Government of **Western Australia**
Department of **Water**

Gingin groundwater allocation plan methods report

Background information and method used to set an allocation limit for aquifers in the Gingin groundwater area allocation plan area

March 2015

Securing Western Australia's water future

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Securing Western Australia's water future

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Summary

This report explains how the Department of Water developed the allocation limits for each of the 35 groundwater resources covered in the *Gingin groundwater allocation plan* (DoW 2015a). The report summarises the hydrogeological, environmental (including potential impacts from a drying climate), cultural and social information available for the aquifers, reviews subarea boundaries and describes the method we used to set allocation limits.

Allocation limits are a management tool we use to maintain the sustainability of a water resource. The department sets allocation limits after balancing the need to make water available for use as well as leaving water in the aquifers to support groundwater levels and aquifer throughflow.

The main change to allocation limits in the *Gingin groundwater allocation plan* (the plan) compared to the 2002 Gingin interim groundwater management strategy is that the rainfall figures used to calculate recharge were reduced. We calculated recharge assuming a 15 per cent reduction in average annual rainfall for the life of the plan, compared to the period from 1975 to 2003. This is consistent with CSIRO's dry-climate projections for the south-west of Western Australia. As well as rainfall, our recharge calculations accounted for aquifer outcrop area, current vegetation cover, soil type and the different characteristics of each aquifer. To calculate the yield, we considered the proportion of recharge to be left in each groundwater resource depending on the presence of groundwater-dependent ecosystems, the contribution of groundwater to river baseflow and proximity of the seawater interface.

To decide the allocation limits for each resource, we compared the calculated yield to the volume of water needed to meet current water use and future demand. Where demand was greater than the water available, we considered how to use allocation limits, licensing and monitoring in a complementary way to manage the risks, and either retained the recharge as the allocation limit or adjusted it to better meet all needs. In the latter case, the allocation limit represents a trade-off between competing needs. The effectiveness of the allocation limits will be assessed annually through our plan evaluation process.

There are about 470 water licensees across the plan area. As the local population increases, so too will the demand for water. The allocation limits make 235 GL/yr available for consumptive use across the 35 resources. Currently, about 140 GL/yr is issued as licence entitlements, 3 GL/yr has been set aside to account for exempt stock and domestic use, and 41 GL/yr is held in reserve for future regional water supply needs as well as an option for future Perth needs. Water is still available for licensing in the plan area.

The allocation limits were developed using the best available information and are designed to maintain the reliability of current groundwater entitlements as well as reduce the risks to the groundwater-dependent environment from abstraction. Details of water availability and how the department will manage allocation limits are included in the plan.

1 Introduction

1.1 Plan area and location

The Gingin plan area is located about 90 km north of Perth and covers about 6000 km^2 of the Northern Perth Basin, extending between Wedge Island and Moora in the north to Guilderton and Bindoon in the south (Figure 1).

The plan area generally follows the proclaimed Gingin groundwater area boundary. Subareas south of Gingin Brook and Moore River form part of the *Gnangara groundwater areas allocation plan* (DoW 2009c). Surface water within the plan area is managed through the *Gingin surface water allocation plan* (DoW 2011a).The Gingin groundwater area was proclaimed on 26 September 1975 under Section 26B of the *Rights in Water and Irrigation Act 1914* (WA). This means that water users require a water licence to lawfully abstract groundwater under Section 5C of the Act, unless exemptions apply.

1.2 Water allocation planning in the Gingin plan area

The Department of Water (the department) manages water abstraction by issuing licences under the *Rights in Water and Irrigation Act 1914*. As the demand and volume of water used increase in a particular area, a water allocation plan is required to guide our licensing decisions.

The plan replaces two previous groundwater allocation plans in the Gingin groundwater area:

- *Gingin groundwater area management plan* (WAWA 1993)
- *Managing the water resources of the Gingin groundwater area, WA – Interim Sub-Regional allocation strategy* (WRC 2002).

The plan sets out how much water can be abstracted from the nine aquifers in the Gingin plan area and how that abstraction will be managed now and in the future. This supporting document to the plan describes how the department developed the plan and decided on the allocation limits for each resource within the plan area.

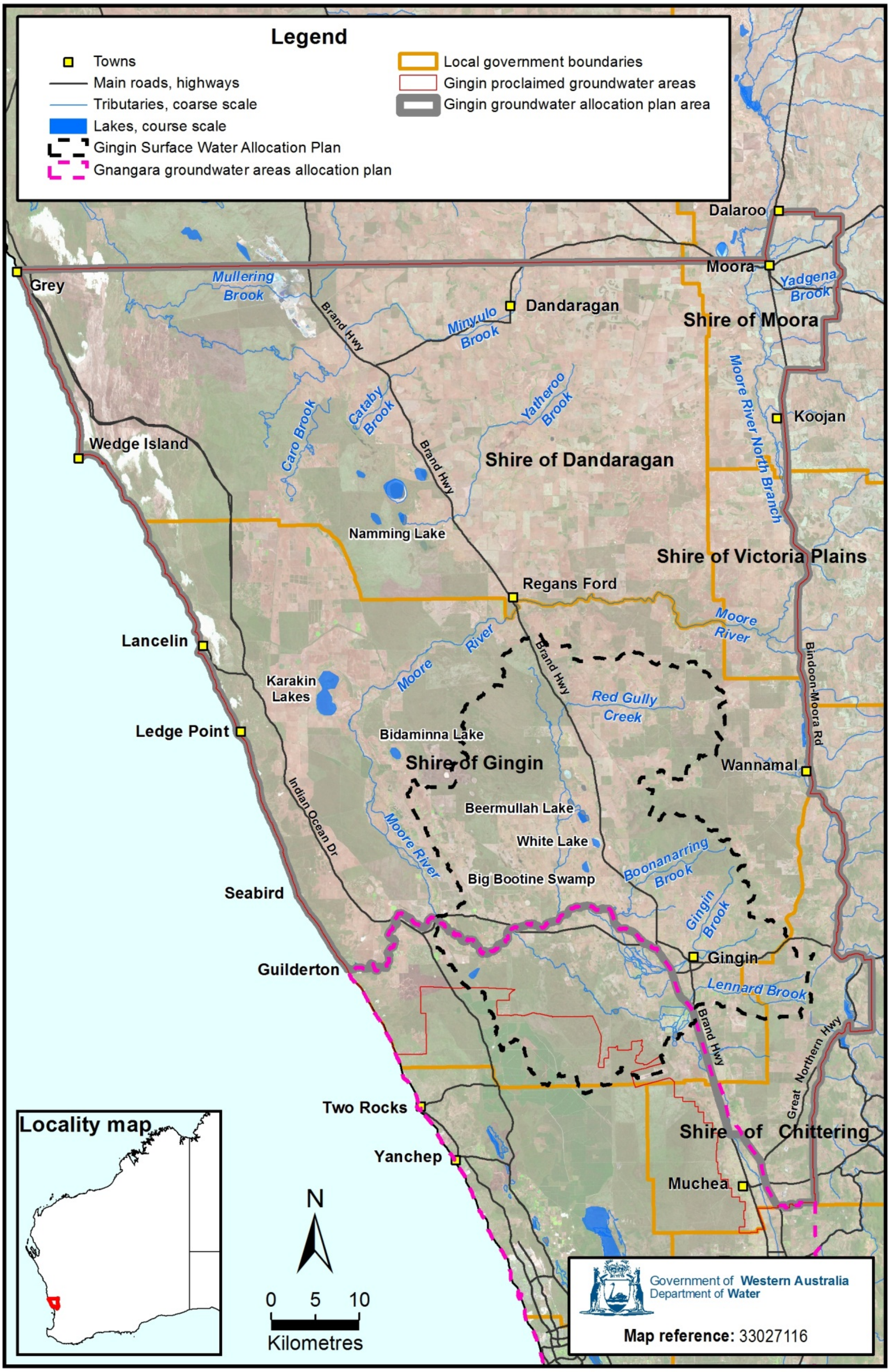


Figure 1 Gingin groundwater allocation plan area

1.3 Allocation limits

An allocation limit is the annual volume of water set aside for consumptive use from the annual recharge of a water resource and does not include water to be left in the system (Figure 2). For administrative purposes, the allocation limit is divided into components for:

- water that is available for licensing:
  - general licensing
  - public water supply licensing
- water that is exempt from licensing
- water that is reserved for future public water supply.

The department uses allocation limits to manage resources sustainably while maintaining security to individual licence entitlements. Water for environmental and social needs is not part of the allocation limit. Water is allocated within the allocation limit through the department's licensing process. Allocation limits are complemented by water resources monitoring, investigations and licence compliance monitoring. This management approach is set out in the plan.

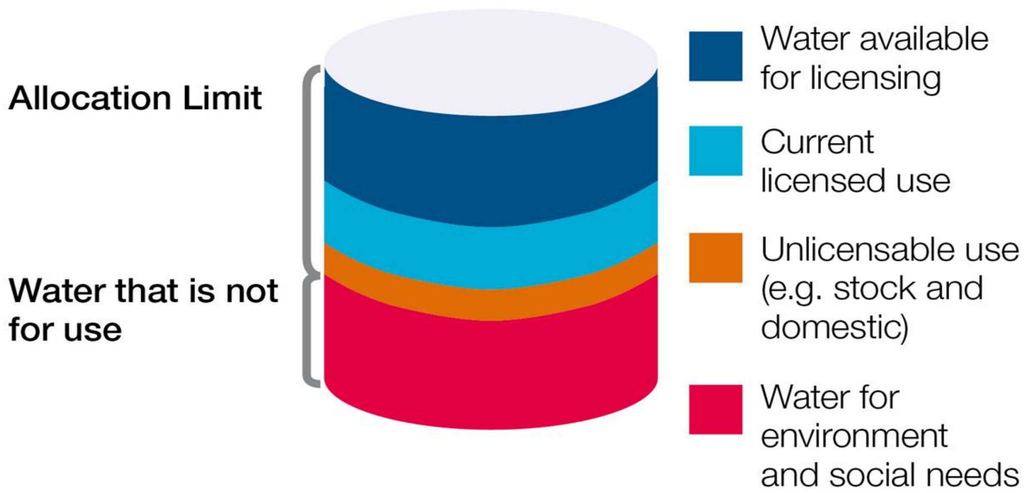


Figure 2 Total recharge comprises the allocation limit (and its components) and water that is not for use.

Previous allocation limits and approach

Allocation limits for the Gingin groundwater area were first set in the *Gingin Groundwater Area Management Plan* by the Water Authority (WAWA 1993). The allocation limits set for each resource in the 1993 plan was equal to the calculated recharge. The total water available for licensing at this time was about 365 GL/yr. The recharge volume for each aquifer was calculated using long-term rainfall averages (1889–1990) and information from geological drilling investigations carried out from the 1960s to the 1980s (WAWA 1993).

In 2000, the Waters and Rivers Commission reviewed the 1993 allocation limits while developing an Interim Strategy for the Gingin plan area. This review was necessary because, at the time, the allocation limits did not account for the environmental values at the level required by the national water reform initiatives and the state's amended *Rights in Water and Irrigation Act 1914*. The recharge volumes for the 2002 Interim Strategy were recalculated using long-term rainfall averages (1889–2000) and new information from hydrogeological investigations carried out by the department and reports associated with licence applications (WRC 2002). A percentage of the recharge was also set aside for environmental values (20 per cent of water was left in the surficial and superficial aquifers and 10 per cent in the Leederville-Parmelia aquifer). The 2002 allocation limits were set equal to these adjusted recharge volumes.

During 2009 to 2013, the department reviewed the 2002 allocation limits and developed the current plan. A new plan was necessary in response to declining groundwater levels, increasing regional demand for water and availability of new information including groundwater and surface water connectivity in Gingin Brook as well as a reduction in the mean annual rainfall in the plan area. Allocation limits were set in 2011, early in the plan development stage to allow us to consult effectively with stakeholders. The allocation limits were based on the same recharge method used in the 2002 strategy, with updated rainfall, environmental and demand information.

1.4 Allocation planning

The department developed the plan using our standard allocation planning model (Figure 3). This report describes how we assessed the information on the water resources in the Gingin plan area (Part A) and how we set the objectives and allocation limits for the Gingin groundwater allocation plan (Part B). Our management approach (Part C of the process) is defined in the *Gingin groundwater allocation plan*.

For more information about allocation planning see *Water allocation planning in Western Australia: a guide to our process* (DoW 2011b), which is available online at <www.water.wa.gov.au>.

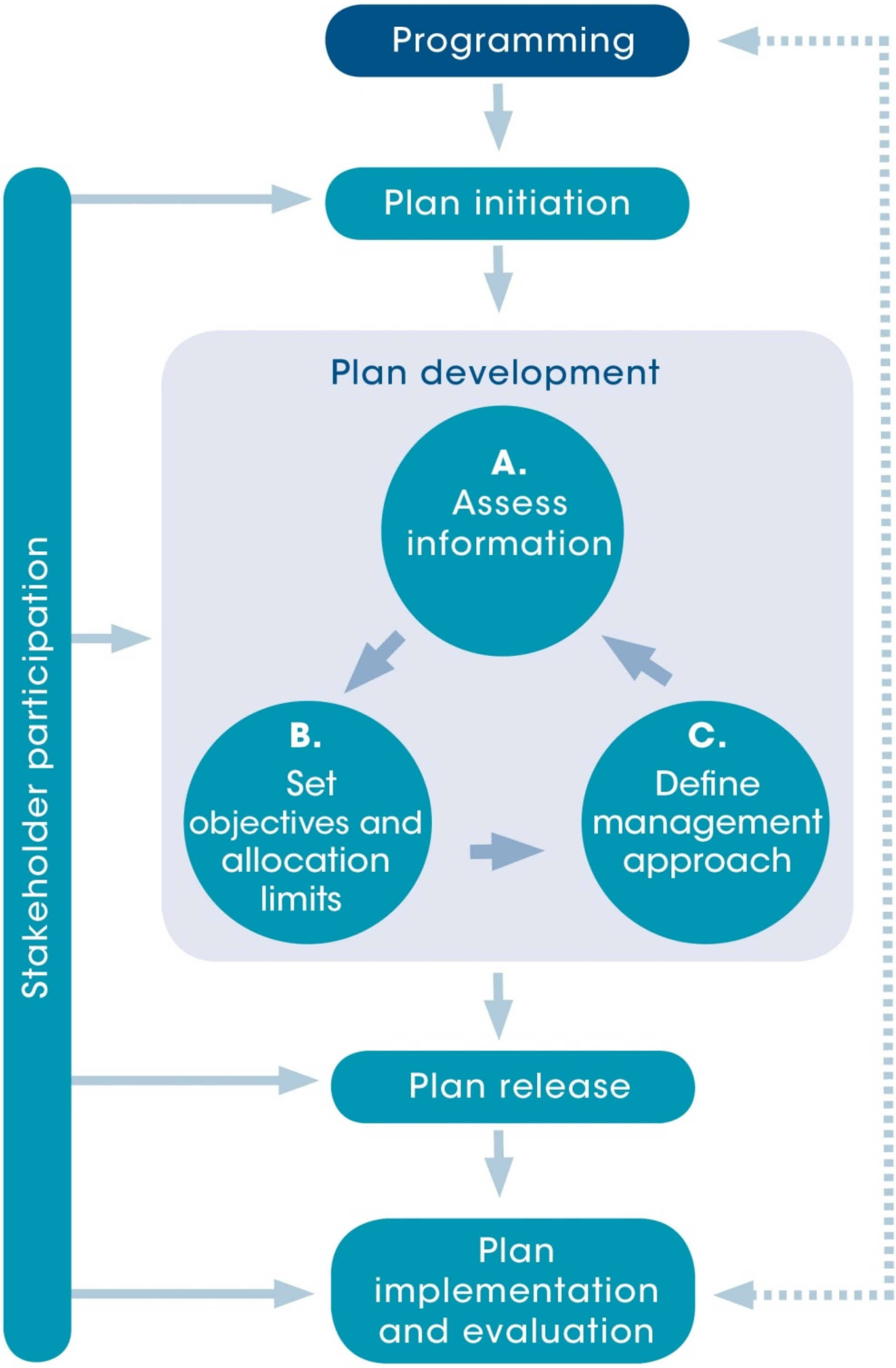


Figure 3 Water allocation planning model

1.5 Working with water users and other stakeholders

Stakeholders participate at all stages of the water allocation planning process (Figure 3). For the Gingin plan, we consulted licensees, other State agencies and other stakeholders (agricultural, industrial, public water supply) to identify water-related values and discuss current and proposed water resource management. We advertised progress on preparation of the plan using newsletters, updates to our website, newspaper advertisements and media releases.

The department also held community information sessions in February 2011 at the Gingin Recreation Centre, with additional sessions held in July 2011 in Gingin, Dandaragan and Wanneroo.

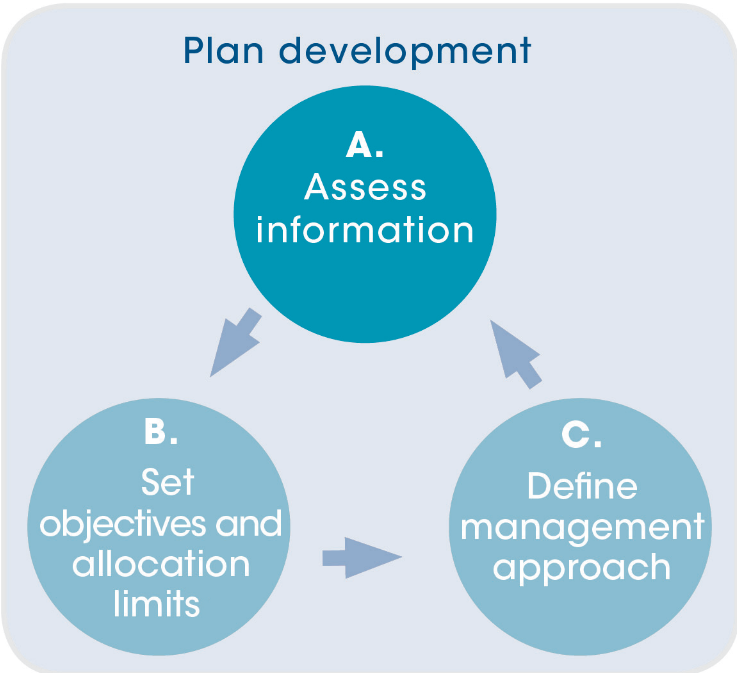
Prior to the release of the plan for public comment (August 2013) and final plan release (April to June 2014), the department met and informed various stakeholders of the plan's progress and discuss points raised in submissions.

Part A – Assessing information

In Part A of plan development for Gingin groundwater, we assessed information on:

- hydrogeology
- climate and rainfall
- recharge
- aquifer trends
- ecological, social and cultural water requirements
- current and future water demand.

Information from Part A informs the plan objectives and the department's allocation limit decisions.



2 Understanding the water resource

Understanding the distribution and variability of the quantity and quality of water resources in the plan area was the first step in deciding how much could be abstracted. This section provides a summary of the hydrogeology, rainfall, recharge, aquifer trends as well as information relating to ecological, social and cultural requirements used to develop the objectives, calculate yields and set allocation limits for the Gingin plan area.

2.1 Hydrogeology

The hydrogeology of the Gingin plan area is well understood and is described in detail in the 2002 Interim Strategy. The plan applies to the nine aquifers within the Gingin plan area. Characteristics of these aquifers are listed in Table 1 and presented in Figure 4 as a conceptual diagram, representing some of the area's hydrogeology. The extents of the aquifers are shown in figures 5, 6, 7 and 8.

