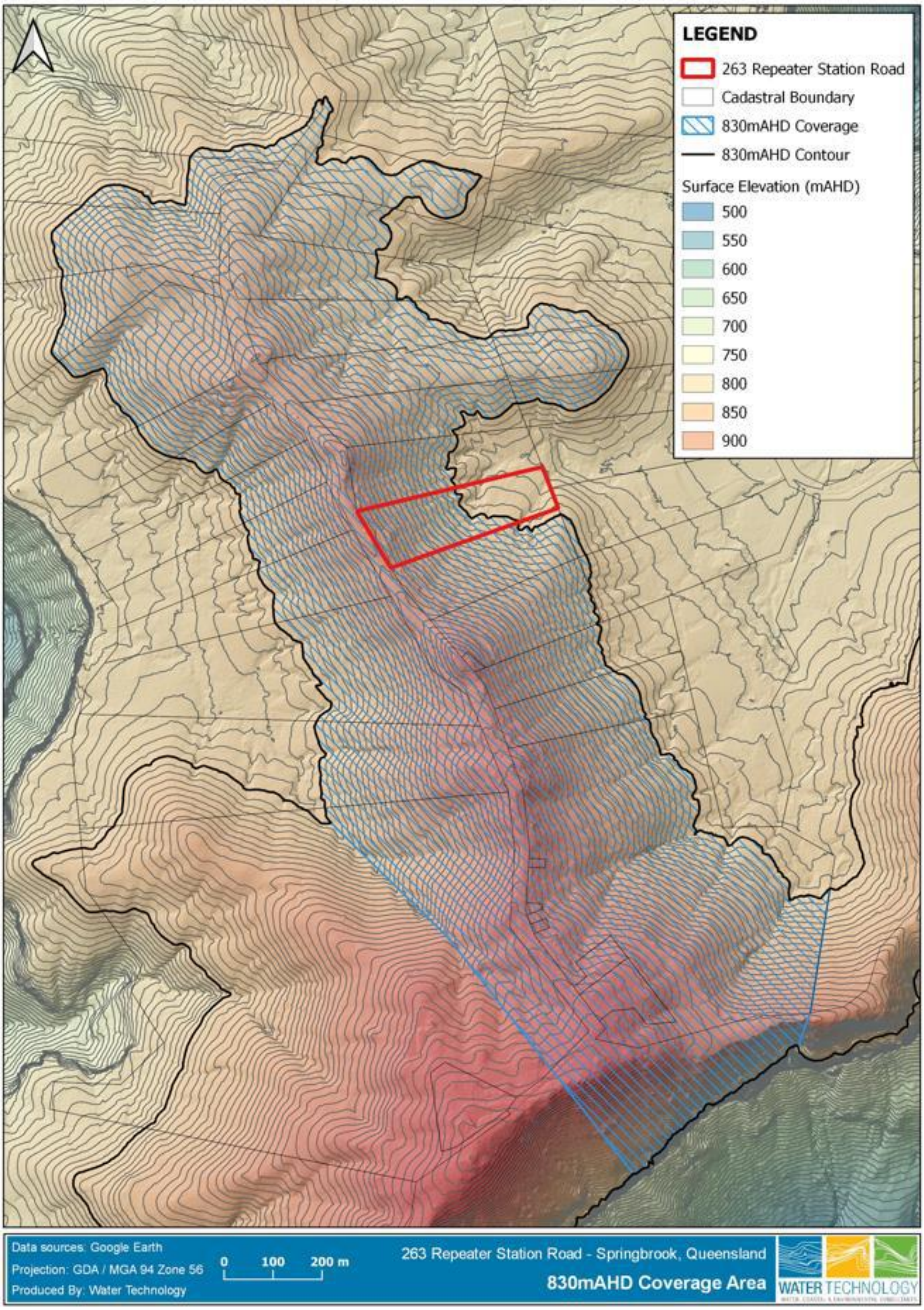

Figure 5-11 830 m AHD Coverage

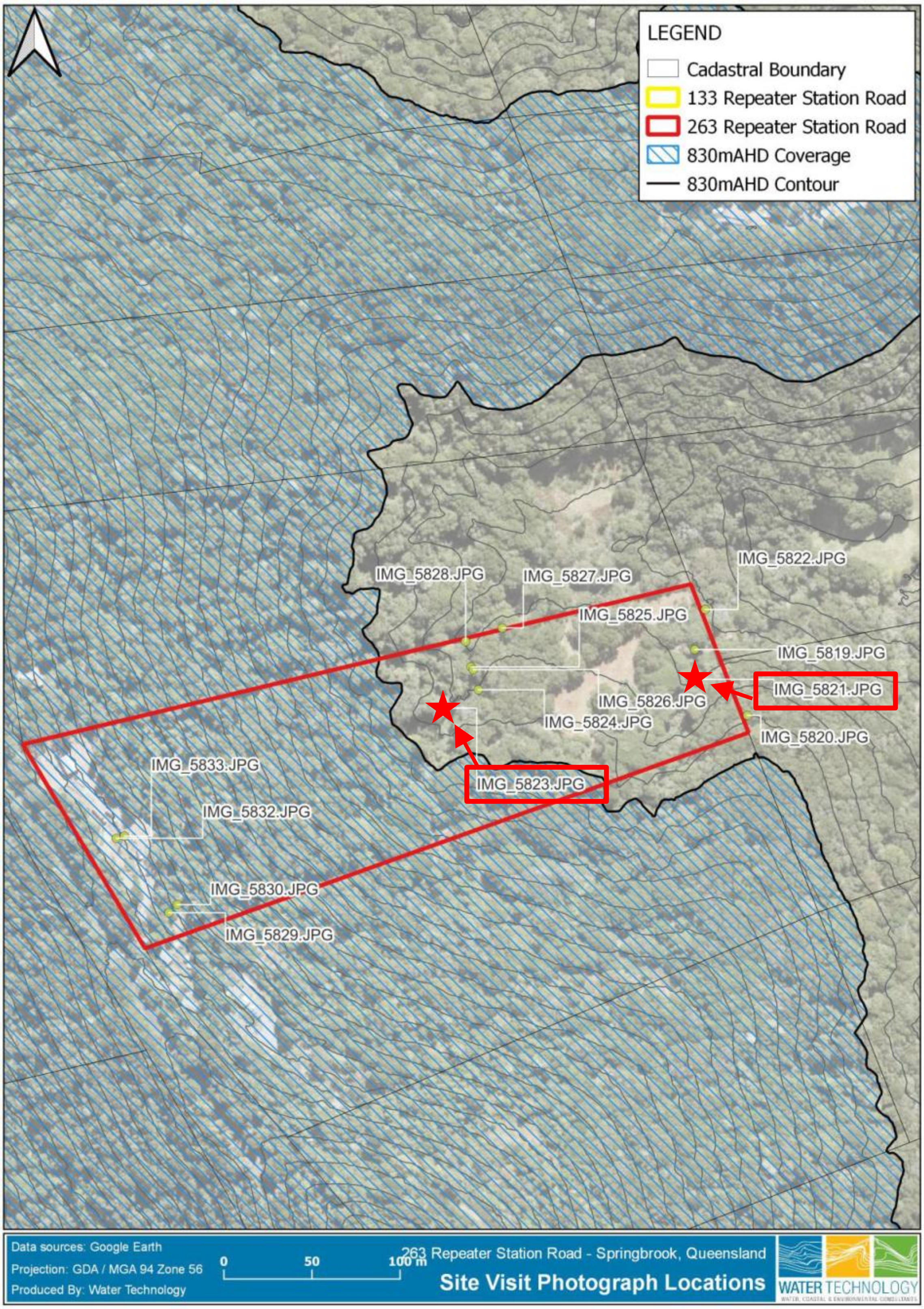

Figure 5-12 Site Visit Photograph Locations (note the contour interval is 5m)

Figure 5-13 Site Image 5821

Figure 5-14 Site Image 5823

6 RECOMMENDED ASSESSMENTS TO DETERMINE SUSTAINABLE YIELD FROM 263 REPEATER STATION ROAD

84. As described in this report, the investigations that have been conducted on the site to date are insufficient to adequately quantify the sustainable yield and the potential influence of the proposed groundwater extraction works. Given the longer duration of initial testing and production monitoring and the more appropriate data set available for the downslope 133 Repeater Station Road, the sustainable groundwater yield from the 263 Repeater Station Road will be less than the applied for 16 ML/yr. In fact, I expect that the sustainable yield will be far less than the 7 – 10 ML/yr range derived at 133 Repeater Station Road - as 263 Repeater Station Road has a smaller area of contribution.

