2 Trial Areas

The GDE sensitivity analysis was developed through application to two trial areas. Some of the datasets and methods are amenable to broad areas while others require detailed study of the landscape and hydrogeology. The first trial area is represented by the regional extent of the Portland Groundwater Management Area (GMA) in southwest Victoria. The second area is the Upper Loddon Water Supply Protection Area (WSPA), in central Victoria. These areas have different geographic locations with distinct geologic and climatic settings.

2.1 Portland Groundwater Management Area

The Portland GMA has an area of ~4000 km^2, located entirely within the Glenelg Hopkins Catchment Management Authority (CMA) region (Figure 2). It is defined to manage the deeper aquifer, primarily in the Dilwyn Formation but, for the purpose of this report, all groundwater within the extent of the formation is considered. Site-specific GDE studies have not been published for this area. Tweed et al. (2007) used remote sensing methodology to map groundwater recharge and discharge points in the volcanic plains of Glenelg Hopkins CMA. Saline wetland GDEs in the adjacent Corangamite CMA were the subject of recent reports (Barton, et al., 2006a, Barton, et al., 2006b, Barton, et al., 2006c).

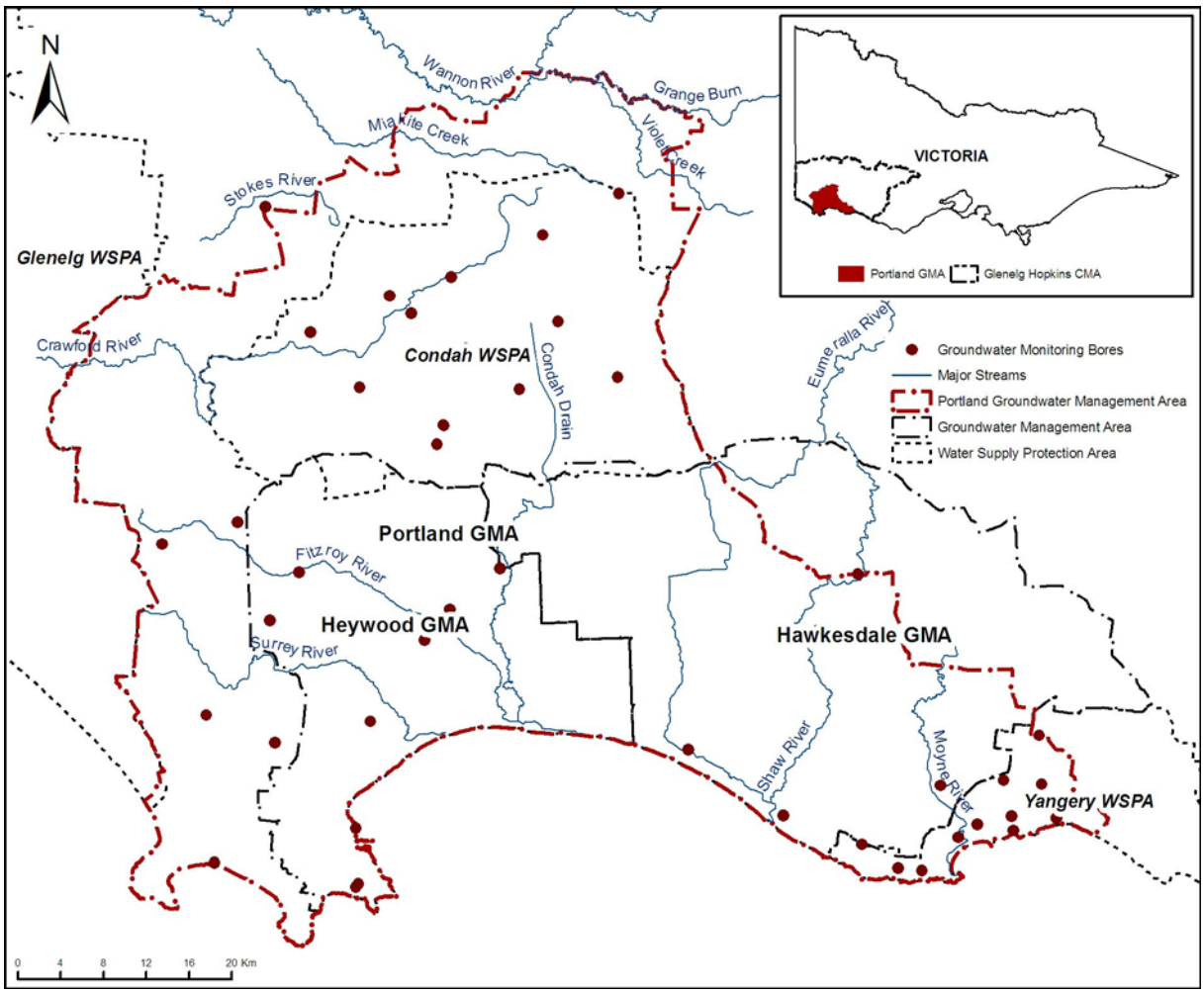

Figure 2 Portland GMA showing associated GMAs and WSPAs

The Heywood GMA and Condah WSPA fall completely within the area of the Portland GMA; the Yangery WSPA and Hawkesdale GMA are partially within the Portland GMA area. Table 2 summarizes information about the Portland GMA and associated Groundwater Management Units (GMUs). Some of the GMUs also include resources in other aquifers but are defined by the resources listed. Water allocations are managed by the Southern Rural Water Authority.

Table 2 Groundwater Management Units in the Portland study area

GMU	2010 Licence Entitlement (ML)	Major Aquifers	Major Formations	General Description
Portland GMA	7677	Lower Tertiary Aquifer	Wangerrip Group Dilwyn Fm.	Confined marine sandstone
Condah WSPA	7400.1	Lower Mid-Tertiary Aquifer	Heytesbury Group Clifton Fm.	Confined limestone & sandy limestone
Hawkesdale GMA	9899.4	Upper Mid-Tertiary Aquifer	Heytesbury Group Clifton Fm.	Unconfined Port Campbell Limestone
