3. Baseline Groundwater Levels

The following section provides an assessment of historical and current groundwater levels in the Central Plains area as well as a summary of projected effects of CPWL scheme development on groundwater levels.

3.1. Environment Canterbury groundwater level data

Assessment of historical groundwater levels in the Central Plains area in this report utilises data stored in the Environment Canterbury groundwater level database. This data set (to October 2013) comprises approximately 90 monitoring wells distributed across the study area which are currently utilised to record groundwater levels either via monthly manual measurements or automated data recorders.

The longest continuous records of groundwater level in the Central Plains area (from a total of seven sites) extend back to the early 1950's. Few sites were added to the network (at least in terms of monitoring sites still operating) until the 1970's when an additional 23 sites commenced operation. While a number of these sites have gaps of varying lengths in the record (particularly during the 1980's), semi-continuous monitoring records are available from a total of 30 sites extending over the past 40 years. Information from these sites provides an invaluable historical context to evaluate current and potential future groundwater level trends.

Details of current Environment Canterbury groundwater level monitoring sites are listed in **Appendix 1**.

Monitoring sites

As illustrated in **Figure 16**, the current Environment Canterbury groundwater level monitoring network includes wells distributed across the entire Central Plains area, with an overall higher density in lowland areas to the east of SH1 and a relatively sparse distribution in some inland areas, particularly around Te Pirita and Darfield.

Figure 17 illustrates the depth distribution of wells included in the current Environment Canterbury groundwater level network. These data show a majority of monitoring wells are shallow, with approximately 60% of all monitoring wells less than 40 metres deep. Most of these shallow wells are located in lowland areas (east of SH1), adjacent to the major river systems or close to the base of the foothills. Monitoring wells deeper than 100 metres are generally restricted to inland areas (within the CPWL scheme area) where the water table occurs at depth.

It is noted that the monitoring network includes a number of sites where groundwater levels are monitored in multiple wells or piezometers screened at different depth at or near the same site. Data from these installations provides useful information to characterise vertical hydraulic gradients across the Central Plains area.

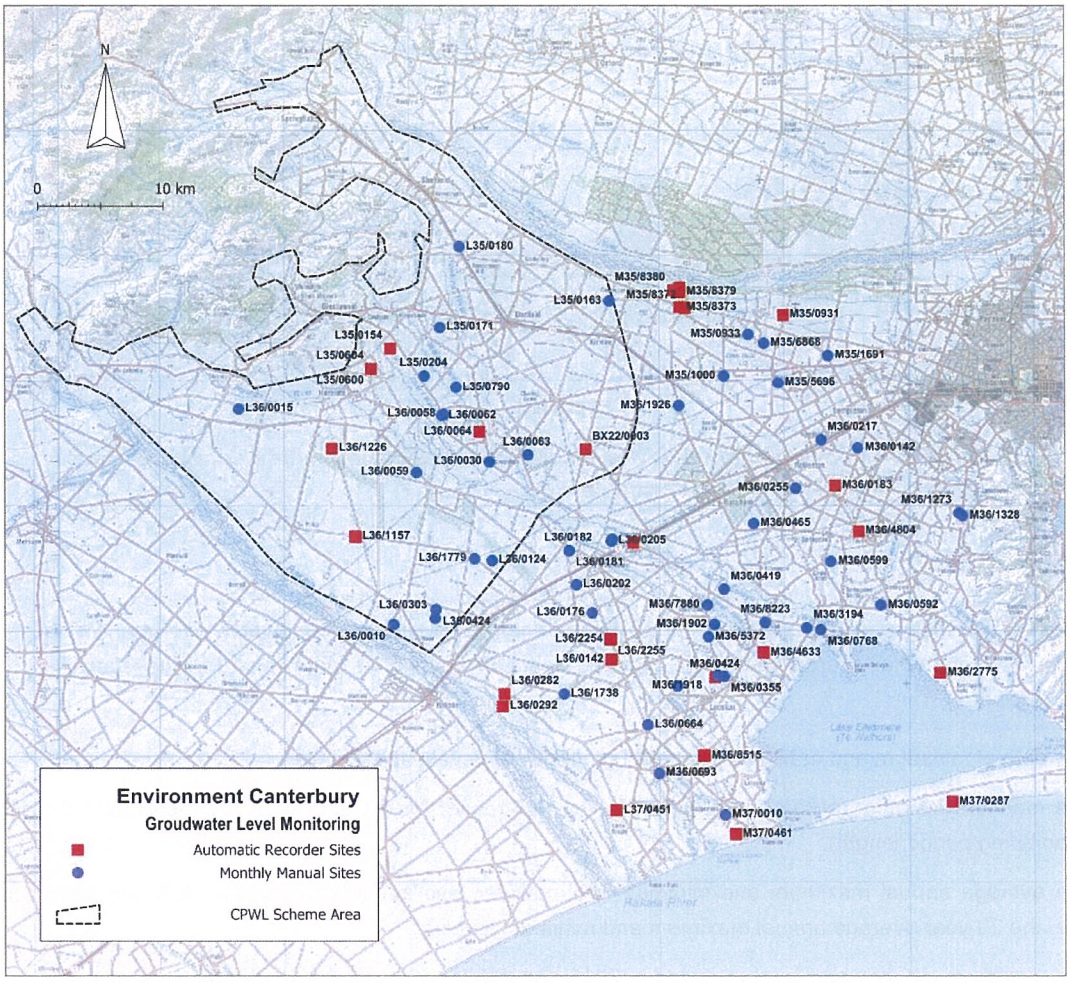

Figure 16. Location of wells included in the current Environment Canterbury groundwater level monitoring network