85. Given this uncertainty, and the recognised major natural environment and social values of the areas surrounding 263 Repeater Station Road, I cannot support any extraction at the site until appropriate pump tests and associated groundwater level and surface flow data collection works are conducted, and the findings of these investigations are reviewed for rigour.

86. I also note that the sustainable yield assessments will need to take consideration of the potential environmental consequences of operations and have advice provided by appropriate specialists in this field.

87. It is important to determine the sustainable yield **before** a development application is lodged, as the sustainable yield will inform the appropriate scale of development (and whether a development of this nature is viable). It is not appropriate to determine the sustainable yield after the development is approved, because I believe that allowing the proposed development to proceed at 16ML/yr will deplete the groundwater in the aquifer, thereby affecting downstream flow patterns for significant time periods. This will be particularly so under dry conditions, due to the limited groundwater recharge at such times. In order to determine what the sustainable yield is, the Appellant should conduct impact assessment works that include at least the following:

- Further pump tests (ideally 2 to 3 separate tests) of suitable duration (most importantly - until steady state[6] conditions develop, as AS 2368-1990 (Test Pumping of Water Wells) would have required and Kruseman and de Ridder (2000) recommend), under drier weather conditions (for example July-October), for the purpose of identifying the sustainable yield;
- Placement/use of sufficient monitoring bores on the site in association with the pump tests;
- Collection of rainfall and atmospheric pressure data on the site for the period of the pump tests, and beforehand;
- Identification of the positions on the site where groundwater expresses itself as surface water run-off (see Figure 5-13 and Figure 5-14), and the collection of baseline and impact flow datasets from these sites in association with the various pump tests proposed; and
- Appropriate post-testing analysis and review of conclusions drawn in regard to the development of a sustainable yield from the site.

88. The amount of rainfall in the months before the testing program should be considered when deciding what a sustainable yield is. If the rainfall is greater than the long-term average for a comparable period, there

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[6] I note that Kruseman and de Ridder state that 'better and more reliable data are obtained if pumping continues until steady or pseudo steady flow has been attained'. And they also state that 'in some tests, steady state… conditions occur a few hours after the start of pumping; in others they occur within a few days or weeks; in yet others they never occur….'. They also state that 'it is good practice to strive for a steady state, especially if accurate information on the aquifer characteristics is desired'.

will have been more recharge and more water will be present in the groundwater resource. As such, if this is the case, a conservative (i.e. lower) pumping rate should be adopted.

89. After the above works are completed, reviewed and the project commences using the sustainable yield derived from these works and associated analyses, there should be ongoing impact monitoring via the same network of boreholes and surface water gauging infrastructure proposed above such that if any impacts are observed, there can be modifications to the rate or pattern of groundwater extraction from the site.

7 DRAFT CONDITIONS OF APPROVAL PROPOSED BY THE APPELLANT

90. I have reviewed the draft conditions of approval proposed by the Appellant and provide the following comments.

91. Firstly and most importantly, the conditions proposed attempt to determine what is an acceptable development - after the project has commenced. This is not acceptable in my opinion for the reasons I express in Paragraph 84.

92. There is no mention of performing testing to confirm what the sustainable yield from the site is. I have addressed this comment previously and believe that such work should be undertaken before the application is actually lodged.

93. There is no mention of baseline or background bore water level measurements to provide a pre-pumping data set against which impacts can be assessed once operations commence. I recommend several months of such data are collected from all relevant monitoring bores on the site so that any impacts associated with the operation can be detected. I also recommend that additional monitoring bores be constructed both downslope and upslope from the current operation to test or assess what, if any, gradients may exist in the groundwater.

94. There is no mention of measuring the flows that are apparent from the springs at the bottom of the site, as illustrated in Figure 5-13 and Figure 5-14. It will be relatively easy to find a suitable location to install instrumentation and a small V notch weir to reliably measure these flows. Again, such works should be conducted for several months prior to operations commencing on the site.