Heywood GMA	4986.5	Quaternary Aquifer and Upper Tertiary Basalt Aquifer	Newer Volcanics & Bridgewater Fm.	Unconfined basalt and alluvial sediments
Yangery WSPA	13983.4	Quaternary Aquifer and Upper Tertiary Basalt Aquifer	Newer Volcanics & Bridgewater Fm.	Unconfined basalt and alluvial sediments

2.1.1 Hydrogeologic Setting

The Portland GMA is located in the Central Otway Basin. The geologic setting has been described previously (Birch, 2003, Wiltshire, et al., 2010). SKM (Wiltshire, et al., 2010) developed an aquifer framework across southern Victoria and applied the system to map aquifer extents and thickness (see Table 2). For the purpose of this report, the important considerations are the location and extent of the unconfined and uppermost confined aquifers and a basic understanding of the possibility of intercommunication between aquifers. It is also important to consider the amount of groundwater extraction, the aquifers exploited, and the locations of irrigated agriculture.

The Lower Tertiary Aquifer is not directly of concern in assessing GDE sensitivity due to its depth. The unconfined Upper Mid-Tertiary, Upper Tertiary Basalt, and Quaternary aquifers are considered to be unconfined in most locations and thus may directly support GDEs. The Lower Mid-Tertiary Aquifer is generally confined, however it likely discharges to upper aquifers or surface water in the vicinity of Condah Swamp (Gippel, et al., 2006, Department of the Environment, 2009). It is also important to assess the possibility of discharge from confined or semi-confined aquifers in other areas.

Groundwater use data were obtained from Southern Rural Water. Not all water supplies have metered data but data are available in recent years from the major supply points. Figure 3 shows the location of groundwater supply bores in the Portland GMA study area, colour coded by GMU. Allocation volumes for bores with license allocation volumes > 50 ML are shown in.Figure 4 The allocation is split evenly where multiple bores are included in a single license. Actual groundwater extraction is significantly less than license allocation volume but the figure generally reflects relative amounts of groundwater extraction.