Table 1 Characteristics of aquifers within the Gingin groundwater plan area

Aquifer	**Description and notes**	**Location**
Surficial	Extensive, patchy aquifer (sand, clay) Unconfined, thin and often unsaturated Generally fresh water (<1000 mg/L TDS) Generally small bore yields (<100 kL/day) Supports groundwater-dependent ecosystems	East of the Brand Highway - Figure 5
Superficial	Extensive and shallow aquifer (sand, gravel, clay) Unconfined with saturated thickness of up to 50 m Generally fresh water (<1000 mg/L TDS) Moderate–good bore yields (up to 2000 kL/day) Groundwater levels tend to be deeper and the aquifer is more resilient to abstraction in coastal areas Inland, water tables are shallower, supporting groundwater-dependent ecosystems such wetlands and remnant vegetation	West of the Brand Highway - Figure 5
Mirrabooka	Partially unsaturated and highly variable thickness (sandstone, shale) Semi-confined aquifer Generally fresh water (<1000 mg/L TDS) Highly variable yields Contributes to most of the summer flow in the headwaters of Gingin Brook including downstream of the Gingin town site to the confluence with Mungala Brook Important for maintaining summer flows in the Moore River	Eastern parts of plan area - Figure 6
Fractured rock	Fractured and weathered crystalline bedrock Very variable water quality Low bore yields (<500 kL/day) Small water storage capacity	Eastern margins of the plan area, east of the Darling Scarp - Figure 6

Aquifer	Description and notes	Location
Cattamarra	Sandstone and shale Water is brackish–saline	Small area in the northwest of the plan area - Figure 7
Lesueur	Mainly sandstone Water is fresh–brackish	Small area in the northwest of the plan area - Figure 7
Leederville	Deep aquifer (sandstone, shale), up to 550 m thick Semi-confined to confined aquifer Variable water quality, generally fresh water (<1000 mg/L TDS) Good bore yields (up to 3000 kL/day) Provides baseflow to Gingin Brook downstream of Mungala Brook confluence Seawater interface is likely to be offshore	South of Wedge Island and west of the Brand Highway - Figure 7
Leederville-Parmelia	Interconnected Leederville Formation and Parmelia Group (sandstone, shale) Semi-confined to the north becomes confined to the south Generally fresh water (<1000 mg/L TDS) Good bore yields (up to 3000 kL/day) Recharged in north-eastern part of the Gingin groundwater area as well as in the Jurien and Arrowsmith groundwater areas. Contributes to baseflow in headwaters of the Gingin Brook and downstream sections Important for maintaining summer flows in the Moore River	East of the Brand Highway - Figure 7
Yarragadee	Deep aquifer (sandstone, shale), up to 2000 m thick Unconfined to confined aquifer Generally fresh water (<1000 mg/L TDS) but groundwater salinity is high along the Darling Fault (Scarp) Very good bore yields (up to 5000 kL/day) Seawater interface is likely to be offshore	Present in most of the plan area - Figure 8

The department has updated the subarea and resource boundaries for the plan area to reflect the latest understanding of the aquifer hydrogeology. These changes are detailed in the plan. In the plan, we have included the Eneabba aquifer as part of the Lesueur because the Eneabba sandstone is indistinguishable from the sandstone in the Lesueur (Rutherford et al. 2005). We have also combined the Poison Hill aquifer with the Mirrabooka as these aquifers are hydrogeologically connected and act as a single aquifer. More information on the hydrogeology of the plan area can be found in Davidson (1995), Water and Rivers Commission (2002), Bekele et al. (2003), DoW (2007; 2009b).

To administer water allocation and licensing, the department has divided the plan area into 25 subareas (figures 5, 6, 7 and 8). A water resource is a portion of an aquifer within a subarea. There are 35 water resources covered by the plan and we have set an allocation limit for each.

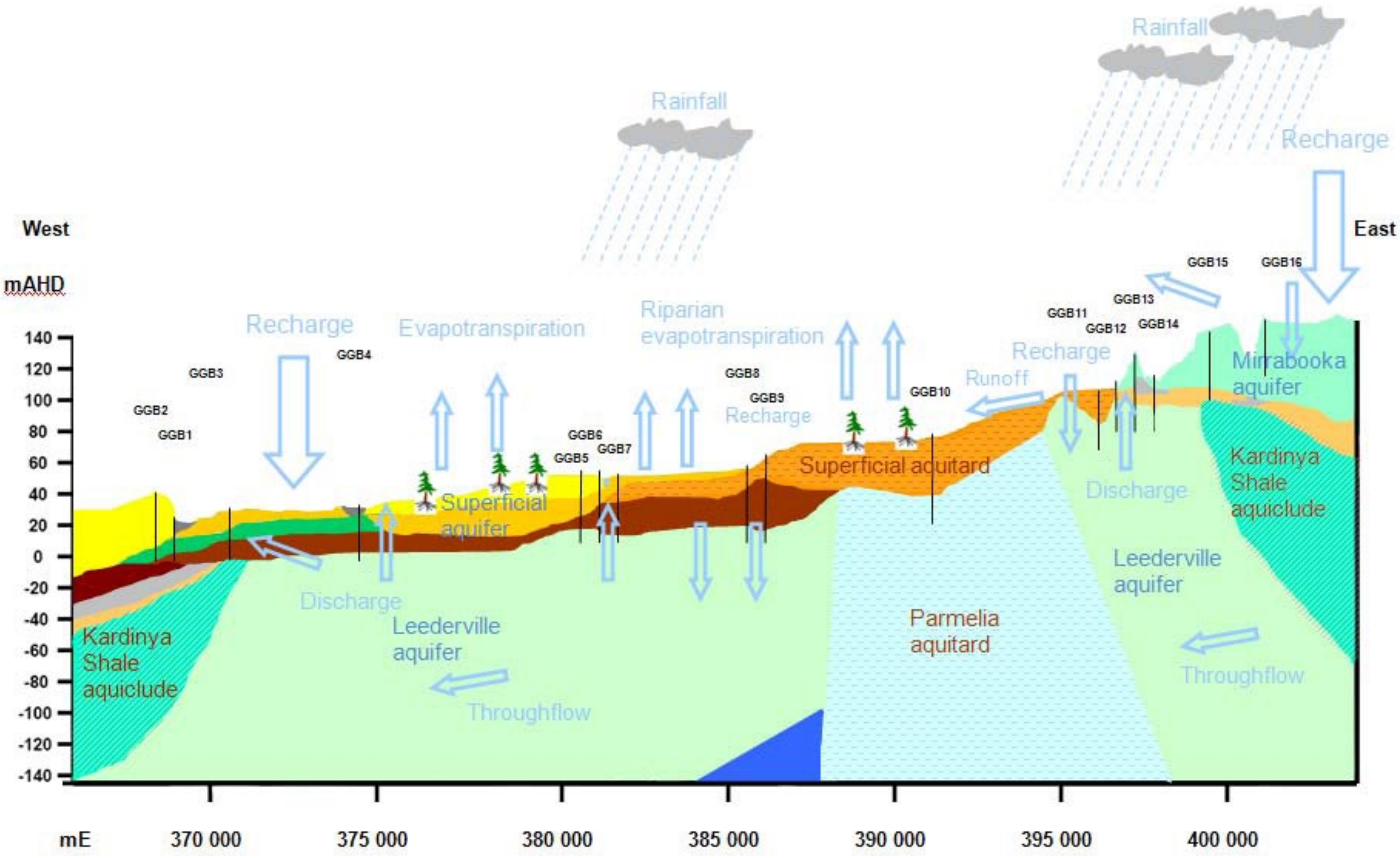


Figure 4 Conceptual model of the hydrogeology in the Gingin groundwater area

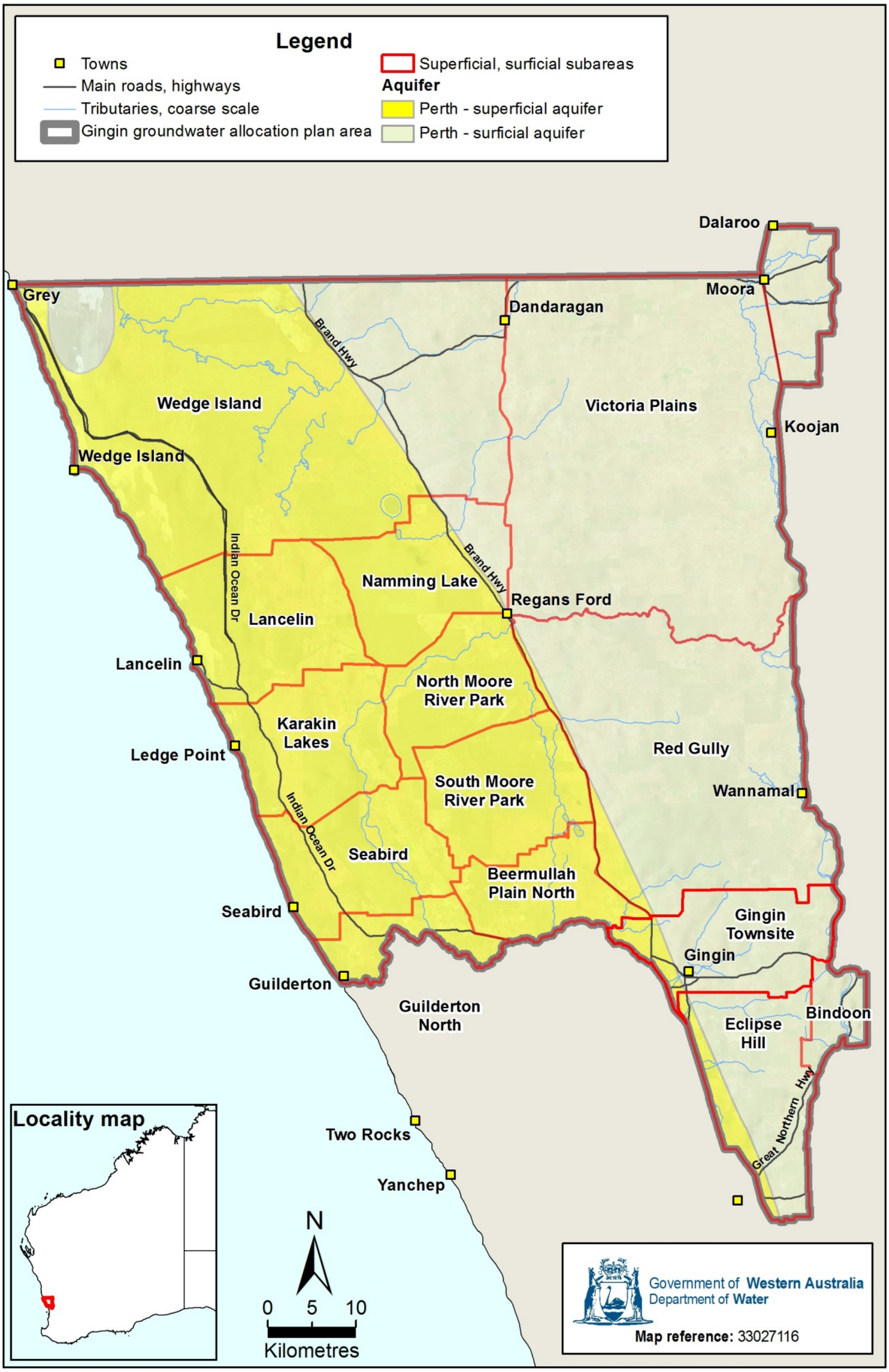


Figure 5 Subareas covering the superficial and surficial aquifers

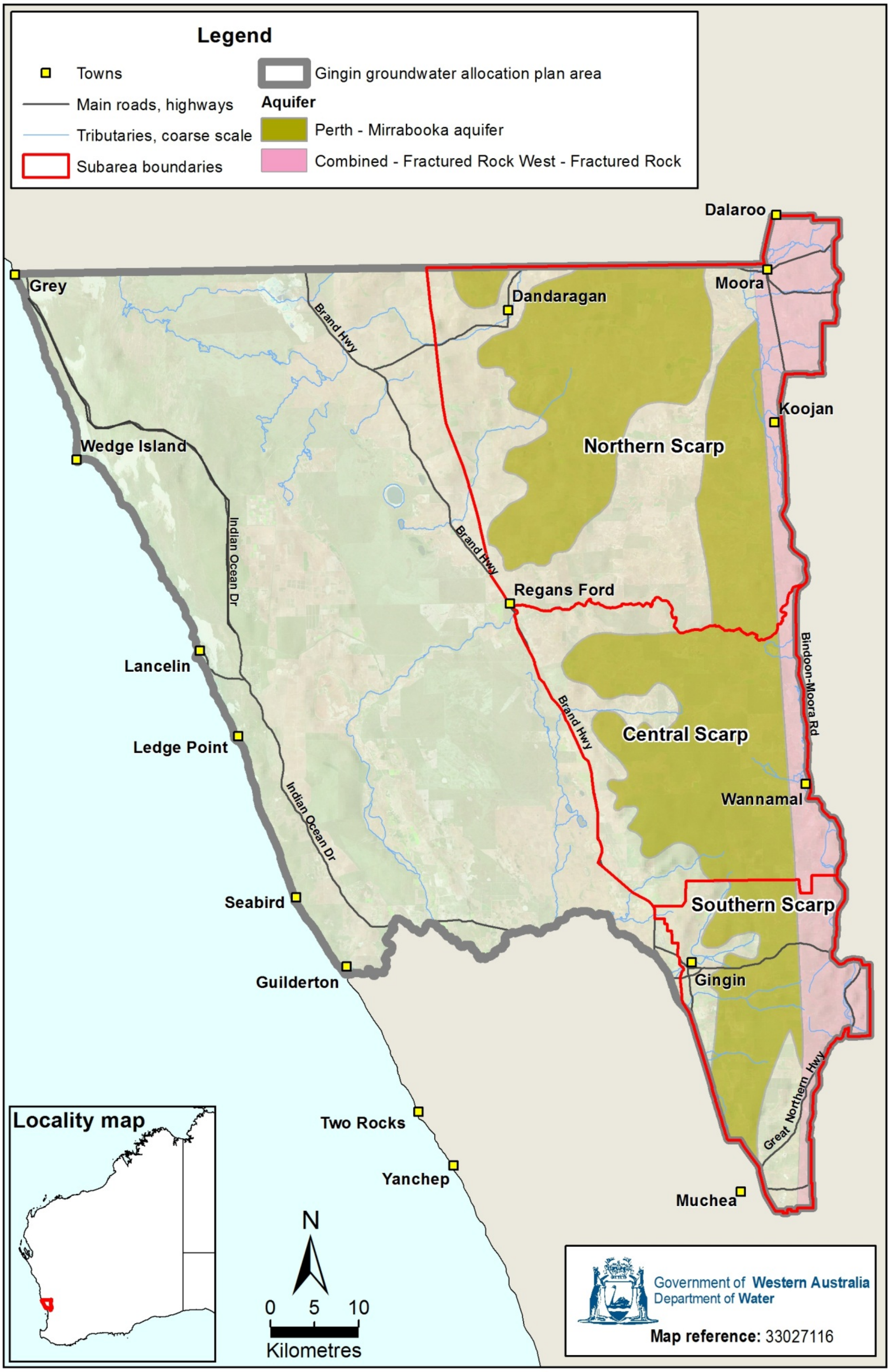


Figure 6 Subareas covering the Mirrabooka and fractured rock aquifers

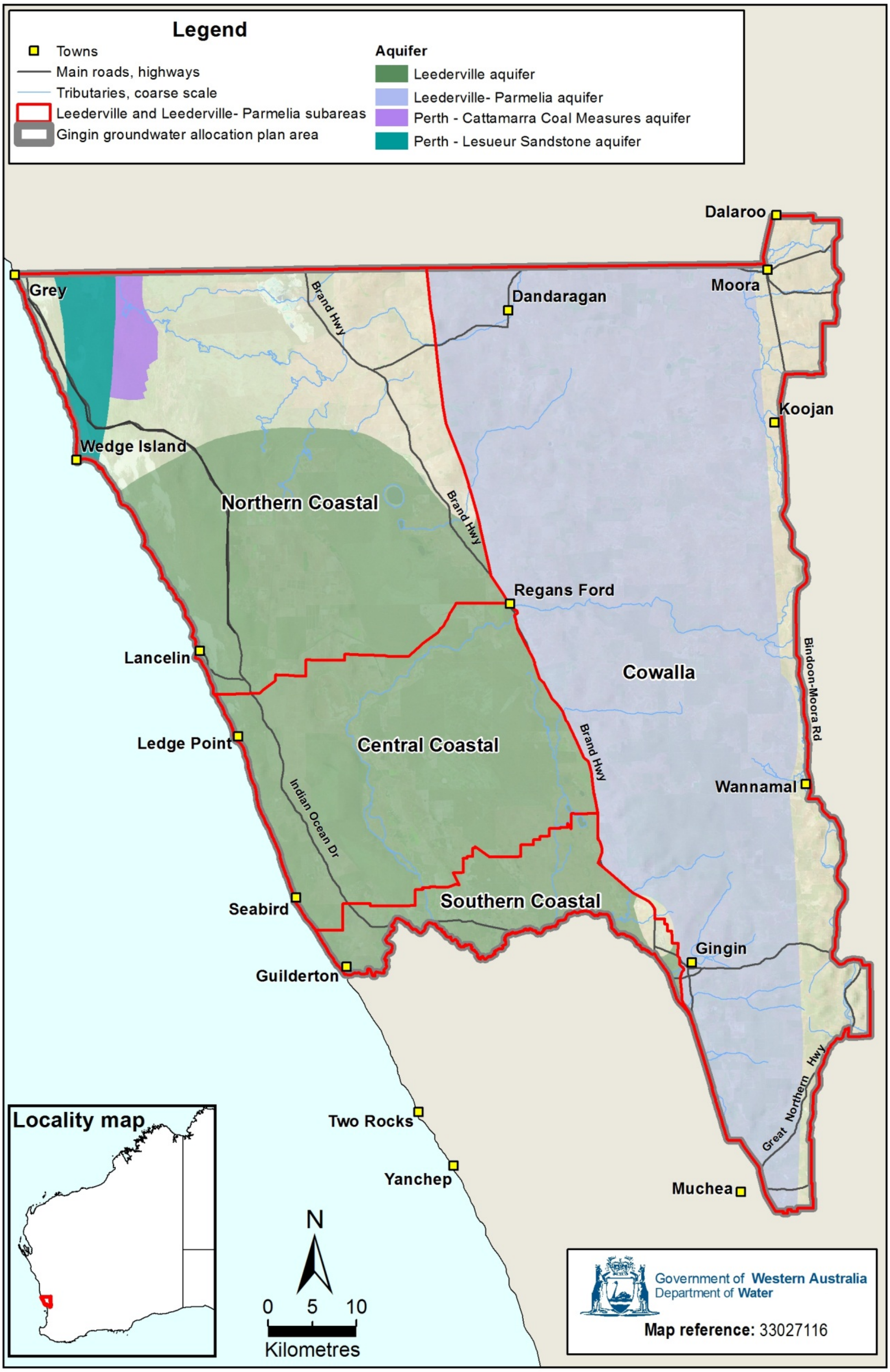


Figure 7 Subareas covering the Cattamarra, Lesueur, Leederville and Leederville-Parmelia aquifer