8 PROPOSED DEVELOPMENT'S COMPLIANCE (OR NONCOMPLIANCE) WITH RELEVANT ASSESSMENT BENCHMARKS

95. I understand that assessment of the development will be against a range of benchmarks that have been nominated. As such, to assist the Court, in the table below I have tried to link my statement to relevant assessment benchmarks where possible.

Item	Benchmark reference	Benchmark	Expert opinion
Strategic Framework			
	Strategic Outcome 3.5.1(9)	Natural resources are sustainably managed for current and future generations and leveraged to support the growth of nature-based tourism in a sustainable manner	The proposed extraction rate does not comply with this benchmark for the reasons outlined in my report
	Strategic Framework – Specific Outcome 3.5.5.1(1)	The prudent use of renewable and non-renewable natural resources supports long-term community needs and only occurs where any immediate or long-term environmental and social impacts can be managed to an acceptable level.	The proposed extraction rate does not comply with this benchmark for the reasons outlined in my report
	Strategic Framework - Strategic Outcome 3.7.1(2)	Land, freshwater, estuarine and marine ecological processes and other matters of environmental significance are protected and supported through a connected green space network.	The proposed extraction rate does not comply with this benchmark for the reasons outlined in my report
	Strategic Framework - Strategic Outcome 3.7.1(9)	Catchments maintain water quality and quantity to supply existing and forecast urban development, support compatible water-based leisure activities and retain future options for water harvesting.	The proposed extraction rate does not comply with this benchmark for the reasons outlined in my report.
Rural Zone Code			

Item	Benchmark reference	Benchmark	Expert opinion
	Rural Zone Code - Overall Outcome 6.2.20.2(1)(a), (b) and (c)	The purpose of the Rural zone code is to: • provide for rural uses including Cropping, Intensive horticulture, Intensive animal husbandry, Animal keeping and other primary production activities; • provide opportunities for non-rural uses that are compatible with agriculture, matters of environmental significance, and landscape character of the rural area where the uses do not compromise the long-term use of the land for rural purposes; and • protect or manage significant natural resources, and processes to maintain the capacity for primary production.	The proposed extraction rate does not comply with this benchmark for the reasons outlined in my report
	Rural Zone Code - Overall Outcome 6.2.20.2(3)(a)	Land uses do not impact on the matters of environmental significance, landscape and scenic amenity values of the land.	The proposed extraction rate does not comply with this benchmark for the reasons outlined in my report
	Rural Zone Code - Overall Outcome 6.2.20.2(3)(b)	Natural landscape and matters of environmental significance are protected and conserved to assist in maintaining a green frame to the city's urban area, particularly on the Hinterland ranges and foothills, which contribute to the city's distinct form, visual attractiveness and role as a major tourist destination.	The proposed extraction rate does not comply with this benchmark for the reasons outlined in my report
Extractive Industry Development Code			

Item	Benchmark reference	Benchmark	Expert opinion
	Extractive Industry Development Code – Performance Outcome 1	PO1 Extractive industry activities are located, designed, operated and staged in a way that: • minimises environmental impacts on site and surrounding areas; • prevents significant adverse amenity impacts on existing sensitive land uses or residential zoned land; and • promises the efficient extraction of resource.	The proposed extraction rate does not comply with this benchmark for the reasons outlined in my report
Environmental Significance Overlay Code			
	Environmental Significance Overlay Code – 8.2.6.2(2)(a)(i)	The purpose of the code will be achieved through the following overall outcomes. Matters of environmental significance are identified, protected in situ and enhanced to maintain flora and fauna diversity within: Hinterland core habitat systems;…	The proposed extraction rate does not comply with this benchmark for the reasons outlined in my report
	Environmental Significance Overlay Code – 8.2.6.2(2)(a)(iv)	The purpose of the code will be achieved through the following overall outcomes: Matters of environmental significance are identified, protected in situ and enhanced to maintain flora and fauna diversity within: … (iv) Hinterland to coast critical corridors.	The proposed extraction rate does not comply with this benchmark for the reasons outlined in my report
	Environmental Significance Overlay Code – Performance Outcome 1	PO1 All matters of environmental significance on and adjacent to the development site are identified and protected.	The proposed extraction rate does not comply with this benchmark for the reasons outlined in my report

