IN THE MATTER OF The Resource Management Act 1991

AND

IN THE MATTER OF Middle River New Applicants Group

EVIDENCE OF NICHOLAS FRANK DUDLEY WARD

1 My name is Nicholas Frank Dudley Ward. I have a BSc from the University of Hull, and Doctor of Philosophy from the University of York, both in Mathematics. I also have a Master of Science in Civil Engineering from Drexel University, United States. Since June 2007 I have been employed as an Environmental Engineer with Pattle Delamore Partners Limited, an environmental consulting firm specialising in groundwater and water resources. During this time I have worked on surface and subsurface hydraulics, pumping test analysis, and water resource consent applications in Marlborough, Canterbury and Otago.

2 Previously I have worked in collaboration with the US Army Corps of Engineers, Philadelphia District and with professional staff at Drexel University on hydraulic engineering projects.

3 I have also held academic and research appointments at the Universities of Pennsylvania, Auckland, Otago, Leeds (UK), and at l'Institut National de Recherche en Informatique et en Automatique, France.

4 I worked for three years as an analyst for a syndicate in Lloyd's of London, where I specialised in the assessment and modelling of environmental risk.

5 The evidence I will present today is within my area of expertise, except where I state that I am relying on information provided by another party. I have not knowingly omitted facts of information that might alter or detract from the opinions I express. I am familiar with

the Code of Conduct for Expert Witnesses and I agree to comply with this code.

SCOPE OF EVIDENCE

6 For this hearing I have been asked to consider the groundwater contribution to flows in the Waitaki River downstream of Waitaki Dam. This is with specific reference to information available from the North Bank Tunnel Concept and Project Aqua reports. Accompanying evidence that reviews the surface water contribution has been prepared by David Stewart from Raineffects Ltd.

7 The basis of this evidence has been the information as described in the following documents prepared by URS and SKM:

- North Bank Tunnel Concept – Water Consents, Water Balance. 28 September 2006.
- North Bank Tunnel Concept – Hydrogeological Assessment of Effects – Volume 1 of 2 – Main Report. 28 September 2006.
- Project Aqua – Water Balance, Appendix AE to Project Aqua: Assessment of Effects on the Environment, final report, rev 11A dated 4 April 2003.
- Project Aqua – Hydrogeological Assessment of Effects: Volume 1 and 2 – Main report and Appendices both dated 4 April 2003.
- Waitaki Catchment Groundwater Information, prepared for Ministry for the Environment, Sinclair Knight Merz, December 2004.

8 The evidence I will present describes the hydrogeological setting and groundwater fluxes in the area where the Middle River New Applicants Group are located. In this evidence, I will discuss some of the issues that have been raised by the Commissioners with regard to the Low Flow Trial undertaken by Meridian Energy and issues raised with regard to seasonal variation in groundwater contribution to the Waitaki River.

HYDROGEOLOGICAL SETTING

9 Figure 1, attached to this evidence shows the geology of the Lower Waitaki river area. The three main units of permeable strata where groundwater contributes to the Waitaki River flow are:

- Post-glacial deposits that occur in the lower surfaces in the centre of the valley. These have been formed by the erosion, re-working and re-deposition of the Pleistocene gravels by the Waitaki River since the last glaciation i.e. during the last 11,000 years.

- Older Pleistocene gravels which occur on the elevated terrace surfaces above the Waitaki River floodplain.

- Smaller and localised post-glacial alluvial fan deposits associated with each of the tributary streams that enter the Waitaki River from the north and south. These vary in extent depending on the location and size of the tributary streams.

These gravels overlay older, less permeable strata.

10 Figures 2 and 3 show the thickness and lateral extent of the gravels in the valley. Figure 2 extends from Waitaki Dam to Black Point and Figure 3 goes from Black Point to the mouth of the Waitaki River. The variability in thickness and lateral extent of these gravels has a significant influence on groundwater gains and losses in the Lower Waitaki Valley. In general where the Post-Glacial alluvial gravels widen or thicken the river loses flow to groundwater and where these gravels become narrower or thinner the river gains flow from the groundwater.

GROUNDWATER FLOWS

11 When considering minimum flow conditions, gains and losses from groundwater must be considered. The main groundwater flows to and from the Waitaki River are associated with the gains and losses within the Waitaki River bed and general seepage from the terraces bordering the valley. This interchange between groundwater and

surface water will be of most significance when the river flows are low. In contrast the groundwater flows associated with the tributary valleys are relatively small.

