Memo

Date	6 August 2018
To	Dan Clark and Melissa Robson-Williams
cc	Lyn Carmichael and Craig Davison
From	Philippa Aitchison-Earl and Matt Dodson

Subject: Alternative water management and water sources for stream depleting takes within the Opihi and Temuka catchments

Memo purpose

The purpose of this memo is to answer questions that the Orari Temuka Opihi Pareora (OTOP) Zone Committee have asked regarding alternative water supplies and management options for stream depleting takes within the area cover by the Opihi River Regional Plan (ORRP). One of the recommendations in the draft Zone Implementation Programme Addendum is to change the stream depletion rules from those in the ORRP, to the more sophisticated methodology of the Land and Water Regional Plan (LWRP). The OTOP Zone Committee are concerned about the impact of these changes on people's irrigation reliability and have asked for advice on alternative water supplies and management options for stream depleting groundwater users. Therefore, in this memo we will specifically address the following questions:

- Is there a deeper groundwater resource available near the Opihi and Temuka Rivers?
- Could managed aquifer recharge (MAR) improve the irrigation reliability of the stream depleting groundwater users in the Opihi and Temuka River catchment?
- Would managed aquifer recharge (MAR) effect the groundwater available?

Please note that to answer these questions we have used the best information at hand and for the curious reader we will provide a reference list. Contained within the references is a description of our methods and our detailed analysis.

File reference:

Summary

Is there a deeper groundwater resource available near the Opihi and Temuka Rivers?

- There is potential for deeper groundwater to be available within areas with greater thicknesses of gravel-based sediments, shown in Figure 1 by the brown shading. We infer this from existing wells and from geological maps.
- Yields from the areas with thick gravel are typically low inland of Temuka-Geraldine.
- Sedimentary rocks are only used as a groundwater source where Quaternary gravels are thin or do not exist.
- The potential hydraulic connection of deeper groundwater to surface waters would still require a case-by-case assessment

Could managed aquifer recharge (MAR) improve the irrigation reliability of the stream depleting groundwater users in the Opihi and Temuka Rivers catchment?

- In short – unlikely. This is because the irrigation reliability of the stream depleting groundwater users will be governed by the flow in the river, not by the levels in the aquifer.
- MAR is where water is deliberately allowed to infiltrate through land into groundwater.
- Drawing on international experiences, MAR is typically designed to either replenish groundwater or add baseflow to downgradient rivers, or to store water in the ground for later use (this isn't a realistic option in the OTOP zone because of the geology of the area).
- If the OTOP zone committee wanted to mitigate the impact of the LWRP stream depletion rules on users, then an alternative management option would be to augment the flow in the river. However, the obvious next questions with this option would be, where would this water come from and who pays?

Would managed aquifer recharge (MAR) effect the groundwater available?

- We note that previous research undertaken in Levels Plains indicates that MAR could be an effective method for replenishing the aquifer.
- The down-gradient impact of MAR elevated groundwater levels on the Seadown Drain needs to be considered.

Is there a deeper groundwater resource available near the Opihi and Temuka Rivers?

The availability of deep groundwater is controlled by the geological structure of the area, so we first give a brief description of the groundwater-bearing units. Groundwater is encountered in three main geological units – Quaternary age gravels that make up much of the Canterbury Plains and river valleys inland, Kowai Formation gravels which are an older gravel unit underlying the Quaternary, and to a more limited extent in even older, underlying consolidated sediments such as sandstones. A simplified geological map of main groundwater bearing units of the area is shown in Appendix A. Table 1 outlines recorded yields from existing wells in each unit.

Quaternary gravels only occur as a thin veneer (estimated at around 20 m thick) in the inland basins of the Te Ana Wai and Opihi/Opuha Rivers and are sometimes constrained to river valleys and adjacent terraces. This is because there is uplift in this area so that sediment is continually eroded away. The gravels only become thicker in the lower plains, which are the southernmost extent of the Canterbury Plains. The gravels have built up because of gradual subsidence in the east. Average yields are 25-30 L/s.

