EXECUTIVE SUMMARY

Historically horticultural land has been developed on the fringes of the urban area of Perth. Land for horticulture has been taken up as freehold broadacre agriculture land and in time increasing land values have funded either future land and water supply purchases further from the fringe or retirement for the horticulturists. This pressure from urban expansion is active in the important east Wanneroo horticulture district and groundwater reserves are over allocated. A replacement for land that will be lost to domestic and industrial uses is urgently required.

The Western Australian Planning Commission has identified a precinct that can be developed for horticulture at Carabooda. It is already well developed, with about 1,000 ha of the 1,800 ha precinct under freehold and more than 60% cultivated. Expectations for freehold land are necessarily different than development conditions that might be imposed on a green-fields site.

DEVELOPMENT SCENARIOS

Three development scenarios have been developed as approaches to addressing the pressure being exerted on horticultural land in east Wanneroo.

1. A Dedicated Horticulture Precinct including the existing freehold land supplemented by the cultivation of up to 1000 ha of existing pine plantation land for horticulture. Some land could be allocated to organic vegetable production. In total about 3,000 ha of pine plantation must be harvested to develop the precinct. The new land will be leased by the government to growers and irrigated by recycled water from the Alkimos Waste Water Treatment Plant (WWTP) as it comes on stream, leading to a development timetable of 40 years. Best practice irrigation will be a condition of the release of the new leasehold land and associated water licences. Projected water supply rates will fall short of daily requirements at the hottest time of year so storage will be required within the precinct. Consequently the cost of water is likely to be even higher than the Class A water that will be delivered to the precinct. For growers using recycled water to compete with others on self supply systems a government subsidy will have to be considered. Wastewater recycling for irrigation purposes has been subsidised by government in Victoria and South Australia to meet other government policy objectives. The cost of the subsidy could be recovered by the sale of newly developed land in the precinct. Strict land use conditions would be applied at sale to ensure that a long term commitment of the precinct to horticulture is guaranteed.

2. Continued production on the fringe of the Metropolitan Area. Historically horticulture has always been located on the fringe of the metropolitan area, with the established areas eventually overtaken by urban expansion. Suitable land is generally not a limiting factor for horticulture in Western Australia and hence this form of agricultural development can continue as long as the areas on the urban fringe have access to water and growers wish to produce crops that are advantaged by a readily accessible labour force, especially family labour. This approach preserves a small but active horticultural “sense of place” for the Wanneroo and Baldivis communities and retains some urban agriculture for Perth. Crops better suited to mechanisation will tend to be located on larger farms more distant from the metropolitan area and in more stable locations by introducing guaranteed water supplies, mechanisation for crop management and harvesting, and a trained labour force with accommodation near to the production site.

3. Greenfields horticulture development requires a State commitment to expanding horticulture in Western Australia that can be enacted by dedicating significant areas of suitable land and associated water resources to horticulture production, without the pressure of urban expansion. Areas to the north and south of the expanding metropolitan area that can satisfy this need are nominated. The Gingin Shire is already established as an important production area for horticultural crops, especially carrots. Similarly the Harvey Shire is establishing as an important location for vegetable production. While no local groundwater areas have more than 10GL/yr available, this water can be allocated to horticulture along with land, and horticulture farms could be established. Water reserved for metropolitan supply could be replaced by alternative sources such as desalination and managed aquifer recharge, allowing the reserves to be freed for horticulture. Soft leafy lines requiring high labour inputs can be accommodated by retaining small urban horticulture plots based on self supply from groundwater reserves currently allocated to horticulture in the north and south of the metropolitan area.

HORTICULTURE PRODUCTION

Fruit and vegetable production is and has always been important in and close to the metropolitan area. The Wanneroo local government area is particularly important for vegetable production where its planted area ranks fourth in the State and in 2001 it had nearly
half of the vegetable growers in Perth.

The Department of Agriculture and Food estimated the value of the horticulture sector in 2006-07 at $646 million representing 12% of the total value of the food and fibre sector in the State. Exports represented nearly one quarter of this production ($150 million).

The Wanneroo accounted for 42% of the total metropolitan horticultural production area in 2005-06 and this area represented about 5% of the State area. Substantial areas were devoted to nurseries, flowers, turf farms, and vegetables.

The main vegetables in the Wanneroo area are lettuce, broccoli, sweet corn, tomatoes, beans, celery and cabbages. These crops covered 83% of the total area planted to vegetables in 2005-06. Of the fruits strawberries and avocado are most important.

Strawberry production accounted for about 54% of WA production and avocados 36%.

The eight crops with the largest planted areas combined to cover 88% of the planted area – tomatoes, lettuce, broccoli, cabbages, strawberries, celery, beans and sweet corn. With the exception of tomatoes and beans these crops individually made up a substantial proportion of State plantings (over 35%). Wanneroo accounts for over half (58%) of the planted area in the State for strawberries, 38% of the area for nurseries and 30% of the turf farm area, but is far less significant in cut flowers.

Vegetables for which the Wanneroo area provides at least 25% of State production occupied 1,037 hectares in 2005-06. With buffer areas, a total precinct of 2,500 hectares in 40 years time might be justified on this basis.

Vegetable production from Local Government Areas located at least in part on the Gnangara Mound account for more than 20% of the State’s vegetable production with the more highly mechanized carrot cropping important on the northern edge of the mound (the Guilderton area).

A comparison of eleven vegetable producing areas in Western Australia confirmed that most were well suited to their production niche, with reliable water supplies being an advantage for Kununurra and the Swan Coastal Plain, especially if recycled water is made available to a precinct at Carabooda. If climate is given a greater importance in the analysis the Swan Coastal Plain is favoured again, but only marginally. Areas such as Kununurra have more marked seasonal production constraints than the Swan Coastal Plain.

THE CARABOODA PRECINCT

The area of the Carabooda precinct totals 1895 hectares. The portion on the west of Old Yanchep Road is generally developed and predominantly in freehold ownership while on the east it is primarily State Forest under pine plantation. The developed private land is generally within the Spearwood soil landscape system and pine plantation land to the east also falls within the Spearwood soil landscape system. There is sufficient land that is well suited to vegetable production.

In a recent survey, growers in the affected areas expressed comfort with access to leasehold land and the use of recycled water, the latter on the condition of meeting industry safety and quality assurance standards. Growers currently pump their own groundwater supplies at a cost of less than ten c/kL. They were conscious of the need for any piped supply to be able to cater for cooling irrigations on very hot days.

GROUNDWATER TO THE NORTH OF PERTH

Growth in population in the South West of Western Australia has progressively increased the demand for water for domestic, agricultural, industrial and recreational uses across the region. Expansion of horticultural activities into the export market has increased water demand at rates that exceed general population growth rates. The stresses on the regional water resources have reduced the water potentially available to support further growth at an acceptable cost. The unit costs of water from the less conventional sources (e.g. desalination) are higher than traditional sources such as self-supplied ground and surface water.

The Gnangara Mound is the most important water source in Western Australia, generating and supporting significant wealth for Perth and the greater metropolitan area. It provides more than 60% of Perth’s water and supports a thriving horticulture industry which provides Perth with a significant proportion of its fresh vegetables. The Mound also serves vital and valued eco-systems such as the iconic caves system at Yanchep and the numerous wetlands and lakes of the coastal plain. Licensed groundwater allocations for irrigated horticulture over the Gnangara Mound total about 66 GL/yr (21 GL/yr in Wanneroo). A total of about 2,500 ha of land is used for irrigated horticulture in the east Wanneroo area. Regional groundwater availability figures indicate the paucity of
water in the northern Perth area, but indicate that significant volumes may be available in the Perth South, Gingin and South West Coastal groundwater areas.

**WATER SOURCES, SUPPLY AND PRICING**

The availability of groundwater from the Gnangara Mound for growth in horticulture in the areas north of Wanneroo is extremely limited. The Department of Water is seeking to reduce allocations to private and public use to enable environmental water level criteria to be met. Water to support growth in horticulture could be obtained by trading of allocations from properties outside the proposed precinct, or by importing water from sources other than local groundwater. Trading of allocations effectively results in a transfer of the geographical location of environmental impacts. Groundwater sources are completely allocated so opportunities for trading are extremely limited. In any case transport costs are likely to be prohibitive.

In terms of a Carabooda horticultural precinct, the primary opportunity for supply additional water appears to be the use of recycled water from the Beenyup and Alkimos wastewater treatment plants. A detailed outline of treatment and standards for recycled water is given in the report. Only Class A water can be used for unrestricted horticulture crop irrigation. Examples of the use of recycled water for horticulture irrigation are given for the Werribee Plains near Melbourne in Victoria and Virginia Plains near Adelaide in South Australia. Both schemes serve to reduce the outflow to the ocean and meet Government recycling targets. The Werribee Plains vision statement recognises that the “Market is not yet prepared to pay a commercial or cost recovery price for the recycled water despite the lack of water in the region.”

In the USA recycled water is used in the key vegetable producing areas of the Salinas and San Joaquin Valleys. Agriculture dominates the economy of the Salinas Valley. Most of the salad greens consumed in the U.S. are grown within this region. The area has earned itself the nickname, "America’s Salad Bowl." The national supply role of the Salinas Valley confirms that many salad vegetables can successfully be transported over large distances to market.

It appears that only the Alkimos WWTP source will be available for a Carabooda Precinct and with 5 GL/yr available by 2020 that would support only 350 to 500 ha of irrigated horticulture. The plant cannot supply 10 GL/yr (650 to 1,000 ha) until 2040. Supply costs for the recycled water are likely to be about 50 c/kL, with storage and reticulation costs additional to this. These costs should be compared to the costs of direct self-supply of groundwater of $0.7/kL.

**WASTE STREAMS AND COMPOST**

In Western Australia the average organic matter content in the topsoil ranges from 0.5% to 1.5% with many farmed soils having a sandy texture, especially the soils used for horticulture on the Swan Coastal Plain. This identifies a clear opportunity for separated municipal solid waste organic material to be recovered and used as compost to replenish the organic material in our poor soils. The use of composted municipal solid wastes has been well researched and shown to benefit the growth of horticultural crops. In spite of successful trials and demonstrations the use of compost by horticulture producers in Western Australia is not widespread. The establishment of a dedicated horticultural precinct at Carabooda offers the opportunity to encourage the application of composted materials, further supporting Government recycling objectives by reducing the costs of landfill.

Uncertainty remains about the costs and benefits of urban organic wastes to compost for agricultural use. While the compost itself is proving to be a worthwhile addition to poor sandy soils, the overall community net benefit is far from clear. To this concern must be added the conflict that arises with the development of waste treatment facilities. The location of these in urban areas is creating as much controversy as landfill sites.

There is no compelling economic case at this stage for diversion of urban organic wastes to compost production. However, there is a government commitment to divert waste from landfill and it is sensible that organic wastes are recycled in some form. Whether the horticulture sector represents the most suitable outlet justifies further dedicated study.

**ENVIRONMENTAL RISKS**

Although the Environmental Protection Authority has expressed in principle support for water recycling it has noted that projects involving recharge to aquifers would require formal assessment under the Environmental Protection Act 1986. The EPA believes that substantial work is necessary prior to implementing large schemes if very high levels of treatment such as reverse osmosis and disinfection, were not to be employed. The EPA recommends a
staged approach initially involving trials and projects of low risk.

The key environmental risks associated with recharge of recycled water have been identified by the EPA as being:

- Groundwater contamination,
- Surface and marine water contamination, and
- Ecosystem degradation.

The two primary aspects of the environmental risks directly associated with a horticultural precinct are associated with the water resource. These are water quality impacts of the proposed land use on the underlying water resources and drawdown impacts of groundwater abstraction affecting groundwater dependent ecosystems. Composted urban and agricultural organic wastes offer potential to address risks for water resources while enhancing other environmental values.

Other risks may be associated with local soil conditions such as the potential to develop acid sulphate soils and Carabooda lies in a low risk area.

**ECONOMIC FACTORS**

A reliable water supply is clearly the key driver for any irrigation enterprise. Vegetable production in Western Australia and some fruits (such as strawberries) would not be grown without an irrigation water supply. Across Australia, ABARE estimated that 82% of vegetable farms irrigated their vegetable crops in 2005-06.

Wastewater could be delivered from the Beenyup wastewater treatment plant to a precinct at Carabooda for a capital cost of $86.5 million. This would provide an annual allocation of 10 GL with a daily maximum delivery of 45 ML and a scheme life of 50 years. The whole of life scheme cost is put at 88 c/kL. There are no estimates of the reticulation cost at this stage, but depending on the storage requirements and pumping costs, they may be significant.

A supply from the proposed Alkimos treatment plant would be less expensive than Beenyup due to the shorter pipeline distance, but a supply of 10 GL a year is not forecast to be available before 2038. The estimated water supply cost of 88 cents/kL compares with an estimate of the current value placed on water of 35 cents. This does not include the cost to store or reticulate the water through the precinct. Growers suggest that storage in the precinct is necessary to ensure a large volume of water is available for the very hot days in summer when all growers will want to water valuable crops and water is also used for cooling crops. Farmers with an allocation in Wanneroo have suggested a water supply cost of less than 10 c/kL.

Clearly growers will not choose to use recycled water unless other options are not available to them or it is made financially attractive for other reasons. Growers might use it under the following conditions:

- The cost was subsidised;
- The option carried a long term guarantee of supply;
- There is no alternative water supply at lower cost in locations where the same crop can be grown and marketed at similar cost.

A recent study using a gross margin approach to estimating the value of water to agriculture concluded that on average, the residual value to water is only marginally above pumping costs.

Horticulture Australia has prepared a strategic vision for Australia that provides guidance on the trends in that industry. The sector faces promising market developments with a rising world population, a trend to greater urbanisation and a growing awareness of the value of vegetables in diet. With increasing disposable incomes there are opportunities for increased fruit and vegetable production. On the supply side, Horticulture Australian believes that the capacity of the Australian industry to supply vegetables far exceeds domestic demand.

Farms producing vegetables and fruit in the Wanneroo area range greatly in size and complexity of operation. Small farms often produce crops that depend heavily on family labour and management. As farm size increases more mechanisation is introduced and casual and permanent labour become more essential. Larger farms have often sought land more distant from the metropolitan area and have encouraged a local permanent labour force by supporting their employees with travel or accommodation.

A simplistic economic analysis of the value of the precinct to Western Australia draws positive conclusions for the location of a precinct at Carabooda or similar locations. The largest single annual cost is the community cost associated with any lost labour, estimated at $20 million. To this can be added a potentially higher cost for fruit and vegetables, produced elsewhere, of $10 million per year. Offsetting these costs are higher energy costs of at least $5 million and a wastewater subsidy projected at
$13 million.

While the analysis is positive the assumptions should be further tested. Significantly more work is needed to determine that issue and current data sources will not provide the information needed.

In the current full employment economy, job losses will be minimal reducing this community cost significantly. In less prosperous times, the cost will be more important.

While the study has recognised that rapidly rising fuel prices will impact on food prices and potentially on the value of a horticultural precinct near Perth no detailed analysis has been undertaken. Such an analysis is recognised as important, but considered beyond the scope of this study. The Government might still choose to preserve suitable land close to the metropolitan area.

**GOVERNMENT INVOLVEMENT IN PROTECTING HORTICULTURAL LAND**

Traditionally, vegetable farms have been located close to urban areas due to the demands for labour and fast market access. In dry places like Western Australia towns tend to be located in areas with water supplies and the same areas are attractive for vegetable farms.

Development pressures are far higher in urban and peri-urban localities than rural and remote centres. The North West Corridor, particularly Wanneroo, has significant strength in primary production. One of the major sectors is horticulture which is almost solely driven by the strength of the sector in Wanneroo. As horticulture and urban development approach each other the risk of land use conflict becomes strong. Conflicts most commonly arise from spray drift, noise, dust and odours with spray drift the greatest risk. Separation of conflicting activities and the use of vegetated buffers are accepted as the standards so urbanisation can exist relatively closely with horticulture. The role for government is to evaluate whether this progression is in the broader interests of the community or whether the dedication of land for such purposes provides greater community benefits.

The issue of food quality in this study is essentially tied to distance to market and perishability as production and packaging and handling methods are likely to be very similar for different growing locations. Any quality issue will be related to the time from harvesting to consumer. Some products are more sensitive than others.

Food security requires that there should be an available and reliable food supply at all times. One aspect of Australia’s approach to food security suggests the need to retain sufficient vegetable production capacity in Western Australia to satisfy local food needs. While the main contributing factor to food insecurity is living on or below the poverty line, the loss of access to local fruit and vegetables may lessen options for addressing food insecurity.

Freehold landowners including horticulturalists have an expectation that as the urban area extends towards their property the land will be rezoned for urban development, with a consequent capital gain over and above that which could be expected over time as horticultural land. Accordingly if the Government is to provide lots with access to a Government financed and subsidised (either fully or partially) recycled water scheme, it is reasonable that the Government would expect that such lots would have restrictions placed upon their disposal to subsequent buyers to ensure that any future capital gain (either partially or fully) is recouped to assist in recovering the initial outlay. The government can choose to recover water subsidy costs by selling the land to vegetable growers and other farmers in a precinct as it is developed. This would still be accompanied with strict land use conditions associated with the supply of recycled water to the blocks.

Leasehold arrangements would be possible, but this will be less attractive to some buyers who would seek to use the property as security against which they would raise loans for capital expenditure. Some Carabooda growers have indicated that leasehold land can be acceptable for their purpose.

The Carabooda precinct lies 5km north east of the current urban front in the suburb of Butler and within 10km of the coast. As the urban area expands, the area will become attractive to residential development and is likely to be under strong urban pressure well within the 50 year lifespan of the wastewater delivery system. Current urban planning has identified future urban development areas that do not include the Carabooda horticulture area. Such planning may be sufficient to avoid expectations for future land use changes to residential.
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1. INTRODUCTION

In August 2007 the Western Australian Planning Commission (WAPC) and the Department for Planning and Infrastructure (DPI) released a land use concept for the East Wanneroo Area. This report was initiated as a result of the problems being experienced in the traditional market gardening areas of East Wanneroo, which, through a combination of drying climate and limited water supplies, were experiencing operational difficulties. Apart from this, the continued urban expansion of Perth northwards was placing pressures on the East Wanneroo area for land use change.

