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**Cover Photograph**: Centre pivot irrigation at Gingin (Seth Johnson)
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Executive summary

The ongoing demand for vegetables for Perth has led to interest in horticultural expansion and development of the land and water resources to the north of Gingin. This Water for Food project was recommended to provide information on water and land availability for growth and development of the horticultural industry. The confirmation of local-scale groundwater resources may provide new opportunities for the development of new horticulture precincts.

This preliminary scoping assessment proposes a number of groundwater resource / groundwater supply options with potential to support horticultural precincts and/or more intensive, local-scale horticultural development. Only the groundwater resource potential has been assessed and described; as such, there is need for additional supporting / linking studies to assess soil suitability and land availability.

A total of 11 prospective groundwater resource / groundwater supply options have been recommended in the Midlands project area with four in the Gingin Groundwater Area; three in the Jurien Groundwater Area; and four in the Arrowsmith Groundwater Area. Despite no attempt to prioritise these options as further studies are required to evaluate soil suitability and land availability, the more prospective areas are likely to be within the superficial aquifer (Karakin and Mimegarra areas); Jurien in the superficial and Lesueur Aquifers; and Eneabba Plains and Hill River in the Yarragadee Aquifer. The watertable is likely to be deeper in those areas on the Danadargan Plateau (Mingenew, Tathra and Dinner Hill). The Greenough Flats and Cullala area are the least likely prospects for horticultural development.

All selected groundwater supply options are positioned in various aquifers of the Northern Perth Basin. The rising of the watertable over past 40 to 50 years associated with land clearing provides opportunities for utilising this new and increased groundwater storage for horticultural purposes. The recommended areas have been selected where groundwater salinity is less than 1000 mg/L TDS; the depth to watertable is less than 50 m bgl; there is either available or potential for reviewing allocation limits; and are not near sensitive groundwater-dependent ecosystems.

Despite a regional appreciation of the hydrogeology and groundwater resources in the Midlands project area, there is local-scale variability that can result in some poor success in securing water supplies. In addition, there are large gaps in the Department of Water’s bore monitoring network that may prevent a reassessment of allocation limits in some of the recommended areas. This project provides an opportunity to improve the local-scale understanding of groundwater resources by addressing the monitoring network gaps by installing new monitoring bores and providing baseline monitoring of groundwater levels.
1. Introduction

1.1 Background

The ongoing growth and expansion of vegetable production for the Perth market has led to interest in horticultural expansion and development to the north of Gingin. The water and land resources within the Midlands project area from north of Gingin to Badgingarra and Dongara have been identified as being prospective for potential agricultural development in the Department of Water’s (DoW) Water for Growth and Water Resources Inventory (DoW, 2014).

The Midlands area is located in the coastal Midwest of Western Australia. It is largely positioned over the Northern Perth Basin, which contains significant groundwater resources that are stored within a thick succession of sedimentary aquifers. Groundwater is present in the Cainozoic and Mesozoic aquifers; it is mainly fresh to brackish, and is used for a variety of horticultural and mining purposes. The Department of Water estimates that there is 90 GL/yr of available groundwater across the region, with around 50 GL/yr potentially available to support industry expansion.

There is a good appreciation of groundwater resource and availability at a regional scale; however, the hydrogeology is known to vary at the property scale. Vegetables WA (2014) highlighted grower frustration at this variability for the development of a reliable water supply suitable for irrigated agriculture.

The Department of Water manages the groundwater resources in the Northern Perth Basin across three major groundwater areas (Arrowsmith, Jurien and Gingin) that are further divided into groundwater sub-areas. In many sub-areas, particularly around Gingin, groundwater resources are either fully allocated or approaching full allocation. Over the past decade, increasing groundwater demand has placed added pressure on these resources and may potentially impact on their long-term sustainability.

There are considered sufficient unallocated groundwater resources across the Midlands project area to meet the needs of the leading producers; however, most existing irrigation operations are located in groundwater subareas that are at full allocation preventing local expansion (Vegetables WA, 2014). As such, any future horticultural expansion opportunities are most likely to be north of the Gingin area. The Department of Water (2014) suggested a number of unallocated superficial groundwater resources with potential for irrigation development including Wedge Island subarea with about 25 GL/yr; Namming Lake subarea with 9 GL/yr; and Karakin Lakes subarea with around 5 GL/yr.

This Water For Food project in the Midlands area will investigate groundwater availability and quality at a local scale to support development of new horticultural activities and expansion of existing horticulture. It is intended to confirm the amount, quality and security of water potentially available from groundwater resources to support new growth and development; as well as identify the availability of suitable land that may support irrigated agriculture.
1.2 Scope and purpose

This scoping document will identify the most prospective groundwater resource options in support of expanded irrigated agriculture in the Midlands area from north of Gingin to Badgingarra and Dongara. Given the large size of the project area, there was a need to focus groundwater investigations and supporting studies in the most prospective areas for horticultural precinct development.