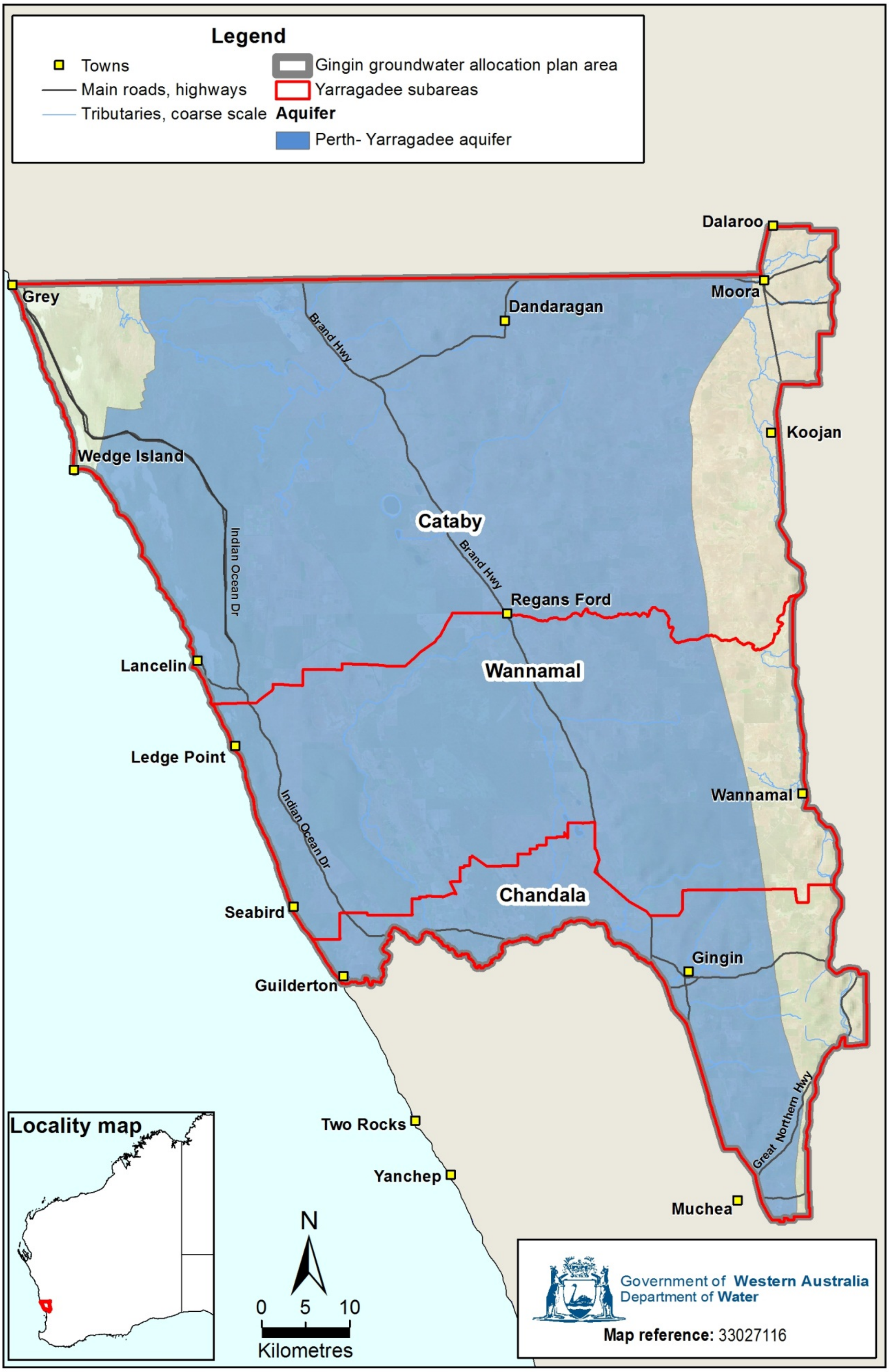


Figure 8 Subareas covering the Yarragadee aquifer

2.2 Climate and rainfall

The climate in the Gingin plan area is characterised by mild, wet winters and hot, dry summers. The annual rainfall received in different parts of the plan area varies significantly, from 440 mm in the north-eastern portion of the plan area to 660 mm in the south-western corner (Figure 9).

There has been a step-change reduction in the mean annual rainfall in the Gingin plan area (Figure 10). This trend is consistent with the rainfall declines recorded since the mid-1970s throughout the south-west of Western Australia. There has also been a marked decline in the mean annual autumn and winter rainfall, a decline in extreme rainfall events, and a rise in temperature (CSIRO 2009).

To support risk-based planning in a drying climate, the CSIRO *South-west Western Australia sustainable yields project* (CSIR0 2009) provides projections of wet, median and dry future rainfall scenarios. Mean annual rainfall in the Gingin area is expected to decline by 1, 10 and 16 per cent, respectively, by 2030 against the 1975–2007 average.

Predicted rainfall over life of the plan

The potential for the continuation of the post-1975 declining rainfall trend is a real risk for the future of water resources and, therefore, water users and the environment in the Gingin plan area. To reduce this risk, the department has used future climate projections to revise allocation limits for the plan. As with all allocation plans, we have set limits for the life of the plan (to 2020) but also considered the risks associated with further drying to 2030.

The department used historical rainfall data to set allocation limits for the 2002 Interim Strategy for groundwater allocation in Gingin but did not consider potential future rainfall scenarios. This plan uses the projections from the South-west Western Australia sustainable yields project to identify a likely range of future rainfall. This allows us to set allocation limits that help us manage the risks associated with the drying climate and decreasing water availability.

The CSIRO's sustainable yields project forecasts mean annual rainfall declines to 2030. Interpolated for the plan horizon of 2020 the wet, median and dry scenarios give 1, 6 and 9 per cent declines, respectively (Figure 11).

In choosing which scenario is the most appropriate to manage to for the Gingin area, we have considered the objectives of the plan (refer to Chapter 2 of the allocation plan). The dry future climate scenario was chosen because:

- Rainfall over the last decade has trended in line with the future dry-scenario.
- Groundwater levels across the plan area are generally declining, including in some areas where the levels of use are not especially high.
- Water users are mostly self-suppliers with limited alternative water supply options.
- We want to maximise reliability for current licence entitlement holders while still making some water available for future demands in some areas.

- Environmental values with high social values that are groundwater-dependent, like those found in the Gingin Brook and Moore River, are already being affected by the drying climate as well as abstraction.

To plan for a dry future scenario to 2020, we have assumed a nine per cent reduction in rainfall compared to the 1975–2003 average. Because rainfall is likely to continue to decline beyond 2020, and the life of the plan may be up to 10 years, we have allowed for an additional three per cent reduction in rainfall.

We have further modified the rainfall projected under the dry scenario because we used the same recharge rates as in the 2002 plan (Section 2.3) but rates decrease with reduced rainfall. The department is yet to complete comprehensive investigations on the changes in recharge rates that result from changes in rainfall. However, estimates suggest that a 10 per cent reduction in rainfall results in a 20 per cent reduction in recharge rate (DoW 2009a). We applied this 20 per cent reduction factor to the recharge rates for the most transmissive geological types found in Gingin, and added the result to the projected rainfall reduction figure giving a further three per cent recharge reduction.

These modifications to plan for a future dry scenario give a rainfall reduction factor of 15 per cent (Figure 12). Planning to the future dry scenario means that current water users will have greater reliability and may not have to make costly adaptations in the future.

2.3 Recharge

Recharge is water that infiltrates the ground to replenish groundwater in aquifers. Recharge to the surficial and superficial aquifers is mainly from direct rainfall infiltration. However, localised recharge may also occur from underlying aquifers, particularly along the coast.

In aquifers such as the Mirrabooka, Leederville-Parmelia or Yarragadee, recharge is highest where the aquifer’s confining layer is absent or patchy. In the eastern portion of the plan area, the Leederville-Parmelia aquifer is overlain by a thick confining layer of shale which restricts vertical recharge. In the same area, the Yarragadee aquifer is also overlain by a layer of impermeable material which restricts vertical recharge to this aquifer system. In the coastal area, there is also less local recharge to the confined aquifers because groundwater flow is mostly upward.

For the Gingin groundwater allocation plan, we calculated recharge as a product of the projected rainfall (using mean annual rainfall for 1975–2003 period), area of recharge and the recharge rate. That is:

Recharge = Projected mean rainfall (mm/yr) × Area of recharge (km^2) × Recharge rate (%)

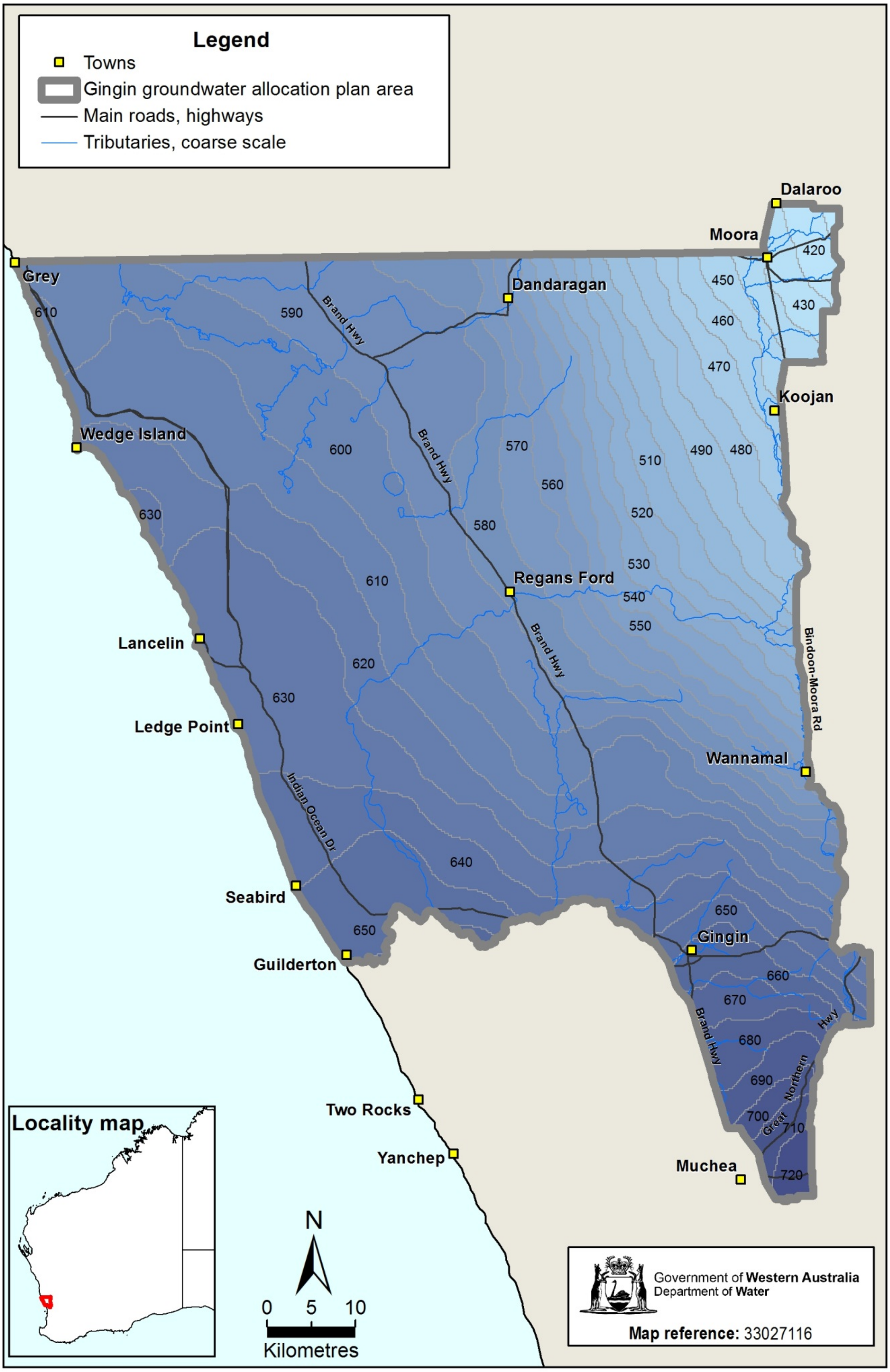
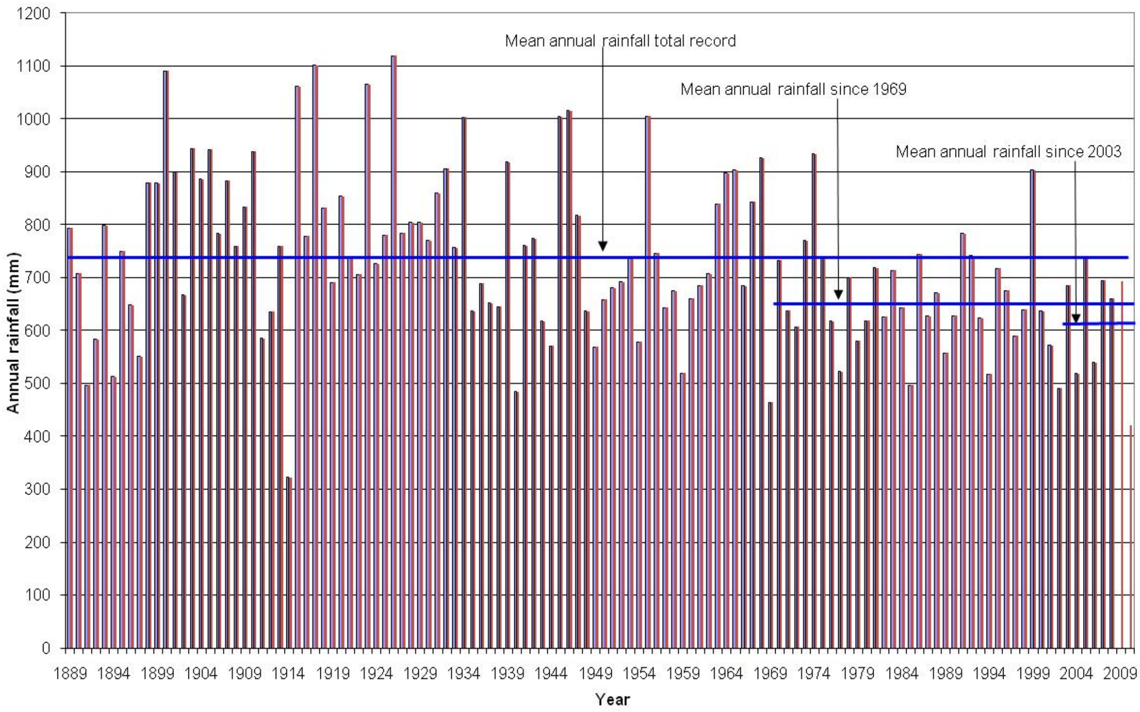


Figure 9 Mean annual rainfall isohyets (mm) in the plan area 1975–2003



Note: Based on composite of Bureau of Meteorology monitoring stations at Gingin town site, RAAF Base Pearce and Moondah Brook

Figure 10 Mean annual rainfall in south-eastern portion of the plan area

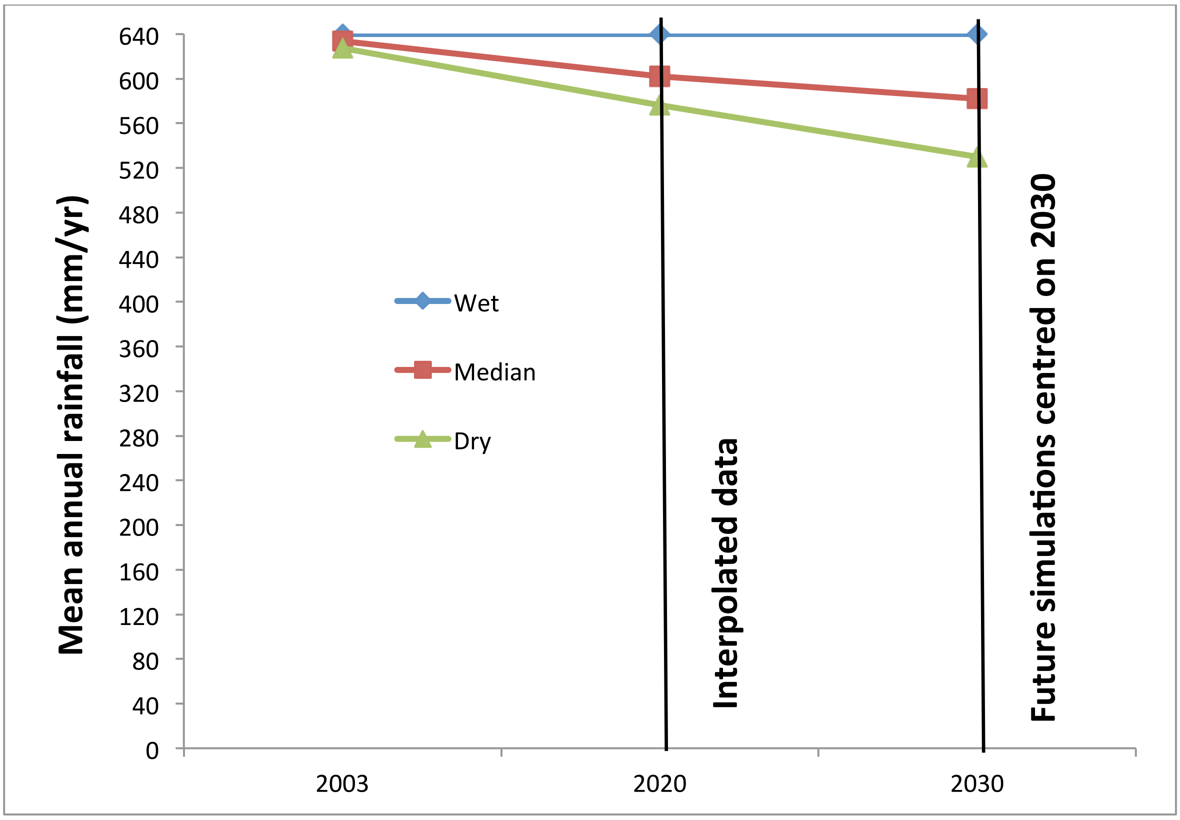


Figure 11 Interpolation of predicted change in mean annual rainfall in the Gingin plan area to 2020

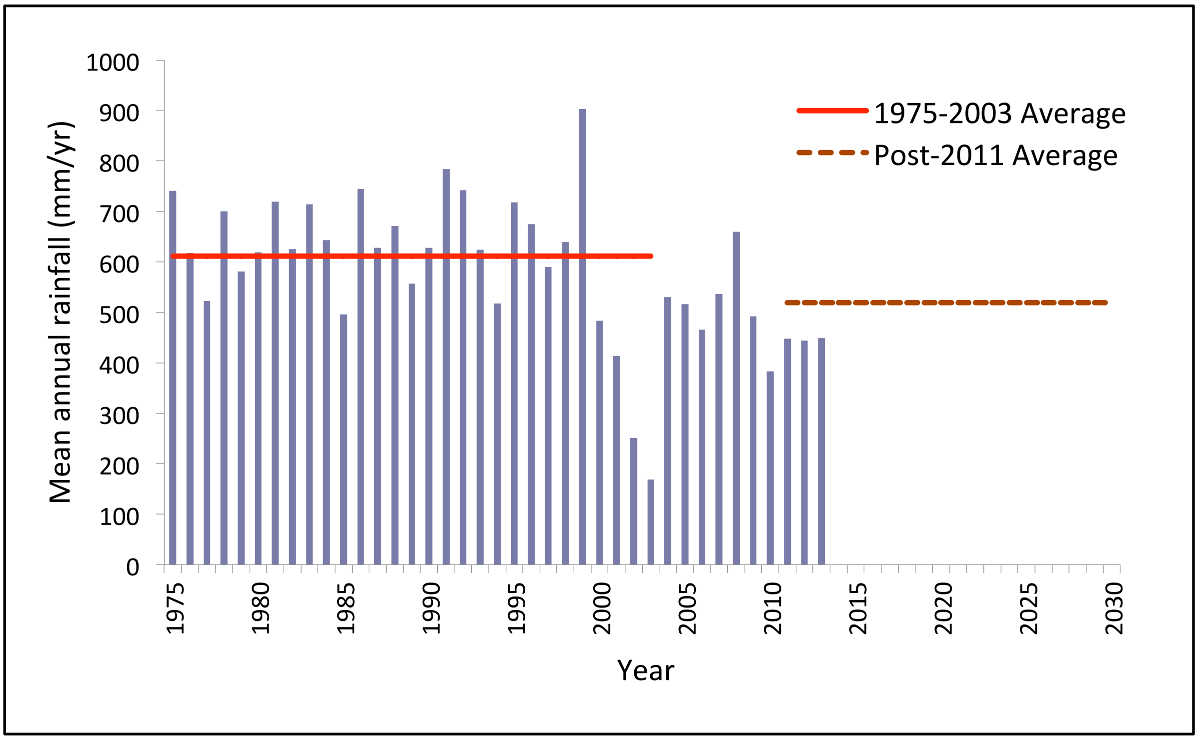


Figure 12 Plots showing the future dry climate scenario used to revise allocation limits (15 per cent reduced mean annual rainfall to 2030 illustrated using Bureau of Meteorology station at Gingin town site)

Recharge rate

The recharge rate is the rate at which water enters an aquifer. The portion of rainwater that enters a system depends on a number of factors. The key factors that control the recharge rates are:

- amount and intensity of rainfall and evaporation
- topography
- vegetation cover and land use
- soil type and geology
- amount of water already present in the soil from other rainfall events.