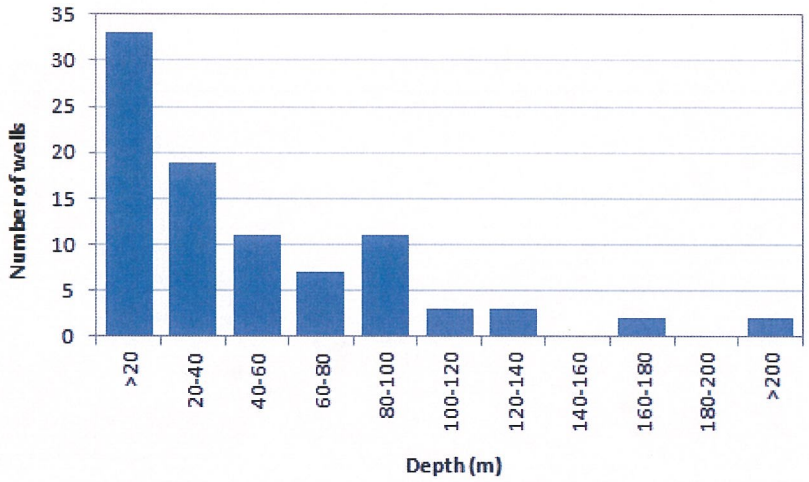

Figure 17. Depth distribution of monitoring wells included in the Environment Canterbury Central Plains groundwater level monitoring network

Monitoring results

Appendix 2 lists summary statistics for current Environment Canterbury groundwater level monitoring sites in the Central Plains area with more than 10 years of continuous data record. The statistics provided include:

- the date of minimum and maximum recorded groundwater levels at each site;
- the median and range of the entire groundwater level record for the site (refer to **Appendix 1** for monitoring period length);
- the average annual maximum and minimum groundwater level recorded between 1993 and 2013 (i.e. the 20-year average annual maximum and minimum levels);
- the maximum groundwater level recorded in 2013 and the departure of the 2013 maximum from the 20-year average annual maximum value;
- the 90 percentile groundwater level

In order to illustrate the spatial distribution of groundwater levels in the Central Plains area, the following section presents a range of maps illustrating the spatial distribution of the various water level statistics outlined in **Appendix 2**. The maps were generated using ArcGIS Spatial Analyst to interpolate the relevant data using the inverse distance weighted (IDW) function with the default parameters applied. In order to constrain the extent of the resulting coverage a mask was applied to the approximate bounds of the Central Plains area.

Figure 18 shows a plot of median depth to groundwater across the Central Plains. The figure shows a progressive increase in the depth to groundwater inland from the coast with deepest groundwater levels occurring in the Te Pirita and Darfield areas. Groundwater levels increase slightly across the intervening section of the plains reflecting the recharge contribution associated with the Selwyn River and its

tributaries. Median groundwater levels are shallowest (~<5 metres below ground) across a broad area around the margin of Te Waihora/Lake Ellesmere.

Figure 19 shows a plot of the minimum depth to groundwater (i.e. highest groundwater level) recorded in monitoring wells located in the Central Plains area. It is noted that the groundwater levels illustrated are not coincident, but represent the minimum depth to groundwater recorded at each individual monitoring site over the available record[2]. This provides an indication of the minimum depth to groundwater which may be expected under 'natural' conditions (i.e. in response to natural climate variability and current groundwater abstraction patterns prior to CPWL scheme development). The figure indicates a relatively large area encompassing the Southbridge, Leeston, Springston and Tai Tapu townships and extending along the margins of the Selwyn River as far inland as Dunsandel may experience groundwater levels within 2 metres of the ground surface during extreme events.

Figure 20 illustrates the 90th percentile groundwater level across the Central Plains area. This statistic represents the groundwater level which is exceeded 10 percent of the time and can be considered broadly representative of the highest sustained groundwater level which is likely to occur under existing conditions (as opposed the peak level illustrated in **Figure 19**). The figure indicates that areas experiencing prolonged periods where groundwater levels are within 2 metres of the ground surface are restricted to areas around the immediate margin of Te Waihora/Lake Ellesmere, extending as far inland as the Leeston township.