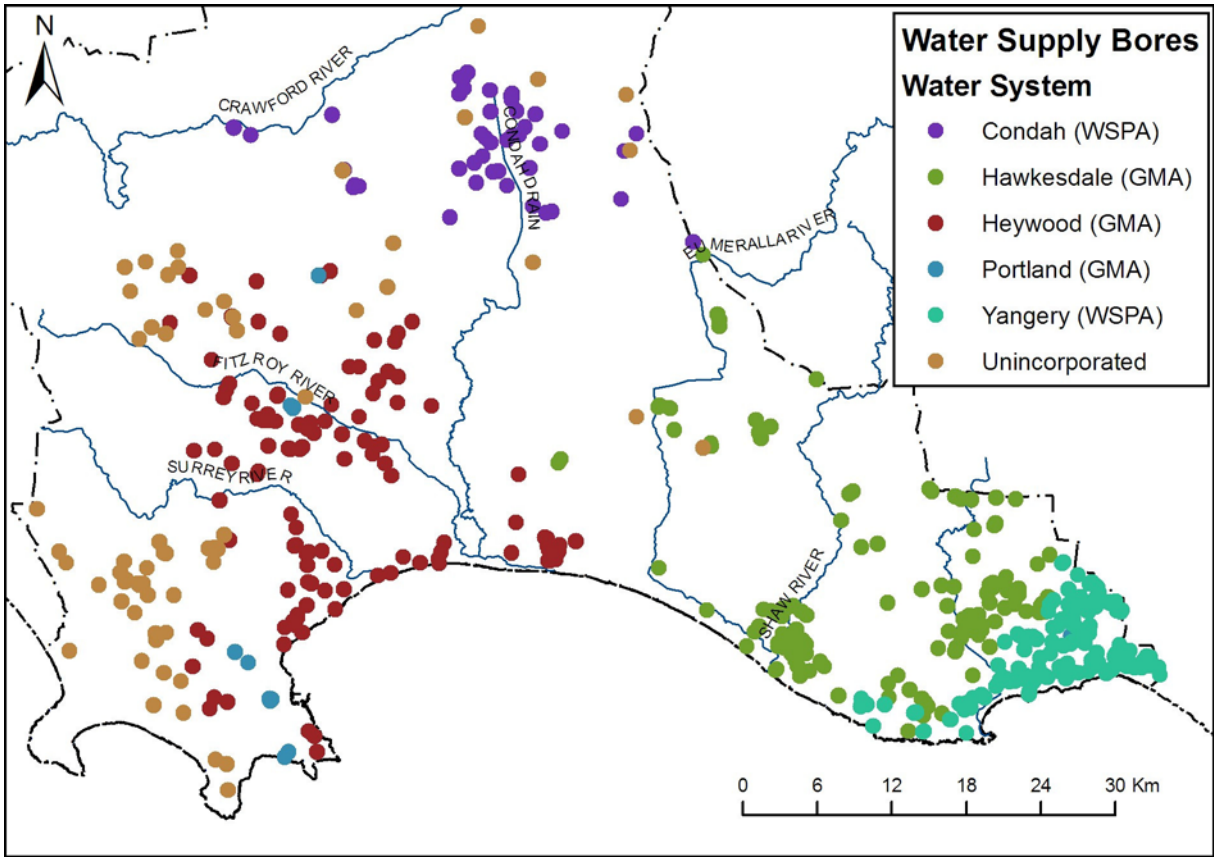

Figure 3 Water supply bores in the Portland GMA region

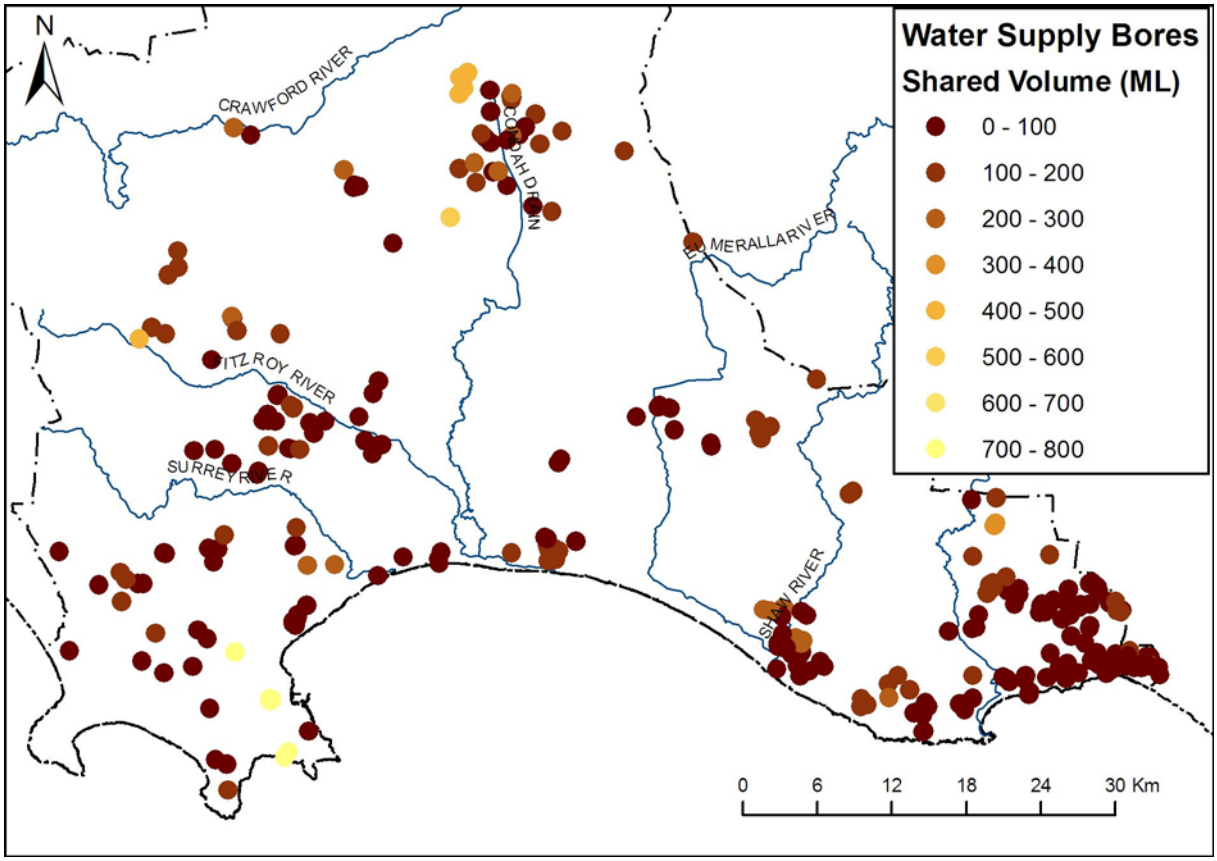

Figure 4 Water volume allocation for bores with annual licenses > 50 ML within the Portland GMA region. Volume is split evenly when more than one bore is included in the license.

2.2 Upper Loddon Water Supply Protection Area

The Upper Loddon WSPA is located in central Victoria along the Great Dividing Range . Approximately two-thirds of the Upper Loddon WSPA is within the North Central CMA region while the rest is within the Glenelg Hopkins CMA region (Figure 5). Water licensing is managed by Goulburn-Murray Water. The most important aquifers are generally in the Newer Volcanics basalt and Calivil Formation alluvium. The annual license entitlements were 13,648 ML in 2008/09 (Goulburn-Murray Water, 2009). The Upper Loddon WSPA was amalgamated with surrounding GMUs into the new Loddon Highlands WSPA at the beginning of August 2010. Allocation volumes are shown in Figure 6. The allocation is split evenly where multiple bores are included in a single license. Water supply bores are mainly located in the southern part of the region. Actual groundwater extraction is significantly less than license allocation volume but the figure generally reflects relative amounts of groundwater extraction.