Item	Benchmark reference	Benchmark	Expert opinion
	Environmental Significance Overlay Code – Performance Outcome 4	PO4 Development within Hinterland Core Habitat Systems, Coastal Wetlands and Islands Core Habitat Systems and Substantial Remnant Areas as identified on the Environmental significance – biodiversity areas overlay map is located and designed to: Protect in situ matters of environmental significance and associated buffers; Protect in situ vegetation identified on the Environmental significance – vegetation management overlap map and habitat for native flora and fauna; and Allow for the rehabilitation of disturbed, cleared or modified areas.	The proposed extraction rate does not comply with this benchmark for the reasons outlined in my report

9 SUMMARY/CONCLUSIONS

96. In summary, in my opinion, the long-term sustainable pumped groundwater yield from the 263 Repeater Station Road site will be considerably less than the desired 16 ML/yr. The sustainable yield has not been demonstrated for 263 Repeater Station Road, and therefore the proposed development with an extraction rate of 16 ML/yr should not proceed. The risk of allowing the proposed development at 16 ML/yr to proceed is that the extraction will deplete the groundwater in the aquifer, thereby affecting downstream flow patterns for a significant time period. This will be particularly problematic under dry conditions, due to the lengthy time period that will be required to recharge the aquifer if excessive extraction has occurred.

97. I have presented in Section 6 of this report my recommendations for minimum further work that should be conducted to properly define what the sustainable yield is. Such works are required to determine, with a reasonable level of certainty, whether the project can proceed, and if so, what extraction rate can be applied without adverse impacts on the groundwater table and downstream ecological and social values.

10 DECLARATION

I confirm the following:

a. The factual matters stated in this report are, as far as I know, true;

b. I have made all enquiries that I consider appropriate;

c. The opinions stated in this report are genuinely held by me;

d. The report contains references to all matters I consider significant; and,

e. I understand my duty to the Court and have complied with that duty.

Tony McAlister
Director
tony.mcalister@watertech.com.au
WATER TECHNOLOGY PTY LTD
22 December 2021

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX A
CURRICULUM VITAE OF TONY MCALISTER

TONY MCALISTER

Tony.Mcalister@watertech.com.au | Level 5, 43 Peel Street South Brisbane, Queensland
Phone: 07 3105 1460 | 0497 611 848

Director, Brisbane

BE Hons, M.Eng.Sc, GCELead

FIEAust, CPEng, RPEQ, GAICD

QUALIFICATIONS

- B.E. Civil (1st Class Honours) James Cook University of North Queensland (1981)
- M.Eng.Sc. University of Queensland (1989) specialising in Water Quality Management
- Grad. Cert in Exec Leadership University of Queensland (2013)

AFFILIATIONS

- Registered Professional Engineer, Queensland.
- National Professional Engineers Register
- Fellow, Engineers Australia
- Adjunct Industry Fellow, Griffith University

SUMMARY

Tony has more than 30 years Australian and International (United Kingdom, the Middle East and South East Asia (Singapore, Thailand, Malaysia and Indonesia)) water engineering expertise in the areas of numerical flood and water quality modelling, field data collection and assessment, non-point source pollution assessment and mitigation, WSUD and IWCM, water quality and catchment management and sewerage and water supply investigations.

AWARDS

- 1991 CBI (Consolidated British Industry) Scholarship
- 1998 Best Paper of Conference Award – IPWEAQ Conference Toowoomba

PROFESSIONAL HISTORY

2017 – Current	Director, Water Technology, Brisbane, QLD
2015 – 2017	Senior Principal Engineer, Water Technology, Brisbane, QLD
2008 – 2015	Managing Director, BMT WBM, Brisbane, QLD
2000 – 2008	Director, WBM and then BMT WBM, Brisbane, QLD
1993 – 2000	Associate, WBM, Brisbane QLD
1992 – 1993	Senior Modeller, HR Wallingford, United Kingdom
1987 – 1991	Senior Engineer, WBM
1982 – 1987	Engineer, Department of Local Government and Planning