Figure 21 illustrates the maximum groundwater level variation observed across the Central Plains area illustrating the significantly increased magnitude of groundwater level fluctuations occurring in inland areas where land surface recharge is the dominant recharge source, compared to lowland areas where seasonal variations are moderated by baseflow discharge for spring-fed streams in the Te Waihora/Lake Ellesmere catchment.

Figure 22 shows a map of average seasonal groundwater level fluctuations recorded over the 1993 to 2013 period. This figure provides an indication of the typical magnitude of seasonal groundwater level fluctuation in response to natural climate variation and current groundwater abstraction patterns. The figure indicates seasonal variations rarely exceed 2 metres around the margin of Te Waihora/Lake Ellesmere but increase significantly in inland areas.

[2] It is noted that the maps illustrated in Figures 18 to 22 utilise data from all Environment Canterbury monitoring bores, regardless of depth. Initial analysis trialled separation of bores on the basis of screen depth however, due to limited vertical hydraulic gradients (typically <2 m except in inland areas with relatively sparse monitoring well coverage), the resulting plots were essentially identical (at a regional scale) except for a loss of spatial resolution. It was therefore considered plots utilising all data were representative at a regional scale (particularly in lowland areas where errors resulting from vertical head differences are likely to be relatively minor in comparison to local-scale topographical variations).