The Kowai Formation, an older silty gravel unit is of similar thickness to the Quaternary gravels. In the eastern plains it underlies the Quaternary, with thicknesses at the Opihi Mouth of perhaps 500 m of combined Quaternary and Kowai gravels. In the inland basins it is around 100 m thick around Ashwick Flat, and several hundred metres this around the upper Te Ana Wai. Average yields are around 14 L/s

Underling the gravels are sedimentary rocks. These sandstones siltstones and limestones are exposed at the east of the plains, and surrounding the inland basins, and buried beneath the gravels of the plains. There is some limited groundwater in these sediments. Average yields are much lower than in the gravel-based units[1].

So, what does this mean for potential deeper groundwater? We summarise aquifer availability in Figure 1. In light pink areas, groundwater would only be available within sedimentary rocks. In the brown areas, groundwater is only available within thin Quaternary gravels or the underlying sedimentary rock. **In orange areas, there is potential for deeper groundwater to be available within the greater thicknesses of the Quaternary and Kowai formation gravels**.

Existing wells that are greater than 30 m deep are plotted in Figure 1, coloured by geological unit. Yellow wells within Quaternary gravels mainly occur in the lower Opihi and around the Geraldine area. Inland of this, wells are more likely to penetrate the Kowai Formation gravels (pink wells). Appendix A includes a map of all existing wells of all depths, showing the dominance of Quaternary wells on the plains areas and inland basins. Kowai Formation and sedimentary rocks tend to only be used as a groundwater source where Quaternary gravels are thin or do not exist. Yields from non—Quaternary gravel sources are typically lower, shown geographically in Figure A2 in Appendix A and in Table 1.

We note that a depth of 30 m does not guarantee that a well is not subject to surface water allocation blocks and/or restrictions within the LWRP. Each well and location would be subject to an individual stream-depletion assessment. We selected 30 m as a depth that broadly grouped shallow water table wells.

For more information on geology and its influence on groundwater occurrence we refer the interested reader to the memorandum 'Orari-Temuka-Opihi-Pareora zone geology: framework and geological cross sections' (Aitchison-Earl and Zarour, 2018), included in the reference list. This memorandum

[1] White Rock Formation contains gravel dominated layers, explaining the higher yields measured.

includes cross-sections showing thicknesses of geological units in the area, one section parallel to the Lower Opihi River is shown in Appendix A for illustration.