In order to support the selection process, this preliminary study proposes a number of groundwater resource / groundwater supply options with potential to support horticultural precincts and/or more intensive, local-scale horticultural development. This document only discusses the groundwater resource potential, and there will be need for additional supporting / linking studies that assess soil suitability and land availability.
2. Project area

2.1 Location

The Water for Project Midlands area extends from Dongara and Badgingarra to the south of Moora and Dandaragan (shown as white outline on Fig. 1). For this study, the project area was extended to the south to include the southern portion of the Gingin Groundwater Area (shown as red outline on Fig. 1).

2.2 Climate

The climate is a Mediterranean-type with hot dry summers and cool wet winters. Average annual rainfall increases southward from 450 mm/yr in Dongara to 600 mm/yr in Gingin, and decreases progressively inland. Most rainfall occurs between April and October with little or no rain during the summer months. Annual evaporation is about 2 m per year and exceeds rainfall for all months except June and July.

2.3 Physiography

The landscape is influenced by the underlying geology of the Northern Perth Basin. At the regional scale, it mostly slopes westward and is drained by westerly-flowing watercourses. There are four dominant physiographic units: Swan Coastal Plain, Arrowsmith Region, Dandaragan Plateau and Yarra Yarra Region (Fig. 2). These units are described in more detail in Playford et al. (1976) and have different landform features that relate to variations in the underlying geology, topography and drainage patterns.

Swan Coastal Plain

The Swan Coastal Plain is characterised by low-lying coastal sediments consisting predominantly of limestone, dune sands and alluvium. The Gingin Scarp marks the eastern boundary of the plain and represents a remnant of the marine processes that eroded the area west of the scarp. The base of the scarp is often poorly drained and almost permanently inundated due to the presence of the clayey and low permeability Guildford Formation. The most common water-related landforms include lagoons, lakes, seasonal swamps and karstic features within the limestone.

Arrowsmith Region

The Arrowsmith Region comprises an undulating and dissected plateau that overlies the Jurassic and Cretaceous rocks. The Gingin and Dandaragan Scarps form the western and eastern boundary of the Arrowsmith Region, respectively. Most of the drainage lines are ephemeral. All of these watercourses terminate in swamps and lakes or sinkholes on the coastal plain, except for the Irwin, Hill and Moore Rivers, which reach the coast.
Figure 1. Water For Food Midlands project area
Figure 2. Physiography (from Rutherford et al., 2005)
Dandaragan Plateau

The Dandaragan Plateau is very similar to the Arrowsmith Region but is less dissected by streams. Most watercourses are sporadic and ephemeral, except in the southern portion of the Dandaragan Plateau where there are a number of perennial groundwater-fed brooks (e.g., Gingin and Lennard Brooks). The Dandaragan and Gingin Scarps form the western boundary and the Darling Scarp marks the eastern boundary of the plateau. The western edge of the Dandaragan Plateau is coincident with subcrop of the Otorowiri Member of the Parmelia Formation along the Dandaragan Scarp.

Yarra Yarra Region

The Yarra Yarra Region is an area of internal drainage between the Dandaragan Plateau and the Darling Scarp and is characterised by swamps and salt lakes. The Yarra Yarra Lakes are terminal salt lakes that receive runoff from the Darling Plateau to the east. In the south, the Coonderoo River flows southward along the line of the Darling Fault to join the Moore River at Moora.

2.4 Geology

The geology has been described in many previous reports and published papers, with regional stratigraphic overviews presented by Playford et al. (1976), Backhouse (1984), and Mory and Iasky (1996).

2.5 Vegetation

Remnant native vegetation covers about 40% of the project area (Fig. 3). There are large areas of native bushland that are preserved along the Swan Coastal Plain within nature reserves and national parks, dominantly comprising low scrub heath (less than 2 m tall). The major national parks and reserves include the Moore River, Nambung, Alexander Morrison, Badgingarra, Mount Lesueur, Drovers Cave, and Watheroo National Parks.

There are large areas of potential groundwater-dependent vegetation throughout the Swan Coastal Plain, primarily associated with the shallow depth to groundwater in the superficial aquifer (Rutherford et al., 2005). Most of these areas are supported by groundwater discharge features including riverine baseflow and springs related to the presence of aquicludes (such as Otorowiri Siltstone).

2.5 Land use

Land use is highly diverse but largely dominated by agricultural activities such as grain cropping, grazing and other horticultural ventures. Most water for domestic and stock uses is sourced from groundwater, soak springs. Broad-acre irrigation occurs mainly in the southeast around Gingin for vegetables, fruit, grapes, olives and timber.