SPECIALIST AREA OF EXPERTISE

- Numerical Modelling and Field Data Collection
- Catchment, Waterway and Coastal Management
- Water Quality Management
- Flood Management and Hydraulic Modelling
- Stormwater Management and Water Sensitive Urban Design (WSUD)
- Sewerage/Water Supply/Tradewaste Management
- Integrated Water Cycle Management (IWCM)

COUNTRIES OF EXPERIENCE

- Australia
- United Kingdom
- Singapore
- Thailand
- Malaysia
- Papua New Guinea
- Indonesia
- Saudi Arabia

RECENT MAJOR PROJECTS

Water Quality and Estuary Management

- Southern Redland Bay Mangrove Offset Studies (2019-2021)
- Merrimac Greenheart Water Quality Modelling assistance (2019-ongoing)
- Healthy Land and Water Ecosystem Health Report Card Water Quality Modelling assistance (2018-ongoing)
- Newstead Riverpark Lake Water Quality Management Improvement Strategy (2017)
- Banksia Beach - Pacific Harbour Canal Tidal Circulation and Water Quality Improvement Study (2017)
- Gold Coast Commonwealth Games Water Quality Expert Participation (2016-2017)
- Holcim (Mooloolah) Quarry Water Quality Advice (2016-7)
- Project Sea Dragon Hatchery and Grow Out Facility EIS Water Quality Support and Guidance (2016-7)
- South East Queensland Estuary (Noosa, Maroochy, Mooloolah, Caboolture, Pine, Brisbane, Logan Albert, Pimpama and Nerang River systems) Water Quality Modelling (2014-2015)
- Gold Coast Water Quality Modelling Review (2013-ongoing)
- Penrith Lakes Water Quality Modelling and Management Assessments (2014-2015)
- Pumicestone Passage Water Quality Modelling for the Caloundra South project (2012-2013)
- Moreton Bay 3D Hydrodynamic Water Quality Numerical Modelling (2011-2012)
- Hawkesbury-Nepean Water Quality and Ecological Modelling Study (2011-2012)
- QWC Loganholme Diversion Water Quality Modelling Study (2008)
- Olympic Dam Desalination/Spencer Gulf 3D Oceanographic Data Collection and Water Quality Modelling Studies (2006-2008)
- Moreton Bay Lyngbya Studies (2006)
- Moreton Bay Water Quality Improvement Plan Water Quality Modelling (2005-2006)
- Tamar Estuary Water Quality Study (2004-2006)
- Maroochy Estuary Sustainable Loads Study (2003-2004)
- Sandgate Estuary Water Quality Modelling Study (2003)
- Lake Illawarra Estuary Processes Study, Management Study and Plan (2001-2002)
- Wonboyn Estuary Processes Study, Management Study and Plan (2000-2001)
- Maroochy Estuary Eutrophication Modelling (2001-2002)
- Batemans Bay and Clyde River Estuary Processes Study (2000)
- Nambucca River Estuary Processes Study (1999-2000)
- Samut Prakarn (Thailand) Wastewater Outfall Water Quality Study (1999)
- Water Quality Action Plan - Central River Basin of Thailand (1995-1999)
- Buran Darat Development, Sentosa Island - Singapore (1994-1995)
- Stour Estuary (UK) Water Quality Modelling (1993)

- Hawkesbury Nepean Blue Green Algal Modelling (1993)
- Avon River Barrage (UK) Blue Green Algal Assessments (1993)
- Benthic Respiration Study, Kent Stour (UK) Estuary (1993)
- Water quality studies for proposed Maleny development (1991)
- Water quality modelling of the Clarence River, NSW (1990)
- Water quality modelling of the Tweed River (1990)
- Banora Point STP Outfall Study, Tweed Heads (1989)
- Gladstone Tradewaste Outfall Study (1989)