12 Figures 4 and 5 identify the main areas of flow losses and gains within the Waitaki River bed. The figures show that the river loses flow to the groundwater in the vicinity of Kurow and in the reach between Station Peak and Wainui Station. In the vicinity of Kurow, the Waitaki River changes from a single river channel to a braided river system. In the reach between Station Peak and Wainui Station the thickness of the gravels increases. Between Wainui Station and Black Point the river gains flow from the groundwater due to the narrowing and reducing thickness of the permeable Post-Glacial gravels. A few kilometres downstream of Black Point, the gravels widen and the river has a small loss of flow to the groundwater in this section of the river.

13 Figures 6 and 7 show a water balance long section of the Lower Waitaki River. These figures have been developed on data from the North Bank Tunnel Concept and Project Aqua (URS). Figure 6 is based on mean daily flows, while figure 7 is based on minimum daily flows. The pink line shows the total surface water contribution and the yellow line shows the total flow in Waitaki River.

14 The blue line in both long sections shows the main groundwater losses and gains to and from the Waitaki River at several locations in the reach between the Waitaki dam and the ocean. Groundwater fluxes within the Waitaki River bed and seepage from the river terraces and groundwater flows associated with tributary streams are included in these long sections. In summary the following trends in groundwater seepage along the Lower Waitaki River valley can be identified:

- The Waitaki River has its largest flow losses to groundwater in the reach between Kurow and Wainui Station (i.e. 4-20 km downstream of Waitaki Dam). Although the river does gain some flow from re-emerging groundwater associated with tributaries, it

predominantly loses flow towards the permeable gravels in the river bed.

- Between Wainui Station and its confluence with the ocean the Waitaki River gains flow from the groundwater. The main gains in this area are just downstream of Wainui Station and general seepage from the terrace gravels bordering the river. Smaller groundwater flows into the river are associated with seepage from the tributary gravels.

- When comparing the contribution of the groundwater for mean daily flows to the total mean daily flow in the Waitaki River the losses and gains are relatively small (-2 m³/s up to +4 m³/s compared to 382 m³/s).

- When considering the minimum daily flows, the groundwater gains and losses compared to the flows from the tributary rivers are somewhat larger (-2 m^3/s up to +2 m^3/s compared to 99 m^3/s) but still do not significantly contribute to the river flows in the Waitaki River.

15 The following two sections will discuss some of the issues that have been raised by the Commissioners with regard to seasonal variation in groundwater contribution to the Waitaki River and issues with regard to the Low Flow Trial undertaken by Meridian Energy and.

SEASONAL VARIATION IN GROUNDWATER FLOWS

16 There is not expected to be a significant seasonal variation in groundwater contribution to and from the Waitaki River. The interaction between surface flow and groundwater along the main channel will remain relatively steady. Although groundwater seepage associated with tributary streams are slightly lower in summer due to lower rainfall, this is offset by higher seepage rates from the river terraces generated from the high volumes of infiltration to the underlying strata during the irrigation season, via border dyke systems.

LOW FLOW TRIAL (LFT)

17 Meridian Energy have conducted a low flow trial as part of the assessment of effects and evaluation process of Project Aqua. The low flow trial progressively reduced flow releases from the Waitaki Dam from approximately 350 cumecs to 90 cumecs between 8th and 12th July 2001. The trial dropped the water levels in the Waitaki River by up to 0.5 meter. On the first day of the low flow trial NIWA undertook river gaugings at Ferry Road and Priest Road. These gaugings have been used to check the validity of the URS Water Balance Model.

18 In the Project Aqua report URS comments on the groundwater contribution towards the Waitaki River flow during the low flow trial. In this report it is recognised that there is an additional contribution to flow in the Waitaki River measured during the low flow trial as a result of increased groundwater drainage caused by the lower stage in the river. I have reviewed the rate of response of groundwater level measurements at various distances from the Waitaki River channel. Based on the pattern of response to the LFT it is possible to estimate the change in hydraulic gradient within the gravel strata at the time of the gauging measurements. By comparing that gradient with the gradient that occurs under stable flow conditions I estimate that the groundwater contribution during the Low Flow Trial may have increased the river flow during the gauging measurements by approximately 25% of the existing groundwater contribution (For mean daily flows: - 2.5 m^3/s to + 5 m^3/s as opposed to - 2 to + 4 m^3/s). The total groundwater effect on river flow is still small relative to the total flow in the river.

CONCLUSIONS

19 The main groundwater flows to and from the Waitaki River are associated with the gains and losses within the Waitaki River bed and general seepage from the terraces bordering the valley.

20 The Waitaki River has its largest flow losses to groundwater in the reach between Kurow and Wainui Station. Between Wainui Station

and its confluence with the ocean the Waitaki River gains flow from the groundwater. This gaining section is where most of the Mid-River New Applicants Group abstract water.

21 When comparing the contribution of the groundwater for minimum and mean daily flows to the total minimum and mean daily flow in the Waitaki River the losses and gains are relatively small.