Large amounts of groundwater are used by the petroleum and mining industries for the processing of gas/condensate and industrial minerals. Several hydrocarbon fields occur throughout the Northern Perth Basin with the production of gas and condensate from the Dongara area and Woodada gasfield in the Eneabba area. There is also heavy-mineral sand mining around Eneabba, Cooljarloo and Cataby.
Figure 3. Remnant vegetation cover (from Rutherford et al., 2005)
3. Hydrogeology

3.1 Overview

Most knowledge on the hydrogeology in the Northern Perth Basin has been acquired through regional groundwater investigations by the Geological Survey of Western Australia and more recently by the Department of Water. Six deep east-west borehole lines (from north to south - Dongara Line, Eneabba Line, Watheroo Line, Moora Line, Gillingarra Line and Gingin Brook Line) were drilled in the Northern Perth Basin being about 50 km apart with bore depths of up to 1200 m. In addition, five shallow regional investigations were completed covering the full extent of the Swan Coastal Plain from Gingin to Geraldton. These installed bores form the basis of the Department of Water’s regional groundwater monitoring program and provide ongoing data on aquifer response to changes in abstraction and land management.

This previous work on the hydrogeology of the Northern Perth Basin has been synthesised by Pennington Scott (2010). This document, referred to as the Northern Perth Basin Bulletin, provides the most comprehensive and up-to-date understanding of the hydrogeology and groundwater resources.

3.2 Regional hydrogeology

There are a number of regional aquifers within the Northern Perth Basin with the most significant being the superficial, Leederville–Parmelia and Yarragadee Aquifers. The Lesueur, Eneabba, Cattamarra, Mirrabooka and Poison Hill, and surficial aquifers are considered minor to local-scale aquifers, while the Kockatea Shale, Otorowiri Siltstone and Osborne Formation are important aquicludes that can influence aquifer connectivity.

Superficial aquifer

Quaternary and Tertiary superficial formations on the Swan Coastal Plain host the major unconfined aquifer system in the Northern Perth Basin. The superficial aquifer extends from the coast up to 40 km inland, and consists of predominantly alluvial, shallow marine and aeolian sequences that have been deposited in bands that parallel the coastline. The sediments range from predominantly clayey (Guildford Clay) in the east adjacent to the Gingin Scarp through a sandy succession (Bassendean Sand) in the central coastal plain area, to sand and limestone (Tamala Limestone) within the coastal belt. The aquifer has an average thickness of about 30 m.

The Tamala Limestone is dominated by sand dunes and limestone ridges along the coastal belt. The depth to watertable is variable being at or near surface in topographic depressions and coastal lakes through to greater than 50 m beneath large sand dunes and limestone ridges.

In central and eastern parts of the coastal plain, Bassendean Sand and the underlying Guildford Formation contain numerous springs, swamps, and interdunal lakes that represent areas of groundwater discharge. The Bassendean Sand dominates the central portion of the coastal plain and as the name suggests is sandy with minor clay. The Guildford Formation is often present at the base of the Gingin Scarp and is largely clayey. The water levels are generally less than 10 metres, although shallow water levels occur mainly at the base of the Gingin Scarp owing to the low permeability of the Guildford Formation.
Figure 4. Regional hydrogeology (from Rutherford et al., 2005)


**Surficial Aquifer**

Saturated Cenozoic deposits east of the Gingin Scarp are considered together to form a surficial aquifer that is separate from the Quaternary deposits on the Swan Coastal Plain comprising the superficial aquifer. The surficial aquifer is less productive, more variable in nature, and generally only used for minor local stock and domestic supplies. It typically comprises colluvium, alluvium and lacustrine sediments on slopes and within valleys; deposits filling palaeochannels, including the Capitela and Monger Palaeochannels; and deposits that have infilled the probable impact crater basin at Yallalie.

Water levels are generally close to the surface with groundwater salinity ranging from fresh to saline. Sufficient groundwater for stock and domestic use can be present for exploitation by shallow wells and soaks (Commander, 1981).

**Mirrabooka Aquifer**

The distribution and hydrogeology of the Mirrabooka aquifer is complex and poorly understood. These aquifers occur predominantly on the Dandaragan Plateau and comprise four Late Cretaceous geological units, including Poison Hill Greensand, Gingin Chalk, Molecap Greensand and Mirrabooka Member of the Osborne Formation.

The watertable is discontinuous making it difficult to determine a regional watertable configuration. The depth to watertable is generally less than 10 m in the eastern areas and increases westward (Kay and Diamond, 2001). The aquifer can be prone to waterlogging problems due to poorly developed external drainage and the near-surface presence of impermeable Kardinya Shale Member of the Osborne Formation.