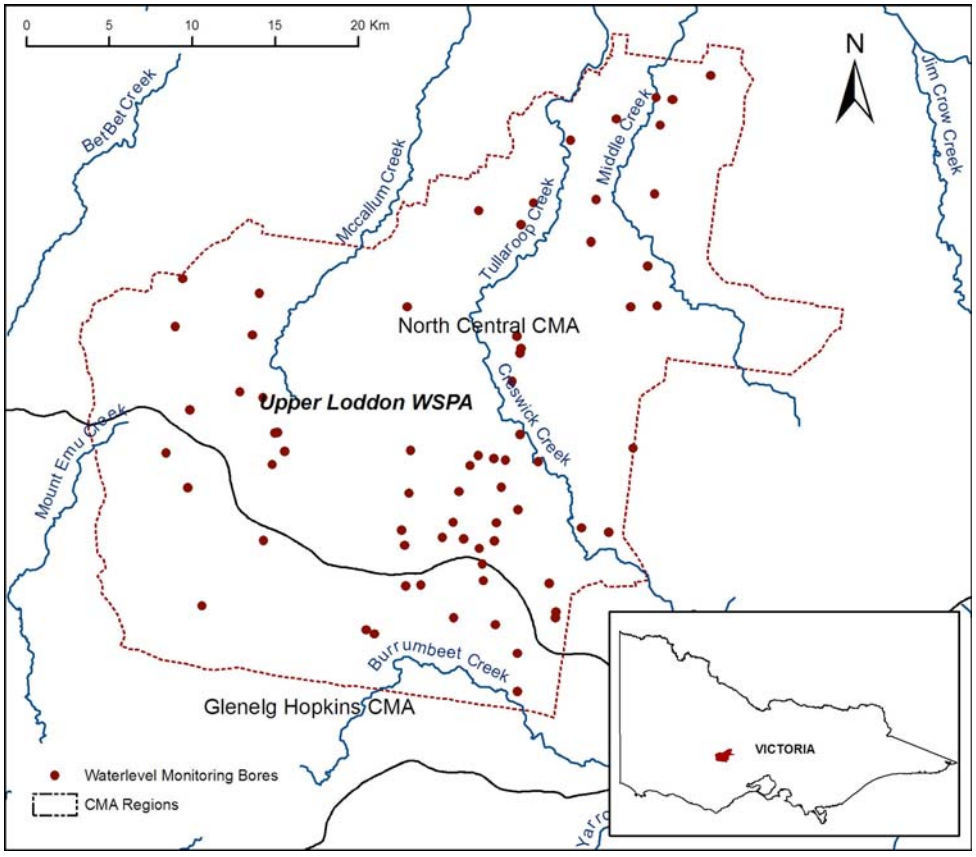

Figure 5 Upper Loddon WSPA showing associated CMAs and monitoring bore locations

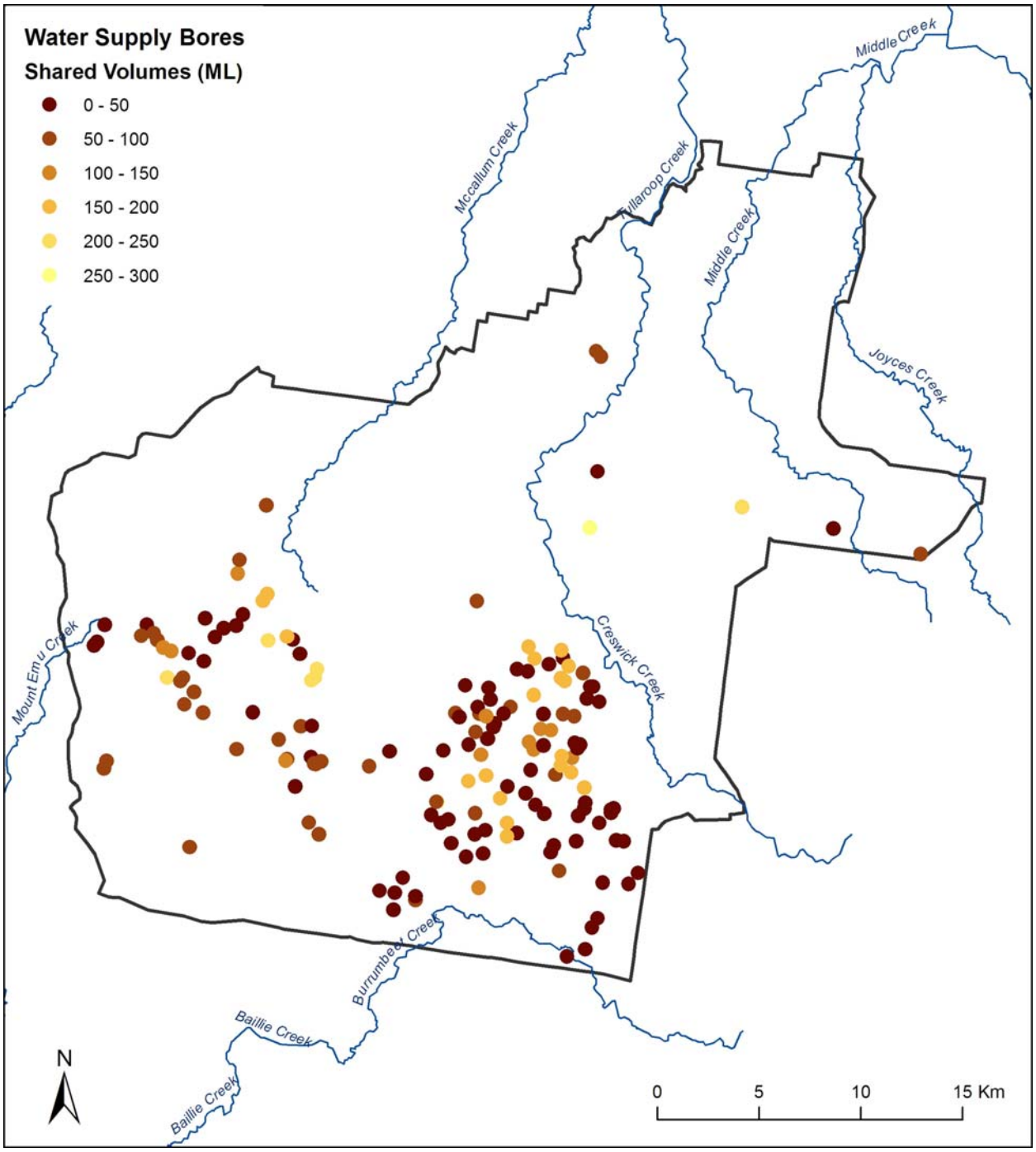

Figure 6 Annual water volume allocation for bores within the Upper Loddon WSPA region. Volume is split evenly when more than one bore is included in the license.

The geology of the Upper Loddon WSPA has been described previously (Birch, 2003). The bedrock of the Upper Loddon area is built of Palaeozoic rocks: folded marine Ordovician sediments (sandstones, mudstones, shales of Castlemaine Group) and intrusive Devonian granites. The Mesozoic sediments are absent in this region due to its denudation in this period. During the Mesozoic it was a stable, low lying area with extensive weathering processes, which formed deep regolith within the bedrock. Deposition of gold-bearing quartz gravels and sands had likely begun by the end of the Cretaceous age. They were deposited in broad, low-relief valleys incised into the Mesozoic palaeoplain (White Hills Gravel). At present these sediments occur as remnant patches on hills and on the higher sides of modern valleys. Their upper parts are mostly lateritised. Late Tertiary weathering caused deeper incision into valleys and

deposition of reworked older gravels (White Hills Gravel) and bedrock material. Accumulated sands and gravels filled in the valleys of the Loddon River and formed well developed aquifers (Calivil Formation). The recharge of these aquifers mainly takes place through present alluvial valleys or where intersected by volcanic cones. The Tertiary alluvial deposits were covered by subsequent volcanic activity, forming the “deep lead” system aquifers.

The Calivil Formation is overlain by fluvio-lacustrine sediments of late Tertiary to Quaternary age Shepparton Formation. It consists of poorly sorted, “shoe-string” sands, clays and silts deposited in an aggradational environment. Aquifers of this formation occur in forms of ribbon-like bodies or considerably spread sheets with their thickness usually not greater than 5m.

The present landscape of the Upper Loddon was formed by the intensive volcanic activity, which started in the Pliocene and was continuous through much of the Quaternary. Lava flows from the volcanic centres dispersed widely through the region, filled the existing valleys and produced broad lava plains (Newer Volcanics). Basalts of the Newer Volcanics group form the most important and widely used aquifers in the Upper Loddon region. They are recharged through most of the area and discharge to the valleys and small depressions occupied by lakes or swamps.