The recharge rates we used to calculate aquifer recharge in the Gingin plan area are shown in Table 2. These rates are based on extrapolation from estimates elsewhere in the Perth Basin (Davidson 1995) and hydrogeological principles, and were used in the 2002 strategy.

As noted in Section 2.2, we have not adjusted recharge rates to match our future projections of rainfall, but have allowed for this through reducing projected future rainfall by three per cent. The department has yet to complete detailed investigations to review how recharge rates across the Swan Coastal Plain (including in the Gingin area) change with declining rainfall.

Recharge to the Leederville-Parmelia aquifer

Pressure heads in the confined Leederville-Parmelia aquifer in the plan area are primarily maintained by groundwater throughflow derived from recharge outside the plan area in the Jurien and Arrowsmith groundwater areas to the north. The major recharge areas are the Dinner Hill and Morrison subareas in the Jurien and Arrowsmith groundwater areas, respectively (Figure 13). There is a groundwater divide in the Morrison subarea to the north where groundwater in the Leederville-Parmelia aquifer flows to the north and south of the divide. It is the groundwater flow to the south of this divide that maintains pressure heads in the Leederville-Parmelia aquifer in the Gingin plan area. As a result, special considerations were necessary for estimating recharge to the Leederville-Parmelia aquifer within the Gingin plan area.

The rate of recharge to the Leederville-Parmelia aquifer within the Gingin groundwater area is controlled by the presence of the Kardinya Shale Member of the Osborne Formation. The Kardinya Shale limits direct recharge to the Leederville-Parmelia aquifer from rainfall and the overlying superficial aquifer. Recharge is greatest where the Kardinya Shale is absent, for example, within some parts of the former Subarea 4 (northern section of the Cowalla subarea) and Subarea 5 (central section of the Cowalla subarea). No significant recharge to the Leederville-Parmelia occurs within the former Subarea 6 (southern section of Cowalla subarea). Based on this conceptual model, we have calculated recharge using mean annual rainfall over the total recharge area of the Leederville-Parmelia aquifer, south of the Morrison groundwater divide, distributed on a subarea basis.

In the 2002 Interim Strategy, the department used 500 mm/yr mean annual rainfall to calculate recharge in the Leederville-Parmelia aquifer. Although the mean annual rainfall data for the period 1975–2003 is actually 460 mm/yr for the Dinner Hill and Morrison subareas, we retained the 500 mm/yr mean to compensate for rising groundwater levels observed in these subareas. The rising groundwater levels are most likely due to increased recharge resulting from land clearing. This trend is likely to continue in the plan area. We used 520 and 570 mm/yr to calculate recharge for the former Subareas 4 and 5, respectively. Recharge calculations for the Leederville-Parmelia aquifer are detailed further in Section 3.4.

Table 2 Recharge rates used to calculate recharge of resources in the Gingin plan area

Aquifer	Outcropping formation strata	Recharge rate (%)
Superficial	Tamala Limestone	18.0
	Bassendean Sand	15.0
	Guildford Clay	6.5
Mirrabooka	Poison Hill Greensand	3.0
	Mirrabooka Member	3.0
Leederville	Overlain by Tamala Limestone	2.5
	Overlain by Bassendean Sand	2.5
	Overlain by Guildford Clay	0.1
Cattamarra	Overlain by Tamala Limestone	1.0
Lesueur	Overlain by Tamala Limestone	3.0
Leederville-Parmelia	Subcropping (Dinner Hill and Morrison subareas)	4.0
	Overlain by non-clayey Cretaceous sediments	1.0
Yarragadee	Subcropping	5.0
	Overlain by Tamala Limestone	2.5
	Overlain by Bassendean Sand	2.5
	Overlain by superficial and Leederville formations	1.0

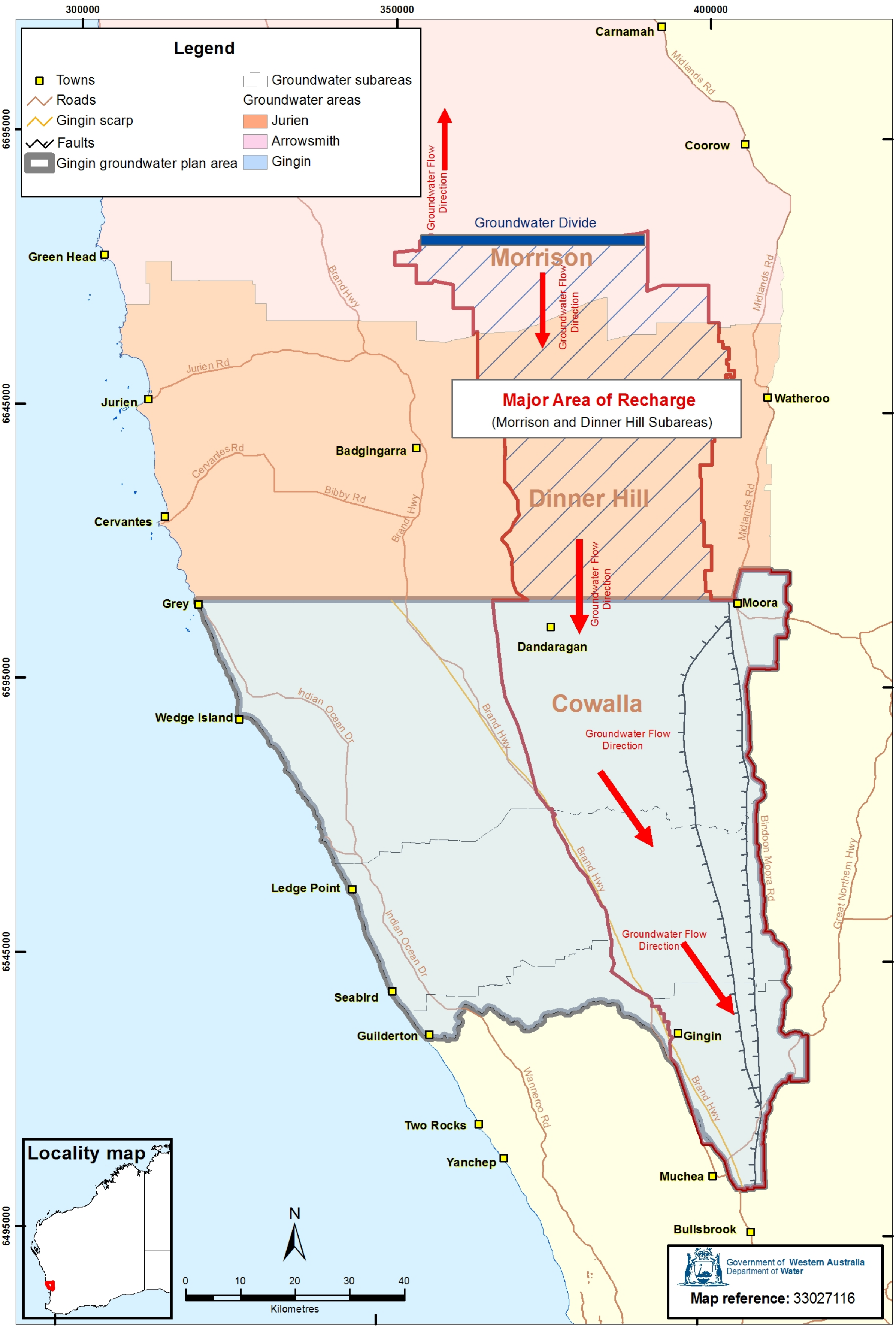


Figure 13 Groundwater recharge and flow within the Leederville-Parmelia aquifer

2.4 Aquifer trends

In 2010, the department commissioned the consultants MWH to analyse groundwater level monitoring data from the plan area. This review was based on both the department's monitoring data and licensees' records for the superficial, Leederville, Leederville-Parmelia and Yarragadee aquifers. The Lesueur, Mirrabooka, surficial and Cattamarra aquifers were not included in the study because there wasn't enough information to develop a trend. The available data for each aquifer was sorted and selected, where available, at five-yearly intervals starting from 1977. To account for seasonal groundwater variation, only monitoring data obtained in the autumn months (March and May) were selected for the study. Across all aquifers, consistent groundwater monitoring data was only available for the period 1997–2007. These were selected for the regional analysis of groundwater trends.

The main findings from this assessment were:

- a widespread decline of less than 1 m of the water table in the superficial aquifer, with localised declines of up to 4 m (Figure 14)
- declines across most of the Leederville aquifer (Figure 15)
- declines in hydraulic head in the Leederville-Parmelia aquifer within the Cowalla subarea (Figure 15)
- widespread decline in hydraulic head within the Yarragadee aquifer (Figure 16).

Our groundwater level data for the surficial resource in the area around Dandaragan shows an upward trend. This is thought to be the result of land clearing locally increasing recharge and the Leederville-Parmelia aquifer discharging into the overlying surficial aquifer.

Some localised anomalies are seen in the figures where a bore does not reflect the regional trend. This may be caused by localised abstraction, equipment failure, or short-term water table rise from land clearing and aquifer properties. For full details please refer to *Gingin aquifer trends review* (MWH 2010) available on our website.

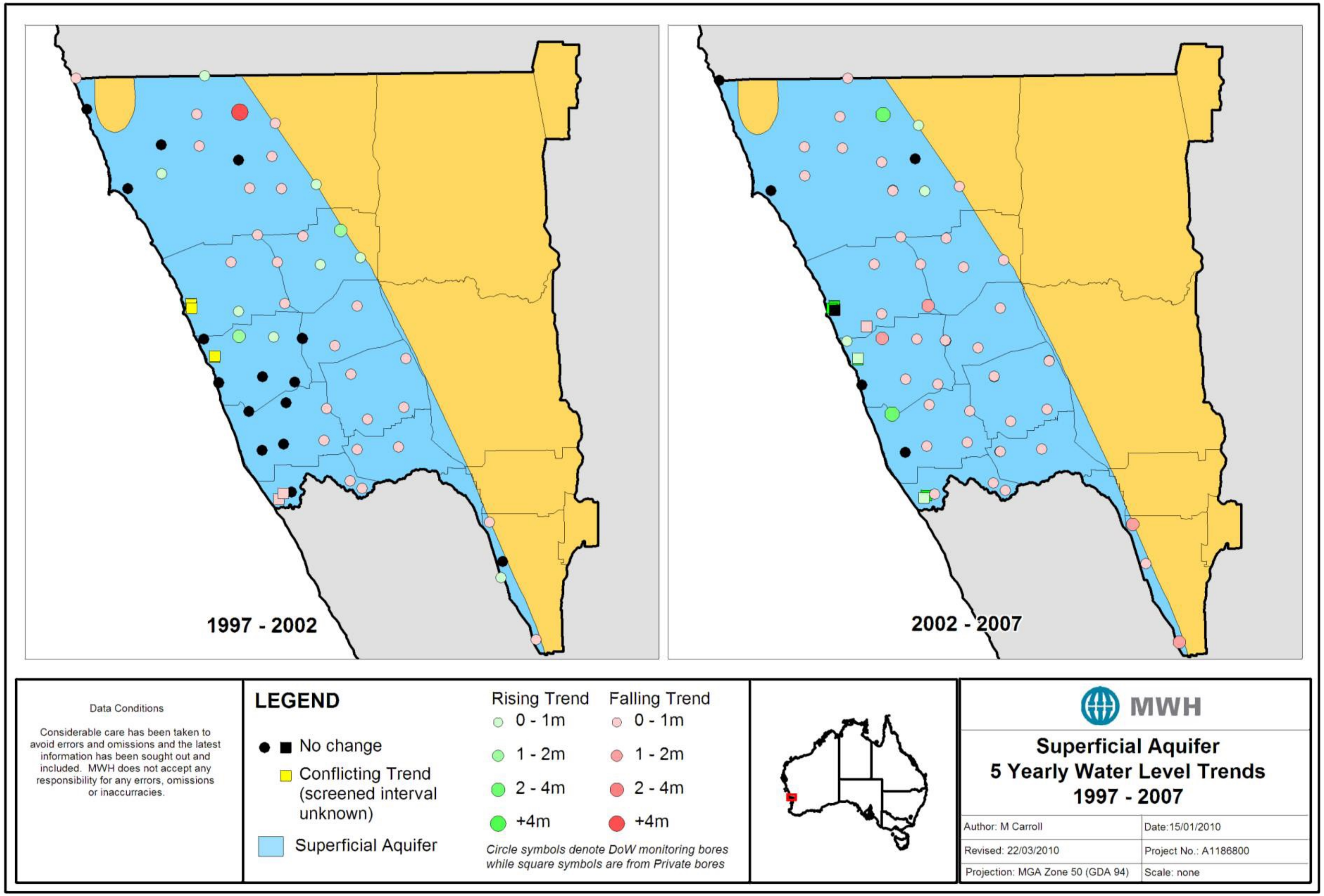


Figure 14 Groundwater trends within the superficial aquifer in the Gingin groundwater area (MWH 2010)

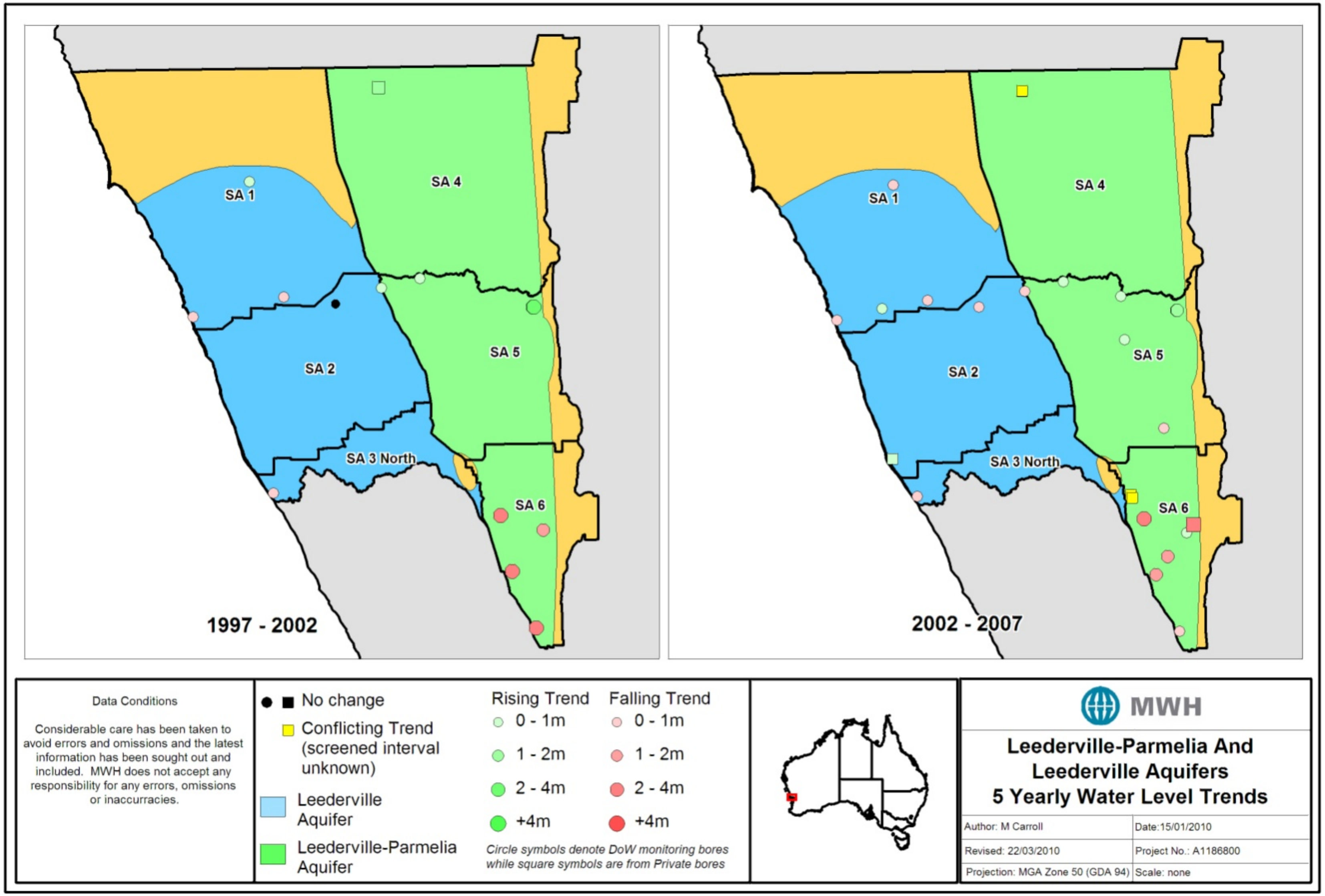


Figure 15 Groundwater trends within the Leederville and Leederville-Parmelia aquifers (MWH 2010)

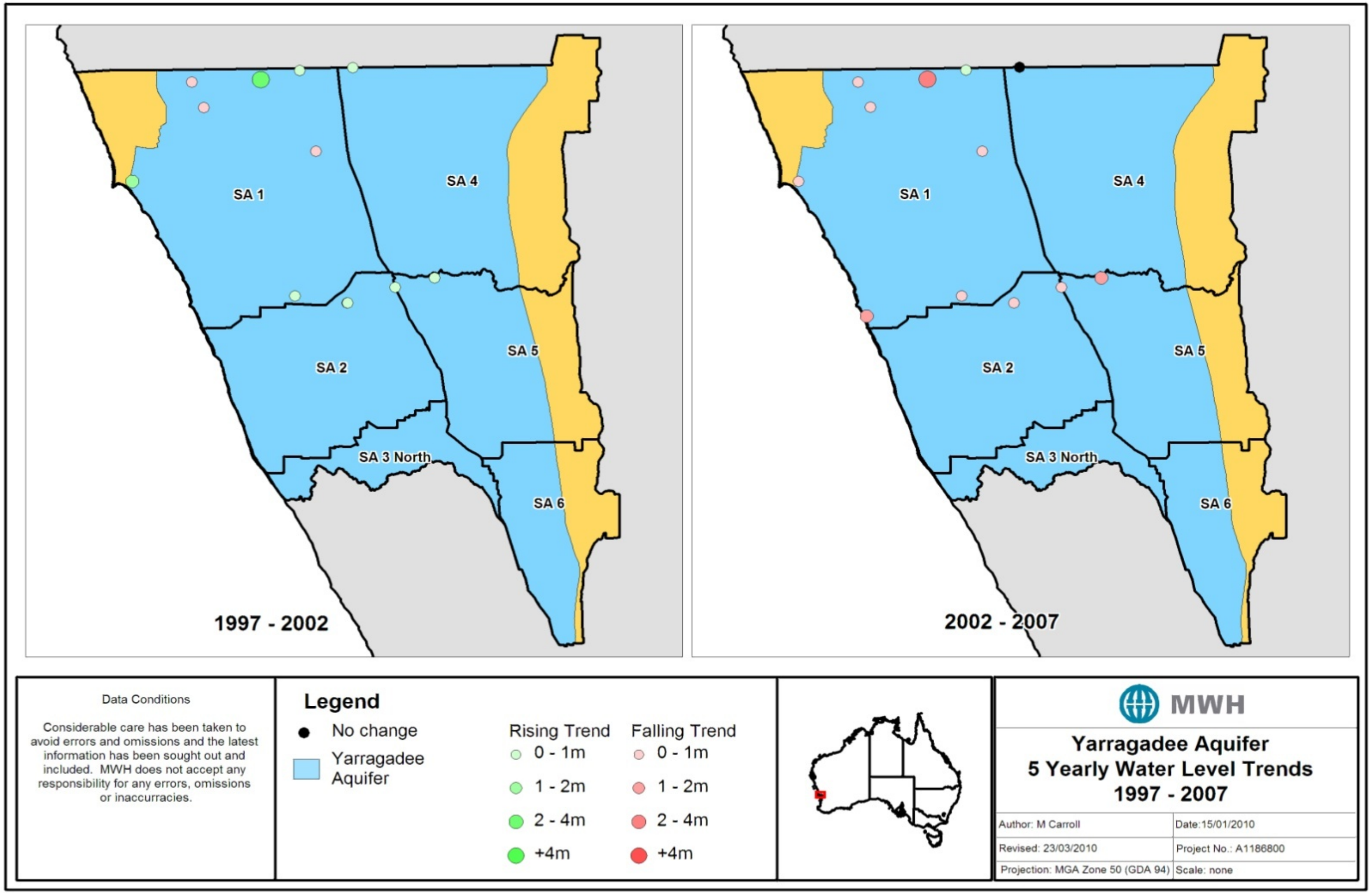


Figure 16 Groundwater trends within the Yarragadee aquifer in the Gingin groundwater area (MWH 2010)

2.5 Ecological, social and cultural water requirements

In the Gingin plan area, groundwater levels and flow are important for maintaining:

- groundwater-dependent ecosystems
- surface water connectivity (wetlands and other surface water features, including brooks and rivers)
- preventing seawater intrusion
- social and cultural values related to water.