The resulting land use concept made provision for new urban development in south east Wanneroo. This concept, however, was predicated on the establishment of a secure agricultural/horticultural precinct in North Wanneroo consisting of the existing rural area (private land) in north east Carabooda and a new area east of the existing Carabooda/Nowergup rural areas on land currently under pines in State Forest 65. Potential was recognised for other areas to the north and/or south of Neaves Road (Crown land to be included) (Plate 1).

The report considered that the new precinct would be based on the use of recycled waste water for irrigation and would have multiple benefits including the replacement of existing market garden areas in east Wanneroo.

**Plate 1 The Identified Precinct**

See plate on the following page.

The report recognised that:

“A coordinated whole of government approach to management of the land and water resources of the Gnangara Mound is needed to deliver a sustainable solution to the competing demands on the groundwater resource to all sectors of the community.”

In accordance with the concept this report investigates the feasibility of a recycled water scheme to provide for the growth of the agricultural/horticultural industry in north east Wanneroo with security of water supply and land tenure.

Implementation of the concept also provides an opportunity for the Government to put into action some of the principles of sustainable environmental management of land, water, wetlands and agricultural resources promoted in the State Sustainability Strategy, State Water Strategy and State Planning Strategy.

Additionally the proposed Gnangara Sustainability Strategy provides an opportunity for a coordinated inter-agency management strategy for the sustainable use of land and water.
EAST WANNEROO LAND USE CONCEPT

THE FEASIBILITY OF A NEW HORTICULTURE PRECINCT ON THE GNANGARA MOUND
resources of the Gnangara Mound.

Within the above context this report investigates the above concept in greater detail. It considers:

- The economics of food production in close proximity to the Perth metropolitan area;
- Necessary infrastructure capital costs and how these may be funded;
- Comparison of social, environmental and economic costs and benefits of using recycled water for horticulture compared to other uses including public drinking water supply options;
- Environmental issues including potential contamination to public water sources;
- Public perception and acceptance of the use of recycled water for growing edible products.

Site specific issues to north east Wanneroo (Carabooda precinct) investigated include:

- Land capability
- Transport links
- Buffer areas and setbacks to wetlands
- Bushland and nearby residential areas
- Likely changes in groundwater hydrology

1.1. THE PURPOSE OF THIS REPORT

The potential precinct identified in several documents released by Western Australian Government agencies (Plate 1) straddles Carabooda Road to the north of Kiln Road and the established horticultural area in Nowergup. To its east lies State Forest, mostly under pine plantation.

The western side of the proposed new Carabooda Precinct is already well developed, with large and small producers investing heavily in infrastructure (Figure 1). Within the identified area and to the east of Old Yanchep Road and into the Pinjar locations most of the potential horticultural land is currently under pine plantation.
While much of the area is well developed irrigated horticultural land continues to be developed to the west of Old Yanchep Road (Figure 2).

Large production nurseries have also been developed within the western side of the precinct (Figure 3).
To the east of Old Yanchep Road most of the potential land is under pine plantation (Figure 4). Bush Forever sites have been identified within the state forest.

The issue of food quality in this study is essentially tied to distance to market and perishability as production and packaging and handling methods are likely to be very similar for different growing locations. Any quality issue will be related to the time from harvesting to the consumer. Modern packaging and refrigeration technology has greatly improved food quality and the distance over which most commodities can be transported. Some products remain sensitive and will be reviewed in this report.

The emphasis in this report is on the five key issues of:
• Food quality and distance to market
• Production methods and labour impact
• Potential for wastewater utilisation
• Energy costs
• Utilisation of urban wastes

This report has been prepared by Science Matters and Economics Consulting Services. Essential support has been provided by Strategen Environment, Landvision, A P Fruit Consultancy and Mercer Mooney.

The study focuses on the near city environment and “intensive horticulture”. These terms are clarified in the context of this study in the first glossary section.

1.2. GLOSSARY

Horticulture comes from a Latin language term meaning garden. It is generally defined as plant production with a focus on individual plants rather than on broadacre crops. Definitions generally include fruit and vegetables, nuts, flowers and vines, and “turf farms”.

The ability to store and transport these products varies widely as do their production requirements and seasonal variability, but the key is that they are all more intensive uses of land than broadacre agriculture.

In the Gnangara Mound context, horticulture is dominated by vegetable production with some fruit orchards. Land is also devoted to grape production, cut flowers, nurseries and turf farms.

Statistics in this publication are generally sourced from the Australian Bureau of Statistics. The nature of sections of the horticulture industry means that production and sale statistics are notoriously “under-reported”. Work by the Department of Agriculture and Food suggests that some fruit and vegetable crops may be as much as 50% underestimated.

The Gnangara Mound (Plate 2) covers the Swan Coastal Plain from the Swan River north to Gingin. It includes parts of the metropolitan area and rural areas in the following Local Government Areas – the Cities of Swan and Wanneroo and the Shires of Gingin and Chittering.

Plate 2 The Gnangara Mound

See plate on the following page.
GNANGARA MOUND MAP SHOWING EXTENT OF CARABOODA PRECINCT
THE FEASIBILITY OF A NEW HORTICULTURE PRECINCT ON THE GNANGARA MOUND
2. BACKGROUND

Rural activities around Perth and horticultural activity in the state are characterised in this chapter to illustrate Wanneroo’s important position in vegetable production where it is the fourth ranked local government authority in Western Australia. Wanneroo is well established as a prominent horticulture area to the north of the Perth metropolitan area. This chapter shows how horticulture production has progressively moved out from the expanding city centre as urban growth exerts strong pressure to replace market gardens and horticulture farms with houses and industrial estates. As this happens farmers have been able to capitalise on increasing land values. When the Swan River colony was first established market gardening began near Perth and on the banks of the Swan River. As the city has expanded horticulture has tended to move to the city’s fringes, using underground water for irrigation. Urban or peri-urban locations are favoured for crops that require plentiful (often family) labour and are perishable. These tend to be salad vegetables and strawberries and are important crops in Wanneroo. Groundwater is a key resource for horticulture and is over allocated in the Perth North region where irrigated horticulture is a major consumer.

Australia is a substantial horticulture producer and is largely self-sufficient in supplies. Most production is destined for domestic consumption although exports and imports have risen over the past decade reflecting the increase in free trade agreements, improved packaging and handling of fresh products and a general increase in globalisation and international awareness. Horticultural produce imported into Australia is increasing and includes off-season supplies and periods of domestic shortage.

Australia is now a net importer of vegetables, with New Zealand the major supplier. The emergence of low wage, technically proficient economies will continue to place greater pressure on Western Australian and Australian growers in the long term. The potential to lift its export performance by targeting areas of strong demand has been identified.

Arguably one of the greatest threats to the continuing viability of the Australian and Western Australian horticultural industries is increasing competition from overseas growers. In recent years, a number of horticultural industries have seen their market opportunities decline sharply, in some cases to the point of industry collapse, as cheap imported products have entered the market.

In 2004 an article in the Sydney Morning Herald described Wanneroo as being located 26km north of Perth, an outer suburb of the city, the focus of popular day trips from the city with motorists making their way out of the city and heading towards Wanneroo, Yanchep and the beaches along the coast. According to the Herald Wanneroo was driven by those industries that thrive on the edge of a capital city, being an area of market gardening, poultry farms, vineyards and purpose built industrial areas. They recognised pressures from housing developments. In his first speech to Parliament in 1998 Dr Mal Washer, the Member for Moore in the House of Representatives, promoted the Shire of Wanneroo as being among the state's top three agricultural regions in terms of value of production. He emphasised the need to preserve the main market garden areas of Wanneroo and Carabooda. The City of Wanneroo has listed old Chinese market gardens on its Municipal Heritage Inventory.

Current horticulture locations at or near Wanneroo are being transformed into residential
and industrial areas as the urban area expands, with much of the East Wanneroo area now zoned for urban development in the Metropolitan Region Scheme. As a result of increasing land prices and constraints on operating practices many producers are selling their properties and relocating or taking the opportunity to sell and retire or move into other economic sectors.

Groundwater availability to support growth in horticulture in the Wanneroo area is now extremely limited, groundwater levels are declining with associated environmental impacts and modelling by the Department of Water has shown the impacts will be difficult to manage. This condition is being exacerbated by low rainfalls over recent decades, with the expected prognosis for climate change indicating that the situation can be expected to continue.

Western Australia’s State Water Plan has the vision of sustainably managing and developing our precious water resources. Its first two objectives are:

1. use and recycle water wisely, and
2. plan and manage water resources sustainably.

In 2005 it was estimated that agriculture consumed 37% of all water used in Western Australia. Of the water used by agriculture 55% was used in horticulture, with this use recognised to have a relatively high economic value. The Gnangara Mound is the major source of water used by horticulture producers in the metropolitan area surrounding Perth.

As part of a broader study into land use options for the Gnangara Mound, it has been proposed that a dedicated horticulture precinct could relieve these land use pressures at Wanneroo and provide greater future land use certainty. Such an area could make a positive economic and environmental contribution by providing:

- A market for recycled wastewater from both the Beenyup and the future Alkimos wastewater treatment plants
- A secure long term production base for fresh vegetables and fruit for the Perth market
- A contribution to relieving the downward movement in groundwater levels in southern parts of the Wanneroo Groundwater Area
- Increased protection of wetlands with relocation of some existing horticulture operations
- Agricultural-based employment
- Opportunities for agri-tourism
- Provide a market for organic wastes that will benefit environmental values while
reducing the use of water, fertilisers and potentially pest control chemicals for food production

- A contribution of agriculture to the Wanneroo economy

Potentially offsetting disadvantages that should be considered include:

- Reduced water availability for other water uses such as the environment, and public and private water supplies as a balance is sought between use for urban development and food production
- A land opportunity cost as a balance is sought between use for urban development and food production
- Community concern over use of recycled wastewater for food production
- Adverse impacts on groundwater quality and levels and other environmental values (e.g. Chemicals, odour, noise, traffic) from a horticultural precinct

2.1. HISTORICAL PRODUCTION PATTERNS

Consistent with the theoretical models which will be introduced later, perishable food crops such as vegetables and to a lesser extent fruits, have traditionally been produced close to the urban centre of Perth.

Early market gardens were established soon after European settlement to feed the new colony. They were located in low lying wet areas with sandy and peat soils and shallow water. The first ones occupied a series of lakes and wetlands just north of the new town. Very early areas were around Thompson’s and Stone’s Lake in Northbridge. By 1845, nine more farm lots had been added around Beaufort and Lord Streets.

Close to the city was Robertson Park (Lake Henderson) and Birdwood Square (Lake Poullet) and Stone’s Lake. Areas around the lakes were drained and slowly filled in to create workable agricultural land. Birdwood Square was used as a rubbish tip and market garden. All three areas were subsequently filled in to create residential land with a recreation area also created at Robertson Park. The current tennis courts appear to be located in the early market garden area.

The Western Australian economy struggled for a long time with the population over the first sixty years only increasing to around 48,000 people. Large areas of market gardens were not needed to service this small population, but small areas close to the new town were developed for food production.

South Perth is a good example of the settlement pattern. It was one of the earlier areas to be cleared for agriculture following settlement of the Swan River Colony by British migrants in 1829. For most of the 19th Century the Peninsula was used predominantly for
agriculture and horticulture – it was close to the city, but separated by the river with a ferry crossing at the Narrows point. The peninsula included a large dairy farm, flour mill and horticulture areas.

During the gold rushes the population boomed with a five fold increase in less than a decade. This placed a huge demand on farmers for food and transport systems to deliver the produce to the goldfield areas. Potatoes were in particular demand and were largely imported until the industry responded.

Flood irrigation was often used for the rowed crops as shown by this picture from 1919 (Figure 5) (source LISWAvi).

**Figure 5 Irrigation Pays in 1919**

Following the short boom (less than ten years), and the reduction in work for prospectors, Chinese immigrants came to dominate the market garden sector. Gardens in Perth were established around the areas now known as Northbridge, North Perth, Bayswater, Jandakot, Osborne Park, and South Perth. Chinese market gardens were also established in towns like York where they could supply the small local population, but also the goldfields.

Chinese market gardeners dominated the horticulture sector for at least fifty years (Figure 6) until new migrants from Italy and Greece following the war entered the industry. The Chinese farmers tended to operate on a cooperative basis with as many as ten workers, often from the same clan. There were close ties between market garden cooperatives and Chinese storekeepers and greengrocers who helped provide gardeners with credit or financial support.
Crop rotation and double cropping methods were used to grow a range of produce including tomatoes, cauliflower, herbs, and leafy vegetables like lettuces. Production methods were labour intensive with significant work effort involved in watering, weeding and daily harvest and delivery to market. Produce was sold either direct to the market or through commission agents.

As the Chinese population in Australia declined so too did Chinese market gardeners. The Greek and Italian community started to move into the industry, particularly after World War II. They dominated the industry in areas like North Perth and Osborne Park and Spearwood to the south.

Continuing population growth and urban expansion made the land more valuable for residential and industrial land use and over time most market garden areas were subdivided into residential lots with the land drained and settled as the urban front arrived.

South Perth, by way of example, was used for horticulture for more than 100 years from 1850. Chinese market gardeners occupied the foreshore area around Coode Street jetty and it was only in 1952 that the last of the riverfront land was acquired by the City of South Perth and converted into Mitchell Park.

Following the redevelopment of areas like North Perth, horticulture areas moved out to new areas like Belmont, Gosnells, and later on to Wanneroo. Drainage of many of the swamps immediately north of the city such as Herdsman in the 1930s encouraged production onto the peat and marl soils within the lakes, these being mainly the Herdsman Association. The better drained sandy border soils were used for winter production and
the peats and marls for summer production.

Since 1850, market gardens have been pressured by residential development to progressively move with the urban fringe where the essential ingredients of cheap land with abundant water were available.

As sprinkler irrigation technology developed in the early 1950s the versatility afforded by the sandy soils surrounding the swamps was appreciated and the vegetable growers drifted further afield from the historically favoured swamp country. Activity was directed to the Spearwood (Cottesloe and Karrakatta) Soil Associations to the north and south of the city because of proximity to the market, relatively shallow water table sand proximity to the ocean and its modifying influence on climate. The effects of winter frost and summer heatwave was minimised by the oceanic influence.

Urbanisation and its effect on land values saw a further wave of development onto the poorer sands of the Bassendean Association in the 1960s and 1970s, and that trend continues. However, the Bassendean sands are considered inferior to the Cottesloe and Karrakatta sands because they are inherently less fertile and tend to be water repellent. They are more prone to extremes of temperature in summer and winter.

From the 1970s, there has been significant dislocation in areas of market gardens around Osborne Park, Tuart Hill, Stirling, and Balcatta and progressively northwards, as urban development has occurred. With each of these moves, as horticulture has shifted from urbanised areas, dislocated growers have had the opportunity to convert their horticultural land into urban developments, with the associated financial gain. Recently that change has been seen as urbanisation introduces changing land values and conflicting land uses to the horticulture producers near Wanneroo.

Wells and Clarke reported that urban expansion had for many years pushed market gardening further out from the city, mainly north and south, parallel to the coast. They noted that some vegetable growers had recently shifted their operations from the yellow Karrakatta sands to the grey sands of the Bassendean series. Even then, they anticipated a requirement for an additional 630 ha of horticulture production, on the assumption of a Western Australian population of more than 2 million.

They also attributed the significance of the vegetable farms of the then Wanneroo Shire to several factors:

1. Low transport costs and travel time (for perishable items) compared to other rural areas.
2. Availability of labour.
3. Aesthetic factors, to break up urbanised stretches.
4. Availability of groundwater provided excessive abstraction was controlled.

5. Freedom from frost and extreme summer heat.

The importance of maintaining the quality of the groundwater resources and associated coastal lakes and wetlands led them to urge caution with the application of fertilisers and agricultural chemicals in the recharge areas as this traditional progression could continue north and south along the suitable soils. A dedicated precinct can offer an alternative to tradition if it offers the essential resources of suitable land and sufficient and guaranteed water, even if just for an extended term.

2.2. RURAL ACTIVITIES IN PERTH

From a planning perspective the “rural area” of the Perth Metropolitan Region was considered a misnomer in the 1955 Stephenson-Hepburn report. While it suggests the following of rural pursuits in fact it really means “non urban” as it is the repository of a range of uses, not necessarily rural in nature. These uses include; quarrying, public institutions such as wastewater treatment facilities, prisons and noxious industry as well as small non-productive rural residential holdings.

Indeed subsequently the former Department of Planning and urban Development’s Metropolitan Rural Policy acknowledges and supports these types of uses in a coordinated and planned distribution in the rural zone.

Notwithstanding the above, areas proposed for intensive agricultural uses were considered the most important parts of the rural area in the 1955 report, as it considered that the anticipated 1.4 million population would be primarily fed from the rural areas of the region. As this has subsequently ceased to be the case, the priority of the rural area as a producer has diminished. Along with this has been lost detailed consideration of the importance of local food in combination with the capacity to manage urban wastes, increased diversity of employment and business opportunity, and the contribution of economically vibrant rural zones to protect environmental values. Studies such as this are charged with considering these aspects of land development.