Stormwater and Urban Water Management

- Max Pawsey Stormwater Harvesting Investigations (2021)
- QUU Effects Based Sewage Overflow Licencing Investigations (2016-2018)
- SPEL Environmental Proprietary Water Quality Improvement Device Peer Reviews (2017-2018)
- Caloundra South Stormwater Harvesting Scheme Technical, Scientific and Approval Investigations (2015)
- Caloundra South Integrated Urban Water Cycle Management Assessments (2014)
- Caloundra South Supplementary Public Environment Report (2013)
- Office of Living Victoria (OLV) Integrated Water Cycle Management modelling review assistance (2014)
- Caloundra South Public Environment Report (2012)
- Victorian Ministerial Advisory Committee (MAC) Integrated Water Cycle Management modelling review assistance (2013)
- National Water Commission WSUD Assessment Guidelines (2007-2008)
- Kalkallo Integrated Water Management Project (2007)
- Forster Palms Stormwater Review (2006)
- Independent Review of Greater Melbourne Urban Water Supply Strategy (2011)
- Forde (Canberra) IUWM Advice (2005)
- Franklin (Canberra) IUWM Advice (2005)
- Pimpama Coomera Water Futures Rainwater Tank Optimisation Study (2004-2005)
- Yarrabilba WSUD and IWCM study (2004)
- Pimpama Coomera Water Futures WSUD Study (2003-2004)
- Victorian WSUD Technical Manual (2003-2004)
- Brisbane WSUD Technical Manual (2004-2005)
- NSW Managing Urban Stormwater (2003-2004)
- Lensworth Lake Doonella (Noosa) (2003)
- Hunter and Western Sydney WSUD Capacity Building Programs (2000-2003)
- Australian Runoff Quality WSUD Chapter (2003-2006)
- Road Runoff Characterisation Study (2002)

- Varsity Lakes Stormwater Management (2002)
- Gold Coast Ecovillage WSUD and IWCM study (2000-2004)
- Springfield Development Scoping and Detailed Design Investigations (1999-2002)
- Stormwater Reuse Background Study (1998)
- Artificial Wetlands for Stormwater Quality Control Design, Wollongong NSW (1995)
- Long Term Consultancy - Brisbane City Council (1993-1995)

Effluent/Tradewaste Management

- Shoreline Project Southern Moreton Bay Sewage Outfall Water Quality Modelling Studies (2019)
- QUU Environmental Improvement Roadmap for Treated Effluent Release to Waterways – Stage 1 (2017)
- QUU Effects Based Sewage Licencing Investigations (2015-2017)
- QUU Sewer Overflow Abatement Program Modelling Studies (2015)
- Batemans Bay Sewage Effluent Transport Study (2003)
- Trinity Inlet/Cairns Wastewater Treatment Plant Advection-Dispersion and Water Quality Model Study (1996)
- Gunns Pulp Mill Outfall Review (2007)
- North South Bypass Tunnel Desalination Brine Outfall Design and Dispersion Study (2007)
- Cement Australia Desalination Brine Outfall Design and Dispersion Study (2007)
- Incitec Pivot Desalination Brine Outfall Design and Dispersion Study Study (2006)
- Moggill Creek Catchment and Sewer Overflow Study (2006-2007)
- Combined Sewer Overflows Assessments - Proposed Tees Barrage (UK) (1993)
- While a Graduate Engineer at the Department of Local Government, Mr McAlister undertook advanced training at the University of NSW in Municipal Wastewater Treatment and subsequently worked as a sewage and water supply process and tradewaste management/effluent disposal specialist supporting Local Governments and industry across Queensland for more than 4 years.

Catchment Management

- Warner Structure Plan Hydraulic and Water Quality Review (2016)
- Black and Ross Rivers Catchment Modelling (2010)
- Pine Shire Sustainable Loads Study (2008)
- Mae Khlong (Thailand) Sustainable Loads Study (2007)
- Coombabah Creek Sustainable Loads Study (2006)
- North Pine Dam Sustainable Loads Study (2006)
- Mooloolah and Logan Albert Sustainable Loads Studies (2005-2006)
- Lake Samsonvale Integrated Catchment Management Strategy (2001-2002)
- Healthy Waterways Task BSES - Broad Scale Evaluation of Sources (2001)
- Gowrie Creek (Toowoomba) Catchment Management Study (1997-1998)
- Moreton Bay Catchment Runoff Pollutant Load Estimation (1997-1998)

- Blue Gum Hills (Newcastle) Catchment Management Strategy (1996)
- Bremer River Catchment Management Strategy (1995-1996)
- Rose Bay Catchment Management Study (1991)