Groundwater-dependent ecosystems

The Gingin plan area has groundwater-dependent ecosystems that may be affected by falling groundwater levels. The ecosystems most at risk are swamps, wetlands, areas of native vegetation and river baseflow systems:

- located on the Swan Coastal Plain where the water table is close to the surface across large areas (west of the Gingin Scarp)
- connected to parts of the Leederville-Parmelia aquifer, particularly along the Dandaragan Scarp (especially Moore River near Mogumber, as well as Gingin and Lennard brooks)
- connected to some parts of the Mirrabooka aquifers.

The Guraga Lake, Karakin Lakes, Wannamal Lake system, Chandala Swamp and Chittering–Needonga Lakes are wetlands of national significance and listed in the *Directory of Important Wetlands in Australia* (ANCA 1996). There are also large areas of remnant vegetation along the Swan Coastal Plain and other features that are recognised under the Environmental Protection Authority's (EPA) Environmental Protection Policy within the plan area.

The department has combined vegetation mapping and depth-to-groundwater data to identify sites where these ecosystems occur in the plan area (Figure 17). This work builds on Rutherford et al. (2005) which identified groundwater-dependent ecosystems in the Northern Perth Basin, which includes the Gingin groundwater area. The mapping shows it is likely that the ecosystems rely on the shallow water table aquifers (superficial and surficial) and sites where groundwater is discharged.

Groundwater-dependent ecosystems are also associated with the Mirrabooka aquifer, although they are hard to identify due to difficulty in accurately mapping the depth-to-groundwater in this aquifer. The Mirrabooka aquifer discharges into the Wannamal Lake system (Kay & Diamond 2001). Discharge from this aquifer also form springs in some areas though more work is needed to establish whether some of these systems are perched.

There are also smaller areas of these ecosystems associated with the Leederville-Parmelia and Yarragadee aquifers. The depth-to-groundwater in the Leederville-

Parmelia aquifer is generally greater than 20 m which limits their distribution to areas of groundwater discharge. Overflow from this aquifer feeds springs along the Dandaragan Scarp associated with outcropping of the Otorowiri Siltstone. The Yarragadee aquifer is confined throughout most of the plan area. The Yarragadee aquifer is close to the surface in the area near Cataby where it is likely to support such ecosystems around Mullering Brook and Minyulo Brook.

Further information on groundwater-dependent ecosystems in the Gingin plan area can be found in:

- *The hydrogeology of groundwater dependent ecosystems in the Northern Perth Basin* (Rutherford et al. 2005)
- *Environmental considerations for groundwater management in the Northern Perth Basin* (DoW 2009b).

In order to maintain ecological, social and cultural water requirements, a proportion of recharge is retained in the system and not allocated for use. The proportion depends on the location and nature of groundwater-dependent wetlands or waterways (see Section 5.1).

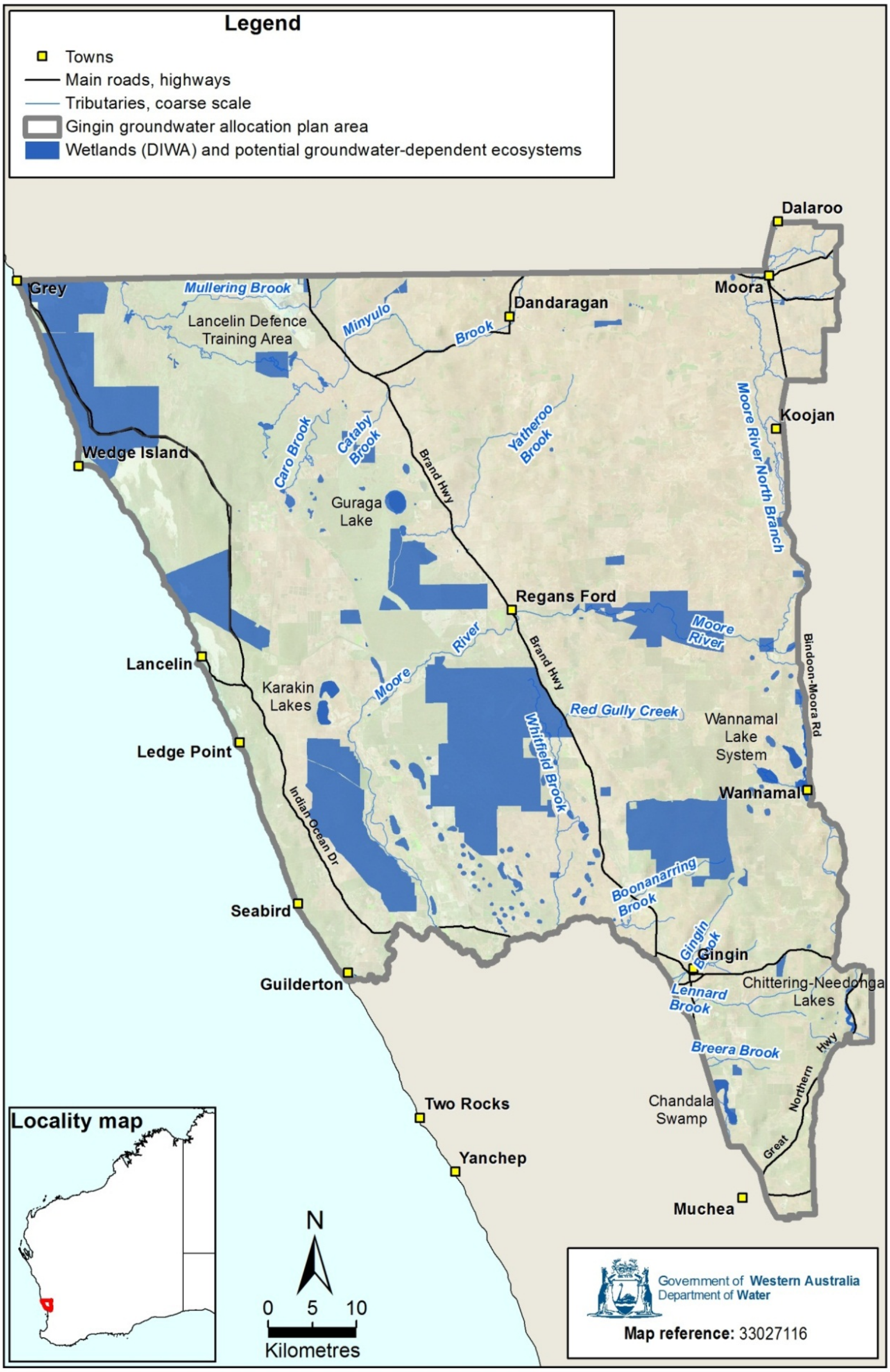


Figure 17 Groundwater-dependent ecosystems in the plan area derived by overlying remnant vegetation and wetlands on depth-to-groundwater data

Surface water and groundwater connectivity

Baseflow is generated where the water table rises above the base of the streambed and groundwater discharges into streams (Figure 18). Baseflow can be intermittent since the water table rises above and then falls below the base of a streambed throughout the year. The water table may naturally fall below the streambed during extended dry periods and may rise after rainfall.

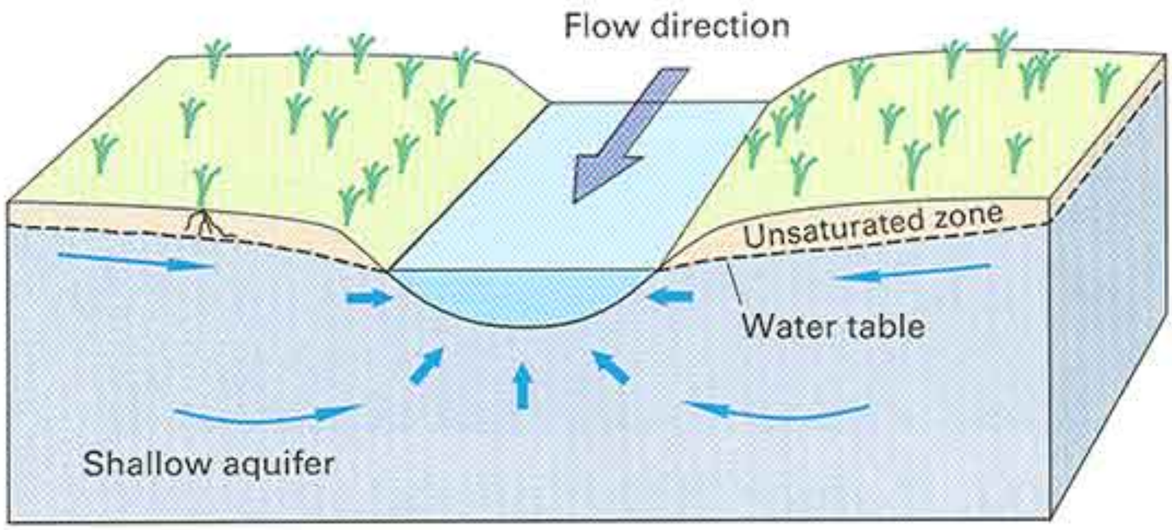


Figure 18 Schematic of areas where baseflow occurs (Winter et al. 1998)

Groundwater discharge provides baseflow to Gingin Brook from unconfined aquifers in two areas (Tuffs 2011):

- The superficial aquifer discharges in the middle to lower sections of the brook.
- The Mirrabooka aquifer discharges in the upper catchment to the north and east of the Gingin town site.

Upward pressure from the Leederville aquifer supports baseflow where it is not overlaid by the Kardinya Shale (Figure 19).

Other surface water features within the plan area also have baseflow contributions. The Mirrabooka aquifer discharges into Lennard Brook, Red Gully Creek and parts of the Moore River. In addition to Gingin Brook, the Leederville-Parmelia aquifer also discharges to Lennard Brook and Moore River (at Quinns Ford). Discharge from the Yarragadee aquifer contributes baseflow to the lower part of Minyulo Brook (Rutherford et al. 2005).

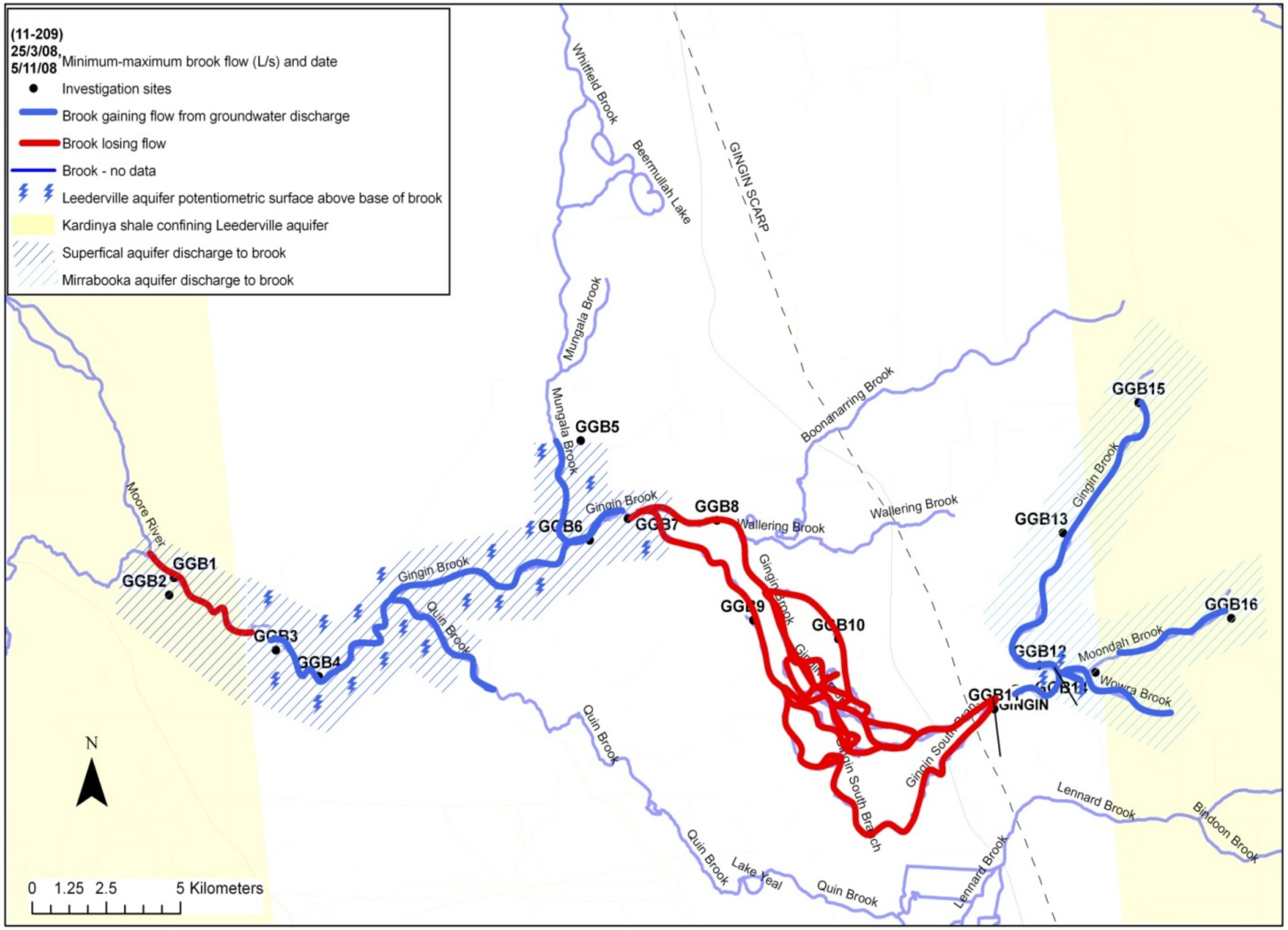


Figure 19 Areas of groundwater contribution to Gingin Brook baseflow (Tuffs 2011)

Seawater interface

A seawater interface (also known as saltwater interface) is the boundary between the freshwater flowing through the aquifer (also known as throughflow) and the denser, saline seawater at the coast (Figure 20). This interaction is present at the coastal boundary of the aquifers that extend to the coast. Abstraction from areas near the coast may draw saline water into the freshwater aquifer. This saline water may also affect the health of groundwater-dependent ecosystems. To maintain water quality within abstraction bores and ecosystems near the coast, it is important that sufficient groundwater discharges to the ocean.

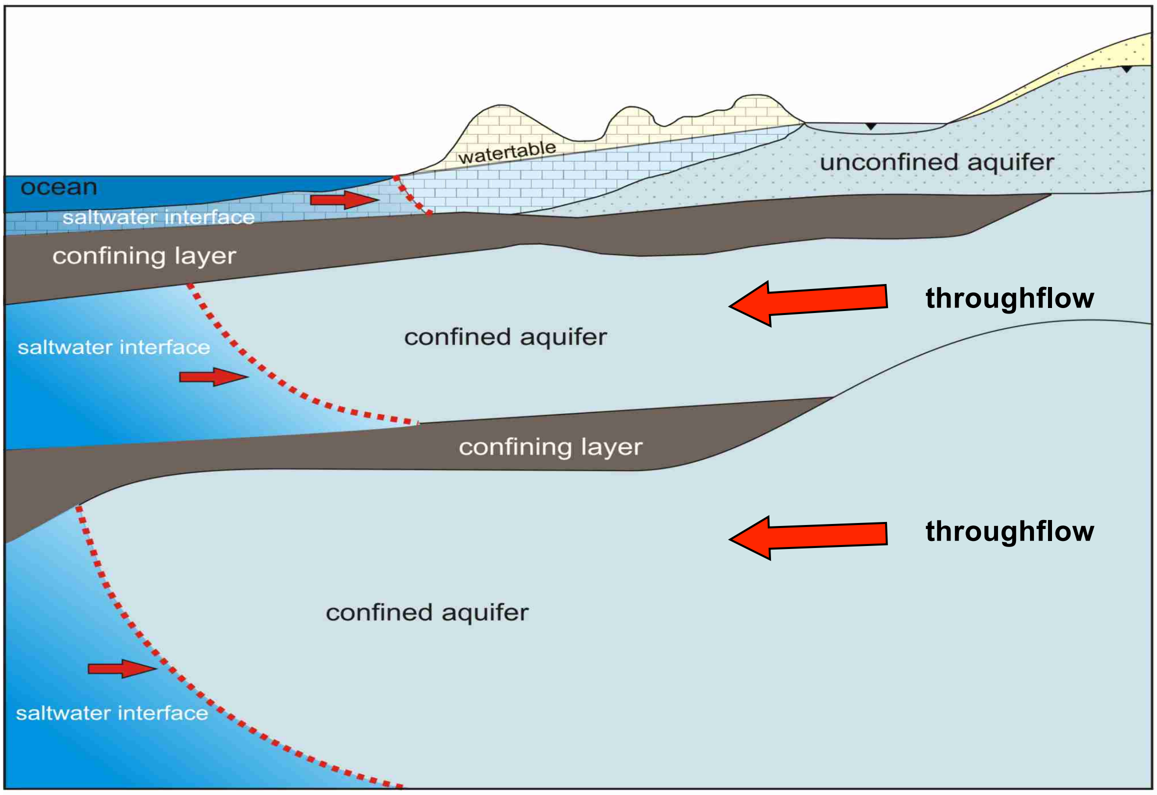


Figure 20 Schematic of seawater interface in a layered aquifer system similar to the plan area

In the Yarragadee aquifer, low salinity groundwater may extend more than 20 km offshore. These estimates are supported by geophysical logs from offshore petroleum exploration wells that indicate groundwater salinity in the Leederville and Yarragadee aquifers is significantly lower than the salinity of seawater. Furthermore, the groundwater pressure head in the Leederville aquifer is about 17 mAHD at Guilderton (Bore AM1A) and 14 to 18 mAHD at Lancelin (Bores GL1B and GL1A1). The Yarragadee aquifer is monitored using the sole monitoring bore GL1A3 at Lancelin where the groundwater pressure head in the Yarragadee aquifer is about 15 mAHD. The presence of the Lancelin Formation confining bed and the groundwater pressure head in the Leederville and Yarragadee aquifers at the coast is likely to provide an effective barrier against seawater intrusion during the life of the plan.