22 There is not expected to be a significant seasonal variation in groundwater contribution to and from the Waitaki River.

23 The groundwater contribution during the Low Flow Trial may have increased the river flow during the NIWA gauging measurements by approximately 25% of the existing groundwater contribution. However, the total groundwater effect on river flow is still small relative to the total flow in the river.

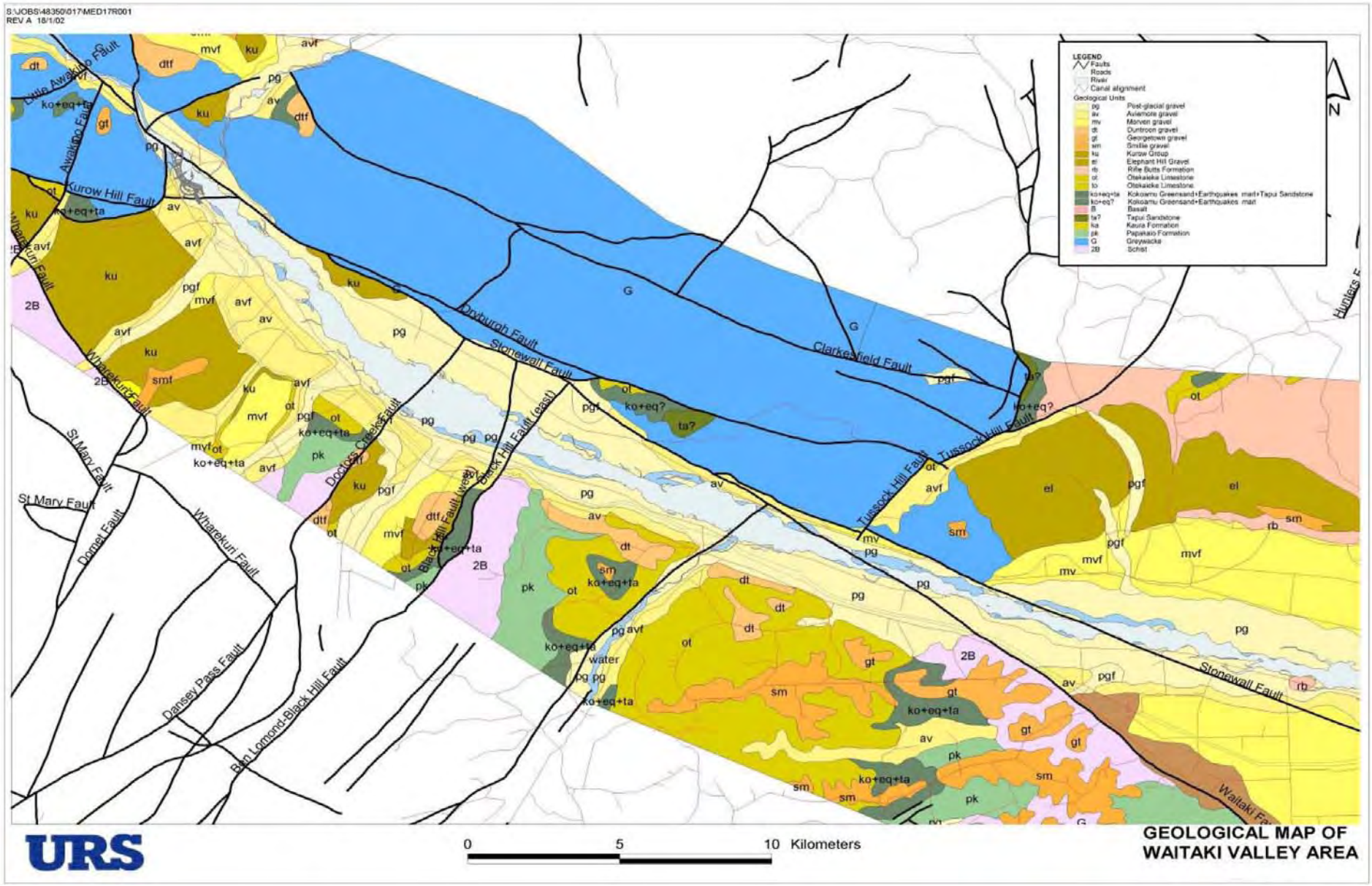

Figure 1: Location of alluvial gravels

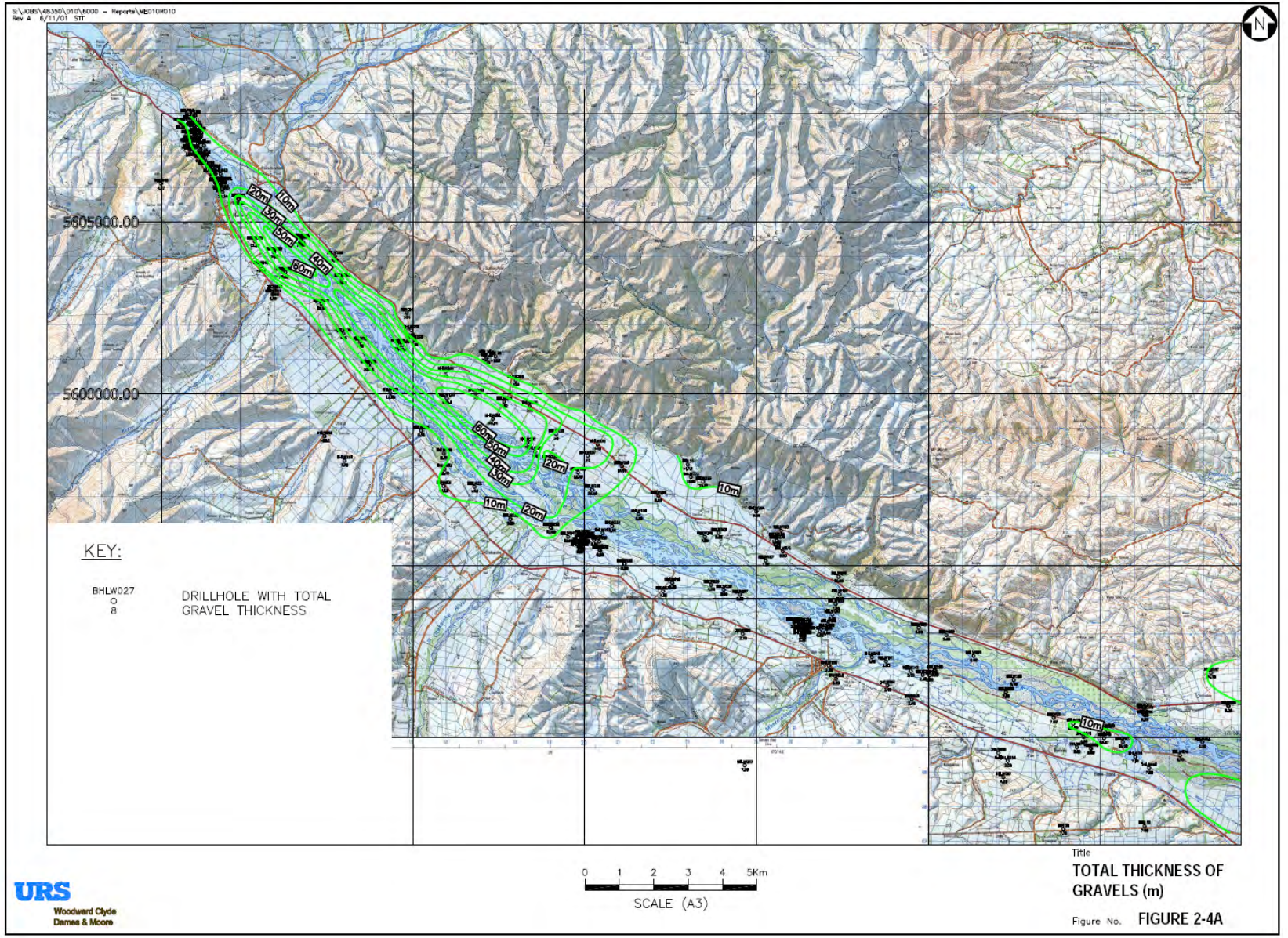