Environmental Management

- Birdsville Wetland Hydrologic Assessments (2017)
- Casino Piggery Audit and Legal Action (2016-2018)
- Ongoing Role with Healthy Waterways Scientific Expert Panels (1996-present)
- Woodlark Island (PNG) ESIA Review (2014)
- AQUIS Development, Cairns, EIS related studies (2013-2014)
- Caloundra South EIS Assistance (2012-2014)
- Olympic Dam Desalination Outfall and EIS Studies (2010-12)
- BG Gladstone EIS Assistance (2008-2009)
- National Prawn Company (Saudi Arabia) Environmental Studies - Stage 2 (2008-2009)
- SANTOS Gladstone EIS Assistance (2008-2009)
- Visy Desalination Outfall Review and Review advice (2008)
- Inner City Bypass Desalination Outfall Design and Review advice (2008)
- Caloundra South Environmental Benefits Report (2008)
- National Prawn Company (Saudi Arabia) Environmental Studies - Stage 1 (2007-2008)
- Thai Oil Spill Fingerprinting and Characterisation Study (2000)
- Malaysian Wetland Sanctuary Hydraulic and Water Quality Studies (1997)
- Logan Waterways Strategy Study (1993-1994)
- Environmental Appraisal of Lake Illawarra (1993-1994)
- Investigation of Dispersion and Hydrodynamic Processes - Halifax Bay, North Queensland (1992)
- Alternative Dredging Strategy Study - Weipa (1990)
- Hydraulic, Sediment Transport and Water Quality Studies, Tweed River (1990)
- Weipa South Channel Siltation Study (1989)
- Tidal Hydrodynamic and Siltation Studies of a Proposed Marina at Fingal Head (1988)

Flood Management and Hydraulic Modelling

- Penrith Lakes Development Corporation P&E Court Appeal (2015)
- Brisbane Flood Class Action assistance to Seqwater (2014)
- Caloundra South Ongoing Flood Assessments (2010-2015)
- Caloundra South Climate Change Flood Assessments (2008)
- TUFLOW Commercialisation and Worldwide Adoption Strategy (2006-2015)
- Maroochy River Floodplain Management Scoping Study (2005-6)
- Banora Point/South Tweed Master Drainage Plan (1996)

- Carseldine - Taigum Master Drainage Plan (1995-1996)
- Cudgen and Mooball Creeks, Clarence, Manning and Maroochy Rivers (1987-1991)
- Gold Coast Broadwater (1989)
- Assessment of Flood Impacts of Pacific Highway-Manning River (1989-1991)

Legal

- Supreme Court
  - JK Williams v Sydney Water (2019 and 2021)
  - Brisbane Flood Class Action assistance to Seqwater (2014-15)
- Qld Planning and Environment Court
  - Gavin John Finger & Ors at BHP Coal Pty Ltd & Ors (2017-2018)
  - Drywound v Lockyer Valley Council & Ors Water Quality Advice (2016)
  - Bertram and Field v QTMR & Ors Flood and Waterway Erosion Advice (2016)
  - PEA 1631/15 Tingalpa Water Quality Advice (2016)
  - Mr McAlister also undertook numerous P&E Court Appeals in the period between 1995 and 2007
- NSW Land and Environment Court
  - Casino Piggery Audit and Legal Action (2016-2018)
  - PLDC v Penrith City Council Hydraulic Advice
  - Mr McAlister also undertook several L&E Court Appeals in the period between 1995 and 2007

Field and Data Collection Studies

- Shoreline Project Southern Moreton Bay Environmental Data Collection Works (2018-9)
- QUU Effects Based Sewage Overflow Environmental Data Collection Works (2017)
- Banksia Beach - Pacific Harbour Canal Tidal Circulation and Water Quality Measurements (2017)
- Collulli (Eritrea) Potash Project Baseline Oceanographic and Environmental Data Collection (2015)
- Caloundra South Hydrologic and Water Quality Data Collection Studies (2012-15)
- Port of Brisbane Long Term Environmental Monitoring Project (2013-ongoing)
- James Point Port Oceanographic Data Collection Studies (2014)
- Pearl Oil (Indonesia) Oceanographic Data Collection Studies (2012)
- Pumicestone Passage Oceanographic Data Collection Studies (2010 and 2014)

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