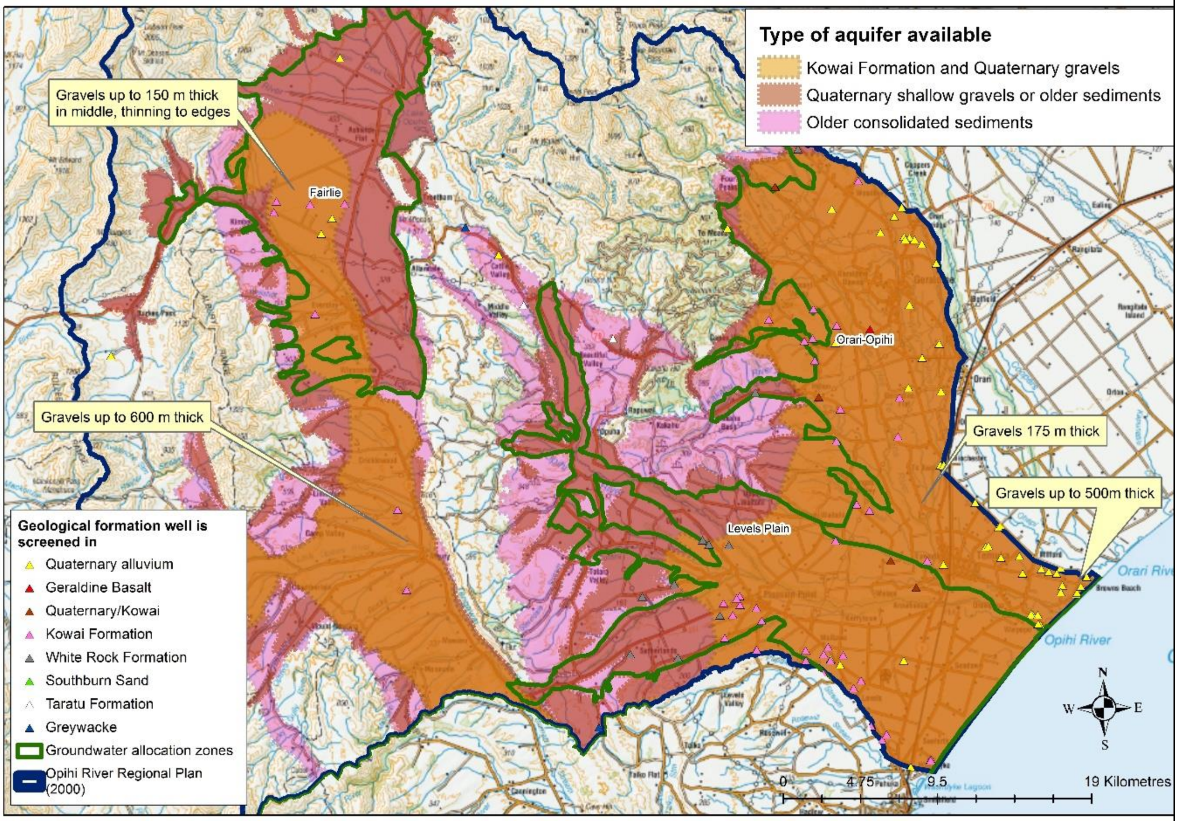

Figure 1: Summary of aquifer availability in the Opihi Plan area.

Table 1: Well yields in different geological units in the Opihi Plan area

Formation screened	Number of wells with yield information	Min Yield (L/s)	Max Yield (L/s)	Average Yield (L/s)
Quaternary gravels less than 30 m	656	<1	136	24.3
Quaternary gravels greater than 30 m	216	<1	87.6	32
Geraldine Basalt	No information			
Kowai Formation	97	<1	100	13.7
White Rock Formation	8	<1	35.7	11.3
Southburn Sand	3	1.3	4	2.3
Taratu Formation	2	0.22	0.33	0.26
Basement greywacke	No information			

Could managed aquifer recharge (MAR) improve the irrigation reliability of the stream depleting groundwater users in the Opihi and Temuka River catchment?

MAR is a simple concept – it is where people deliberately allow water to infiltrate into groundwater. Internationally MAR has been used to replenish groundwater and/or rivers, particularly in area where abstraction has impacted on the resource; or to store water to be used later (this isn't a realistic option in the OTOP zone because of the geology of the area). However, recently in Canterbury (since approximately 2010), MAR has also been suggested as a potential solution to combat high nitrate concentrations (i.e. Hinds) but it hasn't yet been put forth as a method of improving peoples irrigation reliability.

It is well documented fact that groundwater abstraction can impact rivers and streams (PDP and Environment Canterbury, 2000) both in the short and longer term. Stream depletion rules in Canterbury are intended to manage the short-term effects of abstraction of groundwater on nearby surface water bodies. Groundwater allocations are intended to manage the longer-term effects. The Land and Water Regional Plan (LWRP) classifies groundwater takes on their connection to surface water bodies. Those takes classified as having a significant and rapid connection to surface water bodies are managed by a minimum flow condition (Davison and Clark, 2018). When the river reaches minimum flow, abstraction should cease regardless of the level of the aquifer. Therefore, MAR is unlikely to improve the irrigation reliability of the stream depleting groundwater users in the Opihi and Temuka River catchment.

Under the circumstances described above, an alternative management option would be to directly augment the river so that the flows don't decline to the minimum flow level as often. However, as you know, there are issues with this option also; the two most obvious are where do you find the water to augment the river and who pays?

Would managed aquifer recharge (MAR) effect the groundwater available?

MAR for the Levels Plain was considered by the Ministry of Works and Development in the 1980's and is documented in Bird (1986). A groundwater model was built to simulate MAR (termed 'artificial recharge' in the report) via trenches and pits or direct to wells. Field trials were undertaken in 1985-86 at Tregenza's Pit and a trench on the property of J Wilson. Recharge water was observed to easily infiltrate into the aquifer (60 L/s over 120 days was applied at the pit) but no discernible increase in groundwater level was measured in wells surrounding the sites. Direct well injection was undertaken at the Levels Golf Course wells from around 1980 to 1997. Water from the Levels Plain Irrigation Scheme (LPIS) was injected into the well in the off-season to allow for a reliable supply during the irrigation season. The well was pumped at 20 L/s and appeared to not be affected by clogging and not require significant maintenance.

Bird (1986) concluded that the Levels Plain shallow aquifer could not supply all the water required by the scheme without artificial recharge of around 500 L/s, but his model did not allow predictions of suitable sites for recharge.