The former Town Planning Department recorded the area and number of rural holdings between 1962 and 1974. (Table 1)
### Table 1

<table>
<thead>
<tr>
<th>Local Authority</th>
<th>Area in Hectares</th>
<th>Number</th>
<th>% Change</th>
<th>Change</th>
<th>% Change</th>
<th>Total Rural Lots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armadale-Kelmscott</td>
<td>18 918</td>
<td>13 711</td>
<td>-28</td>
<td>510</td>
<td>475</td>
<td>-7</td>
</tr>
<tr>
<td>Canning</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-800</td>
</tr>
<tr>
<td>Cockburn</td>
<td>4 015</td>
<td>2 245</td>
<td>-44</td>
<td>390</td>
<td>265</td>
<td>-32</td>
</tr>
<tr>
<td>Gosnells</td>
<td>3 800</td>
<td>2 519</td>
<td>-34</td>
<td>384</td>
<td>195</td>
<td>-50</td>
</tr>
<tr>
<td>Kalamunda</td>
<td>4 956</td>
<td>3 301</td>
<td>-33</td>
<td>455</td>
<td>350</td>
<td>-23</td>
</tr>
<tr>
<td>Kwinana</td>
<td>3 133</td>
<td>2 233</td>
<td>-29</td>
<td>59</td>
<td>60</td>
<td>+1</td>
</tr>
<tr>
<td>Mundaring</td>
<td>20 018</td>
<td>13 786</td>
<td>-31</td>
<td>485</td>
<td>358</td>
<td>-26</td>
</tr>
<tr>
<td>Rockingham</td>
<td>11 017</td>
<td>9 181</td>
<td>-17</td>
<td>57</td>
<td>94</td>
<td>+65</td>
</tr>
<tr>
<td>Serpentine-Jarrahdale</td>
<td>31 593</td>
<td>33 533</td>
<td>6</td>
<td>197</td>
<td>226</td>
<td>+15</td>
</tr>
<tr>
<td>Swan</td>
<td>49 372</td>
<td>54 571</td>
<td>11</td>
<td>732</td>
<td>826</td>
<td>+13</td>
</tr>
<tr>
<td>Wanneroo</td>
<td>23 104</td>
<td>18 780</td>
<td>-19</td>
<td>190</td>
<td>277</td>
<td>+46</td>
</tr>
<tr>
<td>Outer Areas (Total)</td>
<td>169 926</td>
<td>153 860</td>
<td>-9</td>
<td>3 459</td>
<td>3 176</td>
<td>-10</td>
</tr>
<tr>
<td>Western Australia</td>
<td>10 234 400</td>
<td>115 600 691</td>
<td>+13</td>
<td>22 082</td>
<td>20 500</td>
<td>-7</td>
</tr>
</tbody>
</table>

Source: (1) Rural land utilisation surveys 1962-3 and 1974-5. A rural holding is defined as “a piece of land of one hectare or more in extent, used for the production of agricultural products or for the raising of livestock and the production of livestock products.

(2) Based on count of rural lots from cadastral maps. Town Planning Department 1977 (figures rounded to nearest ten).

As can be seen although the total rural lots amounts to more than 16,000, the rural holdings amount to no more than 3000. Also while 240,920 hectares of land is zoned rural in the Perth Metropolitan Region, only 153,860 ha (64%) are held as parts of active rural holdings. It is clear from these figures that a significant proportion of the rural zone within the Perth metropolitan region is not used by full time farmers (p 32).

During a similar period the rural zone diminished in size (Table 2).
Table 2 Change in the Rural zone in the Metropolitan Region 1962-77

<table>
<thead>
<tr>
<th>Zoning</th>
<th>1962</th>
<th>1977</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hectares</td>
<td>%</td>
</tr>
<tr>
<td>Rural</td>
<td>337,410</td>
<td>63</td>
</tr>
<tr>
<td>Non-Rural</td>
<td>200,000</td>
<td>37</td>
</tr>
<tr>
<td>TOTAL</td>
<td>537,410</td>
<td>100</td>
</tr>
</tbody>
</table>


The current rural zone is 185,540 hectares or approximately 35% of the land area of the Perth Metropolitan Region, approximately half that recorded for 1962.

While the area under agriculture production in the then Shire of Wanneroo fell by 19% (1961 – 1976), the number of farm holdings increased by 46%, probably reflecting the greater movement to horticulture production into the shire and creation of smaller holdings for intensive market gardening.

2.3. HORTICULTURE PRODUCERS IN WESTERN AUSTRALIA

Horticulture production occurs in many areas of Western Australia. Typically, early market gardens for vegetables and fruit developed around towns and cities for local supplies. With the State population distribution dominated by the Perth metropolitan area, fruit and vegetable production areas developed as speciality supplies to this area while other areas developed with an export focus.

A statistical picture of horticulture production is challenging given the widely divergent crops and measures of production. Substantial production occurs in many Local Government Areas when measured on the basis of volume or area planted. For fruit, 22 Local Government Areas (LGAs) had annual production in 2005-06 in excess of 100 tonnes while 14 LGAs had production in excess of 1,000 tonnes (Table 3).
Table 3  Horticulture production by Local Government Area

<table>
<thead>
<tr>
<th>Production measure</th>
<th>Local Government Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit - (more than 100 tonnes)</td>
<td>22</td>
</tr>
<tr>
<td>Fruit - (more than 1,000 tonnes)</td>
<td>14</td>
</tr>
<tr>
<td>Vegetables - (more than 10 hectares)</td>
<td>22</td>
</tr>
<tr>
<td>Vegetables - (more than 100 hectares)</td>
<td>13</td>
</tr>
<tr>
<td>Vegetables - (more than 1,000 hectares)</td>
<td>3</td>
</tr>
<tr>
<td>More than 100 tonnes of fruit or 100 hectares of vegetables</td>
<td>27</td>
</tr>
</tbody>
</table>

Source: Australian Bureau of Statistics, 2005-06 (various publications)

Vegetable statistics on an area basis, record 22 LGAs with at least 10 hectares of planted crops while 13 LGAs had at least 100 hectares and 3 LGAs had more than 1,000 hectares planted.

Combining fruit and vegetables indicates that 27 LGAs in 2005-06 had annual horticulture production in excess of 100 tonnes of fruit or had a planted area of more than 100 hectares of vegetables (Table 4). Of these 10 LGAs are within the Perth Metropolitan Region and 3 LGAs adjoin the Perth Metropolitan Region. This suggests that nearly 20% of the Shires in the State had substantial areas devoted to fruit or vegetable production.

Table 4  Local Government Areas with substantial horticulture production

<table>
<thead>
<tr>
<th>Albany</th>
<th>Donnybrook-Balingup</th>
<th>Mundaring *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armadale *</td>
<td>Gingin</td>
<td>Murray</td>
</tr>
<tr>
<td>Boddington</td>
<td>Gosnells *</td>
<td>Nannup</td>
</tr>
<tr>
<td>Bridgetown-Greenbushes</td>
<td>Harvey</td>
<td>Plantagenet</td>
</tr>
<tr>
<td>Busselton</td>
<td>Jerramungup</td>
<td>Rockingham *</td>
</tr>
<tr>
<td>Capel</td>
<td>Kalamunda *</td>
<td>Serpentine-Jarrahdale *</td>
</tr>
<tr>
<td>Carnarvon</td>
<td>Kimberley</td>
<td>Swan *</td>
</tr>
<tr>
<td>Chittering</td>
<td>Kwinana *</td>
<td>Wanneroo *</td>
</tr>
<tr>
<td>Dardanup</td>
<td>Manjimup</td>
<td></td>
</tr>
</tbody>
</table>

Source: Australian Bureau of Statistics (various publications)
* LGAs in the Perth Metropolitan Area

Flower production, turf farms and nurseries all add to this diversity as do vines with grapes now grown from Carnarvon to Albany.

Production diversity depends on the adaptability of the fruit and vegetable species and the range of climates in which crops may be grown. Some are concentrated only in tropical areas, others in cooler parts of the State and some are able to produce across much broader climate types at different times of the year, so extending their availability to the
market. For example, bananas and papaws are reported in only two areas (Carnarvon and Kimberley), cherries and Kiwi Fruit are restricted to the southern LGAs while apples and citrus species are both produced in large quantities in at least 5 Local Government Areas each. Similar diversity exists for vegetables. For example, 11 LGAs had substantial potato production while virtually all the production of crops such as spring onions, parsley, Chinese cabbages, Asian greens, beetroot, cabbage, herbs, leeks, lettuce, parsnips, peas, rhubarb, radish, silver beet, spinach, swedes and turnips were reported from one or two LGAs, these being close to the main market of Perth and they can be grown throughout the year in that climatic zone.

Western Australia also has areas noted for the specialisation of fruit and vegetable production, but production is also surprisingly diverse when all horticulture commodities are considered.

2.4. OTHER REGIONS OF WESTERN AUSTRALIA

Vegetable and fruit production are diverse as already illustrated. Fruit production is dominated by three Shire areas – Donnybrook-Balingup, Manjimup and Kalamunda and Armadale. Combined they accounted for 60% of fruit production in 2005-06. Wanneroo with 3,729 tonnes (strawberries and avocados) accounted for only 4% of the total (Figure 7). Changes in production patterns from the last agricultural census in 2001 included significant increases in mango and banana production at Carnarvon and large increases in avocados and strawberries in Wanneroo.

**Figure 7** Fruit Production, 2005-6 (tonnes)

Vegetable production was far more diverse than fruit with six Shires recording at least 8%
of the total (Figure 8). Wanneroo ranked third behind the Kimberley and Manjimup. Gingin, Harvey and Carnarvon were all important.

**Figure 8 Vegetable planted areas, 2005-06 (hectares)**

![Pie chart showing vegetable planted areas in 2005-06](image)

Changes in production patterns from 2001 included an overall 10% increase in planted area with significant increases in the Kimberley, Wanneroo, Harvey, and Carnarvon and decreases in Manjimup, Gingin and Rockingham.

It is difficult to rank areas for fruit and vegetables with one measured on production and one on areas planted. In general terms, Manjimup and Donnybrook/Balingup appear to be dominant fruit and vegetable areas with the Kimberley, Manjimup, Wanneroo, Gingin and Harvey important for vegetables and Kalamunda and Armadale key fruit districts.

Another way of examining horticulture production is to look at the number of properties reporting commercial production. In 2005-06, 2,462 farms were recorded as producing some horticultural produce with nearly 800 of these in the South West and a slightly lesser number in the Perth metropolitan area (Table 5).

There were far more fruit producers than vegetable growers with these two sectors dominating the industry. Wanneroo included nearly half of the vegetable growers in Perth, but this was about half of the growers in the South West and a smaller number to that recorded for the Central region of the State.

The Shire of Kalamunda dominated fruit production in the metropolitan area (stone fruit). Wanneroo was important for strawberries.
### Table 5  Horticultural producers, number in 2005-6

<table>
<thead>
<tr>
<th></th>
<th>Farms</th>
<th>Vegetables</th>
<th>Fruit</th>
<th>Nurseries</th>
<th>Flowers</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wanneroo</td>
<td>118</td>
<td>61</td>
<td>32</td>
<td>17</td>
<td>228</td>
<td></td>
</tr>
<tr>
<td>Swan</td>
<td>31</td>
<td>38</td>
<td>12</td>
<td>7</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>Kalamunda</td>
<td>9</td>
<td>85</td>
<td>15</td>
<td>2</td>
<td>111</td>
<td></td>
</tr>
<tr>
<td>Mundaring</td>
<td>4</td>
<td>12</td>
<td>4</td>
<td></td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Gosnells</td>
<td>2</td>
<td>14</td>
<td>6</td>
<td></td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Armadale</td>
<td>1</td>
<td>59</td>
<td>9</td>
<td>8</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>Cockburn</td>
<td>34</td>
<td>4</td>
<td>2</td>
<td>9</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>Rockingham</td>
<td>23</td>
<td>6</td>
<td>5</td>
<td>12</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td>Kwinana</td>
<td>18</td>
<td>1</td>
<td>6</td>
<td>6</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Serpentine/Jarrahdale</td>
<td>15</td>
<td>28</td>
<td>15</td>
<td>8</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Total Perth</td>
<td>262</td>
<td>307</td>
<td>108</td>
<td>70</td>
<td>747</td>
<td></td>
</tr>
<tr>
<td>South West</td>
<td>205</td>
<td>497</td>
<td>40</td>
<td>45</td>
<td>787</td>
<td></td>
</tr>
<tr>
<td>Lower Great Southern</td>
<td>34</td>
<td>98</td>
<td>9</td>
<td>35</td>
<td>176</td>
<td></td>
</tr>
<tr>
<td>Upper Great Southern</td>
<td>4</td>
<td>16</td>
<td>4</td>
<td>7</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Midlands</td>
<td>44</td>
<td>158</td>
<td>20</td>
<td>26</td>
<td>248</td>
<td></td>
</tr>
<tr>
<td>South East</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Central</td>
<td>161</td>
<td>156</td>
<td>8</td>
<td>9</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Kimberly</td>
<td>28</td>
<td>87</td>
<td>11</td>
<td>4</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>Total State</td>
<td>739</td>
<td>1,322</td>
<td>204</td>
<td>197</td>
<td>2,462</td>
<td></td>
</tr>
</tbody>
</table>

#### 2.5. EASTERN AUSTRALIA

Australia is a substantial horticulture producer both for domestic consumption and export. In gross terms, vegetables totalled 3.44 million tonnes in 2002 while fruit production totalled 1.91 million tonnes. Fruit and vegetables are grown in all Australian states with some separation based on climate. For example, tropical species such as bananas and mangoes are nearly all grown in Queensland, Western Australia and the Northern Territory and northern New South Wales. Cold climate fruits such as cherries and many berries are only grown in the southern States.

The top ten varieties by weight accounted for 88% of vegetable production and 92% for fruit (Table 6).
### Table 6 Top ten vegetable and fruit varieties, Australia 2002 (tonnes)

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Tonnes</th>
<th>Fruit</th>
<th>Tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes</td>
<td>1,333,159</td>
<td>Oranges</td>
<td>550,201</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>424,950</td>
<td>Bananas</td>
<td>313,314</td>
</tr>
<tr>
<td>Carrots</td>
<td>331,130</td>
<td>Apples</td>
<td>290,263</td>
</tr>
<tr>
<td>Onions</td>
<td>282,517</td>
<td>Pears/nashis</td>
<td>147,884</td>
</tr>
<tr>
<td>Melons</td>
<td>188,075</td>
<td>Pineapples</td>
<td>119,328</td>
</tr>
<tr>
<td>Lettuce</td>
<td>135,015</td>
<td>Peaches</td>
<td>88,651</td>
</tr>
<tr>
<td>Pumpkins</td>
<td>96,331</td>
<td>Table grapes</td>
<td>86,523</td>
</tr>
<tr>
<td>Cauliflowers</td>
<td>87,586</td>
<td>Mandarins/tangelos</td>
<td>78,912</td>
</tr>
<tr>
<td>Sweet corn</td>
<td>80,467</td>
<td>Mangoes</td>
<td>40,972</td>
</tr>
<tr>
<td>Cabbages</td>
<td>76,093</td>
<td>Lemons/limes</td>
<td>36,197</td>
</tr>
<tr>
<td>Other</td>
<td>407,935</td>
<td>Other</td>
<td>156,766</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,438,958</strong></td>
<td><strong>Total</strong></td>
<td><strong>1,907,196</strong></td>
</tr>
</tbody>
</table>

Source: Horticulture Australia Statistics

In the top ten commodities, Wanneroo plays an important role in Western Australia for lettuces, Sweet corn and cabbages. It is not a significant producer of any of the top ten fruits. The major vegetable production areas in eastern Australia lie close to the capital cities and include the Sydney Basin, Werribee in Victoria and the Adelaide Plains. Detailed notes are included in this report on the latter areas as they both use recycled water.

With most vegetable production targeted at domestic consumption and with proximity to markets a key profitability driver, production and grower numbers will bear some relationship to population numbers. Western Australia has around 10% of the national population and a similar proportion of vegetable producers (Table 7), but Vegetables WA estimates that Western Australia may currently have about 500 growers. Significant departures from the population share arise for Queensland and Tasmania with larger industries than population due to the unique climatic conditions and the establishment of processing facilities that enable a production area to serve larger markets.
Table 7  Vegetable producers by State (2004-05)

<table>
<thead>
<tr>
<th>State</th>
<th>Number</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New South Wales</td>
<td>730</td>
<td>17</td>
</tr>
<tr>
<td>Victoria</td>
<td>793</td>
<td>20</td>
</tr>
<tr>
<td>Queensland</td>
<td>1,282</td>
<td>31</td>
</tr>
<tr>
<td>Western Australia</td>
<td>395</td>
<td>10</td>
</tr>
<tr>
<td>Tasmania</td>
<td>521</td>
<td>13</td>
</tr>
<tr>
<td>South Australia</td>
<td>359</td>
<td>9</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>9</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>4,089</td>
<td></td>
</tr>
</tbody>
</table>

Source: ABS

2.6. AUSTRALIAN FRUIT AND VEGETABLE IMPORT TRENDS

Imports of fruit and vegetables into Australia are rising relatively rapidly, although this is from a low base. Part of the trend is due to a run of dry seasons in the Eastern States and water supply issues in the Murray/Darling basin.

For the year 2000, imported vegetables accounted for less than 10% of total consumption of vegetables in Australia according to the ABS. But in the five years from 2001-02 to 2004-05, the amount of vegetables imported into Australia increased dramatically with processed/preserved fruit and vegetables increasing by 39% and the value of minimally processed (i.e. fresh or frozen) vegetables, fruit and nuts increasing by 50%.

ABARE has estimated that imports now account for

- 38% of processed vegetables
- 68% of frozen vegetables
- 48% of canned vegetables

Processed vegetables mainly come from Italy (25%), China (15%) and the United States (10%). Frozen vegetables come mainly from New Zealand (65%) and China (10%). Fresh vegetables come from New Zealand (40%) and China (25%).

Overall, New Zealand is Australia’s main source of food imports, with an import value of $1.20 billion in 2004-05 followed by the United States ($569 million), Ireland ($400 million), Thailand ($396 million) and China ($372 million).

Australia’s balance of trade in vegetables has turned from a net export position to a net import position.

The most recent figures confirm the continuing trend. For July 2006 to March 2007 vegetable imports in all categories (processed, frozen, fresh, other) recorded increases.
The growth in imports from China continued at a rapid rate, up 40.5%. Imports of frozen and processed potatoes, most of which were sourced from New Zealand, increased by more than 70%.

The top import fruit and vegetables were:

- Capsicum - New Zealand
- Garlic - China
- Tomatoes - New Zealand
- Asparagus - Thailand and USA
- Cucumbers/gherkins - India
- Other vegetables - Thailand
- Kiwifruit - New Zealand
- Avocados - New Zealand
- Oranges - USA
- Cherries - USA
- Figs - Turkey
- Apricots - New Zealand

The growth of imports has also resulted from changes in globally driven Free Trade policies that reduce the competitiveness of local products, while also increasing the associated costs, because of requirements for standards in, for example, environmental management, and food safety. Such policy changes have so far been unable to consider costs associated with any loss of food security and safety, the global environmental impact of carbon emissions, and the loss of environmental values.