Figure 2: Total thickness of gravels

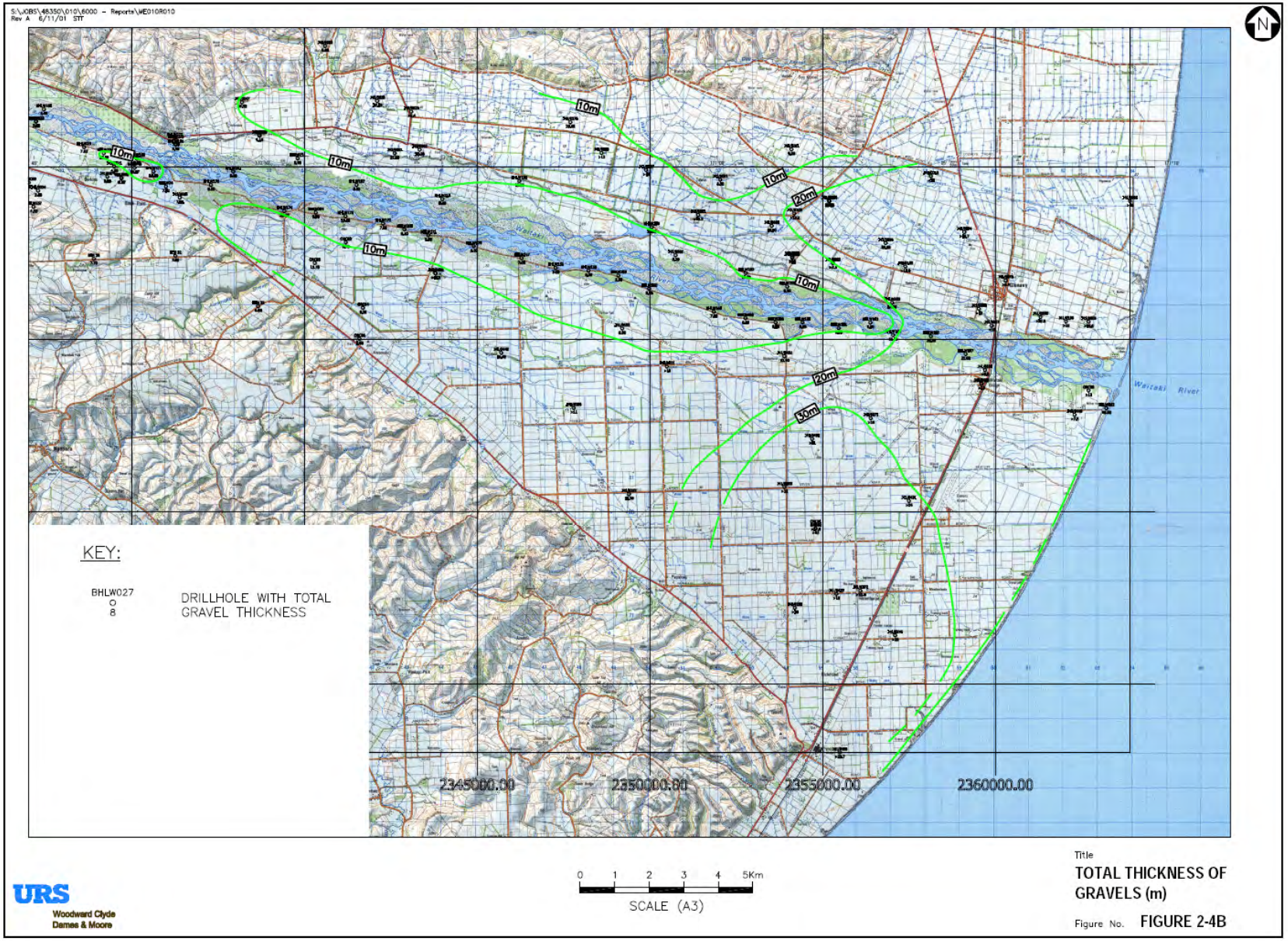

Figure 3: Total thickness of gravels

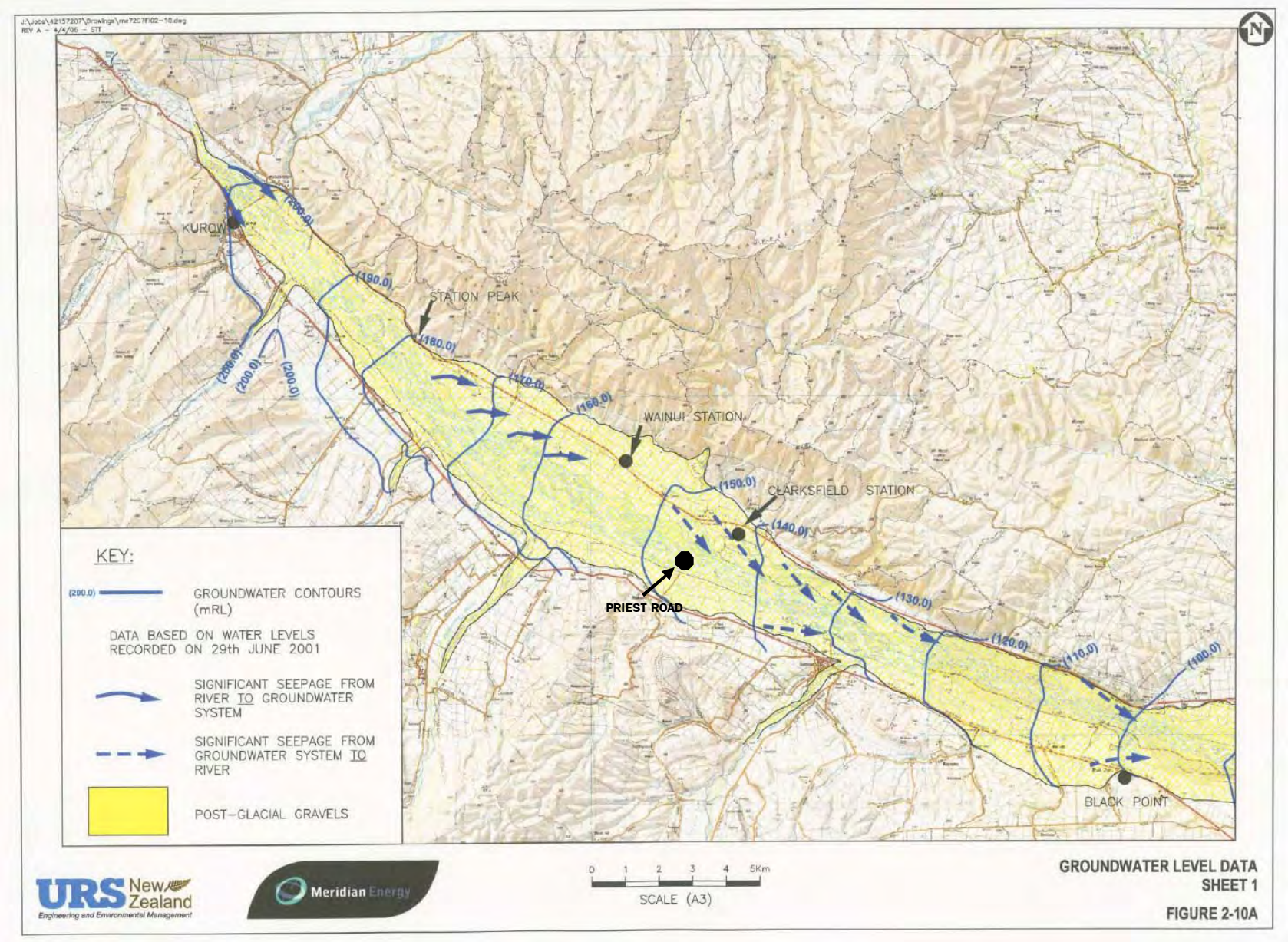