Social and cultural values of groundwater

Social and cultural values of groundwater relate to the non-consumptive values of groundwater in the Gingin plan area. As groundwater contributes to the baseflow of the valued Gingin Brook and Moore River, it is important to support this connection so that these values are maintained.

The following social and cultural values are dependent on surface water and linked to Gingin Brook (Strategen and UWA 2005):

- Naturalness of waterway and riparian vegetation.
- Aesthetic appeal of permanent water associated with built structures (water wheel, bridges, road crossings, walkways, town weir).
- Water quality to protect aquatic fauna (fish, marron, gilgies).
- Indigenous mythological associations.
- Summer pools for swimming, fishing and environmental values.
- Water to allow for lawful riparian and licensed abstraction.

These values would be maintained while water flows in Gingin Brook and Moore River.

The department has also consulted with stakeholders through community information sessions to assess the importance of groundwater to the community. The water-related issues raised by stakeholders and the community through these sessions include:

- concern that the reliability of their licence entitlements will be affected by other nearby abstractions, or by development of the Gingin groundwater resources for Perth's Integrated Water Supply Scheme (IWSS)
- concern for surface water features (Gingin Brook and Moore River in particular) being affected by surface water and groundwater abstraction and for the lower flows being observed as a result of low rainfall
- the need to improve opportunities to trade in areas that are fully-allocated.

These issues are addressed in the plan. Other issues received during the public comment period are addressed in the final plan and the plan's Statement of response (DoW 2015b).

2.6 Points to consider from understanding the water resource

From the information we have on the resources within the Gingin plan area, there are some conclusions we need to consider when setting objectives and allocation limits (see Part B):

- Mean annual rainfall in the plan area has declined since the mid-1970s and this trend is expected to continue.
- By using CSIRO's projections of future climate to select a rainfall to manage to over the life of the plan, this plan improves on the 2002 Interim Strategy which only used historical rainfall records.
- We selected a dry future climate scenario with some adjustments for reducing recharge and projections beyond the life of the plan to manage to for the life of the plan – a 15 per cent reduction to the 1975–2003 average annual rainfall.
- In general, groundwater levels in the superficial, Leederville, Yarragadee and the Leederville-Parmelia aquifers are declining.
- Groundwater is important for maintaining groundwater-dependent ecosystems, surface water features (such as Moore River and Gingin Brook), the position of the seawater interface, and social and cultural values.

3 Understanding current and future water demand

The Department of Water assesses current and future demand for water as part of the allocation planning process. In the Gingin plan area, groundwater is abstracted and is used primarily for irrigated agriculture and horticulture. Some water is also used for public water supply, mining, as well as stock and domestic purposes.

3.1 Current water demand

Most of the water is currently used for agricultural/horticultural purposes with demand still increasing. When setting allocation limits, we considered the current levels of licensed and unlicensed use as well as the current levels of demand. We compared these factors against the yields we calculated and then set allocation limits that will ensure optimum reliability of supply for licensees and other water users.

Licensed abstraction

Licensed water entitlements have increased by 34 GL/yr since the 2002 Interim Strategy was released (from 106 to 140 GL/yr). As at March 2014, about 470 users are licensed to take 140 GL/yr and the department is assessing 30 GL/yr in licence applications. Most of this increase can be attributed to urban development in the northern portion of the Gnangara plan area. The proximity of Gingin to the Perth metropolitan area and large areas of arable land made the area ideal for the establishment of these industries. As the areas surrounding Wanneroo have become more urbanised, market gardens and other intensive agricultural and horticultural industries have been displaced. Most of the licensed use in the plan area is associated with the agricultural and horticultural industries (Table 3).

Table 3 Water uses in the Gingin plan area as a percentage of total licensed water entitlements (as at March 2014)

Usage category	Percentage of total entitlements	Volume of water allocated (ML/yr)
Agriculture/horticulture	85.2	119.5
Mining	9.6	13.5
Public water supply	1.8	2.5
Irrigation scheme supply	1.0	1.4
Stock and domestic	0.9	1.3
Commercial and industrial	0.8	1.1
Industry and power generation	0.4	0.6
Parks, gardens and recreation	0.3	0.4
TOTAL	**100**	**140.3**

Exempt use

The department needs to account for all types of use when setting allocation limits, including water taken for stock and domestic use. In general, stock and domestic use is exempt from licensing. A summary of the estimated stock and domestic use in the plan area is shown in Table 4.

To identify the number of properties likely to use water for stock and domestic purposes (Table 4 – *Number of domestic and garden allocations*), we used land use information from the Department of Agriculture and Food WA (DAFWA). Stock and domestic use was estimated using the following approach and assumptions.

a) Domestic and garden use on agricultural properties

The allocation for domestic and garden use at agricultural properties was based on the assumption that the domestic requirement is 1500 kL/yr (Table 4 – *Volume for domestic and garden*). This includes water for household use, up to 0.2 hectares (ha) of lawns and garden as well as a small number of stock.

b) Lifestyle lot use

Lifestyle lots are considered to be non-town, non-agricultural lots greater than 2 ha (factoring in location and access to scheme water). Water use was assumed to be half that calculated for agricultural properties, based on the assumption that not all properties would be accessing groundwater for exempt uses (i.e. *Number of lifestyle lots* × 750 kL/yr).

All town lots were assumed to be supplied by scheme water and not directly accessing groundwater for exempt uses. Water used for fire fighting is unlikely to have long-term impacts on groundwater and was not included in these estimates of unlicensed water use.

c) Stock and crop use

Information on the *Total cleared area* was provided by DAFWA. We made the following assumptions when estimating crop and stock (grazing) use in the Gingin plan area:

- In subareas south of Regan's Ford, 20 per cent of land is used for cropping and 80 per cent for grazing.
- North of Regan's Ford, 50 per cent of land is used for cropping and 50 per cent is grazed (this assumption was based on advice from DAFWA that land use differs due to soil type and mean annual rainfall across the northern subareas).
- The water use figure for stock was calculated using DAFWA's water application rate for sheep (2 kL/head/yr) multiplied by the area of cleared land and the estimated carrying capacity of stock numbers per hectare.
- Crops would require three sprays per year using an average of 50 L/ha, or 150 L/ha/yr. Water use was calculated using this figure and the area of cleared land.

Total exempt use

After factoring in these assumptions, exempt use in the plan area (Table 4 – *Total estimate of exempt water use*) is calculated to be the sum of:

- volume for domestic and garden
- volume for lifestyle lots
- volume for cropping
- volume for grazing.

Once an estimate of the total exempt use was calculated, it was assigned to an aquifer that was most easily accessible on the assumption that small-scale users would access water at the lowest cost. Where more than one aquifer can be easily accessed, the exempt use was apportioned. A summary of estimated exempt use per aquifer can be found in Table 5.

The total estimated exempt use for the plan area is about 3.4 GL/yr.

Table 4 Calculation of exempt water use in the Gingin plan area

Subarea	Number of domestic and garden allocations (D)	Volume for domestic and garden (kL/yr) (D × 1500)	Number of lifestyle lots (L)	Volume for lifestyle lots (kL/yr) (L × 750)	Total cleared area (ha)	Cropping to grazing ratio	Total cropped area (ha)	Volume for cropping (kL/yr)	Total grazed area (ha)	Volume for grazing (kL/yr)	Total estimate of exempt water use (kL/yr)
Bindoon	143.0	214 500	318.5	238 875	4206	20:80	841	126	3365	22 882	**476 383**
Beermullah Plain North	47	70 500	0	0	11 484	20:80	2297	345	9187	62 473	**133 318**
Deepwater Lagoon North	23.5	35 250	5	3750	2859	20:80	572	86	2287	15 552	**54 638**
Eclipse Hill	128	192 000	91	68 250	14 631	20:80	2926	439	11 705	79 594	**340 283**
Gingin Townsite	98.5	147 750	22	16 500	13 496	20:80	2699	405	10 797	73 418	**238 073**
Guilderton North	49.5	74 250	20	15 000	5687	20:80	1137	171	4550	30 937	**120 358**
Karakin Lakes	42	63 000	3	2250	14 101	20:80	2820	423	11 281	76 711	**142 384**
Lancelin	22.5	33 750	176	132 000	13 972	50:50	6986	1048	6986	47 505	**214 303**
Moora	21.5	32 250	0	0	11 144	50:50	5572	836	5572	37 890	**70 976**
Namming Lake	10.5	15 750	0	0	10 206	50:50	5103	765	5103	34 700	**51 215**
North Moore River Park	24	36 000	4	3000	3678	20:80	736	110	2942	20 008	**59 744**
Red Gully	112.5	168 750	6	4500	42 521	20:80	8504	1276	34 017	231 314	**405 840**
Seabird	85	127 500	33	24 750	10 889	20:80	2178	327	8711	59 235	**211 812**

Subarea	Number of domestic and garden allocations (D)	Volume for domestic and garden (kL/yr) (D × 1500)	Number of lifestyle lots (L)	Volume for lifestyle lots (kL/yr) (L × 750)	Total cleared area (ha)	Cropping to grazing ratio	Total cropped area (ha)	Volume for cropping (kL/yr)	Total grazed area (ha)	Volume for grazing (kL/yr)	Total estimate of exempt water use (kL/yr)
South Moore River Park	22	33 000	0	0	7623	20:80	1525	229	6098	41 466	**74 695**
Victoria Plains	103	154 500	9	6750	105 364	50:50	52 682	7902	52 682	358 238	**519 567**
Wedge Island	49	73 500	16	12 000	55 243	50:50	27 622	4143	27 622	187 826	**277 469**

Table 5 Exempt use by resource in the Gingin groundwater plan area

Subarea	Exempt use (kL/yr)	Aquifer	Proportion of exempt use (%)	Total aquifer exempt use (kL/yr)	Rounded figure (kL/yr)
Beermullah Plain North	133 318	Superficial	100	133 318	130 000
Bindoon	476 383	Surficial	100	476 383	475 000
Deepwater Lagoon North	54 638	Superficial	100	54 638	55 000
Eclipse Hill/Southern Scarp	340 283	Superficial	20	68 057	70 000
		Mirrabooka	80	272 226	275 000
Gingin Townsite/Southern Scarp	238 073	Mirrabooka	100	238 073	240 000
Guilderton North	120 358	Superficial	100	120 358	120 000
Karakin Lakes	142 384	Superficial	100	142 384	140 000
Lancelin	214 303	Superficial	100	214 303	215 000
Moora	70 976	Surficial	100	70 976	70 000
Namming Lake/Northern Scarp	51 215	Superficial	66.7	34 160	35 000
		Mirrabooka	33.3	17 055	20 000
North Moore River Park	59 744	Superficial	100	59 744	60 000
Red Gully/Central Scarp	405 840	Superficial	10	40 584	40 000
		Mirrabooka	90	365 256	365 000
Seabird	211 812	Superficial	100	211 812	210 000
South Moore River Park	74 695	Superficial	100	74 695	75 000
Victoria Plains/Northern Scarp	519 567	Mirrabooka	100	519 567	520 000
Wedge Island/Northern Scarp	277 469	Mirrabooka	33.3	92 397	90 000
		Superficial	66.7	185 072	185 000
Total					**3 390 000**

3.2 Future water demand

The department assessed the likely future demand for water in the Gingin groundwater plan area based on:

- the number of licence applications received over recent years in each resource
- information from WAPC and local councils, including structure plans and strategic planning documents
- scheme water demand projections from the Water Corporation
- DAFWA's agricultural development and industry plans.

Agriculture and horticulture

Agriculture and horticulture in the plan area have already expanded and diversified over the last 10 years. DAFWA has identified that the Shire of Gingin is a major contributor to the Northern Agricultural Region's agricultural and horticultural production (van Gool & Runge 1999). The shire provides:

- 100 per cent of the poultry production
- 99 per cent of the fruit production
- 96 per cent of the grape production
- 95 per cent of the vegetable production in the region.

In the 15 years from 1983 to 1998, the value of agriculture and horticulture has increased from $8.7 million to $55.6 million (Shire of Gingin 2002). In 2006, agriculture and horticulture was worth an estimated $114.6 million (ABS 2010). This trend is likely to continue with agricultural and horticultural ventures moving northwards from the Gnangara area due to increasing pressure from urban development.

Accordingly, we expect the volume of water used for agricultural and horticultural production to increase over the next seven years. Moora has also been identified as a Specialist Food Centre in the government's Agriculture policy.

As well as increasing competition for water in the region, this growth may be limited by:

- availability of suitable land and water determining the extent of growth in agriculture
- infrastructure and higher temperatures in the northern part of the plan area
- increased pressure to subdivide properties as urban and lifestyle lots expand northwards from Perth.

Industry (including mining)

Industry in the plan area is expanding with exploration activities and industrial hubs such as the Muchea Employment Node included in planning schemes (WAPC 2011). Because the timing from such developments is uncertain, water demand is difficult to predict. Water and infrastructure availability is likely to determine growth.

Urban/residential development and town water supply

Estimates by the Western Australian Planning Commission (WAPC 2012) indicate that the combined populations of local government areas in the plan area may increase by about 10 000 by 2026 (Table 6). Additionally, developments such as the Muchea Employment Node are expected to create an additional 1000 jobs (WAPC 2011) which may encourage people to settle in these areas. Proponents scoping developments in this area are encouraged to contact the Department of Water to discuss water availability.

Table 6 Estimates of populations in Chittering, Dandaragan, Gingin and Moora to 2026

Local Government Area	2006	2026
Chittering	3700	9600
Dandaragan	3000	4700
Gingin	4600	6500
Moora	2600	3000
TOTAL	**13 900**	**23 800**

Source: *Western Australia Tomorrow* (WAPC 2012)

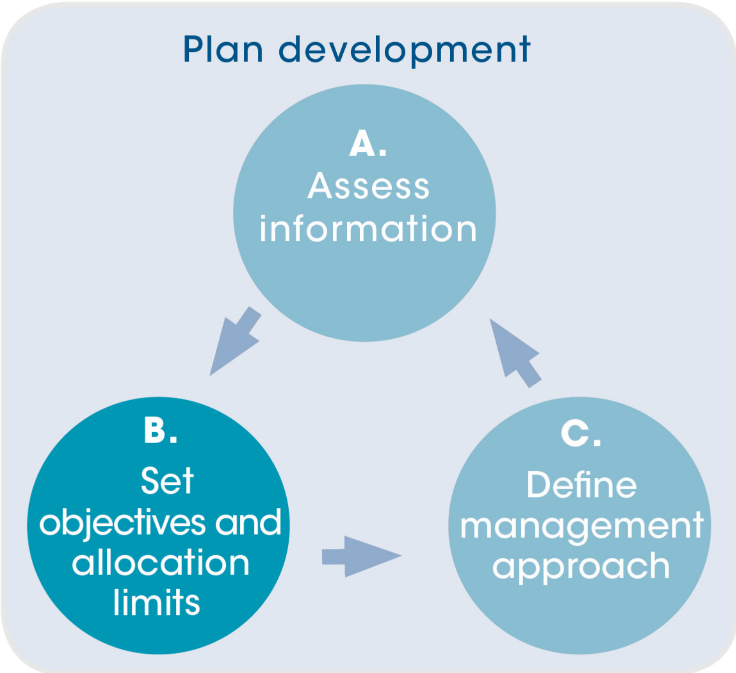
Currently, about 4 GL/yr is licensed for public water supply in the plan area to meet local needs. The department is working with the Water Corporation in assessing local public water supply needs to the plan area's towns, including Bindoon, Chittering, Dandaragan, Gingin, Moora, Victoria Plains, Wannamal and surrounds. The Water Corporation's *Water Forever* strategic planning document (Water Corporation 2009) lists groundwater from the Gingin-Jurien area as a potential future option to support the delivery of sustainable water for local needs as well as Perth. The Water Corporation estimates sourcing about 48 GL/yr, which can be met through 41 GL/yr reserved in the Gingin plan area and a further 7 GL/yr reserved in the Jurien plan area.

3.3 Points to consider from understanding current and future water demand

From the information we have on the 35 groundwater resources in the Gingin plan area, there are a number of points that we need to consider when setting objectives and allocation limits:

- Licensed entitlements have increased by about 34 GL/yr since the 2002 Interim Strategy.
- Most of the water is currently licensed for agricultural and horticultural purposes.
- Demand is expected to keep rising during the life of the plan with further developments in the plan area.
- The estimated exempt use is about 3.4 GL/yr.

Part B – Setting objectives and allocation limits



This stage of the planning process consists of:

- defining the plan objectives
- calculating yields
- deciding on allocation limits.

These steps use the information gathered and analysed in the ‘assess information’ phase (Part A).

4 Setting objectives

In administering the *Rights in Water and Irrigation Act 1914*, the Department of Water provides for both the sustainable use and development of water resources and the protection of ecosystems associated with water resources.

4.1 Outcomes

We manage water resources in the Gingin plan area so that:

- licensed entitlements can be met reliably in most years
- water source options to support growth in agricultural and horticultural industries are clear
- sufficient water is available to support population growth in local towns, as well as to provide a future groundwater source option for Perth's Integrated Water Supply Scheme (IWSS)
- groundwater-dependent ecosystems and watercourses are protected from over-abstraction
- groundwater quality in the coastal aquifers is protected from seawater intrusion.

4.2 Resource objectives

Water resource objectives describe the groundwater regime that is designed to achieve the outcomes of the *Gingin groundwater plan*. They relate to maintaining, increasing, improving, restoring, reducing or decreasing groundwater levels, surface water flow or water quality. Water resource objectives allow us to measure, evaluate and adapt how we are managing water resources over the life of the plan.

The water resource objectives for groundwater in the Gingin plan area are:

a. Groundwater levels or pressure heads are consistent with rainfall trends.

b. Maintain groundwater levels or pressure heads within a target range to avoid adverse effects on groundwater-dependent ecosystems and/or baseflow in the Gingin Brook and Moore River.

c. There is sufficient groundwater throughflow in coastal aquifers to reduce the risk of seawater intrusion.

Objective a relates to all resources whereas b. and c. are resource-specific (see Chapter 5 of the plan).

5 Calculating yields

Before we decide what the allocation limit should be, we need to calculate the aquifer yield. An aquifer yield is the volume of water that can be available for abstraction from the total recharge of a groundwater system, once the environmental water requirements are met. Requirements include water for groundwater-dependent ecosystems, seawater interface, in-situ social and cultural values (Section 2.5). Part of the recharge needs to be retained in the aquifer to meet these requirements. For simplicity, these requirements will be referred to as environmental water.