Western Australian producers are facing steadily increasing competition from overseas producers in both domestic and overseas markets. The emergence of low wage, technically proficient economies will continue to place greater pressure on Western Australian and Australian growers in the long term.

The strength of the Australian dollar and high wages in the resources sector has almost certainly exacerbated this position in the past few years.

In recent years China has made significant inroads into South East Asian markets that have traditionally been Australia’s strongest export markets. Australia’s fresh and dried vegetable exports to Indonesia, Malaysia, Philippines, Singapore and Thailand fell by 15% between 2001 and 2003, while China’s exports to these nations rose by 74% in the same period.
2.7. AUSTRALIA’S FRUIT AND VEGETABLE EXPORTS

Australia’s export performance in horticulture exports has been assessed more harshly in a recent Horticulture Australia report*. According to the “FutureFocus” report Australia's horticulture industry has the potential to lift the value of its production by 28% to $10 billion by 2020, but will have to improve its "unremarkable" export performance, among other things, to reach that target.

“FutureFocus” catalogues in great detail the problems arising from a scattered, diverse and fragmented industry, including a lack of a clear export focus and the impact of rising imports of fresh and processed fruit and vegetables from developing countries.

It also demolishes the dearly held notion that Australia can capitalise in world markets on its "clean, green" image. "Every southern hemisphere producer is now `clean and green'," the report said. “This product characteristic is now a second or third tier support benefit that is expected by consumers and no longer a differentiating part of any offer.”

“Although Australia successfully produces 159 different horticultural crops across a wide range of climatic zones, unlike some other key southern hemisphere producers, such as New Zealand, South Africa, Chile, Brazil and Argentina, Australia's export performance is unremarkable.” “Australia's approach to exports has suffered from a commodity culture tendency.”

It says, however, the best bet for lifting growers' incomes is to "specifically and deliberately" develop market demand. One of the success stories has been the rapidly growing nut industry - expected to be worth about $1 billion a year by 2020. In fruit, avocados, strawberries, and mangoes had the fastest expanding production, while pears, oranges, citrus other than mandarins and oranges, kiwi fruit and pineapples all fell between 1990 and 2005 against a general rising trend for other fruits.

Per capita consumption of fruit and vegetables in Australia has risen sharply post-war, supported by the angst about rising obesity rates and unhealthy eating. Fruit consumption has grown from 81 to 135 kilograms each, and vegetables from 130 to 162kg. In spite of this increase obesity remains a problem to our population and the aim is to shift the focus of diet to a greater consumption of fresh fruit and vegetables. The proposed level of consumption would treble vegetable and double fruit domestic consumption.

“FutureFocus” will develop plans for six areas - making supply more effective, improving the competitive advantage, making effective use of resources, maximising the use of technology, providing a well-functioning commercial environment, and promoting structural change.
2.8. INTERNATIONAL TRENDS

A number of trends affect the horticulture sector including changing patterns of food consumption, food distribution and international trade.

INTERNATIONAL TRADE

Very few countries are able to produce all the fresh horticulture products that the community desires over a full year creating trading opportunities among countries. However, for most countries the major proportion of fresh production is consumed domestically.

In 2004, the Food and Agriculture Organisation (FAO) estimated that the total export in agricultural products was about $600 billion\textsuperscript{xi}. Australia contributed about 3.5% to this total.

Food products made up about 70% of this total representing $US420 billion. Processed foods made up nearly two thirds of the exports (65%), with cereals 11%, and livestock products 9%.

Trade in horticulture products is estimated to exceed $45 billion made up of fresh (70%) and processed products (30%), of which half were fruit juices\textsuperscript{xii}. Annual trade growth has been 8-10% with slower growth of traditional agricultural commodities such as cereals, livestock products, oil seed, fats and oil.

Horticultural trade is characterized by a wide range of products. The composition has changed over time with an increase in the importance of fruit over vegetables. The more traditional varieties of fruit, namely citrus, apples, grapes, bananas, pears, pineapples and peaches, represent some 85% of world production with those of temperature climate origin (apples, grapes, pears and peaches) accounting for 42%. These are mainly produced and consumed in the developed countries.

Major traded products include:

- Bananas - $US5,176 m
- Apples - $US3,835 m
- Tea - $US3,271 m
- Potatoes - $US2,191 m
- Pineapples - $US1,110 m

Banana, pineapple, and mango are the most important tropical fruits and these are mainly produced in developing countries and consumed domestically. The taste for exotic products is rapidly evolving in developed countries. Over the past decade exotic tropical fruits such as avocado, guava, papaya and kiwi have become mainstream trading items.
Tomatoes were the most important single vegetable export followed by varieties such as pumpkins, lettuce, cucumbers, garlic, chillies and peppers, cabbages, cauliflower, carrots, garlic, onions, asparagus and ginger.

**AUSTRALIAN TRADE**

Australia is a substantial horticulture producer and is largely self-sufficient in supplies. Most production is destined for domestic consumption although exports and imports have risen over the past decade reflecting the increase in free trade agreements, improved packaging and handling of fresh products and a general increase in globalisation and international awareness.

The Federal Department of Agriculture and Food prepared a fact sheet on Australian Horticulture in 2005 that describes exports and imports and the balance of trade\[iii\].

Exports included fresh and processed fruits and vegetables including dried, frozen, preserved, canned and bottled products. The total value in 2004-05 of $1,187 million represented 17% of the value of horticulture production in that year.

Exports of fresh (minimally transformed) products increased over the decade to 2004-05. Exports were valued at $800 million in 2004-05 compared with an estimated total value of production of $6,787 million (i.e. 12% exported by value). Fruits dominate exports with many varieties exported in small volumes. The three largest single categories were macadamia nuts ($146 million), oranges ($118 million), and table grapes ($109 million).

Processed foods covered a wide range of fruits and vegetables with no single commodity making up more than 10% of the total. Significant exports included dried beans and peas, orange juice, processed pears, fruit salad mixes and jams and jellies.

Horticultural produce imported into Australia is increasing and includes off-season supplies and periods of domestic shortage. Although imports have been increasing, a wide range of fresh produce is prohibited from entering Australia due to quarantine restrictions. Total imports in 2004-05 closely matched the value of exports with imports worth $1,226 million (exports $1,187 million). Imports have risen rapidly since 2000 when the total value was $920 million. Notable imports included:

- Cashew nuts - $78 million
- Orange juice - $55 million
- Apple juice - $40 million
- Flowers - $38 million
- Jams and jellies - $38 million
- Processed beans - $35 million
- Kiwifruit - $34 million
Western Australian exports are easy to identify, but with most Australian imports coming in as processed foods and then distributed around Australia by wholesalers and supermarket chains, the actual sales of imported products in Western Australia are hard to identify.

A Western Australian Parliamentary Inquiry into Food Distribution in 2005 commented that:

In recent years, a number of growers have seen their profit margins decrease to the point where their business was no longer viable, and for those who have stayed in the industry, profit margins continue to decline. Western Australian growers are not alone - throughout Australia, the horticulture industry is in a precarious state.

Arguably one of the greatest threats to the continuing viability of the Australian and Western Australian horticultural industries is increasing competition from overseas growers. In recent years, a number of horticultural industries have seen their market opportunities decline sharply, in some cases to the point of industry collapse, as cheap imported products have entered the market.

China is considered by many industry groups to pose the greatest threat to local fruit and vegetable growers. In the four years to 2004-05, the value of fruit and vegetable imports from China increased by 80%. The sheer volume of production in China is staggering, and continues to increase - China’s per capita agricultural production index increased by around 6% per year over the past 20 years (compared with a global, and Australian, average of less than 1% per year). Competition from overseas imports is not a transient phenomenon – the emergence of low wage, technically proficient economies will continue to place enormous pressure on the Western Australian and Australian fresh produce industries.

Competition from overseas producers not only affects the domestic market, but local growers are also increasingly competing with other countries in export markets. In recent years, China in particular, has made significant inroads into South East Asian markets that have traditionally been Australia’s strongest export markets.

Since that inquiry, the dry years in the Eastern States have seen increased interest in imported fruit and vegetables including produce from Western Australia. Large supplier groups in the Eastern States are looking at setting up operations/joint ventures in Western Australia to reduce their reliance on the apparently drying Murray/Darling Basin.

**Horticulture Trade and Consumption Trends**

Significant trends in horticulture trade include:

- Increasing interest in tropical fruit and vegetables in developed countries due to
increased

- Food markets are very well supplied from many countries leading to intense competition, lower margins, and lower prices for food
- An emphasis in modern food retailing on the fresh produce department
- Reduced mass marketing and more specific customer focus based on consumer food consumption patterns; food quality, and environment-friendly products
- Year round supply of temperate and tropical foods
- Consolidation of supply chains and concentration of retail and wholesale sectors
- Development of fresh produce farmer markets in urban areas
- Stringent retail imposed quality control systems and consequential rationalisation of producers

Clearly two conflicting trends are occurring in retailing of fresh fruit and vegetables. Supermarket chains are becoming more focused and specialist in quality control, product specification aimed at consumer preferences and year round supplies of a broad product range. Meanwhile, farmer markets and smaller retailers are emphasising the “local” fresh supplies with an emphasis on fresh, organic, flavour and environmentally responsible production. The latter retail sectors are growing, but are likely to remain specialist suppliers to a small and demanding population segment.

The farmer markets and small specialist retailers will focus on farmers closer to the urban areas while distance will be less critical to the supermarket chains. The national chains will seek continuity of supply, reliable deliveries, high standards of quality control, grower involvement in the food chain and participation in marketing and promotion. Sophisticated handling, storage and distribution systems will be involved. The larger retail outlets will seek to work with a smaller number of sophisticated suppliers and growers. Distance to the urban area will be less important that it has been in the past. Another notable trend is the move to supermarket private labels as a marketing tool. This national label suits high volume large producers and disadvantages smaller local producers.
3. HORTICULTURE PRODUCTION

The Wanneroo area has about 30% of the total metropolitan horticultural production area and about 5% of the State area. The more significant sectors are nurseries, cut flowers, turf farms, and vegetables.

The main vegetables produced are lettuce, broccoli, sweet corn, tomatoes, beans, celery and cabbages. These crops covered 83% of the total area planted to vegetables in the area in 2005-06. Of the fruits strawberries and avocado are most important.

An estimated 1,400 ha of horticulture land would be needed to replace the key vegetable production in Wanneroo in 40 years time.

North of Wanneroo the Gingin/Lancelin area has developed into an important production area, producing about 80% of WA’s export carrots in 2005-06.

3.1. WESTERN AUSTRALIA

The Department of Agriculture and Food estimated the value of the horticulture sector in 2006-07 at $646 million representing 12% of the total value of the food and fibre sector in the State. Exports represented nearly one quarter of this ($150 million) with sugar included.

A detailed breakdown is available for 2004-05 when the total value of production was recorded as $574 million. The horticulture sector was dominated by grape production (20%) with all other commodities providing less than 10% (Table 8).
Table 8  Horticulture production in Western Australia, 2004-05

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Value ($m)</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grapes</td>
<td>117</td>
<td>20.5%</td>
</tr>
<tr>
<td>Apples</td>
<td>40</td>
<td>7.1%</td>
</tr>
<tr>
<td>Flowers</td>
<td>40</td>
<td>6.9%</td>
</tr>
<tr>
<td>Potatoes</td>
<td>35</td>
<td>6.2%</td>
</tr>
<tr>
<td>Carrots</td>
<td>34</td>
<td>6.0%</td>
</tr>
<tr>
<td>Nurseries</td>
<td>34</td>
<td>5.9%</td>
</tr>
<tr>
<td>Olives</td>
<td>33</td>
<td>5.8%</td>
</tr>
<tr>
<td>Cultivated turf</td>
<td>26</td>
<td>4.5%</td>
</tr>
<tr>
<td>Strawberries</td>
<td>17</td>
<td>2.9%</td>
</tr>
<tr>
<td>Plums</td>
<td>11</td>
<td>1.9%</td>
</tr>
<tr>
<td>Mangoes</td>
<td>10</td>
<td>1.8%</td>
</tr>
<tr>
<td>Bananas</td>
<td>10</td>
<td>1.8%</td>
</tr>
<tr>
<td>Pumpkins</td>
<td>10</td>
<td>1.8%</td>
</tr>
<tr>
<td>Onions</td>
<td>10</td>
<td>1.8%</td>
</tr>
<tr>
<td>Rock melons</td>
<td>10</td>
<td>1.7%</td>
</tr>
<tr>
<td>Lettuce</td>
<td>9</td>
<td>1.6%</td>
</tr>
<tr>
<td>Water melons</td>
<td>9</td>
<td>1.6%</td>
</tr>
<tr>
<td>Avocados</td>
<td>8</td>
<td>1.4%</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>8</td>
<td>1.4%</td>
</tr>
<tr>
<td>Nectarines</td>
<td>8</td>
<td>1.3%</td>
</tr>
<tr>
<td>Peaches</td>
<td>7</td>
<td>1.3%</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>7</td>
<td>1.2%</td>
</tr>
<tr>
<td>Broccoli</td>
<td>7</td>
<td>1.2%</td>
</tr>
<tr>
<td>Pears</td>
<td>6</td>
<td>1.0%</td>
</tr>
<tr>
<td>Capsicum</td>
<td>6</td>
<td>1.0%</td>
</tr>
<tr>
<td>Other vegetables</td>
<td>60</td>
<td>10.5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>571</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: Department of Agriculture and Food Infonet

**Grapes**

Grapes are produced for wine production, table consumption and dried fruits. The total area planted in 2005-06 was estimated at 12,276 hectares producing 65,000 tonnes. Winemaking dominated production using over 93% of the total with Table grapes and dried grape products now very small parts of the vineyard sector.
Fruits

Value of production statistics are not available on a local area basis but production levels provide an indication of scale. In 2005-06, apples dominated fruit production accounting for over half of the total of 83,430 tonnes (Figure 9). Apples (43%) were followed by pears (12%), oranges (9%), bananas (6%) and strawberries (6%). All other fruits provided 5% or less of the total.

Figure 9  Fruit production in Western Australia, 2004-05 (tonnes)

Source: ABS Cat. 7125.0, Agricultural Commodities, Small Area Data

Fruits in this table exclude grapes, olives and nuts although these are included in the ABS fruit category. Olives in 2005-6 were just over 7,000 tonnes and expanding rapidly.

Vegetables

ABS statistics for the key vegetable categories indicate plantings of over 8,000 hectares in 2005-06 (Table 9). Plantings were dominated by potatoes and carrots and melons making up over half of the total (52%). ABS classifications include melons in the vegetable category. Plantings of some crops such as mushrooms are not reported for confidentiality reasons.

Total production was estimated at 287,000 tonnes which represented over three times the volume of fruit production at 83,430 tonnes. A major contribution to production was made by potatoes (34%) followed by carrots (27%) with the rest individually contributing 10% or less than to the total.
Table 9  Vegetable production in Western Australia, 2005-06

<table>
<thead>
<tr>
<th>Crop</th>
<th>Planted area (hectares)</th>
<th>%</th>
<th>Production (tonnes)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asparagus</td>
<td>53</td>
<td>1%</td>
<td>111</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Beans</td>
<td>249</td>
<td>3%</td>
<td>1122</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Broccoli</td>
<td>478</td>
<td>6%</td>
<td>5741</td>
<td>1%</td>
</tr>
<tr>
<td>Cabbages</td>
<td>118</td>
<td>1%</td>
<td>5,792</td>
<td></td>
</tr>
<tr>
<td>Capsicums etc</td>
<td>164</td>
<td>2%</td>
<td>3,917</td>
<td>1%</td>
</tr>
<tr>
<td>Carrots</td>
<td>1,019</td>
<td>12%</td>
<td>62,064</td>
<td>27%</td>
</tr>
<tr>
<td>Cauliflowers</td>
<td>307</td>
<td>4%</td>
<td>5,508</td>
<td>4%</td>
</tr>
<tr>
<td>Celery</td>
<td>180</td>
<td>2%</td>
<td>7,234</td>
<td></td>
</tr>
<tr>
<td>Lettuces</td>
<td>498</td>
<td>6%</td>
<td>11,221</td>
<td>6%</td>
</tr>
<tr>
<td>Melons</td>
<td>1,145</td>
<td>14%</td>
<td>36,029</td>
<td>10%</td>
</tr>
<tr>
<td>Onions</td>
<td>234</td>
<td>3%</td>
<td>14,951</td>
<td>6%</td>
</tr>
<tr>
<td>Potatoes</td>
<td>2,149</td>
<td>26%</td>
<td>89,421</td>
<td>34%</td>
</tr>
<tr>
<td>Pumpkins</td>
<td>894</td>
<td>11%</td>
<td>22,478</td>
<td>7%</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>350</td>
<td>4%</td>
<td>13,752</td>
<td>3%</td>
</tr>
<tr>
<td>Total</td>
<td>8,252</td>
<td>100%</td>
<td>287,372</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: ABS Cat 7121

3.2. WANNEROO

Wanneroo has about 30% of the total metropolitan horticultural production area and about 5% of the State area. Significant sectors are nurseries, cut flowers and turf farms, and vegetable production. The area’s total value-added production (value beyond the farm gate) was at least $239 million.

Wanneroo accounts for about 22% of the State’s total nursery, flower and turf production by value. In 2005-06 it represented about 42% of the Perth metropolitan area by area. Cut flower and turf producers and nurseries are generally larger wholesale operations supplying plants to retailers and the landscape gardening sector.

The area planted to turf farms and nurseries in the Wanneroo area increased substantially between the agricultural census years of 2001 and 2005-06. The combined area jumped from 287 hectares to 404 hectares. These horticulture industry sectors increased substantially in the State as a whole and appear to have made a significant impact in the Wanneroo area where they accounted for more than one third of the total State area.

Substantial areas are planted to vegetables with the more extensive crops including...
lettuce, broccoli, sweet corn, tomatoes, beans, celery and cabbages. Vegetable plantings in Wanneroo accounted for 14% of the State total in the 2005-06 census for a total area of 1,300 hectares (Figure 10). The area ranked third in planted area after the Kimberley and Manjimup.