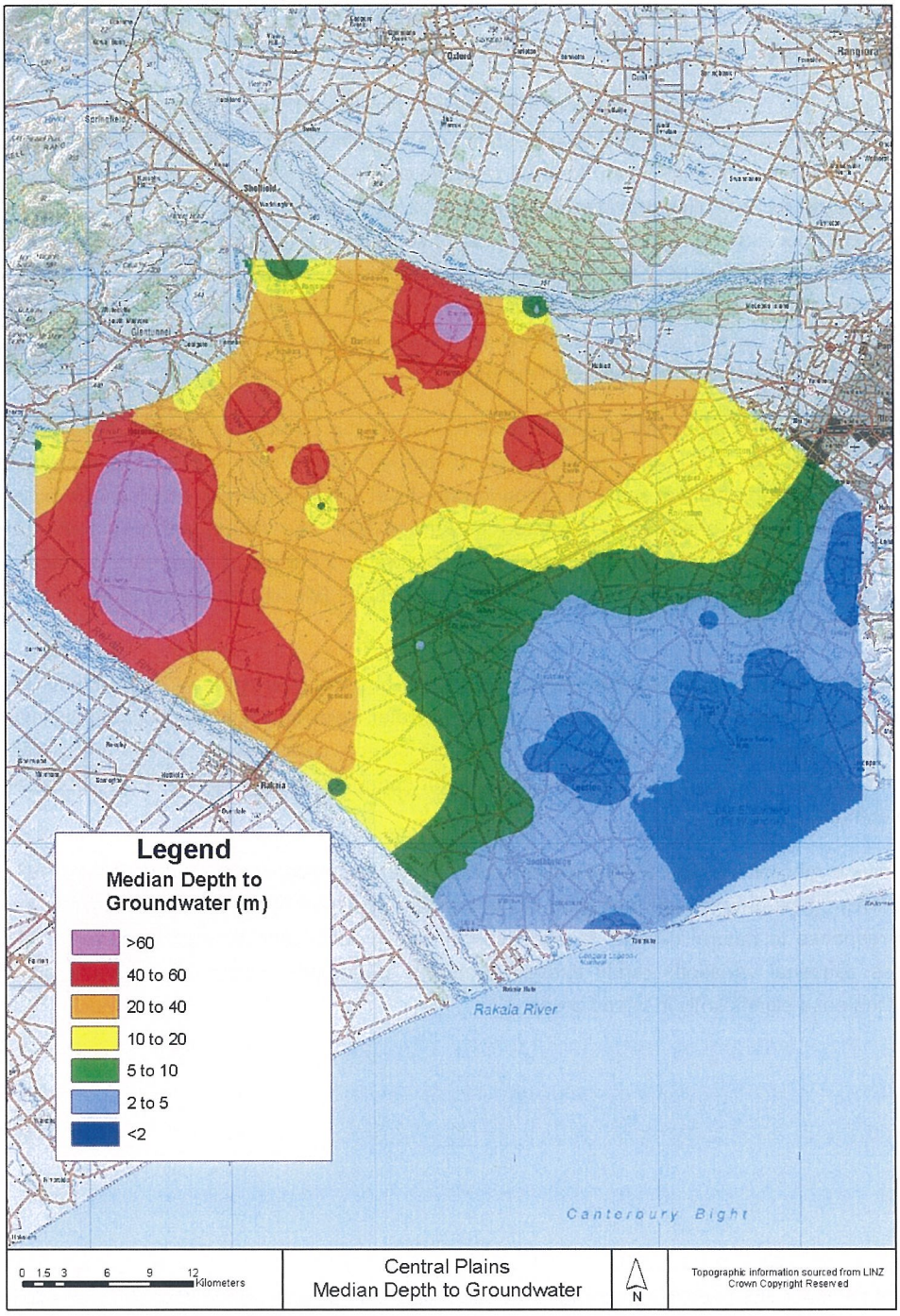

Figure 18. Median depth to groundwater in the Central Plains area

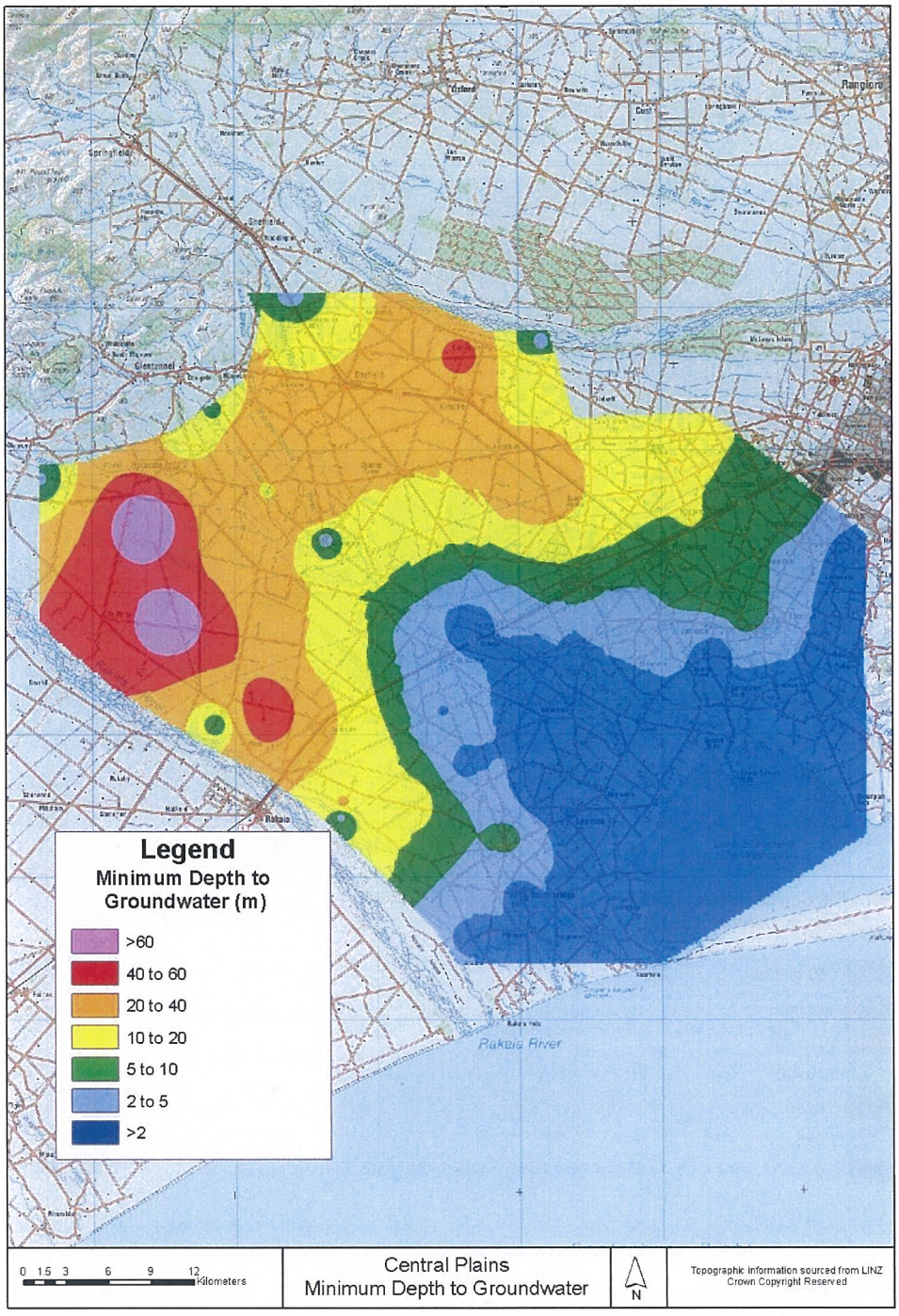

Figure 19. Minimum depth to groundwater in the Central Plains area

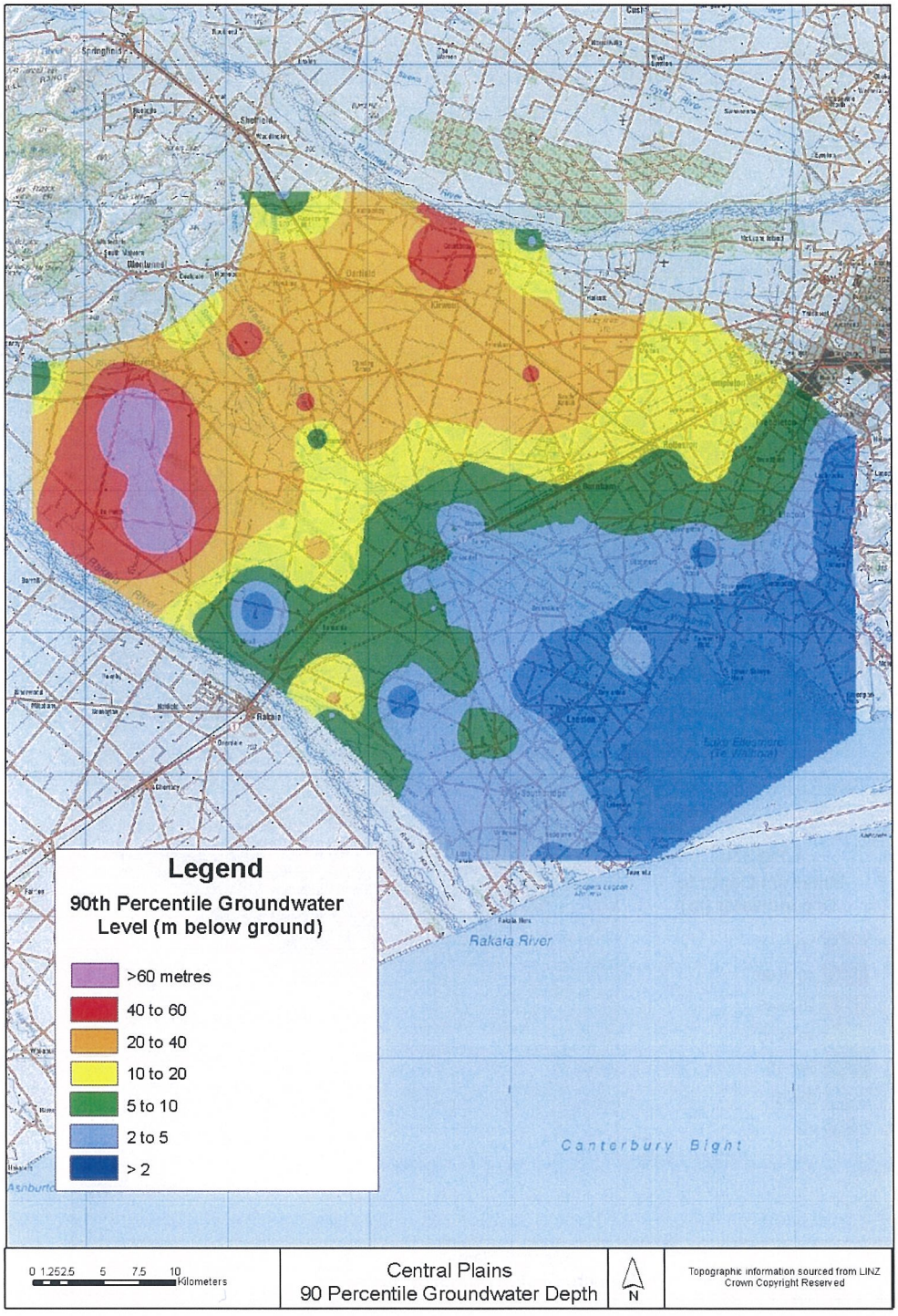

Figure 20. 90th percentile groundwater levels in the Central Plains area

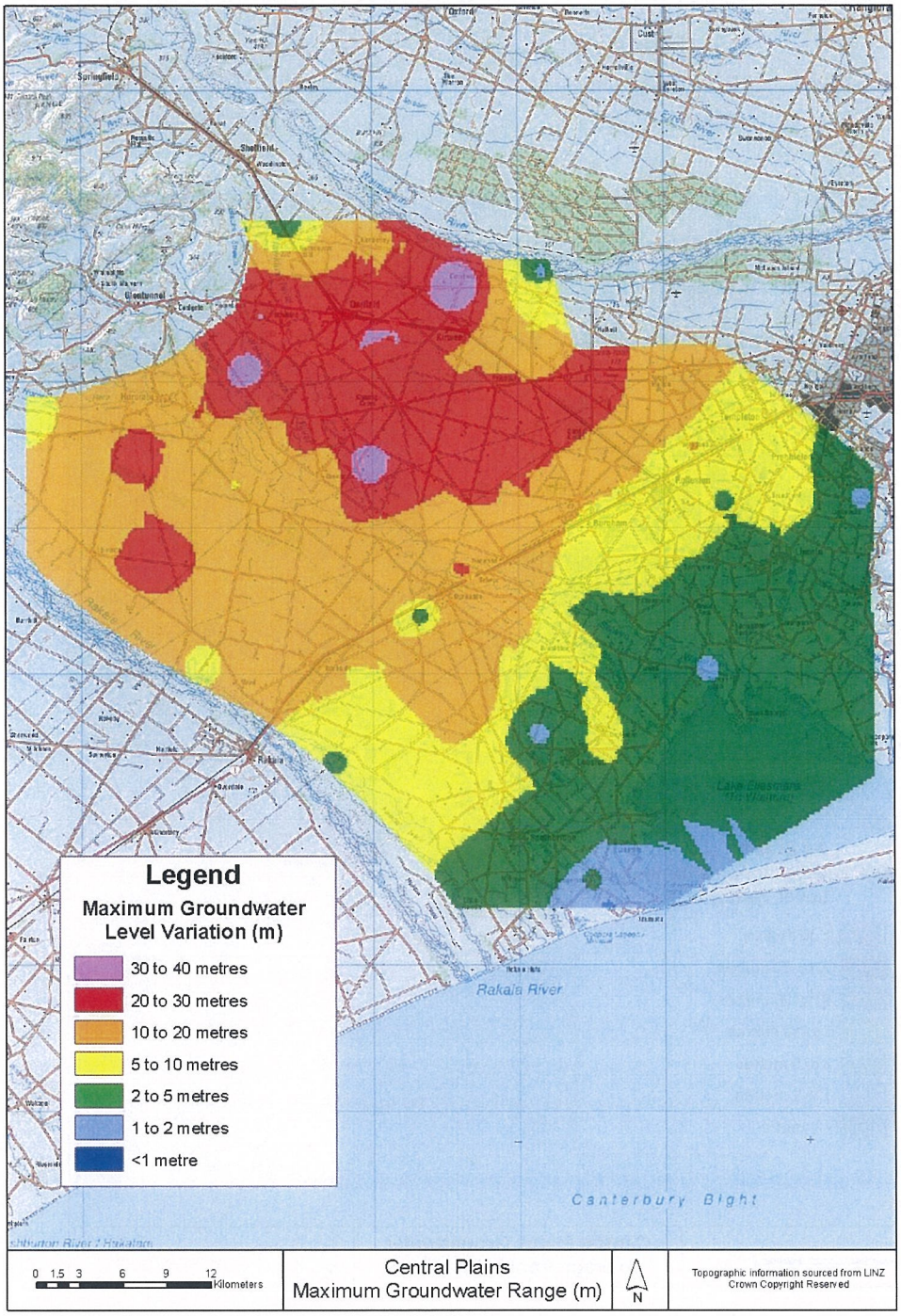

Figure 21. Maximum groundwater level variation in the Central Plains area

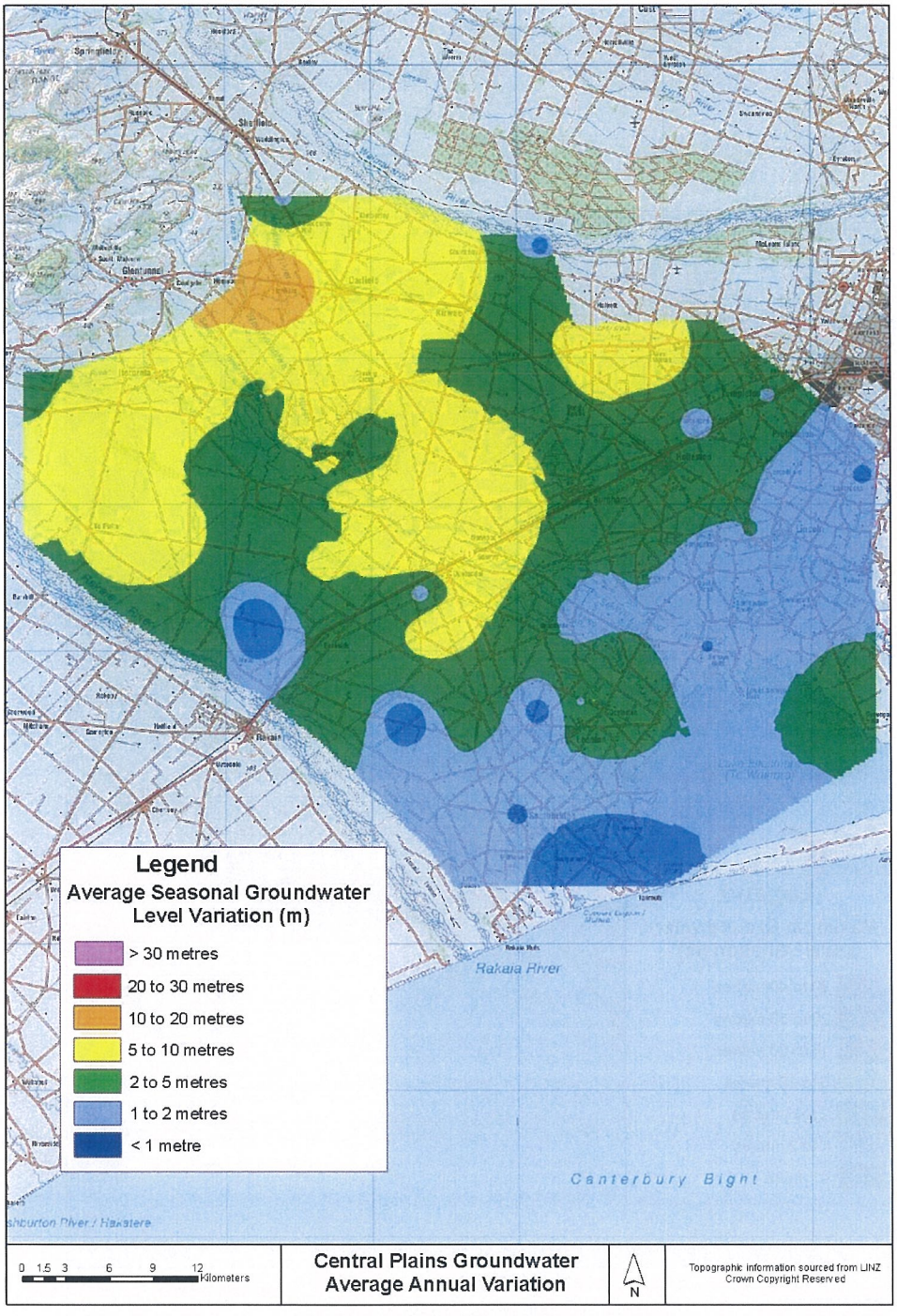

Figure 22. Average seasonal groundwater level variation in the Central Plains area, 1993 to 2013

3.2. Historical Groundwater Levels