Groundwater in the Levels Plain has historically been recharged leakage from LPIS races and on-farm border-dyke practices over the years, leading to elevated groundwater levels during the irrigation scheme and lower levels in winter. With more efficient irrigation practices, losses under the scheme are reducing leading to lower on-season groundwater levels (Williams and Aitchison-Earl, 2011). The measured effect of scheme leakage on groundwater levels indicates that MAR may be successful. We would note that the LPIS scheme delivers potential recharge water over a widely distributed network which will result in different recharge effects than smaller-scale site specific MAR. Further modelling would be required to identify the best potential sites for maximum benefit for the aims of MAR (reliability, dilution of nitrate, spring flow). When considering MAR, the down-gradient effect of elevated groundwater levels on the Seadown Drain would need to be considered.

References

Aitchison-Earl, P. and Zarour, H. 2018: 'Orari-Temuka-Opihi-Pareora zone geology: framework and geological cross sections' Memorandum to Dan Clark, 23/2/2018

Bird, T. 1986: '*Levels Plain Irrigation Scheme groundwater supply simulation'* National Water and Soil Conservation Organisation Report WS11

Davison, C. and Clark, D. 2018: '*Stream Depletion in the Opihi and Temuka Catchments'*. Memorandum to the OTOP Zone Committee, 29/6/2018

PDP and Environment Canterbury. 2000: '*Guidelines for the Assessment of Groundwater Abstraction on Stream Flow'*. Environment Canterbury Technical Report R00/11

Williams, H. and Aitchison-Earl, P. 2011: *'The influence of recharge mechanisms on shallow groundwater in the Levels Plain, South Canterbury'* Environment Canterbury Technical Report R11/31