**Figure 10  Vegetable plantings (ha) in Western Australia, 2005-06**

![Bar chart showing vegetable plantings in Western Australia, 2005-06](chart.png)

Significant fruit crops in the area included citrus, avocados, strawberries, olives, early stone fruit and table grapes.

In a State context, strawberry production in Wanneroo accounted for about 54% of WA production and avocado production in Wanneroo accounted for about 36% of State production. All other fruit crops do not make significant contributors to the State total. Most of the exports of strawberries from Western Australia originate in this area ($8.4 million in 2005-06).

Changes in production patterns since 2001 saw the Ord River Irrigation area (Kimberley) replace Manjimup as the area with the greatest vegetable plantings with Manjimup falling by around 500 hectares. This large reduction (nearly 30%) is attributable to a collapse in export plantings.

A detailed breakdown of Wanneroo production in 2005-06 shows a broad range of crops with many planted in small areas. The statistics reflect the vegetable farming nature of the area with many crops of relatively small scale (Figure 11).
The seven crops with the largest planted areas combined to cover 83% of the total area – tomatoes, lettuce, broccoli, cabbages, celery, beans and sweet corn. With the exception of tomatoes and beans these crops individually made up a substantial proportion of State plantings (over 35%). Other crops that also made up more than a third of State plantings included Chinese vegetables, fennel, leeks, artichokes, parsley, radish and snow peas.

Crops that are thus considered significant to the State (over 25% of production) accounted for 1,037 hectares of plantings in the 2005-06 census (Table 10).
<table>
<thead>
<tr>
<th>Crop</th>
<th>Planted area (hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomatoes</td>
<td>106</td>
</tr>
<tr>
<td>Lettuce</td>
<td>254</td>
</tr>
<tr>
<td>Broccoli</td>
<td>204</td>
</tr>
<tr>
<td>Cabbages</td>
<td>73</td>
</tr>
<tr>
<td>Celery</td>
<td>76</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>23</td>
</tr>
<tr>
<td>Sweet corn</td>
<td>115</td>
</tr>
<tr>
<td>Asian vegetables</td>
<td>50</td>
</tr>
<tr>
<td>Leeks</td>
<td>20</td>
</tr>
<tr>
<td>Radish</td>
<td>6</td>
</tr>
<tr>
<td>Artichokes</td>
<td>13</td>
</tr>
<tr>
<td>Beans</td>
<td>78</td>
</tr>
<tr>
<td>Fennel</td>
<td>3</td>
</tr>
<tr>
<td>Garlic</td>
<td>6</td>
</tr>
<tr>
<td>Snow peas</td>
<td>3</td>
</tr>
<tr>
<td>Parsley</td>
<td>2</td>
</tr>
<tr>
<td>Beetroot</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>1,037</td>
</tr>
</tbody>
</table>

Source: ABS Cat 7125

In addition to these vegetable plantings, strawberries and avocados play an important role in the area as do cut flowers, nurseries and turf farms. Wanneroo accounts for over half of the planted area in the State for strawberries, 36% of avocados production 30% of the turf farm area and 38% of the area of nurseries, but is far less significant in cut flowers.

The area required for a horticulture precinct to replace current plantings will depend on the reasons for such an approach. Benefits set out in the study terms of reference include the advantages of fresh fruit and vegetables, employment, landscape values, wastewater use, energy costs and utilisation of urban organic wastes. Each of these reasons would suggest a different planted area. For example, use of wastewater implies that the planted area should relate to the available volume of water and timeline for delivery of that water. A case for “fresh” produce would suggest an examination of each commodity with respect to the potential to produce acceptable quality in other areas or using other production methods (such as glasshouse production).

The Western Australian Planning Commission has estimated an irrigated area in Wanneroo of 2,500 hectares including fruit, grapes, vegetables, cut flowers, nurseries, and
turf farms\textsuperscript{xiv}. Allowing an expansion rate of 1.8\% per annum\textsuperscript{v} to cover metropolitan population growth over the next forty years implies a total area to replace the current plantings of 5,000 hectares.

Some of the benefits do not relate to all of the crops planted. For example, nurseries, cut flowers and turf farms have limited claims to a “fresh” produce requirement although they do have values in landscape and utilisation of water and urban wastes. The large area planted to grapes includes table and wine varieties. The shift of the viticulture sector away from the metropolitan area over the last forty years suggests that a near metropolitan location is no longer a prime decision factor.

Restricting the area to those commodities that have a “fresh” justification suggests concentration on vegetables and in particular those that the area dominates in State production. Vegetables for which the Wanneroo area provides at least 25\% of State production included 1037 hectares in 2005-6. With strawberries, the total comes to 1,143 hectares. Assuming a metropolitan growth rate of 1.8\% implies that an area of 2,000 hectares would be needed to encompass these varieties and their role in State production in 40 years time. With buffer areas, a total precinct of 2,500 hectares might be justified on this basis.

3.3. GNANGARA MOUND

The Gnangara Mound covers the Swan Coastal Plain from the Swan River north to Gingin. It includes parts of the metropolitan area and rural areas in the following Local Government Areas – the Cities of Swan and Wanneroo and the Shires of Gingin and Chittering.

The overlap with Shire boundaries makes it difficult to be precise on planted and production areas with available statistics limited to Shire boundaries. This study uses the full Shire statistics as the mound area. Hence it overstates Gnangara Mound production to the extent that areas in the Gingin Shire and Chittering to a lesser extent lie outside the Gnangara mound watertable.

Vegetable production on the Gnangara Mound accounts for more than 20\% of the State’s vegetable production which was valued at $ 228 million (GVP 2005, ABS) with the more highly mechanized carrot cropping important in the northern area of the mound (the Guilderton area). About 80\% of WA’s export carrots, which were valued at $ 37.5 million fob 2005-06, are produced in the Guilderton area on the Mound and further north in the Lancelin area.

Total production is 74,795 tonnes with carrots (largely export) making up over a third of the total followed by lettuce (12\%), cucumbers (11\%) and tomatoes 9\% (Table 11).

Vegetable production in volume terms is dominated by a small number of commodities
although the total range grown is extensive. Total production of carrots, lettuce, potatoes, tomatoes, cabbages, celery, cucumber and broccoli provided 90% of the total quantity.

Table 11  Gnangara Mound vegetable production, 2005-06

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Production (tonnes)</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrots</td>
<td>27,018</td>
<td>36%</td>
</tr>
<tr>
<td>Lettuce</td>
<td>8,830</td>
<td>12%</td>
</tr>
<tr>
<td>Potatoes</td>
<td>4,861</td>
<td>6%</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>6,411</td>
<td>9%</td>
</tr>
<tr>
<td>Cabbages</td>
<td>4,349</td>
<td>6%</td>
</tr>
<tr>
<td>Celery</td>
<td>3,700</td>
<td>5%</td>
</tr>
<tr>
<td>Broccoli</td>
<td>3,578</td>
<td>5%</td>
</tr>
<tr>
<td>Asian vegetables</td>
<td>2,602</td>
<td>3%</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>1,023</td>
<td>1%</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>7,936</td>
<td>11%</td>
</tr>
<tr>
<td>Sweet corn</td>
<td>1,065</td>
<td>2%</td>
</tr>
<tr>
<td>Pumpkins</td>
<td>403</td>
<td>1%</td>
</tr>
<tr>
<td>Melons</td>
<td>569</td>
<td>1%</td>
</tr>
<tr>
<td>Beetroot</td>
<td>212</td>
<td></td>
</tr>
<tr>
<td>Beans</td>
<td>296</td>
<td></td>
</tr>
<tr>
<td>Capsicums, chillies</td>
<td>246</td>
<td></td>
</tr>
<tr>
<td>Swedes, turnips</td>
<td>135</td>
<td></td>
</tr>
<tr>
<td>Leeks</td>
<td>193</td>
<td></td>
</tr>
<tr>
<td>Parsnips</td>
<td>123</td>
<td></td>
</tr>
<tr>
<td>Silverbeet, spinach</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>Onions</td>
<td>114</td>
<td></td>
</tr>
<tr>
<td>Zucchini, squash</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td>Spring onions, shallots</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>Radish</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>Total herbs</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Artichokes</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>74,795</td>
<td></td>
</tr>
</tbody>
</table>

Source: ABS Cat. 7125.0, Agricultural Commodities, Small Area Data

Horticulture areas on the Mound have been slowly moving north and east with the current pressure on East Wanneroo an expression of a much longer trend.
4. THE CARABOODA PRECINCT

The Carabooda Precinct is characterised as having nearly 60% of its area under freehold title, of which about 60% is under cultivation or production. The developed land is mainly located on the Spearwood soil landscape system. The undeveloped pine plantation is also located mainly on the Spearwood soil landscape system. This land system is characterised as being well suited to irrigated horticulture. Farmers in the developed area have established a variety of lot sizes from small (<4ha) and medium (4ha to 20ha) to large (> 20ha) and have a range of enterprises from vegetables to nurseries. The precinct’s climate is Mediterranean with hot dry summers and mild wet winters. The Swan Coastal Plain is well suited to horticultural production and land has been identified to the north and east of the precinct that allows for expansion of the precinct, but dependent on the Water Corporation allowing access to land to the east of one of its surveyed bore lines.

The chapter reports a grower survey that examined attitudes to recycled water and the likely impact of future urbanisation. Vegetated buffers were advocated by growers to ensure separation and reduce land use conflict. Attitudes to leasehold are positive provided associated water is guaranteed.

The identified precinct comprises cultivated freehold land alongside State Forest currently covered by pine plantation (Plate 3).

The area of the Carabooda precinct totals 1895.36 hectares. The portion on the western side of Old Yanchep Road is generally developed and predominantly in freehold ownership. The area to the east of Old Yanchep Road is primarily State Forest under pine plantation. The developed private land is generally within the Spearwood soil landscape system as is the pine plantation land to the east. Nearly 60% of the freehold land is cultivated (Table 12 and Plate 4).

Table 12 Carabooda Precinct Ownership and Land Use

<table>
<thead>
<tr>
<th></th>
<th>West of Old Yanchep Road (ha)</th>
<th>East of Old Yanchep Road (ha)</th>
<th>Yanchep Total (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area cultivated</td>
<td>629.94</td>
<td>-</td>
<td>629.94</td>
</tr>
<tr>
<td>Area in freehold ownership including roads</td>
<td>1091.85</td>
<td>-</td>
<td>1091.85</td>
</tr>
<tr>
<td>Area in Crown ownership</td>
<td>74.79</td>
<td>728.72</td>
<td>803.51</td>
</tr>
</tbody>
</table>

Farmers already established in the precinct operate on a variety of lot sizes (Plate 5).

Farming activity is best illustrated by a recent aerial photograph of the area (Plate 6).

Plate 3 Carabooda Precinct - Land Tenure and Lot Areas

See plate on the following page.

Plate 4 Carabooda Precinct Showing Cultivated Land

See plate on the following page.
4.1. **TOPOGRAPHY**

The Swan Coastal Plain is formed almost entirely of depositional material either from fluviatile or Aeolian activity\(^\text{xvi}\). The Coastal Dunes at the western edge of the alluvial terrain beneath the Darling Scarp comprise a series of sand dunes, the Bassendean Dune System being the most easterly, followed by the Spearwood Dune System and finally the Quindalup Dune System fringing the present coastline. The study area lies mainly to the west of the diffuse boundary between the Spearwood and Bassendean Dune systems. The Spearwood Dune System consists of a core of aeolianite with a hard capping of secondary calcite overlain by a variable depth of sand. The Bassendean Dune System usually shows as low sand ridges with occasional swamps. The topography is best described as undulating parallel dunes (Figure 12).

**Figure 12**  **Parallel Dunes on Swan Coastal Plain**
CARABOODA PRECINCT SHOWING LOT SIZES
THE FEASIBILITY OF A NEW HORTICULTURE PRECINCT ON THE GNANGARA MOUND
4.2. CLIMATE AND WATER

Climate (rainfall) is the primary input to the water resources of the Gnangara Mound, including the underlying confined aquifers, Drying trends in regional rainfalls since the late 1960s, as an apparent consequence of global warming driven climate change, have significantly affected the overall sustainability of these important water resources. Recent modelling of the groundwater system has confirmed the importance of climate to maintenance of water levels in the system.

The prognosis for future regional climate is uncertain, with the exception that it is likely to become drier, and this outcome is being accepted by managers to ensure that future management actions are most likely to be effective. A drier climate will most likely mean reduced levels of groundwater availability, and higher water demand for climate dependent activities such as horticulture.

The current stresses on the Mound, together with the potential for further stress as a consequence of reducing rainfall have raised the need to consider options such as use of treated wastewater to supplement the naturally occurring water resources. The recent Department of Water draft report proposes reductions in groundwater abstraction rates for both public and private uses as a response to achieving the water level criteria set as mandatory requirements under the Environmental Protection Act 1986 approval of groundwater management plans for the Mound.

The climate of the Swan Coastal Plain is suitable for the production of high quality horticultural produce, although there are restrictions on the range of crops that can be grown in particular areas. In the past the coastal plain has been broken into three major climatic zones, northern, central and southern. The study area lies within the Perth Central zone that is characterised by warm summers and mild winters making it suitable for year round production of vegetables. In recent years rainfall has decreased, but, given the use of irrigation for most horticulture production, that suitability has not been diminished.

Micro-climatic effects are important to growers on the Swan Coastal Plain with these effects being difficult to measure, but impacting on the crops grown and their timing at some locations. Sandy soils allow year round cropping due to their excellent drainage so winter waterlogging is rarely a problem. Strong winds and winter hail may also be micro-climatic problems.

4.3. LAND CAPABILITY

Soils and land capability have been assessed for potential precinct locations at Neerabup (Neaves Road), and at Carabooda/Pinjar. On the Gnangara Mound the Yellow deep sands of the Spearwood soil-landscape system found in the Carabooda area and under the Pinjar
Pine Plantation are considered most suitable for horticulture. Both the Gavin Sands and Jandakot sands of the Bassendean soil-landscape system are used for pine plantation and horticulture is currently practiced on areas of Jandakot Sands adjacent to the plantation. The main limitations for annual and perennial horticulture for the Jandakot and Gavin sands are the risk of wind erosion, the risk of phosphorous export and the poor moisture retention ability of the sand. All of the sandy soils are readily leached and inherently infertile. Nitrogen, phosphorus and potassium are almost absent in the acid Bassendean sands.

These soils are readily cultivated, allowing continuous cropping and destruction of crop residues by cultural means between crops.

As a result of a preliminary Department of Agriculture and Food study this feasibility study has focussed on the Carabooda/Pinjar precinct.

Jandakot sands and possibly Gavin sands can be used for horticulture (and currently are widely so) provided appropriate management is applied to overcome the limitation of nutrient leaching, particularly to reduce groundwater contamination. Recent developments in nutrient applications at commercial scale have demonstrated the ability to apply optimum fertilisation with minimal losses to groundwater and produce quality crops. Perennial horticulture may be easier to manage on the Gavin sands than annual horticulture, with suitable soil amendment to address moisture retention and utilising low input technology for irrigation and fertigation.

Recycled waste, as compost, offers a further opportunity to improve soils and reduce nutrient losses from sandy soils. The biggest challenge will be to put in place management regimes to ameliorate high rates of phosphorous leaching. Detailed soil surveys will be required to establish the croppable areas based on the better drained pale deep sands of the Spearwood system as these have the greatest capacity to buffer nutrient leaching. Compost would also allow better phosphorus management and even more importantly, significantly reduce nitrogen requirements.

The broad land capability assessment of the Carabooda site is included here to indicate the nature of the land resource available.

**CARABOODA/PINJAR LOCATIONS**

The Carabooda/Pinjar locations include some State Forest land planted to pines in the Carabooda and Pinjar areas along the Old Yanchep Road, and some freehold land used for agriculture and horticulture at Carabooda. These freehold areas are located within the Spearwood soil-landscape system. Several areas have been mapped and all indicate suitable soils for horticulture development. Soil descriptions from those locations covering and adjacent to the nominated precinct have been included here.
**Pinjar North-East** - This soil survey covers 6,319 ha, including 5,537 ha of existing pine plantation (Figure 13). The boundaries follow the edges of Sections B, D and E of the Pinjar Pine Plantation. It is located to the east of the Pinjar North area described below, and to the north of the Pinjar South area. The west of this location lies within the Spearwood soil-landscape system while the east falls within the Bassendean soil-landscape system.

The main soil-landscape subsystems mapped in this location by McArthur and Mattiske (1985) are Jandakot (Ja – 2,355 ha) in the Bassendean System and Karrakatta Grey Sand (Kg – 2,009 ha) in the Spearwood System. Also present in the Spearwood System are Karrakatta Yellow Sand (Ky – 880 ha), Karrakatta shallow soils (Kls- 850 ha) and Spearwood sand (Sp - 224 ha). Schoknecht et al. (2004) considered that more than a third of this area (2,272 ha) has a high capability for perennial horticulture, with a further 3,067 ha having fair capability. Most of the area (5,328 ha) was considered to have a fair capability for annual horticulture, with only 980 ha having poor capability for either form of horticulture.
Pinjar North - This soil survey covers 1,579 ha, including 1,243 ha of existing pine plantation. It extends north from Old Yanchep Road along Aqua Road to Pigeon Road (Figure n). The boundaries follow the edges of Section C of the Pinjar Pine Plantation.

The main soil-landscape subsystems mapped in this location by McArthur and Mattiske (1985) (1985) are Karrakatta Yellow Sand (Ky – 1,140 ha) with some Karrakatta shallow soils (Kls- 271 ha), Karrakatta Grey Sand (Kg – 116 ha) and Spearwood sand (Sp - 53 ha). Schoknecht et al. (2004) estimated that almost two thirds of this location (904 ha) has a high capability for perennial horticulture, with a further 240 ha having fair capability. Most of the location (1,144 ha) was estimated to have a fair capability for annual horticulture, with 435 ha having poor capability for either form of horticulture.