Figure 4: Main areas of losses and gains within the Waitaki River bed

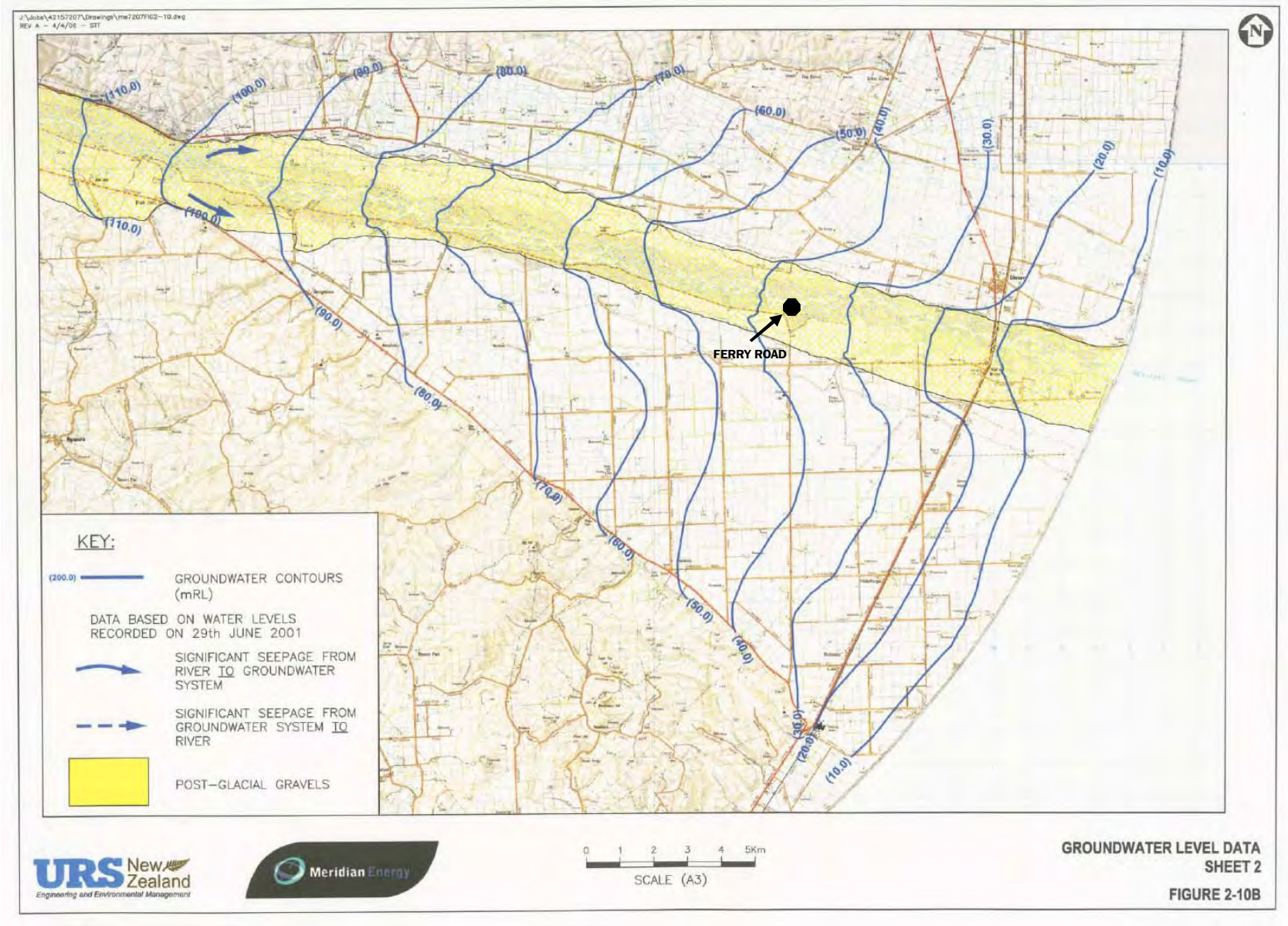

Figure 5: Main areas of losses and gains within the Waitaki River bed