Appendix 3 contains groundwater level hydrographs from the 8 groundwater level monitoring sites in the Central Plains area with more than 40 years of record. These sites provide the longest continuous (or semi-continuous in some cases) record of historical groundwater levels in the Central Plains area. Overall, these data reflect the primary controls on temporal and spatial groundwater levels discussed in **Section 2** whereby:

- Groundwater levels adjacent to major surface water features (e.g. alpine rivers, Te Waihora/Lake Ellesmere and/or the coastal margin) generally exhibit limited overall variation (maximum range rarely exceeding 1 to 2 metres) with no obvious seasonal or long-term trends but show significant short-term variability reflecting stage height variations in the relevant surface water features. An example hydrograph is shown in **Figure 23** below;

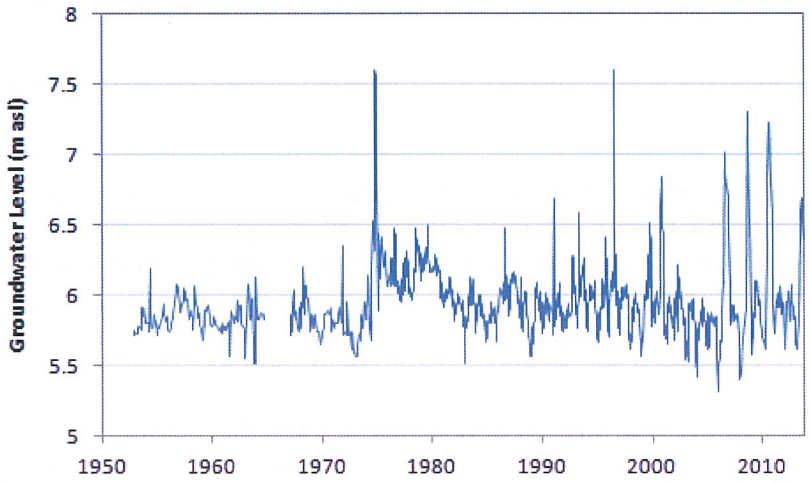

Figure 23. Hydrograph from M37/0010, a 7.6 m deep monitoring well located at Sedgemere, 1950 to 2013

- Groundwater levels in areas removed from the major river systems exhibit appreciable seasonal and long-term variability (typically exceeding 10 metres) which, although in places affected by short-term drawdown resulting from groundwater abstraction, track long term variations in rainfall and consequent land surface recharge (as illustrated in **Section 2.2.1)**. These variations are reflected in the example hydrograph shown in **Figure 24** below.