Carabooda - This soil survey covers 1,958 ha. It contains no existing pine plantation, being mostly private land, much of which is currently used for horticulture. It is bounded in the east by Old Yanchep Road and in the west by Wanneroo Road (Figure 14).
The main soil-landscape subsystems mapped in this location by Wells and Clarke (1986) and McArthur and Bartle (1980) are Spearwood sand (Sp - 1,152 ha), Karrakatta Yellow Sand (Ky - 539 ha), with some Karrakatta shallow soils (Kls- 184 ha) and Lakes (50 ha). Schoknecht et al. (2004) estimated that more than half of this location (1,022 ha) has a high capability for perennial horticulture, with a further 198 ha having fair capability. Around two thirds of the location (1,166 ha) was estimated to have a fair capability for annual horticulture, with 739 ha having poor capability for either form of horticulture.

Pinjar South - This location covers 1,263 ha, including 905 ha of existing pine plantation. It is bounded to the east by Pinjar and Old Yanchep Roads (Figure 14). The boundaries follow the edges of Section A of the Pinjar Pine Plantation.

The main soil-landscape subsystems mapped in this location by Wells and Clarke (1986) are Karrakatta Yellow Sand (Ky – 939 ha) with some Karrakatta Grey Sand (Kg – 169 ha), Seasonal swamps (Ws – 101 ha) and Karrakatta shallow soils (Kls- 39 ha). Schoknecht et al. (2004) estimated that almost two thirds of this location (768 ha) has a high capability for perennial horticulture, with a further 205 ha having fair capability. Most of the location (973 ha) was estimated to have a fair capability for annual horticulture, with 289 ha having poor capability for either form of horticulture.
4.4. GROWER ASPIRATIONS

Growers in the East Wanneroo area and Carabooda precinct were approached on-farm with a prepared questionnaire to elicit their views on the Carabooda Precinct. The survey was directed to growers with a range of crop types, property sizes and scales of operation. About one third of growers who were approached did not wish to respond or take part in the survey. Twenty eight growers were approached and of these ten refused to participate, nine respondents were external to the potential Carabooda precinct, three were on the periphery and six operated within the Carabooda area.

Most growers to the south of the Carabooda/Nowergup area anticipate leaving the area because of urban encroachment within the next five to ten years. Many older growers anticipate exiting the industry with no family succession. Larger family businesses have already experienced generational change and seek opportunities with larger areas. Many
of the smaller growers already lease land and are comfortable with future leasing opportunities on the conditions that water resources are secure and leases have long terms. Block sizes ranging from 5 hectares to 200 hectares are sought. Growers in the Gingin area already seek blocks of up to 400 ha.

Recycled water is acceptable provided it meets industry safety and quality assurance standards. Growers were concerned about increases in water prices, suggesting that a cost of $1000/ha for 15,000 kL/ha (approx 7 cents/kL) was fair and acceptable. The ability of a piped scheme to cope with hot weather when all growers may need to irrigate at the one time was important.

Labour is a key input and major cost to most growers with labour coming from family, the local population and backpackers. Growers who have established on-site accommodation have better retention rates.

The growers expressed some concern about the nominated area to the east of Old Yanchep Road, believing it could rapidly be impacted by urban encroachment with associated constraints applied to essential sprays and the odour of manure. Vegetative buffers will be required to ensure such constraints are not introduced to any new precinct.
5. GROUNDWATER TO THE NORTH OF PERTH

This chapter discusses groundwater availability in the area of the Swan Coastal Plain immediately north of Perth and south of Gingin Brook. The resources are essentially those associated with the Gnangara Mound and the Swan Valley. The groundwater available for abstraction more than the majority of these areas has been allocated to a variety of uses: predominantly agricultural production, including horticulture, and public water supply and little remains for further expansion of horticulture. A similar situation applies in the Swan Valley. While urbanisation of current rural areas may result in the relinquishment of groundwater allocations, the Department of Water is not proposing to make the water available for reallocation because of the need to reduce abstractions to meet environmental criteria that have become problematic as a consequence of the recent drying trends in climate. Horticultural expansion can only proceed at locations such as Carabooda if water can be obtained from sources other than local groundwater, such as from recycled water.

5.1. WATER AVAILABILITY

Growth in population in the South West of Western Australia has progressively increased the demand for water for domestic, agricultural, industrial and recreational uses across the region. Expansion of horticultural activities into the export market has increased water demand at rates that exceed general population growth rates. The stresses on the regional water resources resulting from: horticultural and other competing uses; drying climate and associated reduction in surface water flows and groundwater recharge; and a desire to maintain in situ water dependent environmental (ecological and social) values, have reduced the water potentially available to support further growth at an acceptable cost. The recent construction and planned construction of major desalination plants to supplement the South West Integrated Water Supply Scheme is a demonstration of the move away from conventional water supply sources, to sources that are climate independent, to maintain a reasonable level of reliability against the backdrop of inter-annual climate variability and longer-term climate change. However, the unit costs of water from the less conventional sources are higher than traditional sources such as self–supplied ground and surface water.

Agricultural production on the Swan Coastal Plain (between Geraldton and Busselton) progressively increased during the past century, with accelerated growth in recent decades as a result of increasing the proportion of produce to the export market. The source of water across the area, with the exception of the public irrigation areas between Waroona and Harvey, has been local groundwater. The growth in production has resulted in increasing use of these groundwater resources, such that when the agricultural demand is added to demands from other sectors, the difference between levels of use and availability have diminished, such that in many areas little or no additional water is available. Revisions of availability estimates made as the result of the expectations of a further drying climate have further reduced the potential for groundwater to be able to support
further growth in demand. This is particularly the case in the southern half of the Swan Coastal Plain.

Groundwater availability in excess of use increases north of Gingin, towards Geraldton, through the northern Gingin Groundwater Area, and the Jurien and Arrowsmith Groundwater areas (see Figure 17).

The recently reduced agricultural production in the eastern states resulting from drought conditions and severely reduced water allocations has resulted in increased pressure/opportunity to increase production in WA. This in turn has further increased the demand pressure on the local water resources.

In considering potential locations for a horticultural precinct in the south–west of Western Australia, the possibilities are extensive, given that most agricultural land can be productive provided sufficient good quality water and fertiliser are applied. Water availability is not a limiting factor in the strictest sense as water can be made available to any location, at any desired volume, at any desired level of security, and at any desired quality – at a cost. Other factors such as proximity to markets, transport distances, and the availability of labour, are also largely cost–based.

For example, the Myalup area has developed as an irrigated agriculture area more than recent decades, and could be considered as a potential precinct area. Labour is less available than in the metropolitan area, so practices change to match this need. Local groundwater provides the water source for the current level of development, but is limited and very little opportunity exists for expanding the current areas of horticulture because of restrictions on additional water being available. Additional water could be made available from a range of potential sources, such as:

- diversion and storage of winter drainage water from the areas to the east
- import of surface water from Darling Range sources
- desalination of seawater.

The primary factor that mitigates against these sources is cost. A further consideration for the use of water from conventional sources such as Darling Range surface water is competition from other uses, many of which are of higher economic value than horticulture and better able to pay the costs of supply.

The current quality of water from Wellington Reservoir is marginal for horticultural irrigation, but is progressively improving from catchment management activities designed to reduce saline runoff. Proposals such as desalination of Collie East Branch will further improve quality into the future; however, the extent of competition of water from this source will increase as the quality improves. The competing uses include public water supply (into the South West Integrated Scheme) and power generation in the Collie Basin,
both of which are high value uses with an ability to pay the full costs of supply. The ability of irrigated horticulture in the Myalup area to pay the costs of supply, including conveyancing more than distances in excess of 60km, will limit its viability.

While the primary focus of this study is on the Gnangara Mound, particularly the nominated precinct in the Carabooda area, there is an extensive range of alternative locations for a horticultural precinct, or other sources of production that can replace East Wanneroo.

5.2. THE GNANGARA MOUND

The Gnangara Mound is the most important water source in Western Australia, generating and supporting significant wealth for Perth and the greater metropolitan area. It provides more than 60% of Perth’s water and supports a thriving horticulture industry which provides Perth with a significant proportion of its fresh vegetables and injects around $240 million, in value-added terms, into the local economy. The Mound also serves vital and valued eco-systems such as the iconic caves system at Yanchep and the numerous wetlands and lakes of the coastal plain.

The Gnangara Mound is known to be under stress due to an historic run of low rainfall, which is highly likely the result of permanent climate change. Extensive planting of pines in the Gnangara, Pinjar and Carabooda areas has also significantly reduced recharge and exacerbated the stress. On the demand side, the Mound is also under great stress due to competing uses by agriculture, forestry, domestic water and the environment. All want to maintain their current access. This has resulted in:

- progressive and ongoing decline in water levels with impacts on wetlands, cave systems and abstraction infrastructure; and
- a decline in water quality with certain areas experiencing increased salinity, iron, nitrates and acidity.

The government regulator’s response has been restrictive, including measures such as:

- shutting off public water supply bores in order to maintain environmental water provisions;
- refusing licences for new or additional allocations; and
- attempting to claw back water through administrative means, for example making it difficult to renew licences.

Innovative solutions to the problems of the Gnangara Mound might provide a model for approaches to similar problems in the future. In addressing the needs of the Mound an approach where land use planning and restructure are driven by the needs of water management is favoured. Water management and allocation are to be used as drivers for
restoring sustainability of the mound. An integrated approach to economic, social and environmental development requires close collaboration from the responsible authorities and leadership at a high level to ensure cooperation is maintained and that difficult decisions are made in a timely and fair manner.

The Government is investing $7.5 million for the development of a Gnangara Sustainability Strategy intended to provide a coordinated whole-of-Government action plan to ensure the sustainable use of water for drinking and commercial purposes, and to protect the environment. The Department of Water is leading development of the Strategy, which will establish a framework for long-term sustainable management of the Mound. The Strategy, which is due for completion in 2009, is considering a range of land use and water management options, of which a horticultural precinct is one aspect.

It has been suggested that the Strategy would need to consider the following actions regarding land uses:

1. Replacing some of the Gnangara, Pinjar and Carabooda pines with a horticultural precinct suited to extensive horticulture (requiring large areas to be viable) and broiler/egg production units, and retaining the more intensive horticultural enterprises (requiring smaller areas), such as nurseries and strawberry growing, to maintain diversity in existing rural living areas.

2. Rezoning areas near the wetlands to urban (with suitable buffers) to reduce water use and protect environmentally sensitive areas. Urban areas tend to increase recharge and may help reduce the nutrient and pesticide inputs. Much of the urban and transport infrastructure already exists within a short distance.

Such planning has led to this feasibility study for a new dedicated horticultural precinct to the north of the existing urban area.

Development of a Gnangara Horticultural Precinct in the existing pines area utilising recycled water may provide a number of advantages for the State:

1. Return groundwater abstraction rates from the Gnangara Mound to a more sustainable level.

2. Secure land at scale and facilitate long-term investment in horticultural production in the north-east Wanneroo area.

3. Secure water entitlements for irrigators in an area with comparatively less immediate environmental and social consequences, encouraging investment in horticultural development at scale.

4. Increase recharge to the Gnangara Mound through the progressive removal of pine plantations in the north-eastern Wanneroo Shire pine plantation area.
5. Provide a long-term use option for treated wastewater from the Alkimos and Beenyup Wastewater Treatment Plants, by utilising water through recharge to the superficial or underlying confined aquifers, or by direct supply.

6. Secure fresh vegetable and fruit supplies for the domestic Perth market and increase possibilities of increased export of Western Australian horticultural products.

7. Enable establishment of horticultural ventures which permit economies of scale, within areas accessible to a large labour force (e.g. metropolitan Perth). New horticultural ventures with security of land and water tenure would invest in best available irrigation technologies and management practices, with associated high water use efficiencies.

8. In the medium to longer term, potentially reduce demand for water in the immediate vicinities of the lakes areas around Nowergup and Carabooda areas.

9. Provide an option for complementary intensive agricultural industries from within the Wanneroo Shire to be relocated to the new horticultural precinct. The poultry industry is the prime example of a complementary industry under pressure from urban development and associated lifestyle conflicts in Wanneroo. Security of land use tenure and protection from encroaching urban/lifestyle development would facilitate the relocation of such industries.

10. Maximise buffer zones between the horticultural precinct and rural lifestyle and urban developments, thereby minimising land use conflict issues.

11. Potentially allow for redevelopment of land currently used for horticulture in areas adjacent to urban/rural lifestyle developments in the Wanneroo Shire as irrigators choose to relocate to the Carabooda Horticultural Precinct.

Some significant relocation of horticultural operations has already taken place to the north of Wanneroo with large growers and nursery operators well established on freehold land in the Carabooda area (Figure 15).
Those horticulturists who are already established in the Carabooda area are located to the west of Old Yanchep Road where the best Spearwood soils are found.

For an expanded horticulture precinct to be established in the Carabooda area it must also satisfy the needs of the market and be determined to be the best use of the resources it will consume.

The Gnangara Mound is the most valuable source of fresh water in the Perth Region. The sustainability of the resource and its ecological and socio-economic uses are under threat because water levels have fallen across most of the Mound since the mid 1970s. Through the State Water Strategy\textsuperscript{xxi} the Government has committed to develop and implement a sustainable management framework for land and water use on the Mound. The recent announcement to develop and implement the Gnangara Sustainability Strategy\textsuperscript{xxii} is the means through which this commitment is to be delivered. In developing the strategy, the agencies have committed to presenting a number of proposed land use options to the community in a draft strategy. These options include establishment of a horticultural precinct using treated wastewater and revising groundwater allocation to public and private water supplies. The options may be implemented either singly, or in combination.

The Gnangara Mound was examined to determine water availability in two areas: the Carabooda area, and the western Swan Valley.

5.3. CARABOODA

The Department of Water has recently reviewed water allocation limits within the management sub–areas across the extent of the Gnangara Mound, together with existing allocations and levels of use. This information is summarised below.
In terms of potential locations of a horticultural precinct associated with the Gnangara Mound, the Carabooda area and Swan Valley are the two primary areas identified for examination within the project brief. Water availability within these two areas is discussed in more detail below.

The Department of Water is preparing a water management plan (allocation plan) for the Gnangara groundwater areas to guide water licensing decision-making in the period prior to the long term sustainability goal being set through the Gnangara Sustainability Strategy. From a policy perspective, the allocation plan will set management objectives for each sub-area. These individual management objectives will be underpinned by a fundamental approach of beginning recovery of the superficial aquifer, protecting ecological values, respecting existing uses, promoting water use efficiency amongst all users and ensuring protection of Public Drinking Water Source Areas. Water allocated for future public water supply use is expected to be the only future use categorisation to be considered within the management objectives.xxiii

The water availability figures presented in Table 13 through to Table 16 will be reflected in the management plan. Overall, water availability from local groundwater on the western Gnangara Mound sufficient to cater for substantial growth (>500 ML/yr) without involving conveyance from the source point to the point of demand is confined to one sub-area in the superficial aquifer north of Gnangara Road (Yanchep sub-area). This area is coastal and does not overlie the Carabooda area.
<table>
<thead>
<tr>
<th>Groundwater Area</th>
<th>Sub–area</th>
<th>Allocation Limit (ML/yr)</th>
<th>Water availability (ML/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gnangara</td>
<td>Reserve</td>
<td>9 000</td>
<td>Fully allocated</td>
</tr>
<tr>
<td></td>
<td>Wanneroo</td>
<td>12 000</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Gwelup</td>
<td>Gwelup</td>
<td>7 950</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Mirrabooka,</td>
<td>Ballajura</td>
<td>6 000</td>
<td>Fully allocated</td>
</tr>
<tr>
<td></td>
<td>Beechboro</td>
<td>1 000</td>
<td>632</td>
</tr>
<tr>
<td></td>
<td>Henley Brook</td>
<td>1 600</td>
<td>Fully allocated</td>
</tr>
<tr>
<td></td>
<td>Improvement Plan 8</td>
<td>5 500</td>
<td>168</td>
</tr>
<tr>
<td></td>
<td>Landsdale</td>
<td>1 400</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Plantation</td>
<td>600</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>State Forest</td>
<td>1 000</td>
<td>201</td>
</tr>
<tr>
<td></td>
<td>Whiteman Park</td>
<td>1 000</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Wanneroo</td>
<td>Adams</td>
<td>1 000</td>
<td>Fully allocated</td>
</tr>
<tr>
<td></td>
<td>Carabooda</td>
<td>6 400</td>
<td>Fully allocated</td>
</tr>
<tr>
<td></td>
<td>Carramar</td>
<td>1 700</td>
<td>Fully allocated</td>
</tr>
<tr>
<td></td>
<td>Jandabup</td>
<td>200</td>
<td>Fully allocated</td>
</tr>
<tr>
<td></td>
<td>Joondalup</td>
<td>1 500</td>
<td>Fully allocated</td>
</tr>
<tr>
<td></td>
<td>Lake Gnangara</td>
<td>7 500</td>
<td>Fully allocated</td>
</tr>
<tr>
<td></td>
<td>Mariginiup</td>
<td>4 000</td>
<td>Fully allocated</td>
</tr>
<tr>
<td></td>
<td>Neerabup</td>
<td>2 650</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Nowergup</td>
<td>2 000</td>
<td>Fully allocated</td>
</tr>
<tr>
<td></td>
<td>Pinjar</td>
<td>500</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Yanchep</td>
<td>Yanchep</td>
<td>10 870</td>
<td>800</td>
</tr>
<tr>
<td>Totals:</td>
<td></td>
<td>85 370</td>
<td>1 893</td>
</tr>
</tbody>
</table>