**Leederville–Parmelia Aquifer**

The Leederville–Parmelia Aquifer is a significant multi-layered aquifer system in the Northern Perth Basin, where the Parmelia Formation is unconfined and outcrops on the northern portion of the Dandaragan Plateau. In the southern section of the project area, the Leederville Formation overlies the Parmelia Formation forming a gradational contact in vicinity of Dandaragan. The Kardinya Shale Member of the Osborne Formation locally confines the Leederville–Parmelia Aquifer. The depth to watertable is often large being more than 20 m.

**Yarragadee Aquifer**

The Yarragadee Aquifer is a major multi-layered aquifer system in the Perth Basin, and largely comprises sandstone and minor shale horizons. The aquifer is confined for the most part beneath the Otorowiri Siltstone, and is unconfined where the Yarragadee Formation outcrops between the Gingin and Dandaragan Scarps. The depth to watertable, where unconfined, is generally greater than 20 m except in discharge areas along the Irwin and Hill Rivers.

**Cattamarra Aquifer**

The Cattamarra Formation comprises an interbedded siltstone, shale and sandstone aquifer. The aquifer is associated with the sandstone beds comprising only 25% of the formation. The formation outcrops in a narrow faulted block that is bound by the Warradargee Fault and Lesueur-Peron Faults.
The groundwater in the aquifer is brackish to saline, and is a factor in land salinization to the east of Leeman.

**Eneabba and Lesueur Aquifers**

The Eneabba Formation forms an interbedded confined aquifer that is undifferentiated from the Lesueur Sandstone. The aquifers are bound to the east by the Lesueur Fault and Beagle Fault in the west. The thick shale and siltstone beds of the Eneabba Formation may confine groundwater in the Lesueur Sandstone; however, where the Eneabba Formation comprises sandstone it is indistinguishable from the Lesueur Sandstone.
4. Groundwater resource potential

4.1 Overview of groundwater resources

In the Northern Perth Basin, the largest fresh groundwater resources are contained within the superficial, Leederville, Leederville-Parmelia and Yarragadee Aquifers. Other significant fresh groundwater resources are contained in the Mirrabooka, Cattamarra and Eneabba-Lesueur Aquifers. These aquifers have active groundwater flow systems that receive recharge, and ultimately discharge to the coast, rivers or are utilised by vegetation.

Pennington Scott (2010) suggest that the total fresh stored groundwater resource in the Northern Perth Basin is greater than 3 million gigalitres, being equivalent to about 10,000 years of Perth’s public water supply. The renewable resource is considered to be at least several hundred gigalitres per year.

As part of groundwater resource management by the Department of Water, allocation limits have been determined based on a percentage of average annual rainfall over the aquifer as an estimate of groundwater recharge. The recharge rate varies corresponding to soil types, land use and areas where the aquifer is confined by overlying units. This approach has also set aside a proportion of annual recharge for environmental water requirements to account for the needs of groundwater dependent ecosystems, with the remainder being available for use by private developers or for public water supply.

4.2 Aquifer utilisation

The following discussion on aquifer utilisation is based on descriptions provided in the Northern Perth Bulletin (Pennington Scott, 2010) to provide context on the mixed usage of groundwater resources.

Superficial aquifer

The superficial aquifer is used for town water supplies for Cervantes, Lancelin, Ledge Point and Guilderton and in conjunction with the Eneabba-Lesueur Aquifer for Jurien, Green Head and Leeman. There are numerous domestic garden and industrial users around Jurien; however, there has been limited development between Jurien and Lancelin owing to the lack of available land with most land being preserved in national parks and nature reserves. Significant superficial groundwater resources are used for mineral processing at Cooljarloo. South of Lancelin, there are numerous horticultural users ranging from small market gardens to significant operations that utilise many gigalitres each year. There are also numerous stock and domestic users throughout the Swan Coastal Plain, where water quality permits.

Surficial aquifer

The surficial aquifer provides locally important stock and domestic water supplies. Water levels are often close to surface; however, groundwater salinity is highly variable. The Yallalie Basin and channel deposits, such as those in the Capitela Palaeochannel, may have potential for local-scale development. The shallow depth to watertable suggests that abstraction can be constrained by the proximity to wetlands and other groundwater dependent ecosystems. Previous development of the surficial aquifer has been limited to mainly stock and domestic bores, with limited horticultural or garden use where yields are favourable.
**Mirrabooka aquifer**

The Mirrabooka Aquifer provides water supplies for numerous farm bores, soaks and wells on the Dandaragan Plateau in the Gingin Groundwater Area. There are few known abstractions from this aquifer in the Jurien Groundwater Area; however, the aquifer may extend as far north as the Watheroo National Park. There has been recent success in locating groundwater resources from the Mirrabooka Aquifer to the southwest of Moora near Koojan.