Yield (ML/yr) was calculated as:

Yield = Recharge – Environmental water (factor)

Where:

Recharge = the estimated annual volume of water entering the aquifer after accounting for climate (Section 2), and

Environmental water = percentage of recharge required to maintain *in situ* values (Section 2.5).

The same method was used to calculate yields for the 2002 Interim Strategy though, as described in Chapter 2, values for rainfall and the percentage to be left in the aquifer to protect in-situ values have been revised.

Yields for each aquifer are presented in Table 11 in Chapter 6.

5.1 Assessing water to be left in aquifers

The environmental water or proportion of recharge to be retained in each aquifer, for each subarea depends on the presence of groundwater-dependent ecosystems, groundwater contribution to river baseflow, proximity of the seawater interface as well as social and cultural values.

More water was left in the aquifers for resources that are shallow, support high-value vegetation, or support baseflow to the Gingin Brook and Moore River.

In the 2002 strategy, the land area classified as Regional Parks or Nature Reserves, was proportionally removed from the yield calculation. In this plan, we have calculated recharge for the full land area instead, and allowed for parks and reserves partly through the proportion of recharge retained in aquifers.

The proportion of water to remain in the system involved an iterative process where we balanced groundwater level information, current levels of use and predicted demand (Section 6 outlines in more detail how we did this). The percentages of water to be left in the system to support the environmental, social and cultural values are summarised below (Table 7).

To improve confidence about whether or not the proportion of water retained will be enough to protect *in-situ* values, we are currently undertaking further hydrogeological investigations. Information from the investigations will be considered when we evaluate the allocation plan (refer to chapters 5 and 6 of the plan).

Table 7 Percentage of water left in the system (environmental water) by aquifer and the risks considered when setting allocation limits

Aquifer	Considerations	Water left in the system (%)
Surficial	• Lower density of groundwater-dependent ecosystems. • Thin nature of the aquifer means system is resilient to natural fluctuations. • Inland, no seawater interface. • Patchy aquifer, small bore yields.	20
Superficial	Subareas on Swan Coastal Plain closer to the coastline: • Groundwater levels are deeper and more stable in these locations due to the Tamala Limestone's capacity to store and transmit water. • Proximity to seawater interface.	25
	Subareas on Swan Coastal Plain closer to the Gingin Scarp: • Water tables are generally shallower, and more likely to support groundwater-dependent ecosystems. • Significant wetlands including springs and seepages are present.	30
	Subareas on Swan Coastal Plain: • There are significant areas of groundwater-dependent ecosystems, remnant vegetation and land reserved for conservation and recreation (e.g. North Moore and South Moore River Parks).	40
Mirrabooka	• Localised baseflow contribution is important for watercourses. • Limited data is available on groundwater-dependent ecosystems interactions for the Mirrabooka resource. • Generally low yielding and localised.	80
Leederville	Northern and Central Coastal resources: • No surface outcropping. • Discharges into superficial aquifer. • Proximity to seawater interface.	10
	Southern Coastal resource: • Contributes to baseflow for watercourses. • Proximity to seawater interface.	40
Leederville-Parmelia	• Localised baseflow contribution is important for watercourses. • Limited data is available on groundwater-dependent ecosystems interactions.	10
Yarragadee	• Proximity to seawater interface • Limited hydraulic connection.	10

6 Deciding allocation limits

The allocation limit is the management tool we use to manage risks at the resource scale. It is complemented by management through local-scale water licences.

To make an allocation limit decision we considered:

- the outcomes and objectives of the plan
- groundwater levels and trends
- current water use and future demand
- the risk to the sustainability of the resource and to water users
- our ability to manage risk using allocation limits, licences or other mechanisms.

Based on these factors, we set the allocation limit above, at or below the yield. Setting an allocation limit can involve making trade-offs between competing needs. In all cases, we consider how to use allocation limits, licensing and monitoring in a complementary way to manage the risks associated with abstraction. The effectiveness of the allocation limits will be assessed annually through our plan evaluation process.

6.1 Surficial resources

In general, the department has retained the same allocation limits for the surficial resources, as stated in the 2002 Interim Strategy. These allocation limits are set lower than the revised yield estimate because, in practice, the surficial resource is low yielding so:

- water may be difficult to access
- demand for water is generally low.

For the Bindoon resource, we have retained the previous allocation limit. It is higher than the new estimated yield. This was acceptable because, at the current level of use, the environmental values within the subarea have not been adversely affected and risks from use can be managed through licensing.

6.2 Superficial resources

The allocation limit was set equal to the yield for 11 of the 13 superficial resources in the plan area. In Guilderton North, Red Gully and Karakin Lakes we have set the allocation limits approximately at yield (rounded up or down) depending on the level of use. Groundwater levels in these resources have generally declined by up to 2 m since 1997 due to the combined effects of climate and groundwater abstraction. As the superficial groundwater is shallow and easily accessed, demand from this aquifer is likely to increase in the future. We have set the allocation limit at the yield to ensure the rate of decline in groundwater levels does not increase over the life of the plan.

The department has retained the allocation limits for the South Moore River Park and North Moore River Park resources as stated in the 2002 Interim Strategy. The allocation limit for South Moore River Park superficial resource is less than the yield. As there are significant groundwater-dependent features across about 70 per cent of the subarea, the allocation limit will reduce the risks to these ecological values. Also, large parts of these subareas are parks and reserves, so water is generally not accessible for consumptive use.

The allocation limit for the North Moore River Park superficial resource is higher than the yield estimate. There are also significant groundwater-dependent features in the North Moore River Park subarea such as Moore River and the Moore River National Park. However, as groundwater levels in this resource have declined by less than 1 m since 1997, the resource can be managed under the current allocation limit.

6.3 Mirrabooka resources

The Mirrabooka aquifer is important for maintaining the high social and environmental values associated with Gingin Brook and Moore River. It contributes most of the summer flow in the headwaters of Gingin Brook and is important for maintaining summer flows in the Moore River. As described in Table 7 we have left 80 per cent of recharge in the system to protect these values (this water will not be available for use).

As we have already made sufficient provision for the protection of values that depend on Mirrabooka resources, allocation limits have been set at the yield estimate (rounded up to the nearest 100 ML/yr). The ability to access water due to variable yields across the Mirrabooka aquifer means that demand for water from this aquifer is low.

6.4 Leederville resources

Allocation limits in all three Leederville resources are set equal to the yield. We have already left a sufficient volume of water in the aquifer to manage the risk of the seawater interface moving inland significantly (10 per cent of recharge; Table 7), and in the Southern Coastal resource, to protect contributions to the baseflow of Gingin Brook (an additional 30 per cent of recharge; Table 7). Groundwater levels have also declined by less than 1 m even though groundwater use has increased in recent times.

Setting allocation limits for the Northern and Central Coastal resources at yield makes these resources over-allocated (in the general licensing component). We will manage the risks associated with over-allocation by recovering unused water through our licensing process and, if necessary, reconsider the reserve component through the evaluation process. The approach to managing over-allocated resources is described in Chapter 4 of the plan (DoW 2015a).

6.5 Yarragadee resources

We have set allocation limits equal to the yield for the Yarragadee resources because, as with the Leederville resources, we have left a sufficient volume of water in the aquifer to manage the risks associated with abstraction. The Cataby and Wannamal resources are close to being fully-allocated and groundwater pressure heads have declined by up to 2 m in these resources.

Managing seawater intrusion in the Leederville and Yarragadee resources

Davidson (1995) recommended leaving 30 per cent of recharge in groundwater resources on the Swan coastal plain to maintain the position of the seawater interface. The department has only set aside 10 per cent in the Yarragadee and Northern and Central Coastal Leederville resources because they are important resources for use (almost fully allocated) and we are able to manage any risks through licensing.

During the life of the plan, we will also review the status of the groundwater pressure heads in the confined aquifers at the coast. Any significant reduction outside the normal historical range (14 to 18 mAHD) for groundwater pressure head in the Leederville and Yarragadee aquifers will trigger a review of the risk of seawater intrusion and, potentially, the allocation limits to these resources as well. More information on how we will monitor, implement and evaluate the allocation plan can be found in chapters 5 and 6 of the plan (DoW 2015a).

6.6 Leederville-Parmelia resources

The allocation limit is set equal to the yield in the Leederville-Parmelia aquifer. Table 8 illustrates the method we used to calculate the yield for the Leederville-Parmelia aquifer in the plan area. In summary:

- Pressure heads in the confined Leederville-Parmelia aquifer in the plan area are primarily maintained by groundwater throughflow derived from recharge north of the plan area (Jurien/Dinner Hill and Arrowsmith/Morrison subareas). There is a groundwater divide in the Morrison subarea where groundwater in the Leederville-Parmelia aquifer flows to the north and south of the divide. It is the groundwater flow to the south of this divide that maintains pressure heads in the Leederville-Parmelia aquifer in the Gingin plan area.
- Total recharge of the Leederville-Parmelia aquifer system is about 39 530 ML/yr.
- Water for the environment was set at 10 per cent of total recharge in accordance with Rutherford et al. (2005), giving a total yield of 35 600 ML/yr.

To set an allocation limit for the Cowalla Leederville-Parmelia resource (the portion of the resource in the plan area), we took into account the allocation limits already in place for the Arrowsmith and Jurien resources. The aquifer’s yield is 35 600 ML/yr and the current allocation limits in place for the Arrowmith and Jurien resources are

4000 and 12 600 ML/yr, respectively. Deducting these allocation limits from 35 600 leaves 19 000 ML/yr for the Cowalla resource.

At a regional scale, groundwater monitoring in the Leederville-Parmelia resource indicates rising pressure heads in the northern portion (up to 7 m between 1991 and 2007) and declines in the southern portion of the resource (up to 10 m since 1980 and 4 m since 2002). There is some evidence that pressure heads might have stabilised over the last five years.

There is no recharge to the Leederville-Parmelia aquifer in the southern portion of the subarea (Figure 21) which is the area of highest abstraction. To alleviate this stress on the aquifer, we have encouraged a redistribution of abstraction to the northern part of the aquifer and have amalgamated the SA4, SA5 and SA6 subareas into a single subarea (Cowalla subarea) and established three trading zones. This enables us to manage the Leederville-Parmelia as a single resource and enables trading across the whole resource but only in a northerly direction (Figure 22). This will reduce the risk to the reliability of supply to current licensees abstracting from this aquifer.

To make decisions for water trades we will use the rules outlined in Table 9. These rules only allow northward trades to occur.

Table 8 Recharge calculations for the Leederville-Parmelia aquifer

Groundwater area/ subarea		**Area of subarea likely to receive local recharge (km^2)**	**Mean annual rainfall (mm/yr)**	**Recharge rate (%)**	**Recharge (ML/yr)**	**Allocation limit (ML/yr)**
Gingin / Cowalla	Gingin/SA4	537	520	1	2790	**19 000**
	Gingin/SA5	96	570	1	550	
	Gingin/SA6	N/A	N/A	N/A	N/A	
Arrowsmith/Morrison		524	500	4	10 480	**4000**
Jurien/Dinner Hill (a)		1177	500	4	23 540	**12 600**
Jurien/Dinner Hill (b)		433	500	1	2170	
Total Recharge					**39 530**	**Total of allocation limits**
Yield (Recharge less 10 per cent environmental water)					**35 600**	**35 600**

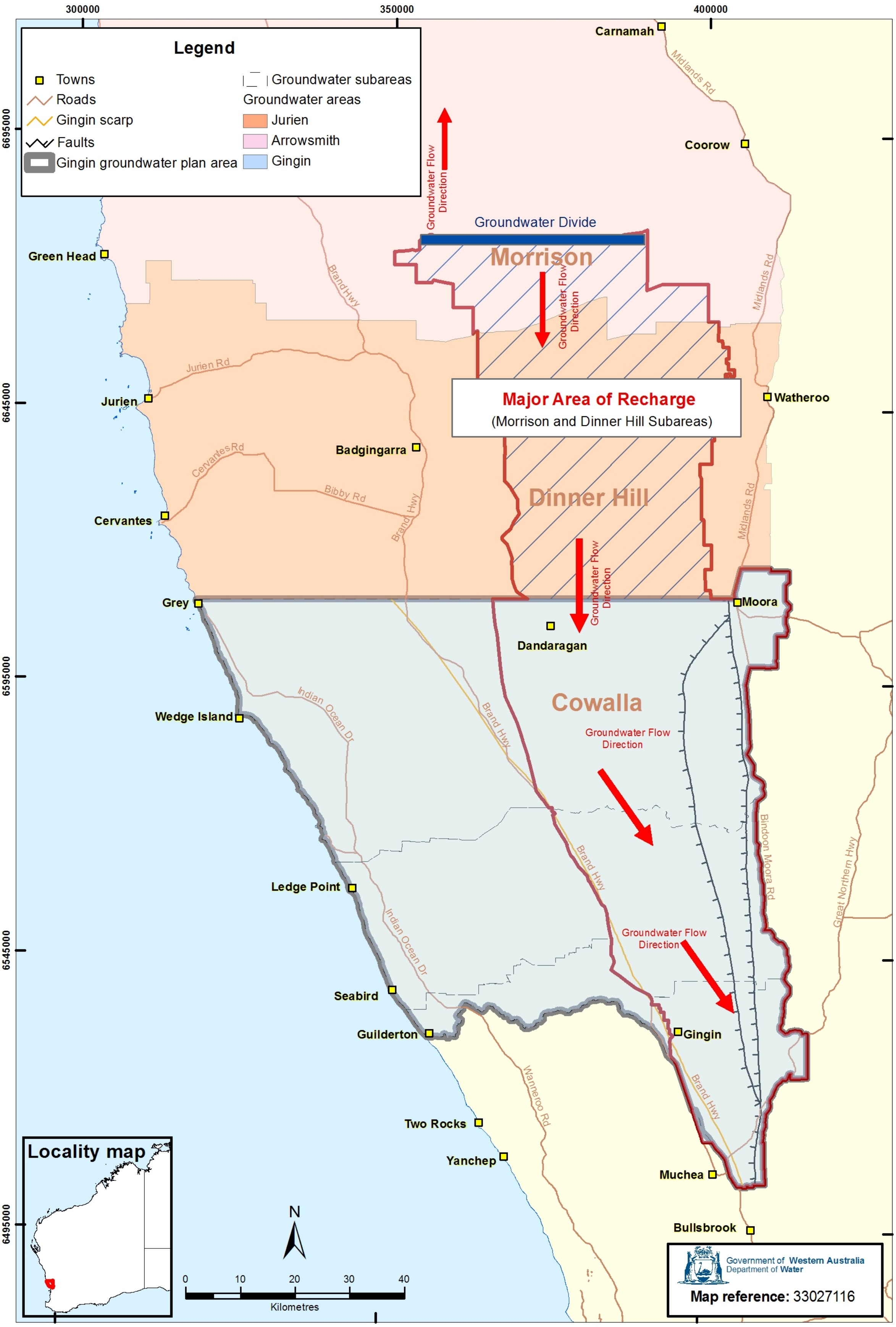


Figure 21 Groundwater recharge and flow within the Leederville-Parmelia aquifer

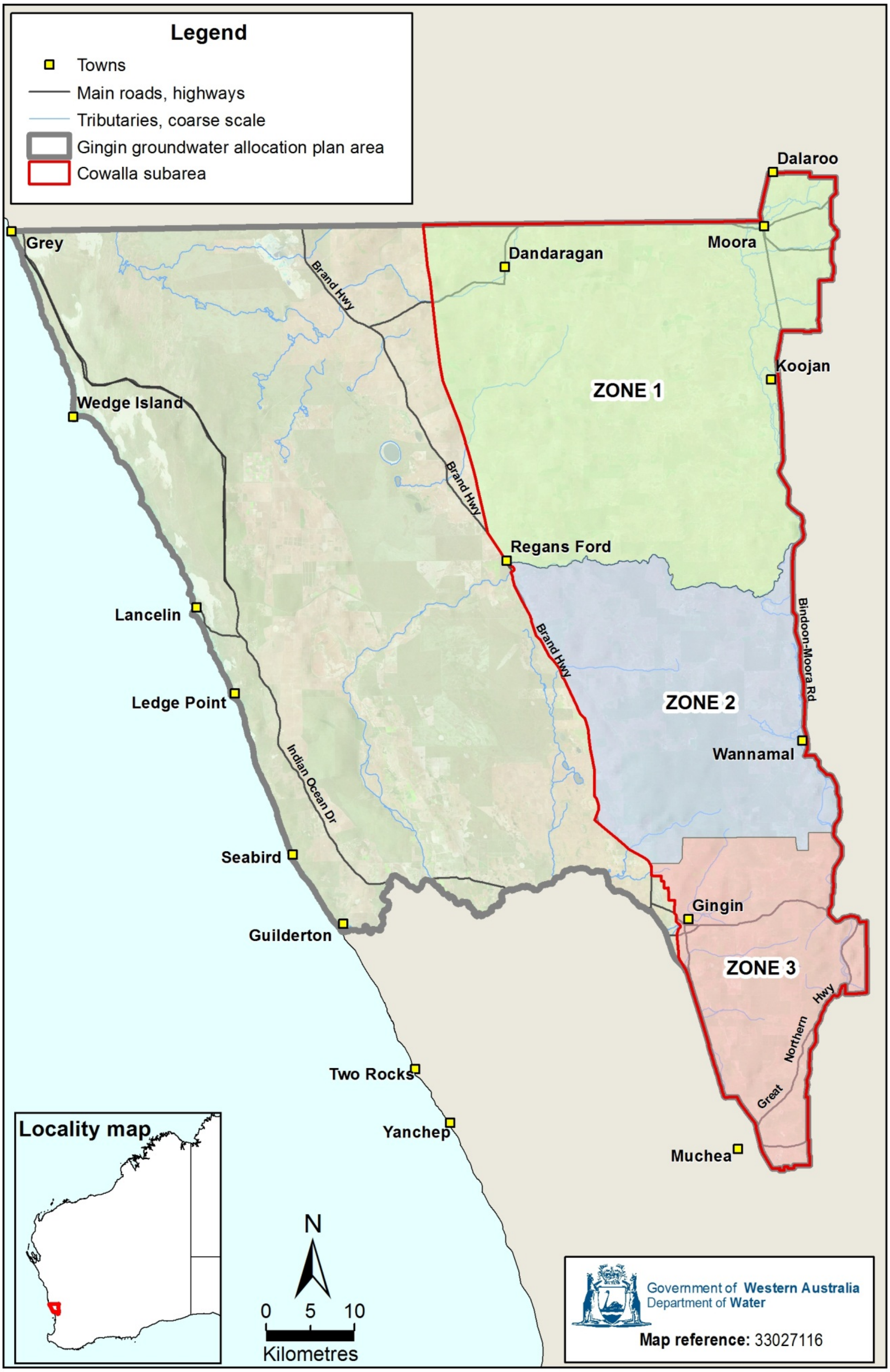


Figure 22 Trading zones in the Leederville-Parmelia aquifer

Table 9 Trading rules between and within trading zones for the Leederville-Parmelia resource

		Trading to		
		Zone 1	**Zone 2**	**Zone 3**
Trading from	**Zone 1**	Trading is permitted.	Trading is not permitted.	Trading is not permitted.
	Zone 2	Trading is permitted.	Trading is permitted.	Trading is not permitted.
	Zone 3	Trading is permitted.	Trading is permitted.	Trading is permitted.