A map of the superficial aquifer sub–areas is presented in Figure 16.
Figure 16 is based on Figure 5 from: The future of east Wanneroo, Land and water management in the context of Network City, Western Australian Planning Commission, Department for Planning and Infrastructure, August 2007. Superficial aquifers are named in white print.
<table>
<thead>
<tr>
<th>Groundwater Area</th>
<th>Sub–area</th>
<th>Allocation Limit (ML/yr)</th>
<th>Water availability (ML/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gnangara</td>
<td>Reserve</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Wanneroo</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gwelup</td>
<td>Gwelup</td>
<td>3 600</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Mirrabooka</td>
<td>Ballajura</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Beechboro</td>
<td>0</td>
<td>Fully allocated</td>
</tr>
<tr>
<td></td>
<td>Henley Brook</td>
<td>360</td>
<td>360</td>
</tr>
<tr>
<td></td>
<td>Improvement Plan 8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Landsdale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Plantation</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>State Forest</td>
<td>200</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Whiteman Park</td>
<td>400</td>
<td>113</td>
</tr>
<tr>
<td>Wanneroo</td>
<td>Adams</td>
<td>No allocation limit set</td>
<td>No water available</td>
</tr>
<tr>
<td></td>
<td>Carramar</td>
<td>No allocation limit set</td>
<td>No water available</td>
</tr>
<tr>
<td></td>
<td>Jandabup</td>
<td>No allocation limit set</td>
<td>No water available</td>
</tr>
<tr>
<td></td>
<td>Joondalup</td>
<td>No allocation limit set</td>
<td>No water available</td>
</tr>
<tr>
<td></td>
<td>Lake Gnangara</td>
<td>No allocation limit set</td>
<td>No water available</td>
</tr>
<tr>
<td></td>
<td>Mariginiup</td>
<td>No allocation limit set</td>
<td>No water available</td>
</tr>
<tr>
<td>Totals:</td>
<td></td>
<td>4 560</td>
<td>523</td>
</tr>
</tbody>
</table>
Table 15  **Gnangara Mound management sub-area groundwater allocations and availability – Leederville aquifer**

<table>
<thead>
<tr>
<th>Groundwater Area</th>
<th>Sub-area</th>
<th>Allocation Limit (ML/yr)</th>
<th>Water availability (ML/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gingin</td>
<td>SA3 South</td>
<td>2 600</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Gnangara</td>
<td>Gnangara Confined</td>
<td>15 100</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Gwelup</td>
<td>Gwelup Confined</td>
<td>5 300</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Mirrabooka</td>
<td>Mirrabooka Confined</td>
<td>6 000</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Perth</td>
<td>Perth North Confined</td>
<td>10 700</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Swan</td>
<td>Swan Confined</td>
<td>5 000</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Wanneroo</td>
<td>Wanneroo Confined</td>
<td>1 250</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Yanchep</td>
<td>Yanchep Confined</td>
<td>360</td>
<td>Fully allocated</td>
</tr>
<tr>
<td><strong>Totals:</strong></td>
<td></td>
<td><strong>46 310</strong></td>
<td>Fully allocated</td>
</tr>
</tbody>
</table>

Table 16  **Gnangara Mound management sub-area groundwater allocations and availability – Yarragadee aquifer**

<table>
<thead>
<tr>
<th>Groundwater Area</th>
<th>Sub-area</th>
<th>Allocation Limit (ML/yr)</th>
<th>Water availability (ML/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gingin</td>
<td>SA3 South</td>
<td>0</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Gnangara</td>
<td>Gnangara Confined</td>
<td>5 150</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Gwelup</td>
<td>Gwelup Confined</td>
<td>7 500</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Mirrabooka</td>
<td>Mirrabooka Confined</td>
<td>1 580</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Perth</td>
<td>Perth North Confined</td>
<td>21 000</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Swan</td>
<td>Swan Confined</td>
<td>500</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Wanneroo</td>
<td>Wanneroo Confined</td>
<td>5 000</td>
<td>Fully allocated</td>
</tr>
<tr>
<td>Yanchep</td>
<td>Yanchep Confined</td>
<td>390</td>
<td>Fully allocated</td>
</tr>
<tr>
<td><strong>Totals:</strong></td>
<td></td>
<td><strong>41 120</strong></td>
<td>Fully allocated</td>
</tr>
</tbody>
</table>

Other than for the Yanchep sub–area, the Department of Water groundwater allocation review indicates that groundwater potentially available to support growth in the proposed Carabooda precinct is fully allocated. Water to support expansion would need to be sourced from either recouping allocations from other existing uses, or importing water, such as recycled water. As outlined in a previous section, a recent Department of Water draft report\textsuperscript{xiv} proposes reductions in groundwater abstraction rates for both public and private uses as a response to the need to achieve the water level criteria set as mandatory requirements under the Environmental Protection Act 1986 approval of groundwater management plans for the Mound. The proposed approach to reducing water abstractions by agricultural activities is through the surrendering of agricultural groundwater allocations when land in the East Wanneroo area becomes urbanised. This will effectively reallocate any recouped water to the environment.
5.4. SWAN VALLEY

The Swan Valley was proclaimed as a Groundwater Area under the Rights in Water and Irrigation Act 1914 in 1975 to enable management of the resource where falling water pressures in the confined aquifers and drying of previously artesian wells was occurring as a consequence of abstractions for irrigated horticulture, particularly vineyards.

The Swan Groundwater Area Groundwater Allocation Plan acknowledged that about 76% of the 18.6 GL/yr available from the superficial aquifer was allocated in 1997 and that while there was no evidence of regional scale increases in salinity, some well owners were replacing wells due to increasing salinity. Advice from the Department of Water on water allocations in the superficial aquifer is the resource on the western side of the valley is fully allocated, with approximately 106ML/yr available in the north eastern sub-areas.

The plan noted that the Leederville aquifer was preferred by a large number of users and that the declining water levels indicated that the resource was over-allocated. The plan proposed that the allocation limit for the Leederville aquifer be set at current abstraction levels in most sub-areas implying no further allocations should be made.

The Yarragadee aquifer is located at depth though the Swan Valley and contains brackish groundwater, and consequently unlikely to be required/used for irrigated horticulture. The plan notes that: “Due to the regional trend of declining potentiometric levels of the Yarragadee aquifer, abstraction from this aquifer in the Swan Groundwater Area is not generally permitted.”

The Department of Water groundwater allocation review of the Gnangara Mound extends to the western side of the Swan Valley (the eastern flank of the Gnangara Mound) and has determined that all superficial aquifer sub-areas in this area are fully allocated. The Mirrabooka Aquifer in the western Swan Valley has less than 200 ML/yr available and the Leederville and Yarragadee Formations are fully allocated. Overall, the availability of additional groundwater for new enterprises in the Swan Valley is extremely limited. Most sub-areas are fully allocated, and where there is additional water available, the quantities are small (generally less than 100 ML/yr in any sub-area). Based on nominal water use requirements of irrigated horticulture, this would be sufficient to enable an additional 12 to 40 ha to developed within the valley, depending on the crop mix, with the higher figure applying if the use was predominantly for viticulture which requires less water per unit area.

Substantial expansion of horticulture within the valley would not be possible unless water was recouped from other uses, or imported. Recouping water from other uses to establish a horticultural precinct would need to be focussed in the locality of the precinct as the hydrogeology of the shallower resources does not allow substantial spatial relocation of
the abstraction points.

Transport of recycled water from the major northern metropolitan wastewater treatment plants (Beenyup and Alkimos [proposed]) to supplement groundwater availability in the Swan Valley is feasible, but would be substantially more expensive than supplying that water into the western Gnangara Mound areas because of the additional conveyancing costs. Use of local recycled water from treatment plants servicing communities in the Darling Range, or from sewer mining from nearby sewer mains would only supply relatively small amounts of water, insufficient to support the scale of horticultural precinct being envisaged. The costs of treatment and conveyancing would be of similar order to the costs estimated for the Carabooda Precinct (see Section 6.3).
6. WATER SOURCES, SUPPLY AND PRICING

6.1. CURRENT GNANGARA SITUATION

The costs of self supplied groundwater are relatively low (about 10 c/kL). Given that there is little additional local groundwater available to support horticultural expansion, water must be imported to enable the development of any “greenfields” precinct on the northern Perth coastal plain (Carabooda or the Swan Valley). In fact the Department of Water is seeking to reduce allocations to private and public use to enable environmental water level criteria to be met.

While regional groundwater data indicates a paucity of water in the immediate northern Perth area, significant volumes may be available in the Gingin, Perth South and South West Coastal Groundwater areas. The chapter concludes that in terms of a Carabooda horticultural precinct, the primary opportunity for supply appears to be the use of recycled water from the Beenyup and (proposed) Alkimos treatment plants.

The chapter describes the treatment required to enable use of recycled water in horticulture, the associated risks, how those risks can be managed and the crop tolerances of the various constituents of recycled water. Major existing and planned horticultural developments in South Australia, Victoria and California, based on the use of recycled water, are discussed. These examples demonstrate the successful use of recycled water for this purpose.

The options for use of recycled water in a horticultural precinct at Carabooda are examined, including direct supply or via managed aquifer recharge, and the potential sources of the Beenyup and Alkimos treatment plants are examined. This assessment identifies that water from recycling will not become available in any substantial quantities until 2020 and that the major portion of this water (the water from Beenyup) is proposed for use in augmenting the public water supply system. Consequently the Alkimos source is the most likely. The costs of recycled water vary from $0.40/kL to $1.22/kL, depending on the source and percentage of demand realised, which is considerably higher than the costs of self–supplied groundwater (less than $0.07/kL). The requirement for additional storage to buffer peaks in demand would increase the costs of using recycled water.

Virtually all horticulture production is based on groundwater pumped by the farmers and distributed on farm through their own reticulation systems. The cost of government reticulated water is a significant impediment to use in any field situation with potable water use confined to human and animal consumption, household use and probably in nursery situations.

The cost of water for irrigation is thus a function of the cost to develop and reticulate the supply. Bores are generally relatively shallow. On farm reticulation systems can be complex with a range of delivery mechanisms. Pumping costs are a significant component once established.

The survey of small horticulture producers suggested water costs of around 7 cents/kL.

The government has introduced a requirement for water meters on the Gnangara Mound. All licensed private water users who have entitlements between 5,000 kilolitres per year (kL/a) and 500,000 kL/a will require water meters fitted to their bores / wells. The
Carabooda area was one of the first selected for such metering given the pressures on water supplies and the sensitive environment in the area.

Research by CSIRO suggested that the water pumping cost was around 5 cents a kilolitre and capital costs associated with sprinkler reticulation were less than $10,000 a hectare. With a fifteen year system life and water deliveries of 15 ML a year, an approximate estimate of the capital cost is around 4 cents a kilolitre. Bore costs add to this. For financial evaluation purposes in this report, total water supply costs including water source development and reticulation for this study are assumed to be 10 cents a kilolitre.

Licensed groundwater allocations for irrigated horticulture more than the Gnangara Mound total about 66 GL/yr. A total of about 2 500 ha of land is used for irrigated horticulture in the east Wanneroo area. Licensed allocations from the Wanneroo Groundwater Area total 21 GL/yr.

As outlined in Chapter 6, the availability of groundwater from the Gnangara Mound for growth in horticulture in the areas north of Wanneroo is extremely limited. The Department of Water is seeking to reduce allocations to private and public use to enable environmental water level criteria to be met. This suggests that the only means by which water to support growth in horticulture in any area determined as appropriate for a horticultural precinct, could be obtained is either by trading of allocations from properties outside the proposed precinct, or by importing water from sources other than local groundwater.

There is a perception that thinning/removal of the pine plantations in State Forest No. 65 will increase recharge, consequently increasing groundwater availability. This is not the case, as progressive thinning of the plantation was an assumption in setting the environmental water level criteria for environmental features through the region. The delays in the anticipated thinning program have been a major contributor to many of the criteria levels not being reached more than the past decade. The extent to which thinning beyond the levels expected will further increase net recharge will depend partly on the replacement land use, and its associated impact on recharge and abstraction levels. Given the impacts of climate change, and the apparent desire of the Department of Water to endeavour to continue to protect the environmental values as defined in management plans prepared during the mid 1980s and 1990s, it is unlikely that the total removal of pines would result in any substantial increase in groundwater availability in the Carabooda area.

The opportunity for trading is limited as the primary constraint on water allocation in the region is the environmental impact on groundwater dependent ecosystems (wetlands and phreatophytic vegetation). Trading of allocations effectively results in a transfer of the geographical location of environmental impacts. The lack of available additional
groundwater in most sub-areas is because the environmental limits have been reached in those areas. Consequently, any trading resulting in any translocation of the abstraction point would potentially increase drawdown impacts in the new pumping location, and exacerbate non-compliances with groundwater level management criteria. Such trading could expect to be opposed by the Department of Water.

The possibilities for importing water from alternative sources are discussed in the next section.

6.2. ALTERNATIVE WATER SUPPLY SOURCES

Water can always be made available to meet a demand at any location, at a cost, and the range of sources is consequently essentially infinite. The cost has economic, social and environmental components in varying proportions depending on the specific characteristics of the source. Desalinated seawater provides a source of effectively infinite magnitude at high security levels, in which the financial costs are high, with a moderate environmental component, and very low social cost. Most other sources, while at a lower financial cost, tend to be climate dependent with an associated impact on short and longer-term security, and have a proportionately higher social impact component (particularly in terms of competition between users and uses. Environmental costs of alternative sources to desalination have a range of environmental aspects, depending on the specific source, its location and association with environmental values.

Given the competition for use of water from conventional sources such as groundwater and surface water systems located with reasonable distances from the northern Perth coastal plain (Carabooda and the Swan Valley), the opportunity to utilise these sources to import water to demand centres at Carabooda or the Swan Valley would be limited, apart from the high costs associated with transporting water. The context report for the Expert Panel examining Kimberley water supply options highlighted the current and projected high growth rates in licensed allocations. The report notes that in the South West of Western Australia, new licensed allocations are running at 100 GL/yr. At the broad scale the report indicates very little unallocated surface water remains within the Perth region. Approximately 9 GL/yr is available within the Swan Coastal River Basin, however, this would be distributed across a number of small watercourses in the Darling Range, and of variable quality. The economics of harvesting this water into a transport system to serve a horticultural precinct on the coastal plain would be prohibitive. These sources would also be subject to normal inter-annual variability overlain with the potential for permanently reduced yields as a consequence of climate change.

The report notes the reductions in surface runoff being experienced in the region as a consequence of a drying climate more than the past several decades. In the period 2002-2005, rainfall was 36% less than the long-term average, and runoff was 88% less. The
impact of reduced rainfalls on groundwater recharge has not been quantified to the same extent. However, CSIRO (2005) quotes an unpublished report that shows that recharge under pine trees only occurs when the monthly rainfall exceeds 200mm and rainfall needs to exceed 150mm in Banksia woodlands. Months with this level of rainfall have been scarce in recent decades after being relatively common in the 1960s and early 1970s.

The drying climate is expected to result in the Department of Water revising its water availability estimates for the Gnangara Mound (and other regional resources) downwards, further reducing the opportunity to use local conventional sources.

Regional groundwater availability figures indicate the paucity of water in the northern Perth area, but indicate that significant volumes may be available in the Perth South, Gingin and South West Coastal groundwater areas.

In terms of a Carabooda horticultural precinct, the primary opportunity for supply additional water appears to be the use of recycled water from the Beenyup and Alkimos wastewater treatment plants. This opportunity is discussed in detail in the following sections.

The information presented in Figure 17 reflects an aggregated view of availability from all aquifers across the extent of the groundwater area as reconciled in 2005 and should be treated with caution. The volumes available for allocation within various areas are constantly changing as allocation limits are reviewed and as new allocations are issued under licence. In some cases, the aggregated availability figures represent the total available from low yielding aquifers such that an impractically large number of wells would be required to abstract water for major horticultural enterprises. In others, such as the Kemerton North sub–area, the water in the aquifer with substantial unallocated volumes (Cattamarra Aquifer) is of higher salinity than would be suitable for irrigation purposes, being between 2 510 and 26 100 mg/L TDSxxviii.

Advice from the Department of Water has indicated that, at the detailed level in the Gingin Groundwater Area, no single management sub–area has greater than 10 GL/yr currently available for additional allocation with the exception of the Wedge Point area in the extreme north west of the area. This water is distributed across the sub–area in the superficial formations and its distributed nature means that development is more conducive to self–supply than a public reticulated scheme. The Karakin Lakes sub–area has just more than 5 GL/yr available, insufficient for the scale of precinct being considered in this study, but sufficient for a small development of between 350 ha and 500 ha. Soil types in this area are of the Spearwood and Karrakatta series and so are suitable for further horticulture developmentxxix. If water currently allocated to the public water supply reserve was made available as a result of the development of other sources (desalination, water trading, managed aquifer recharge) then horticulture developments
could be encouraged where the water can be abstracted.

In the South West Groundwater Area, the Myalup sub–area is virtually fully allocated. The only substantial quantities of water available in this Groundwater Area are within the Lake Preston North sub–area (∼ 8 GL/yr). However, the primary management constraint on this resource is saline intrusion from groundwater underlying Lake Preston and abstractions need to be spatially distributed to avoid point concentrations of draw. The Department of Water allocation rules for this area have been consequently set to limit use to 4 000 kL/yr/ha to ensure the required abstraction distribution. These application rates would substantially limit the crop choices available, and consequently affect its viability and attractiveness as a horticultural precinct. Distributed abstraction partnered with horticulture could ensure the safety of the water resource, but supply would be more expensive than normal self-supply.

Approximately 10 GL/yr is theoretically available from the superficial formations in the Harvey sub–area, however, the clayey nature of the aquifer (Guildford Formation) is such that high yielding wells capable of delivering sufficient water for horticultural enterprises are not practically achievable. Irrigation in this area is consequently based on reticulated surface water from Darling Range sources. As indicated above, the other large quantities of available groundwater in this region are saline (>2 500 mg/L).
6.3. THE USE OF RECYCLED WATER

Recycled water (sometimes called reclaimed water) is former wastewater (sewage) that has been treated and purified for reuse, rather than discharged into the environment to dispose of it as waste. The cost of disposal of wastewater is increasing and the availability of new or additional conventional water supplies is diminishing as a result of increasing use and a drying climate. Recycled water presents as an additional resource and its use is increasing nationally and internationally, and in both developed and developing countries,
particularly in situations where the demand is for non-potable uses.

Wastewater treatment reduces the numbers of disease causing organisms. Untreated wastewater is not to be used, and primary treated wastewater will rarely be approved for reuse.

**WASTEWATER TREATMENT PROCESSES**

Wastewater is normally subjected to primary, secondary or tertiary treatment depending on the proposed fate of the water, and water quality requirements associated with that fate.

Primary treatment is essentially a sedimentation process with or without chemical assistance which removes about 50% of the suspended solids. Primary treatment with lagooning can generate Class D recycled water.