**Leederville aquifer**

Most development in the Leederville Aquifer has been to the south of Lancelin. A proportion of the town water supply for Gingin and Seabird are sourced from the Leederville Aquifer. There has also been significant development of the Leederville Aquifer for agriculture in the Guilderton and Gingin areas, with several developments utilising more than 1 GL/year for horticulture, including vegetables and olives.

**Leederville-Parmelia Aquifer**

The Leederville-Parmelia Aquifer has historically been significant for town water supply in the region. More recently, there has been significant development of the aquifer for irrigated horticulture and pasture. In the Gingin Groundwater Area, the aquifer is extensively used for olives, grapes, tree plantations, and mixed pasture. Further north, in the Jurien Groundwater Area, there are several major horticultural operations that utilise the Leederville-Parmelia Aquifer for citrus, mangoes and stone fruit, together with some pasture and tree plantations. In the Arrowsmith Groundwater Area, the aquifer has been developed for flower farming, olives, pasture, and piped to the east for use in magnetite processing for iron ore mining.

**Yarragadee Aquifer**

Historically the three major users of groundwater from the Yarragadee Aquifer in the region have been the Allanooka town water supply scheme, about 20 km northeast of Geraldton, and the two mineral sands mining areas at Eneabba and Cooljarloo. In the past decade, pasture operations have started drawing significant volumes of groundwater from the Yarragadee Aquifer near Dongara. There are also further pasture developments proposed around Cataby and significant horticultural developments, especially tree plantations, orchards and almonds have been evaluated around Badgingarra and Eneabba.

**Cattamarra Aquifer**

The most significant historical use of groundwater from the Cattamarra Aquifer has been for mineral sands mining near Eneabba at the Eneabba West Mine, which is no longer operational (Rockwater, 1990). There is some limited horticultural development where water quality and yields permit, with the remaining use primarily for stock and domestic purposes.

**Eneabba-Lesueur Aquifer**

The Eneabba-Lesueur Aquifer has been developed for town water supplies for Green Head, Leeman and more recently Jurien and has in the past been used for processing in mineral sand mining around Jurien (McPhar Geophysics, 1975). Limited use is also made of the aquifer for pasture irrigation (Kern, 1997) with the remainder used for stock water, and domestic and garden purposes.
5. Prospective groundwater resources for horticultural precincts

This section provides an overview of the key groundwater resource options and most prospective areas for horticultural precinct development. The areas have been identified at a preliminary level as having potential to support horticultural precincts and/or more intensive, local-scale horticultural development. The descriptions below provide a brief overview of the groundwater resource potential, possible limitations and important references that provide additional detail on the hydrogeology.

This assessment is preliminary and provides a first-pass consideration of the more prospective groundwater resources for horticultural purposes in the project area. Prior to the final selection of the investigation areas, it will be necessary to undertake additional supporting / linking studies that assess soil suitability and land availability.

A total of 11 prospective groundwater resource / groundwater supply options have been recommended in the Midlands project area – four in the Gingin Groundwater Area; three in the Jurien Groundwater Area; and four in the Arrowsmith Groundwater Area (Fig. 5). There has been no attempt to prioritise these options, as it is recommended that further studies are required that consider soil suitability and land availability.

All groundwater supply options are positioned in various aquifers of the Northern Perth Basin. The rising of the watertable over past 40 to 50 years associated with land clearing provides opportunities for utilising this new and increased groundwater storage for horticultural purposes. The recommended areas have been selected where groundwater salinity is less than 1000 mg/L TDS; the depth to watertable is less than 50 m bgl (Fig. 6); there is either available or potential for reviewing allocation limits; and are not near sensitive groundwater-dependent ecosystems.
Figure 5. Location of prospective groundwater resource areas
Figure 6. Depth to watertable at prospective groundwater resource areas
- adapted from Pennington Scott (2009)
5.1 Gingin Groundwater Area

Four prospective groundwater resources for horticultural development have been identified in the Gingin Groundwater Area. There are water resource allocation issues for review and re-evaluation for each proposed area requiring an appreciation of the proportion of actual water usage with respect to existing allocations.

Karakin

Characteristics: The area is to the north of Cowalla Road horticultural precinct, south east of the Moore River (Fig. 7), and is likely to have fresh groundwater in the superficial aquifer. It is south of the WFF project area; however, it is worthy of consideration as there is no obvious horticultural development.

Aquifer: Superficial (Leederville as a secondary target)

Allocation status: To be confirmed – possible availability in Karakin Lakes subarea

Depth to water: Less than 20 m bgl

Salinity: Superficial aquifer has 500 to 1000 mg/L TDS groundwater salinities that become increasingly brackish towards the Moore River and west of the river. The Leederville Aquifer has 500 to 1000 mg/L TDS groundwater salinities.