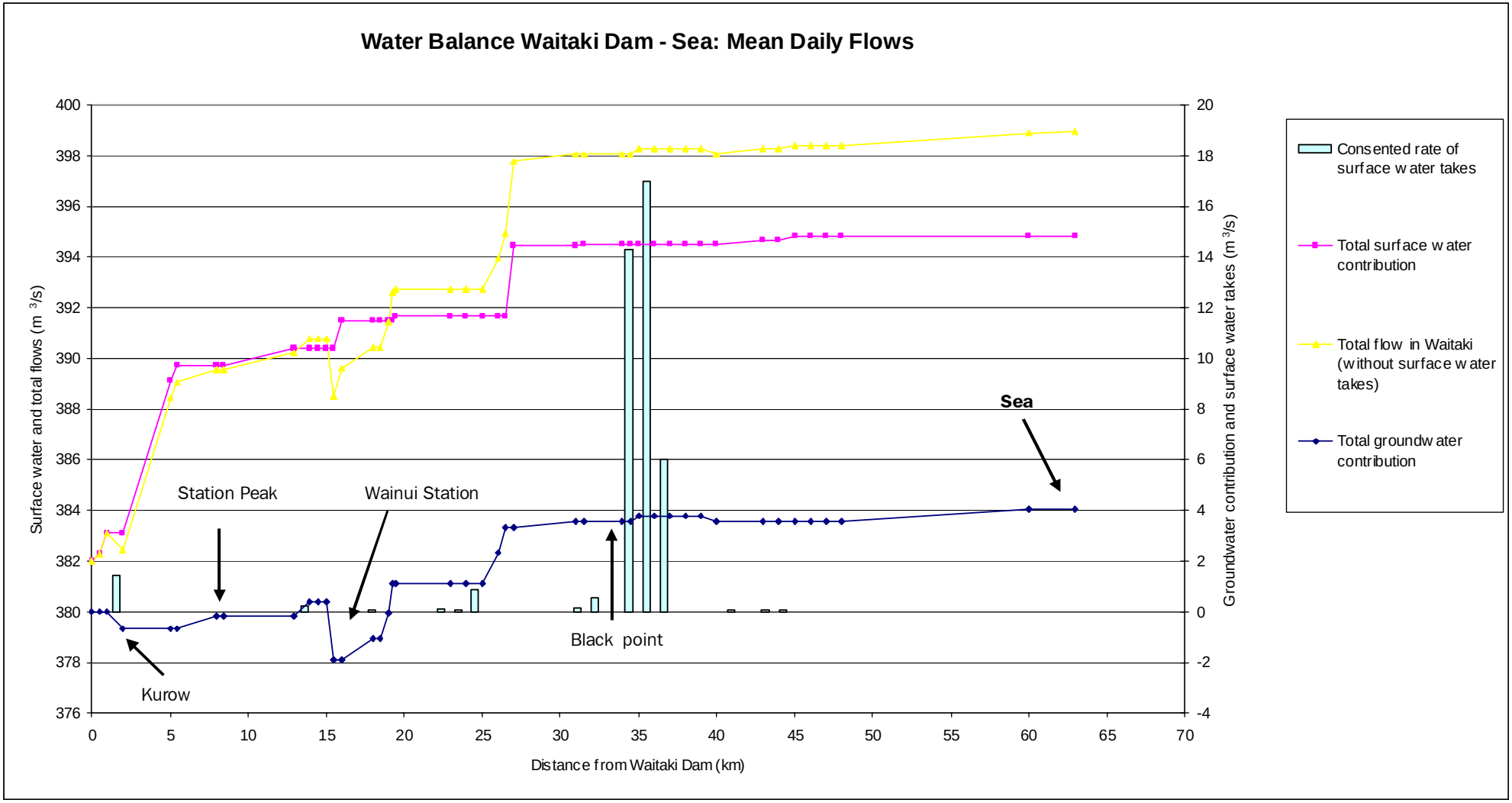

Figure 6: Long section mean daily flow

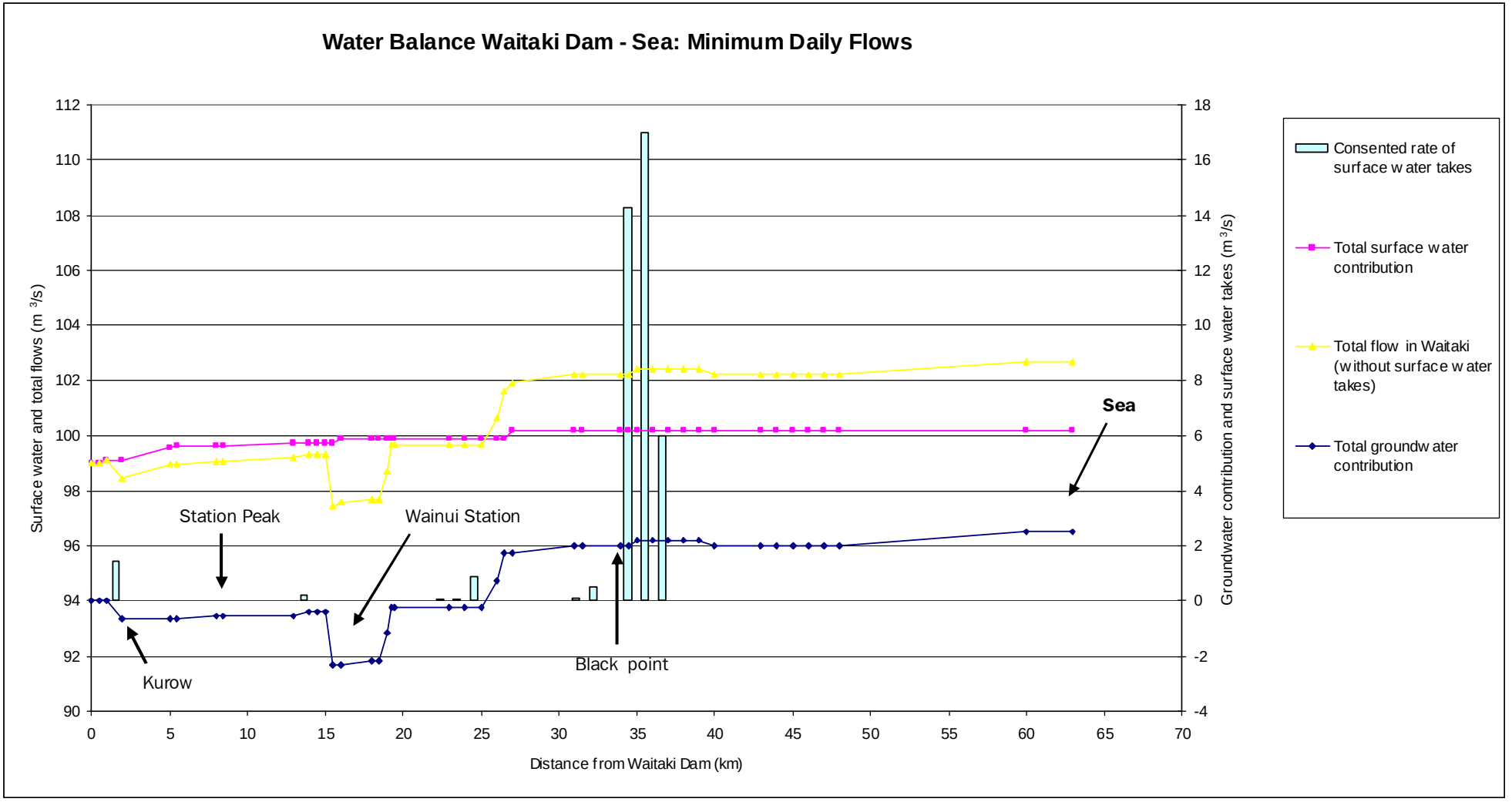

Figure 7: Long section minimum daily flow