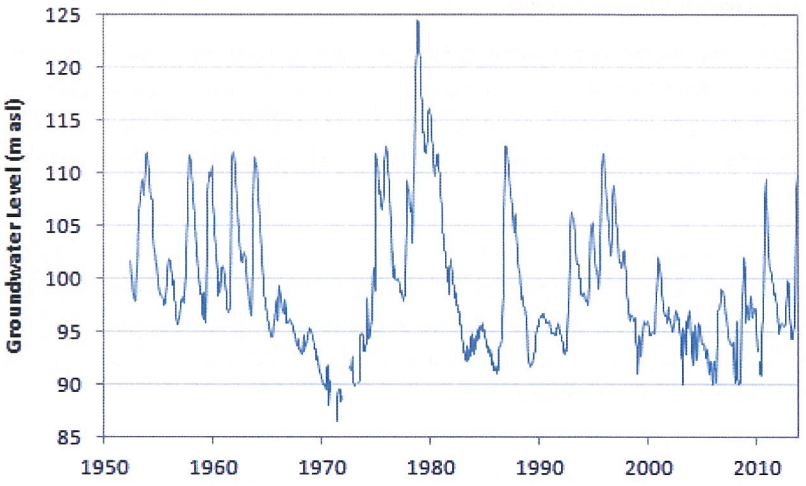

Figure 24. Hydrograph from L35/0163, a 83.8 m deep monitoring well located at Kirwee, 1950 to 2013

To illustrate the relatively consistent influence of land surface recharge on long-term groundwater levels across a majority of the Central Plains area, **Figure 25** through **Figure 27** show representative hydrographs from the upper, mid and lower plains respectively. Although distributed across a wide area and screened at a range of depths, the hydrographs show a consistent long-term trend which tracks long-term variations in land surface recharge.