Bore yield: High – commonly above 500 kL/day

Soils: To be confirmed - most likely Spearwood Sands

Land tenure: Private cleared land

GDE constraints: Small wetlands such as Bidaminna Lake; the Moore River; and the Moore River National Park is located to the east


Figure 7. Location setting of Karakin prospective area
**Mimegarra**

**Characteristics:**
The area is a possible extension of Cowalla Road horticultural precinct on the northern side of the Moore River in the Karakin Lakes, Lancelin and Wedge Island subareas. There is already large existing irrigation along Nilgen Road (Fig. 8).

**Aquifer:**
Superficial (Leederville as a secondary target)

**Allocation status:**
To be confirmed – possible availability in Karakin Lakes and Wedge Island subareas

**Depth to water:**
Watertable is shallower to the east being less than 20 m bgl, but increasing towards to the west being up to 50 m bgl

**Salinity:**
Superficial aquifer has groundwater less than 500 mg/L TDS in the south and 500 to 1000 mg/L TDS in the north

**Bore yield:**
To be confirmed - likely to be high

**Soils:**
To be confirmed - eastern edge of the Spearwood Sands

**Land tenure:**
Some cleared farmland but mostly uncleared in the north

**GDE constraints:**
Varied wetlands from coastal swales through to potential perched systems upon the Guildford Formation

**References:**
Figure 8. Location setting of Mimegarra prospective area
**Cullala**

**Characteristics:** This area, shown in Figure 9, is located near the Darling Scarp and based on information from Red Gully Bore RG2 associated with a thinly saturated portion of Mirrabooka Aquifer. There has also been local-scale groundwater resources located in the surficial aquifer, such as at Barn Road Aquifer. This is considered a lower priority, as there is little information and prospects are small.

**Aquifer:** Mirrabooka, surficial

**Allocation status:** To be confirmed

**Depth to water:** Highly variable – surficial aquifer less than 20 m bgl but may be up to 50 m bgl in Mirrabooka Aquifer

**Salinity:** Very low less than 500 mg/L TDS

**Bore yield:** To be confirmed

**Soils:** To be confirmed – most likely red weathered greensand loams

**Land tenure:** Most of the area is under Nature Reserve in the vicinity of Wannamal Lakes; however, there is some private cleared land.

**GDE constraints:** Wannamal Lakes and adjoining areas; upper reaches and recharge area for the Gingin Brook

**References:**


Figure 9. Location setting of Cullala prospective area
Capitela

Characteristics: This area is located south of Dandaragan and Moora (Fig. 10). It has a complicated geology with infilled valleys (surficial aquifer), weathered greensands (Mirrabooka Aquifer), Kardinya Shale (aquitard resulting in land salinisation issues) and underlain by the Leederville-Parmelia Aquifer. There is also a recently-discovered palaeochannel, known as the Capitela Palaeochannel, which flows from the Darling Scarp and merges with Caren Caren Brook.

Aquifer: Surficial, Mirrabooka, Leederville-Parmelia

Allocation status: Groundwater resources in surficial and Mirrabooka Aquifers are poorly estimated, and Leederville-Parmelia Aquifer is most likely fully allocated

Depth to water: Highly variable – less than 20 m in surficial but may be up to 50 m bgl in Mirrabooka Aquifer towards the north.

Salinity: Less than 500 mg/L TDS in the surficial and Mirrabooka Aquifers. In the Leederville Aquifer, it is less than 500 mg/L TDS towards the west but becomes increasingly saline in the east

Bore yield: Highly variable – some bores in surficial and Mirrabooka Aquifers capable of more than 1000 kL/day

Soils: To be confirmed – commonly white sands in valleys and red weathered greensand loams on slopes

Land tenure: Mostly cleared private land

GDE constraints: A number of wetlands and waterholes within Caren Caren Brook. Yangy Lake is an ephemeral wetland within the Capitela Palaeochannel.

Figure 10. Location setting of Capitela prospective area
5.2 Jurien Groundwater Area

Three prospective groundwater resources for horticultural development have been identified in the Jurien Groundwater Area. There are a range of different aquifers from superficial through Yarragadee Aquifer for consideration with some areas requiring a review of allocation limits with respect to drawpoints and the reserving of groundwater resources for public water supply.

Hill River

Characteristics: This area is a groundwater discharge area for the Yarragadee Aquifer with groundwater baseflow contributing to surface water flows in Hill River (Fig. 11). There is no existing irrigation, but there may be potential for horticultural development associated with the alluvial flats.

Aquifer: Yarragadee

Allocation status: To be confirmed - Badgingarra subarea

Depth to water: Highly variable depending on topography – less than 20 m bgl near river but increasing to 40 m bgl away from river.