6.7 Lesueur and Cattamarra resources

The allocation limit is equal to the yield in the Lesueur and Cattamarra resources. Due to their remote location, there is currently no licensed use or demand for these resources. Little is known about the groundwater-dependency of the environmental features in the subarea and data from one monitoring bore in the Lesueur indicates a slight decline in groundwater level of 0.2 m since 2002. As a result, we did not retain any water for environmental water in the yield estimates for these resources (i.e. allocation limit is set close to the recharge only). Any risks to the resource and its environmental features will be managed through licensing. As the water of the Lesueur is 'fresh', the resource would be suitable for future public water supply and we have reserved 1700 ML/yr for this purpose.

6.8 Fractured rock resources

We have set an allocation limit of 50 ML/yr for each of the three fractured rock resources because:

- It is impractical to calculate reliable yields for these resources as they are highly variable.
- There is low demand and licensed use.
- These resources have small storage capacities and provide low bore yields (less than 6 L/s).
- The quantity and quality of water from these resources are highly variable.

The current level of use in these resources and their values can be managed through licensing.

6.9 Public water supply reserves

Aquifers in the Gingin and Jurien groundwater areas have long been identified as a potential future water supply option for Perth. However, to date, other options have been more feasible. With increasing demand, Gingin/Jurien groundwater options may be re-evaluated during the next 10 to 20 years.

About 41 GL/yr is reserved across nine resources in this plan (Table 10) for future local public water supply and as an option for the Perth Integrated Water Supply Scheme (IWSS). This is a reduction of 31.5 GL/yr from the reserves published in the 2002 Interim Strategy (72.5 GL/yr).

In general, the department has reduced the volumes of water reserved for future public water supply proportionally when setting allocation limits in those resources that had long-standing indicative reserves. Where local use may be affected, the public water supply reserve was reduced further. This is consistent with the Water Corporation's *Water Forever* document which states that 'the Water Corporation would need to ensure that local users were not unduly impacted by the development of this source (the Gingin-Jurien groundwater scheme) for public water supply' (Water Corporation 2009).

The Guilderton, Beermullah Plain, Deepwater Lagoon and SA3 subareas were divided for administrative purposes during the Gnangara planning process (DoW 2009c), and the public water supply reserve volumes were not distributed in proportion to the subarea size. As a result, the reserved volumes that remained in the Gingin plan area were artificially high. These have now been removed from the Gingin plan.

Table 10 Public water supply reserves in the Gingin plan area

Subarea	Aquifer	Public water supply reserve (ML/yr)
Guilderton North	Superficial	500
Karakin Lakes	Superficial	4500
Lancelin	Superficial	5500
North Moore River Park	Superficial	3000
Seabird	Superficial	4000
Wedge Island	Superficial	9750
Northern Coastal	Lesueur Sandstone	1700
	Leederville	3000
Cataby	Yarragadee	9000
Total		**40 950**

6.10 Allocation limits summary

A summary of recharge and yield calculations and allocation limit decisions are presented in Table 11. The final allocation limits for each of the 35 resources in the plan area are shown in Table 12. The allocation limits are divided into components to account for water available for general licensing, existing exempt use and potential future public water supply.

The allocation limits make 235 GL/yr available for consumptive use across the 35 resources. This is a reduction of 67 GL/yr from the allocation limits established in 2002. Currently, about 140 GL/yr is issued as licence entitlements, 41 GL/yr is held in reserve for future public water supply and 3 GL/yr has been set aside to account for exempt stock and domestic use. There is a further 30 GL in applications that the department is currently processing. If all applications are approved, this leaves about 20 GL/yr available for future licensing in the plan area.

Table 11 Summary of recharge and yield calculations and the allocation limit decision

Groundwater resource (subarea and aquifer)		Area (km^2)	1975–2003 Mean annual rainfall (mm/yr)	Recharge rate (%)	Recharge after applying 15% climate reduction factor (ML/yr)	Total recharge estimate (ML/yr)	Environmental water (%)	Yield (ML/yr)	Allocation limit (ML/yr)	Yield decision[1]
Surficial and superficial aquifers										
Beermullah Plain North	Superficial	55.52 106.54 2.23	630	6.5 15.0 18.0	1932.51 8557.83 214.95	10 705	40	6423	6500	At yield
Bindoon	Surficial	64.00	650	6.5	2298.40	2298	20	1838	2400	Above yield
Deepwater Lagoon North[2]	Superficial	29.25 2.87	650	6.5 15.0	1050.44 237.85	1288	30	901	900	At yield
Eclipse Hill	Surficial	222.60	680	6.5	8363.08	8363	20	6690	3000	Below yield
	Superficial	40.00	680	6.5	1502.80	1503	30	1052	1050	At yield
Gingin Townsite[2]	Surficial	205.62	650	6.5	7384.33	7384	20	5907	5000	Below yield
	Superficial	0.58	650	6.5	20.83	20	0	20	20	At yield
Guilderton North	Superficial	11.03 21.31 67.61	650	6.5 15.0 18.0	396.11 1766.07 6723.81	8886	30	6220	6500	At yield
Karakin Lakes	Superficial	257.00	630	18.0	24 772.23	24 772	30	17 340	17 000	At yield
Lancelin	Superficial	292.90	630	18.0	28 232.63	28 233	25	21 175	21 000	At yield
Moora	Surficial	114.00	430	6.5	2708.36	2708	20	2166	800	Below yield
Namming Lake	Surficial	44.01	600	6.5	1458.93	1459	20	1167	300	Below yield
	Superficial	176.00 17.40	600	15.0 18.0	13 464.00 1597.32	15 061	30	10 543	10 500	At yield

Groundwater resource (subarea and aquifer)		Area (km²)	1975–2003 Mean annual rainfall (mm/yr)	Recharge rate (%)	Recharge after applying 15% climate reduction factor (ML/yr)	Total recharge estimate (ML/yr)	Environmental water (%)	Yield (ML/yr)	Allocation limit (ML/yr)	Yield decision[1]
North Moore River Park	Superficial	135.70 67.90	600	15.0 6.5	10 381.05 2250.89	12 632	25	9474	12 900	Retain 2002 limit (Above yield)
Red Gully	Surficial	813.96	570	6.5	25 633.64	25 634	20	20 507	5600	Below yield
	Superficial	30.72	570	6.5	967.45	967	25	725	750	At yield
Seabird	Superficial	249.42	640	18.0	24 423.21	24 423	30	17 096	17 000	At yield
South Moore River Park	Superficial	76.12 82.17 88.23	600	15.0 18.0 6.5	5823.18 7543.21 2924.82	16 291	40	9774	7500	Retain 2002 limit (Below yield)
Victoria Plains	Surficial	693.35	510	6.5	19 536.87	19 537	20	15 630	4400	Below yield
Wedge Island	Surficial	376.20	600	6.5	12 471.03	12 471	20	9977	3000	Below yield
	Superficial	655.70 364.30	600	15.0 18.0	50 161.05 33 442.74	83 604	30	58 523	58 500	At yield
Mirrabooka aquifer										
Central Scarp	Mirrabooka	504.50	570	3.0	7332.91	7333	80	1467	1500	At yield
Northern Scarp	Mirrabooka	13.45 36.26 503.65 236.10	600 600 510 510	6.5 3.0 6.5 3.0	445.87 554.78 14 191.60 3070.48	18 263	80	3653	3700	At yield
Southern Scarp	Mirrabooka	122.34 96.54	680 650	3.0	2121.38 1600.15	3721	80	744	800	At yield
Leederville, Cattamarra and Lesueur aquifers										
Central Coastal	Leederville	228.62 199.44	620	2.5 0.1	3012.07 105.10	3117	10	2805	2800	At yield

Groundwater resource (subarea and aquifer)		Area (km²)	1975–2003 Mean annual rainfall (mm/yr)	Recharge rate (%)	Recharge after applying 15% climate reduction factor (ML/yr)	Total recharge estimate (ML/yr)	Environmental water (%)	Yield (ML/yr)	Allocation limit (ML/yr)	Yield decision[1]
Northern Coastal	Leederville	15.60 46.30 425.95	600	2.5 0.1 2.5	198.90 23.61 5430.86	5653	10	5088	5100	At yield
	Cattamarra	55.45	600	1.0	282.80	283	0	283	250	At yield
	Lesueur	108.70	600	3.0	1663.11	1663	0	1663	1700	At yield
Southern Coastal	Leederville	106.55 4.14 182.33	640	2.5 2.5 0.1	1449.08 56.30 99.19	1605	40	963	1000	At yield
Yarragadee aquifer										
Cataby	Yarragadee	201.00 485.00 633.00	600	5.0 2.5 1.0	5125.50 6183.75 3228.30	14 538	10	13 084	13 000	At yield
Chandala	Yarragadee	40.02 174.00	670 640	1.0	227.91 946.56	1174	10	1057	1050	At yield
Wannamal	Yarragadee	247.00 30.58	620 570	1.0	1301.69 148.16	1450	10	1305	1300	At yield
Leederville-Parmelia aquifer										
Cowalla[3]	Leederville-Parmelia	-	-	-	-	-	-	-	19 000	At yield

[1] At yield – equal to yield; Above yield – greater than yield; Below yield – less than yield

[2] The Deepwater Lagoon North subarea has now been amalgamated into the Gingin Townsite subarea to manage the superficial aquifer as a single resource.

[3] As described in Section 6.6

Table 12 Allocation limits and their components for the Gingin plan area (ML/yr)

Groundwater resource (subarea and aquifer)		Allocation limit components (ML/yr)				
		Allocation limit	Licensable		Unlicensable	Reserved water
			General	Public water supply	Exempt	Public water supply
Superficial and surficial aquifers						
Beermullah Plain North	Superficial	6500	6370	0	130	0
Bindoon	Surficial	2400	1925	0	475	0
Eclipse Hill	Superficial	1050	980	0	70	0
	Surficial	3000	3000	0	0	0
Gingin Townsite	Superficial	920	865	0	55	0
	Surficial	5000	5000	0	0	0
Guilderton North	Superficial	6500	5510	370	120	500
Karakin Lakes	Superficial	17 000	12 240	120	140	4500
Lancelin	Superficial	21 000	13 875.5	1409.5	215	5500
Moora	Surficial	800	730	0	70	0
Namming Lake	Superficial	10 500	10 465	0	35	0
	Surficial	300	300	0	0	0
North Moore River Park	Superficial	12 900	9840	0	60	3000
Red Gully	Superficial	750	710	0	40	0
	Surficial	5600	5600	0	0	0
Seabird	Superficial	17 000	12 790	0	210	4000
South Moore River Park	Superficial	7500	7425	0	75	0
Victoria Plains	Surficial	4400	4400	0	0	0
Wedge Island	Superficial	58 500	48 565	0	185	9750
	Surficial	3000	3000	0	0	0

Groundwater resource (subarea and aquifer)		Allocation limit components (ML/yr)				
		Allocation limit	Licensable		Unlicensable	Reserved water
			General	Public water supply	Exempt	Public water supply
Leederville, Cattamarra, Lesueur, Mirrabooka and fractured rock aquifers						
Central Coastal	Leederville	2800	2700	100	0	0
Northern Coastal	Cattamarra Coal Measures	250	250	0	0	0
	Lesueur Sandstone	1700	0	0	0	1700
	Leederville	4100	630	470	0	3000
Southern Coastal	Leederville	1000	1000	0	0	0
Central Scarp	Mirrabooka	1500	1135	0	365	0
	Fractured Rock	50	50	0	0	0
Northern Scarp	Mirrabooka	3700	3070	0	630	0
	Fractured Rock	50	50	0	0	0
Southern Scarp	Mirrabooka	800	285	0	515	0
	Fractured Rock	50	50	0	0	0
Leederville–Parmelia aquifer						
Cowalla	Leederville–Parmelia	19 000	17 617.3	1382.7	0	0
Yarragadee aquifer						
Cataby	Yarragadee	13 000	4000	0	0	9000
Wannamal	Yarragadee	1300	1300	0	0	0
Chandala	Yarragadee	1050	1050	0	0	0
Total		**234 970**	**186 777.8**	**3852.2**	**3390**	**40 950**

*Please contact our Swan Avon regional office on 08 6250 8000 for up-to-date information on the volume of water available for future use. Resource status indicates how much of the water available for general licensing has been allocated and whether water is available for new licences. Water available means < 70 per cent has been allocated and limited water available means 70 to 100 per cent has been allocated. Note that water available is assessed for each licence application at the local scale (see Chapter 4 of the plan).

7 Further work to inform future allocation planning

The allocation limits for the resources in the Gingin plan area are based on the best available information. As more information becomes available, such as from hydrogeological and monitoring reports, it will be considered in the annual plan evaluation process and used to re-assess our management regime and allocation limits. The following are further work that we may do in the future or are already doing as actions from the plan. All additional information will be used to continually improve the way we manage the water resources and help us achieve the desired outcomes outlined in the plan.

Understanding surface water-groundwater connectivity along Moore River

We are considering the benefits of a study to improve the understanding of the surface water–groundwater connectivity along the Moore River similar to that done for Gingin Brook (Tuffs 2011; Section 2). This is a future action in the allocation plan.

Groundwater-dependent ecosystems

The department requires years of data to quantify the ecological water requirements of groundwater-dependent ecosystems to a high level of confidence. To date, Rutherford et al. (2005) have provided the most comprehensive review of the location of potential groundwater-dependent ecosystems in the Northern Perth Basin, which includes the Gingin plan area. This study was based on a desktop review of hydrogeological data and visual assessments of around 100 potential groundwater-dependent ecosystems. The study divided the potential groundwater-dependent ecosystems into three categories based on the estimated depth-to-groundwater. The report study did not identify critical areas or recommend how the categories should be used for the management and licensing of groundwater.

To further develop Rutherford et al.'s (2005) review, the department has recently carried out investigations to assess ecological water requirements for groundwater-dependent ecosystems in the Northern Perth Basin. We are currently completing a report that summarises this work. This report will help the department to manage licensing in the Gingin plan area by providing:

- guidelines on the water requirements of groundwater-dependent ecosystems which could be used to assess the allocation limits we have set
- information that can be used to decide if additional monitoring needs to be in place when we receive licence applications.

Additional monitoring for seawater interface

With more information on the seawater interface, we could estimate the volume of throughflow required to stabilise or prevent significant harm from seawater intrusion with greater accuracy (DoW 2009b).

The Gingin plan area has a shortage of deep monitoring bores to estimate the location of the seawater interface in the confined Leederville and Yarragadee aquifers at the coast. The department's *North Gingin groundwater investigation* project, funded through the State Groundwater Investigation Program, will install four lines of deep Leederville and Yarragadee aquifer monitoring bores (24 bores in total) on the Swan Coastal Plain. These four lines will be positioned within the Gingin plan area between the coastal settlements of Wedge Island in the north and Seabird in the south and move inland to the Brand Highway near Gingin Scarp in the east.

Construction of the new monitoring bores started in 2012 with the project due for completion in 2014. Before the investigation is completed, existing deep monitoring bores at Guilderton (AM1A, just outside the southern boundary of the plan area) and Lancelin (GL1A3, GL1A1 and GL1B) are being used to estimate the distance of the seawater interface offshore. The new bores will enable us to better understand and manage the confined groundwater resources in the Gingin groundwater area.

This program also ensures that we are well placed to manage growth in the demand for water from the agricultural and horticultural ventures moving northwards from the Gnangara area. The new data collected will also improve our conceptual geology model and be incorporated into future models for more precise allocation limits. Following the installation of the monitoring bores on the coastal plain, the project will extend eastward to address the monitoring gap on the Dandaragan Plateau. It is anticipated that this work will commence in 2015–16.

Appendix

Map information and disclaimer

Map information and disclaimer

Datum and projection information

Vertical datum: Australian Height Datum (AHD)

Horizontal datum: Geocentric Datum of Australia 94

Projection: MGA 94 Zone 50

Spheroid: Australian National Spheroid

Project information

Client: K Youngs, M Tiong and G. Chandler

Map authors: S. Edgar, G. Floyd, D. Abbott, C Samuel, S Shah, M Fifield and G Paul.

File path: J:\gisprojects\Project\330\20000_29999\33027116..For all maps

File name: J:\gisprojects\Project\330\20000_29999\33027116\0001_Gingin_Allocation_Plan..For all maps

Compilation date: 28 September 2012

Disclaimer

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Sources

The Department of Water acknowledges the following datasets and their custodians in the production of these maps:

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Hydrography, Linear (Hierarchy) – DoW – 2007

Global Map Data Australia 1M – Geoscience Australia – 2001

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WA Coastline, WRC (Poly) – DoW – 2006

Local Government Authority and Locality Boundaries – Landgate – 2012

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WIN Monitoring Boresites – DoW – 2012

WIN Surface Water Sites, Stream Gauging (DoW) – DoW – 2012

Groundwater Allocation Plan Area – DoW – 2012

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Mean Annual Rainfall Surface (1975-2003), Southwest Australia – DoE – 2006

Mid-West Potential GDE and Associated Values – DoW – 2012

WA Satellite Imagery – Landgate – 2005

Shortened forms

AHD	Australian height datum
DAFWA	Department of Agriculture and Food (WA)
DoW	Department of Water
DWAID	Divertible water allocation inventory database
IWSS	Integrated Water Supply Scheme
WAWA	Water Authority of Western Australia
WRC	Water and Rivers Commission
WRL	Water Resource Licensing (database)

Volumes of water

One litre	1 litre	1 litre	(L)
One thousand litres	1000 litres	1 kilolitre	(kL)
One million litres	1 000 000 litres	1 megalitre	(ML)
One thousand million litres	1 000 000 000 litres	1 gigalitre	(GL)

Glossary

Abstraction	Withdrawal of water from any surface water or groundwater source of supply.
Allocation limit	Annual volume of water set aside for use from a water resource.
Baseflow	The component of stream flow supplied by groundwater discharge.
Consumptive use	Water used for consumptive purposes considered as a private benefit including irrigation, industry, urban and stock and domestic use.
Discharge	The water that moves from the groundwater to the ground surface or above, such as a spring or the ocean. This includes water that seeps onto the ground surface, evaporation from unsaturated soil, and water extracted from groundwater by plants (evapotranspiration) or engineering works (groundwater pumping).
Groundwater area	An area proclaimed under the *Rights in Water and Irrigation Act 1914* for the purposes of licensing and managing water use.
Licence (or licensed entitlement)	A formal permit which entitles the licence holder to take water from a watercourse, wetland or underground source under the *Rights in Water and Irrigation Act 1914.*
Over-allocation	Where the total volume of water allocated out of the resource (that could be abstracted at any time) is over the set allocation limit.
Over-use	Where the actual volume of water abstracted from the resource is over the set allocation limit.
Pressure head	Hydrostatic pressure expressed as the height of a column of water that the pressure can support at the point of measurement.
Public water supply reserve	Reservation of a volume of water to supply drinking water for human consumption.

Reliability	The frequency with which a water licence holder can take their full licensed volume.
Recharge	Water that infiltrates into the ground to replenish an aquifer
Seawater interface	The boundary between the freshwater flowing through the aquifer and the denser, saline seawater at the coast. This interaction is present at the coastal boundary of the aquifers that extend to the coast.
Self-supply	Water users (individuals or organisations) who divert from a source for their own individual requirements.
Social value	An in-situ quality, attribute or use that is important for public benefit, welfare, state or health.
Social water requirement	The water regime needed to maintain social and cultural values.
Subarea	A subdivision, within a surface or groundwater area, defined to better manage water allocation. Subareas boundaries are not proclaimed and can therefore be amended without being gazetted.
Throughflow	The flow of water within an aquifer, and between, aquifers.
Water reserve	An area proclaimed under the *Metropolitan Water Supply, Sewerage and Drainage Act 1909* or *Country Areas Water Supply Act 1947* to protect and use water for public water supply.
Yield	The yield is the calculated volume of water that can be taken from a system renewably; subject to the effects of climate, variability, water quality and in-situ water dependencies.

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