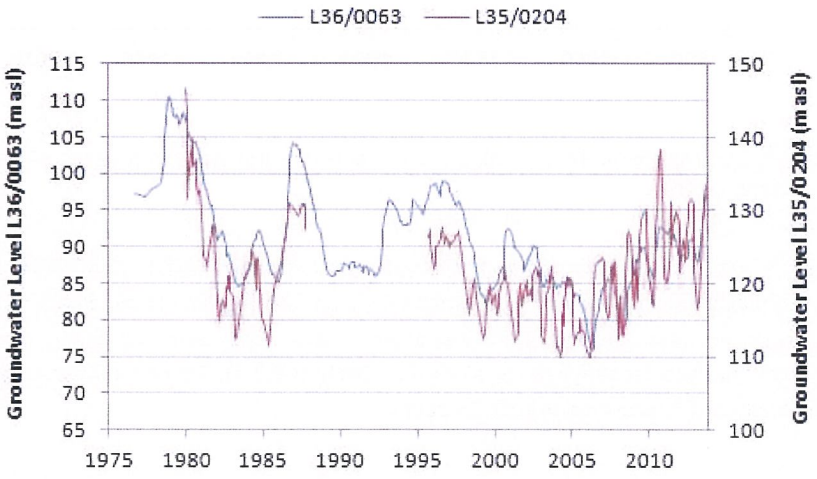

Figure 25. Representative groundwater hydrographs from the mid to upper plains (L36/0063 - Greendale (56m) and L35/0204 - Glenroy (12.5m))

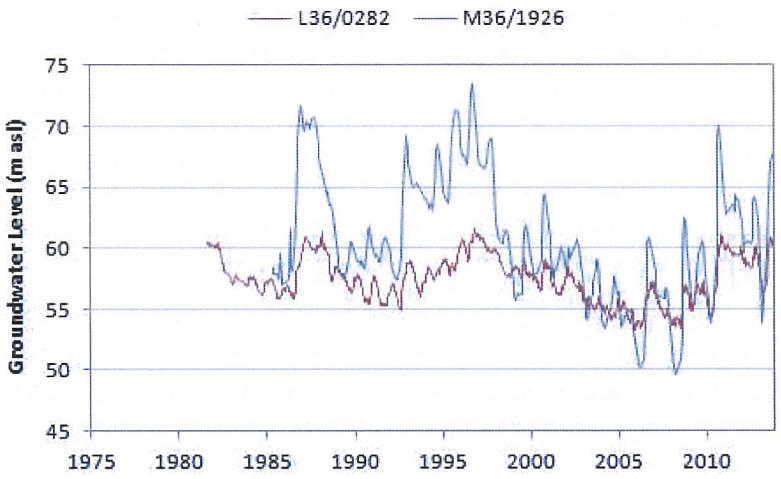

Figure 26. Representative groundwater hydrographs from the mid-plains (L36/0282 - Bankside (40.2m) and M36/1926 - Aylebury (78.9m))

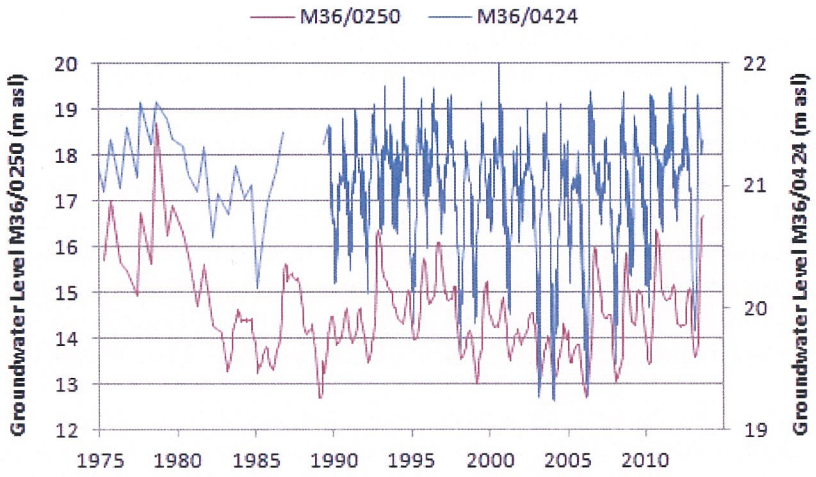

Figure 27. Representative groundwater hydrographs from the lower plains (M36/0250 - Broadfield (18m) and M36/0424 - Doyleston (12.8m))