Salinity: Less than 500 mg/L TDS (300 to 500 mg/L in WL10)

Bore yield: To be confirmed

Soils: Alluvial flats derived from Yarragadee Formation

Land tenure: Large cleared lots

GDE constraints: Nature reserve along the river. The Hill River Spring has been identified as a potential GDE (#55) in Rutherford et al. (2005)

Reference:

Figure 11. Location setting of Hill River prospective area
Jurien

Characteristics: This area is positioned to the east of Jurien town site and in the eastern part of the Swan Coastal Plain (Fig. 12). There has been recent property subdivision which may restrict or diminish the potential of this resource for horticultural development. This resource has been previously developed for the Black Sands Borefield which was operated for many years.

Aquifer: Superficial, Lesueur Sandstone

Allocation status: To be confirmed. Cervantes subarea – the Lesueur Aquifer is fully allocated for future public water supply and should be reviewed for release; and there is also available allocation in the superficial aquifer

Depth to water: Typically less than 40 m bgl

Salinity Less than 1000 mg/L TDS – commonly between 400 to 700 mg/L TDS

Bore yield: To be confirmed - more than 1000 kL/day

Soils To be confirmed - Spearwood and Bassendean Sands

Land tenure Cleared private land

GDE constraints: Drovers Cave National Park and Hill River


Figure 12. Location setting of Jurien prospective area
**Dinner Hill**

**Characteristics:** This area is positioned in the eastern Dandaragan Plateau, to the north of Moora and Dandaragan (Fig. 13). There has a range of horticultural developments in the area with most substantial being olive production at Dandaragan Estate (Dandaragan Olives) just across the southern boundary in the former Victoria Plains subarea.

**Aquifer:** Leederville-Parmelia; possibly Mirrabooka.

**Allocation status:** To be confirmed – the Leederville-Parmelia Aquifer is possibly fully allocated; however, most allocation is associated with Dandaragan Estate which is present in the southwest corner of the Dinner Hill subarea and suggests other allocation may be considered in the north of the subarea.

**Depth to water:** Shallower near Minyulo Brook being less than 30 m bgl but increasing to the east.

**Salinity**
- Some areas of less than 500 mg/L TDS but mostly 500 to 1000 mg/L TDS

**Bore yield:** Very high

**Soils:** To be confirmed - sandplain on Kardinya Shale and greensands

**Land tenure:** Large lots of cleared private land

**GDE constraints:** Springs along Minyulo Brook (Muthawandery Spring) associated with discharge from Leederville aquifer

**Reference:**
- Balleau, W.P. and Passmore, R., 1972, Geology and groundwater resources at the Agaton exploratory Borefield, Geological Survey of Western Australia, Record 1972/11.
Figure 13. Location setting of Dinner Hill prospective area
5.3 Arrowsmith Groundwater Area

Five prospective groundwater resources for horticultural development have been identified in the Arrowsmith Groundwater Area. There are a range of different aquifers from superficial through Yarragadee Aquifer for consideration with some areas requiring a review of allocation limits with respect to drawpoints and reviewing the current / future usage by mineral sands operations.

Irwin River Valley

Characteristics: This area is associated with the broad valley and fringing flats of the Irwin River (Fig. 14). It is located to the southeast of the locality of Irwin. There is groundwater discharge from the Yarragadee Aquifer at Irwin and Mendara Springs in the river.

Aquifer: Yarragadee

Allocation status: To be confirmed

Depth to water: Possibility of artesian flow

Salinity: Possibly less than 750 mg/L TDS based on data from Dongara Line

Bore yield: High

Soils: Alluvial and weathered Yarragadee Formation

Land tenure: Numerous small lots

GDE constraints: Riparian vegetation within the Irwin River as well as Irwin and Mendara Springs identified as potential GDE (#7 and 9) in Rutherford et al. (2005)


Figure 14. Location setting of Irwin River Valley prospective area
Greenough Flats

Characteristics: This area is associated with the alluvial plain of the Greenough River and narrow coastal plain (Fig. 15), which generally underlain by brackish to saline groundwater. There is some limited irrigation that is potentially using brackish groundwater. Further work is required to determine the source water from the adjacent Yarragadee aquifer to the east. Some studies have been completed for Waldeck’s table grape vineyard; however, this may be supplied from scheme water. To the north, the tomato growers in Geraldton tend to use scheme water.

Aquifer: Superficial and underlying/adjacent Yarragadee
Allocation status: To be confirmed
Depth to water: Shallow – less than 20 m bgl
Salinity: mostly above 2000 mg/L TDS in the superficial aquifer
Bore yield: To be confirmed
Soils: To be confirmed – alluvial and coastal limestone
Land tenure: Variety of small to medium sized lots that are all cleared
GDE constraints: Back-dune coastal swale wetlands such as Nhargo Spring - identified as potential GDE (#5) in Rutherford et al. (2005)
Figure 15. Location setting of Greenough Flats prospective area
Eneabba Plain

Characteristics: This area is associated with alluvial fans on the eastern edge of the coastal plain at the foot of the Gingin Scarp that broadly extends from Eneabba to Irwin (Fig. 16).