Appendix A: Hydrogeological maps

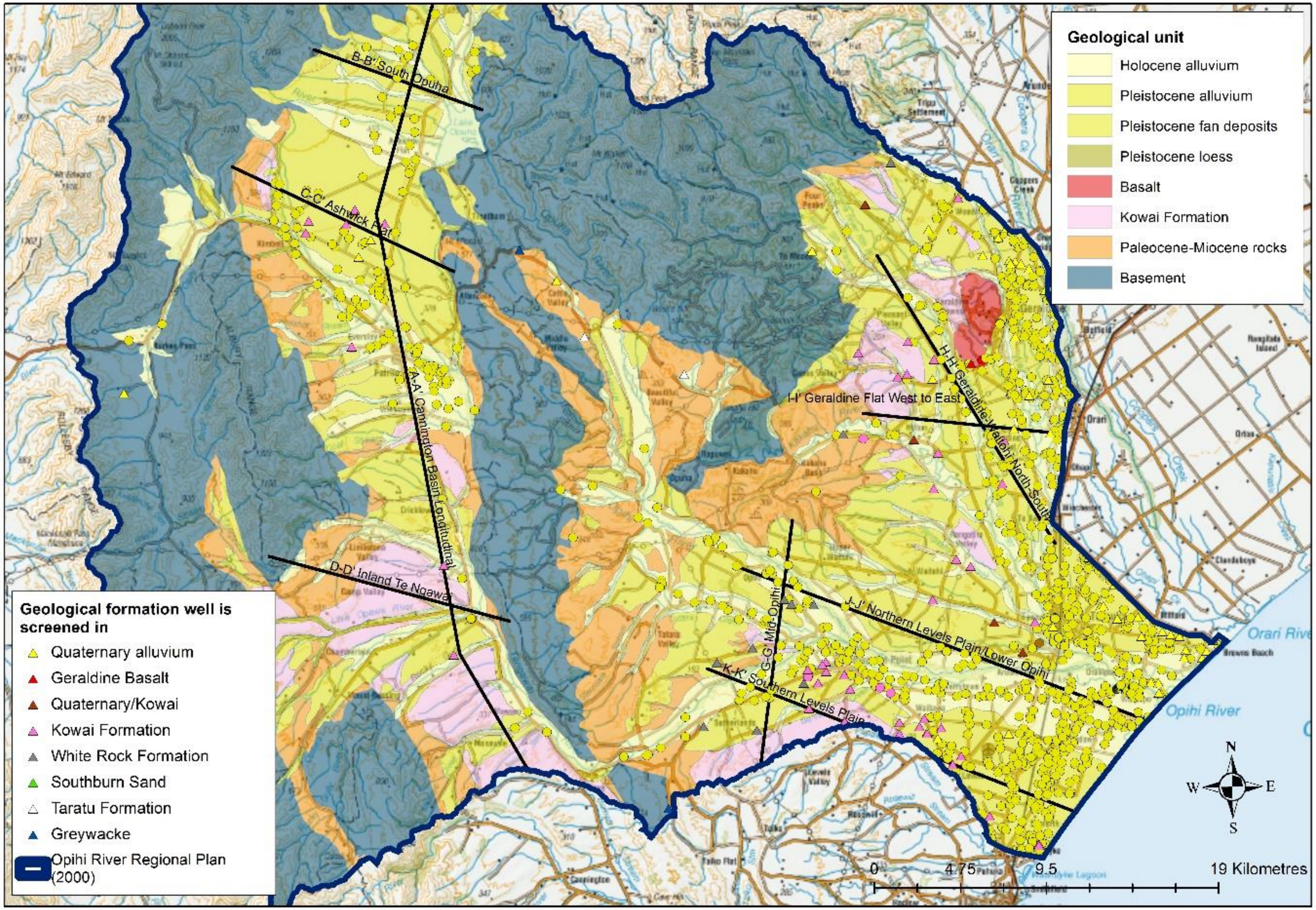

Figure A1: Simplified geology of the Opihi Plan area, existing wells by formation screened and location of geological cross-sections.