Aquifer: Yarragadee

Allocation status: Large allocations to mineral sands mining

Depth to water: 30 to 50 m bgl

Salinity: 350 to 700 mg/L TDS in mineral sand borefield at Eneabba and less than 1000 mg/L TDS towards the north. The groundwater becomes brackish close to the Arrowsmith River.

Bore yield: Potentially large, some bores at Eneabba mineral sands mine are capable of up to 6000 kL/day

Soils: Silty sands derived from weathered Yarragadee Formation

Land tenure: Large, mostly cleared lots. There are extensive mineral sand exploration and mining tenements, as well as a Nature Reserve to the south of Irwin.

GDE constraints: There are a number of springs and wetlands at the base of the scarp – these may be associated with shallow Guildford Formation.

References: Commander, D.P., 1981, Hydrogeology of the Eneabba Area, Perth Basin, University of Western Australia, MSc Thesis.

Figure 16. Location setting of Eneabba Plain prospective area
**Mingenew and Tathra**

**Characteristics:** These two areas are located on the Dandaragan Plateau (Figs. 17 and 18), which have limited irrigation at present. The watertable is deeper in these areas preventing large-scale irrigation; however, there may be potential for large yields from the Parmelia Aquifer towards the west / Dandaragan Scarp.

**Aquifer:** Parmelia

**Allocation status:** Mingenew and Tathra subareas

**Depth to water:** 30 to 60 m becoming deeper to the east

**Salinity:** 500 - 1000 mg/L TDS; however, there may be areas of less than 500 mg/L TDS in the south

**Bore yield:** To be confirmed - likely to high

**Soils:** To be confirmed - sandplain

**Land tenure:** Large, mostly cleared lots

**GDE constraints:** Arrowsmith River and Otorowiri Spring along the Dandaragan Scarp - elsewhere deep watertable.

**References:**

Commander, D.P., 1981, Hydrogeology of the Eneabba Area, Perth Basin, University of Western Australia, MSc Thesis.


Figure 17. Location setting of Minegnew prospective area
Figure 18. Location setting of Tathra prospective area
7. Conclusions

The ongoing demand for vegetables for Perth has led to interest in horticultural expansion and development of the land and water resources to the north of Gingin. This Water for Food project was recommended to provide information on water and land availability for growth and development of the horticultural industry. The confirmation of local-scale groundwater resources may provide new opportunities for the development of new horticulture precincts.

This preliminary scoping assessment proposes a number of groundwater resource / groundwater supply options with potential to support horticultural precincts and/or more intensive, local-scale horticultural development. Only the groundwater resource potential has been assessed and described; as such, there is need for additional supporting / linking studies to assess soil suitability and land availability.

A total of 11 prospective groundwater resource / groundwater supply options have been recommended in the Midlands project area with four in the Gingin Groundwater Area; three in the Jurien Groundwater Area; and five in the Arrowsmith Groundwater Area. Despite no attempt to prioritise these options as further studies are required to evaluate soil suitability and land availability, the more prospective areas are likely to be within the superficial aquifer (Karakin and Mimegarra areas); Jurien in the superficial and Lesueur Aquifers; and Eneabba Plains and Hill River in the Yarragadee Aquifer. The watertable is likely to be deeper in those areas on the Danadargan Plateau (Mingenew, Tathra and Dinner Hill). The Greenough Flats and Cullala area are the least likely prospects for horticultural development.

All selected groundwater supply options are positioned in various aquifers of the Northern Perth Basin. The rising of the watertable over past 40 to 50 years associated with land clearing provides opportunities for utilising this new and increased groundwater storage for horticultural purposes. The recommended areas have been selected where groundwater salinity is less than 1000 mg/L TDS; the depth to watertable is less than 50 m bgl; there is either available or potential for reviewing allocation limits; and are not near sensitive groundwater-dependent ecosystems.

Despite a regional appreciation of the hydrogeology and groundwater resources in the Midlands project area, there is local-scale variability that can result in some poor success in securing water supplies. In addition, there are large gaps in the Department of Water’s bore monitoring network that may prevent a reassessment of allocation limits in some of the recommended areas. This project provides an opportunity to improve the local-scale understanding of groundwater resources by addressing the monitoring network gaps by installing new monitoring bores and providing baseline monitoring of groundwater levels.
8. References


Balleau, W.P. and Passmore, R., 1972, Geology and groundwater resources at the Agaton exploratory Borefield, Geological Survey of Western Australia, Record 1972/11.

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