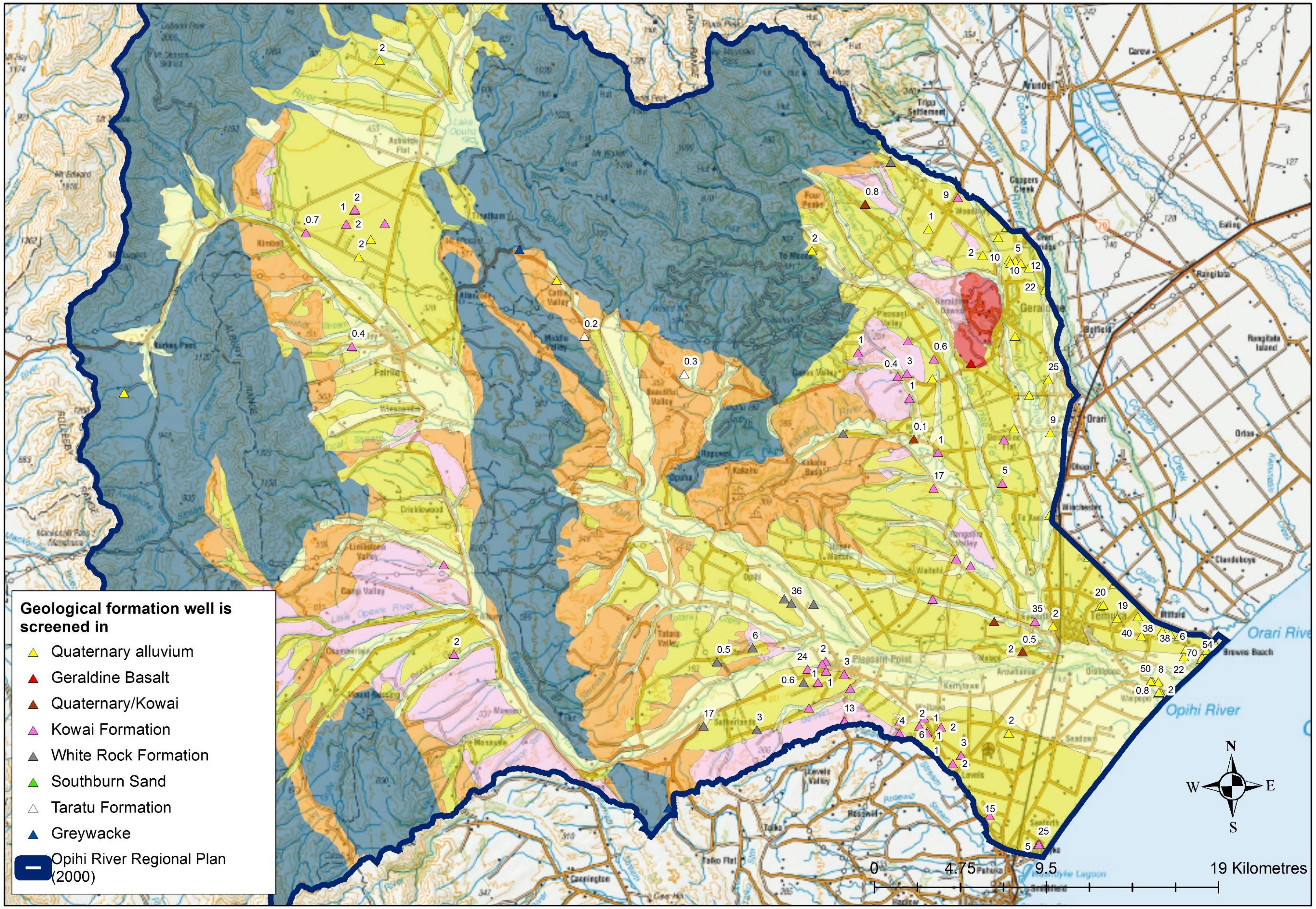

Figure A2: Well yields in wells greater than 30 m deep by formation

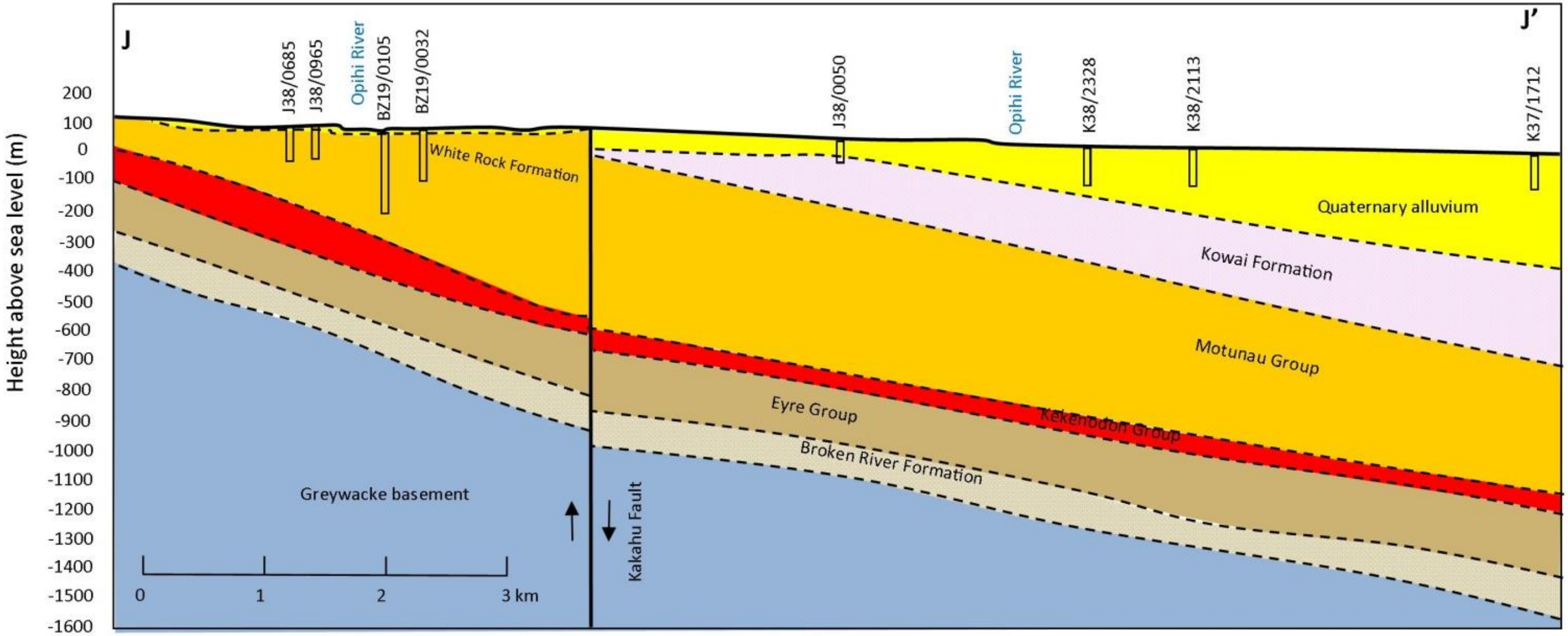

Figure A3: Cross-section J-J' orientated north-west to south-east along the Opihi River.