Secondary treatment removes dissolved and suspended organic material by biological oxidation and sedimentation. Processes include activated sludge, trickling filters and oxidation ditches, all with secondary sedimentation, and lagoons or oxidation ponds. Full secondary treatment can generate Class C recycled water, and if supplemented with disinfection, can generate Class B recycled water.

Tertiary treatment removes further suspended solids and pathogenic organisms. Processes include filtration (conventional and membrane) and detention in lagoons or wetlands. Tertiary treatment involving tertiary filtration and disinfection can generate Class A recycled water.

All treatment processes lead to some reduction in the numbers of pathogens. Specific pathogen reduction can be achieved by chemical or ultraviolet (UV) disinfection or by detention in lagoons. Disinfection methods include lagooning (sunlight photo oxidation and natural die-off), chlorination, UV irradiation and chlorine dioxide. Any proposed disinfection method must demonstrate inactivation of all types of disease-causing organisms considered to represent a risk associated with the proposed reuse. Disinfection is usually the final step in a treatment process train.

The section below on Quality of recycled water sets out the treatment requirements for use of recycled water in horticultural and food production.

**RECYCLED WATER IN HORTICULTURE**

Australia currently disposes of almost 86% of its wastewater without reuse, although the extent of use of recycled water is increasing (4% of water supplied in 2000/2001 (Boland 2005). There are more than 270 recycled wastewater schemes providing water to agriculture across Australia (National Heritage Trust 2007). Of the 517 GL/yr of total recycled water use in Australia, 423 GL/yr is used for agriculture, equating to about
10.6% of the total water use by that sector. However, the majority of that use (395 GL/yr) is for amenity horticulture (recreation area irrigation), with the lesser amount (51 GL/yr) used for production horticulture (Boland 2005).

**POSITIVE ASPECTS**

The use of recycled water from wastewater treatment plants in horticulture is subject to a number of considerations. The positive aspects for growers are:

- The source provides a secure supply of water largely independent of climate variability and change
- The source provides water of a consistent and known quality
- The water contains nutrients.

There is also a range of positive public aspects, including the environmental benefits of reduced disposal of wastewater into sensitive environments and reduced demand for water from conventional sources and associated environmental impacts.

**MITIGATING FACTORS AND RISKS**

There are several factors working against the use of recycled water for horticultural production:

- Water quality issues and treatment to satisfy health, environmental and water resources management concerns
- Food safety and public health concerns and perception issues associated with marketing produce grown with recycled wastewater
- On–farm management issues such as salinity/sodicity, nutrients and on–farm storage
- Economic aspects, in terms of costs and pricing, and who (polluter, beneficiary, or public) pays
- Externalities such as greenhouse gas emissions associated with water treatment.

The potential risks associated with recycled water use are environmental or health related. The common environmental risks are:

- Salinity: development of soil salinity through importing salts in the recycled water
- Sodium and sodicity: can cause soil dispersion/swelling and can be toxic to plants
- Nitrogen and phosphorous: beneficial to cultivated plants, but can cause eutrophication of natural water bodies
• Chlorine residuals: by-product of disinfection processes may be harmful to aquatic or marine ecosystems at higher levels

• Hydraulic loading: excess groundwater recharge, waterlogging and secondary salinity

• Boron: toxic to plants if it accumulates in soil

• Surfactants: can be harmful to aquatic organisms.

The key potential health risks relate to microbial pathogens (bacteria, viruses, protozoa [Giardia Lamblia, Cryptosporidium parvum] and Helminths [tapeworm, hookworm]) being present in recycled water. The presence of pharmaceutical chemicals and their metabolites potentially found in recycled water raise issues of risk. However, health impacts from these vectors should be minimal because of the relatively low exposure. However, monitoring is required to ensure appropriate risk management.

**MANAGEMENT OF RISKS**

All the risks listed above are manageable and national guidelines (National Heritage Trust 2007) have been prepared as a summary of the key requirements and procedures for planning and implementing use of recycled water in horticulture. The Department of Water has published a Water Quality Protection Note (DoW 2006) that is intended to reduce the environmental risks associated with use of irrigation water to which nutrients have been added (fertigation). The document extends its advice to consider the application criteria for organic matter and trace elements, and managing other potential water contaminants such as micro–organisms, salts, metals, surfactants, petroleum derivatives, pesticides and radioactive substances.

**QUALITY OF RECYCLED WATER**

Recycled water is defined as water that has been treated to a “fit for purpose” standard for a specific application. The primary guide to the level of treatment and consequent fitness for various purposes is through a classification system as presented in the Code of Practice appended to this study.

Recycled water is currently being utilised to irrigate horticulture on relatively large scales in South Australia (Adelaide Plains) and Victoria (Werribee Plains). These projects are discussed in more detail in the following sections. Crops harvested from areas where recycled water is used are subject to more intensive monitoring than crops that are not, and under such monitoring regimes have been well accepted by the major retailers in Australia.
EXAMPLES OF HORTICULTURE PRODUCTION BASED ON RECYCLED WATER

ADELAIDE PLAINS (SOUTH AUSTRALIA)

The Virginia Plains Irrigation area in South Australia uses treated wastewater from the Bolivar Sewerage Treatment Plant which will ultimately process up to 70% of Adelaide wastewater. The treatment plant for irrigation was built and is operated by a private company under a long term 20 year contract. Farmers are required to have on-farm storage for three days supply and take the water from an open channel system. The total cost of the plant and distribution system was around $56 million and significant funding was provided by the State and Commonwealth governments. Around 250 farmers source water from the scheme under long term contracts. They generally use all of the Bolivar plant output of treated water in summer, but most is sent to an ocean outfall in winter.

The Adelaide Plains in South Australia is promoted within South Australia as a premier integrated horticultural region, utilising sustainable industry best practices, delivering high quality, clean, fresh products to the consumer xxxii. The horticulture industry of the Adelaide Plains grows around 16% of South Australia’s horticulture production, or $92m farm gate value. This includes the overwhelming majority of greenhouse crops such as tomatoes, cucumbers and capsicum.

Large vegetable packing plants are significant employers in the region, and these also process fresh potatoes, carrots and onions grown other regions of the State. The potential for the Horticultural Industry of the Adelaide Plains to double production to $200m Farm Gate Value by 2030 has been identified. Analysis shows the total impact would be an increase in regional output of $164m, an increase in regional income of $41m and creation of an additional 2,400 jobs.

Analysis has shown that there are limited areas in South Australia where all the requisite factors are present to support a horticulture industry. Suitable soil and climate, water supply, infrastructure and an available workforce are all present in the Adelaide Plains, but unlike Western Australia, there are few other areas in South Australia where these conditions are replicated. The South Australian Government has considered strategies for the retention of horticulture in the current production area as a matter of priority.

Metropolitan Adelaide is encroaching in the Virginia area so a coordinated approach to expanding horticulture, is expected to ensure more efficient use of land and infrastructure by the horticulture industry.

The vision for the Adelaide Plains includes an expansion of the horticulture area along with the associated and required infrastructure. A recycled water pipeline is to be extended to service new areas as will be gas mains and 3 phase electricity required to enable coordinated and efficient development of horticulture industries. The blueprint for
development of the Adelaide Plains includes the establishment of a regional coordinating body. It has been recommended that water supplies must be guaranteed for existing and future horticulture requirements. Water supplies in this location include aquifers, recycled water and stormwater capture for both irrigation and food processing/value adding activities.

The quality of Adelaide’s raw water sources is poor in comparison with other state capital cities. This is particularly true in terms of aesthetic indicators such as turbidity, colour, salinity and hardness. This is due to natural factors and Adelaide’s water supply catchments being shared with other uses such as agriculture.

Adelaide already reuses nearly 20% of its treated wastewater, which is a far higher percentage than most other cities. The Virginia Pipeline Scheme north of Adelaide is one of the largest wastewater reuse schemes in the Southern Hemisphere and is designed to supply more than 20,000 ML to local market gardeners and other irrigators.

The South Australian Experience has found that treating wastewater to a standard suitable for reuse is expensive as are the pipeline systems needed to transport the water. They have concluded that wastewater reuse, therefore, lends itself better to large projects where economies of scale can be gained. The opportunity in South Australia is for reuse of wastewater to reduce demand on existing supplies rather than as an extra supply for other uses. The Bolivar wastewater treatment plant servicing the Adelaide metropolitan area is seen as the primary source of recycled water for use on the Adelaide Plains. Such an approach is relevant to the considerations for a horticulture precinct that might replace demand already imposed by operations in East Wanneroo.

**WERRIBEE PLAINS DEVELOPMENTS (VICTORIA)**

The Werribee Irrigation District (WID) is one of Melbourne’s vegetable gardens, located appropriately on Melbourne’s doorstep in the estuarine flood plain of the Werribee River. The region was settled immediately after the first arrivals in Melbourne of European settlers and has been an important agricultural centre since the early nineteenth century.

Although the section of the district north of the Maltby By-pass is being subdivided at an increasing rate, the district remains an important source of fresh food for the metropolis and SRW is committed to the long term future of the WID as a viable and essential agricultural infrastructure operation. The current 4,377 ha of irrigation land are owned by 161 customers, who hold a total of just under 10 GL/yr of water rights. These comprise 9.5 GL/yr for irrigation and 0.5 GL for other purposes. Nearly 3,000 ha is irrigated from the scheme and of this 2,100 ha is dedicated to horticulture.

In January 2005, the Western Treatment Plant began supplying recycled water to the Werribee Irrigation District project. Supplying recycled water will take pressure off the
Werribee River and local groundwater, which were the previous main sources of irrigation water in the region. The Werribee Irrigation District Recycled Water Scheme supplies millions of litres of Class A recycled water to farmers for irrigating crops such as lettuce, broccoli and cauliflower. The scheme began in January 2005 and is one of Victoria's largest commercial water recycling schemes. It is expected to reach full capacity by 2010 when it will deliver up to 8.5 GL/yr of Class A recycled water to more than 100 farmers in the Werribee area. The project will increase the reliability of water supply for local growers and has significant environment benefits to the area.

When established several potential economic, environmental and social benefits were promoted. These include:

- providing Werribee market gardeners with a secure supply of high quality water,
- easing pressure on existing water supplies from the Werribee River and the local aquifer, and
- reducing the amount of treated water discharged into Port Phillip Bay.

The water is produced at a new recycled water plant, built by Melbourne Water at its Western Treatment Plant. The new plant uses state of the art technology to meet strict EPA Victoria and Department of Human Services requirements for the safety of Class A recycled water.

Recycled water in Victoria is supplied to about 85 farmers in the Werribee irrigation area by the Southern Rural Water Authority. The supply cost in 2008 is $207/ML of water. The water is partly treated at the Werribee Sewerage Treatment plant and then shandied with river water before delivery. The capital cost of the additional water treatment plant was around $20 million.

The Victorian Government has developed the “Vision for the Werribee Plains” intended to position the region as a world leader in sustainable development, based on sustainable agricultural development and high value outputs from agricultural land.

The Western Treatment Plant in Werribee has been upgraded to improve the quality of water discharged in Port Philip Bay and to create increased opportunities for using recycled water in the region. Infrastructure was put in place to supply recycled water to the Werribee Irrigation district Project, with the intention of supplying 3 GL/yr of Class A recycled water to more than 100 farmers in the area by 2006-07, with potential to expand to 8.5 GL/yr after 2009. The cost was more than $20 million, including planning activities and approvals, and for institutional arrangements to operate the scheme. Existing irrigation channels and pipelines are used to distribute the water throughout the district.

Instead of being discharged into Port Phillip Bay, some of the treated water from the Western Treatment Plant is pumped to the recycling plant where it is further treated with
The recycled water is then pumped to Southern Rural Water's existing distribution system for the Werribee Irrigation District where it is mixed with river water. Water quality is stringently monitored throughout the recycling process. Treated water at Werribee has a high salt content, which reduces opportunities to reuse the water. Until 2009, the recycled water will be mixed with water from the Werribee River to reduce the salt content. A Salt Reduction Strategy sets out a clear plan to significantly reduce salt in the water by more than 40% by 2009. This will be achieved through a combination of cleaner industrial production processes and using desalination technology to remove the salt from the water after it has been treated. Recently Werribee growers have warned of “catastrophic crop failure” unless action is taken to reduce the high salinity levels contained in the recycled water\textsuperscript{xxvii}.

Recycled water schemes currently being examined for development of agricultural land on the Werribee Plains also include a piped supply for irrigated horticulture at Balliang, using water from the Western treatment Plant, and an expansion of agricultural enterprises through the Cranbourne-Koo Wee Rup corridor.

However, in developing the schemes, the Werribee Plains vision statement recognises that the “Market is not yet prepared to pay a commercial or cost recovery price for the recycled water despite the lack of water in the region.”

The cost estimates for supply of water in the Werribee Plains proposals range from $2.68 to $3.00/kL. Interestingly, the first growers on the Northern Adelaide Plains signed at to take their contracted entitlement at a price of 5.0 to 9.5 c/kL for their contracted water (irrespective of use), the actual price depending on season. More recent sales have been at slightly higher prices. These prices are substantially below the production and delivery costs of the water. The Government initially proposed prices of about $0.95/kL, but growers refused. There are also charges for connection ($1200) and an annual supply fee ($750).

QUEENSLAND

An ambitious Queensland scheme to take recycled water from Brisbane, Logan and Ipswich to the Lockyer Valley and the Darling Downs has been declared unviable by the Queensland Government, as it would potentially have involved subsidies of between $1 million and $2 million per farm. Barton\textsuperscript{xxviii} notes that it can be difficult to meet the economic expectations of proponents. The issue of the removal of subsidies for irrigation schemes was a major focus of the national water reform agenda in Australia since the mid 1990s, and proposals to introduce subsidised schemes could be directly counter to initiatives taken over the past decade to address these issues.
The Salinas Valley in the Central Coast region of California lies along the Salinas River between the Gabilan Range and the Santa Lucia Range. It encompasses parts of Monterey County. Cities and populated places in the Salinas Valley include Bradley, Castroville, Chualar, Gonzales, Greenfield, Jolon, King City, Lockwood, Salinas, San Ardo, San Lucas, Soledad and Spreckels.

Agriculture dominates the economy of the valley. In particular, a large majority of the salad greens consumed in the U.S. are grown within this region. Strawberries, lettuce, tomatoes, and artichokes are the dominant crops in the valley. Other crops include broccoli, cauliflower, wine grapes, celery, and spinach. Due to the intensity of local agriculture the area has earned itself the nickname, "America's Salad Bowl." The national supply role of the Salinas Valley confirms that many salad vegetables can successfully be transported over large distances to market.

The climate is ideal to grow these crops, and Salinas Valley has an extended period of time in which crops can be grown compared to more northern regions where the winter causes quite an obstacle to farmers. While the area is an agricultural powerhouse only 18% of the workforce is involved in that industry with more than 50% employed in services and government.

One of the major producing areas is Monterey Countyxxxix where agriculture is worth more than US$3 billion each year. Over-pumping of ground water has caused sea water to intrude into wells located near the coast. In an effort to reduce ground water extraction in the northern Salinas Valley, the Monterey Regional Water Pollution Control Agency in partnership with the Monterey County Water Resources Agency began providing recycled water to 4,900 hectares of prime farmland used to grow cool season vegetables in April 1998. Recycled water, blended with well water, has been used to irrigate artichokes, broccoli, Brussels sprouts, celery, cauliflower, lettuce, and strawberries. Growers were concerned that salts, particularly Na and Cl, in the recycled water would reduce yield and quality of their crops so a long term study was developed to monitor salinity levels in commercial vegetable fields. After 3 years of monitoring, the data showed that using recycled water for vegetable production increased ECe (saturated paste extract) of the soil profile from 2.0 to 2.9 dS/m, but decreased the sodium adsorption ratio (SAR) from 2.9 to 2.6. The SAR and EC of soil samples from all sites were in a range acceptable for vegetable production.

A significant amount of research was completed to evaluate the quality of recycled water and its impact on crop productionxl. The Monterey Wastewater Reclamation Study for Agriculture (MWRSA), which was completed in 1987, was an extensive 11-year study that determined that produce grown in fields irrigated with recycled water was absolutely...
safe. In addition, the appearance and yields of the crops tested were as good as or better than those grown with well water. In short, the MWRSA study proved that irrigation using recycled water was beneficial. This study has been internationally acclaimed as definitive research assuring the safety of recycled water for irrigation of crops that are consumed without cooking.

**SAN JOAQUIN VALLEY**

The San Joaquin Valley Bioregion in the heart of California is the state's top agricultural producing region, and like the Salinas Valley sometimes called “the nation's salad bowl”, recognising the great array of fruits and vegetables grown in its fertile soil. The bioregion is bordered on the west by the coastal mountain ranges. Its eastern boundary joins the southern two-thirds of the Sierra bioregion, which features Yosemite, Kings Canyon, and Sequoia National Parks. The San Joaquin Valley is California's leading agricultural producing bioregion, and five of its counties rank among the state's top 10 counties in farm production value.

The San Joaquin Valley has been labelled as "the most productive unnatural environment on Earth". Up to 25% of the United States' agricultural production (as measured by dollar value) comes from California, and the vast majority of that is in the San Joaquin Valley. Grapes (table, raisin, and to a lesser extent wine) are perhaps the valley's highest-profile product, but equally (if not more) important are cotton, nuts (especially almonds and pistachios), citrus, and vegetables. The J. G. Boswell Company's farming operation in Kings County is the largest single cotton farm in the world, occupying more than 40,000 acres (162km²). Certain places are identified quite strongly with a given crop: Stockton produces the majority of the asparagus consumed in the United States, and Fresno is sometimes incorrectly credited as the birthplace of the raisin.

Cattle and sheep ranching are also vitally important to the valley's economy. During recent years, dairy farming has greatly expanded in importance. As areas such as Chino and Corona have become absorbed into the suburban sprawl of Los Angeles, many dairy farmers have cashed out and moved their herds to Kings, Tulare, and Kern counties. Since dairy farms emit considerable quantities of methane and other noxious gases, this has exacerbated the region's air quality problems.

Between 1990 and 2004, 70,231 acres (28,092 hectares) of agricultural land was lost to urban development in the San Joaquin Valley. In an effort to confront the problem of urban sprawl, the eight Valley counties are participating in a "regional blueprint planning process" that may result in denser developments and more public transportation.

Water is recycled for agricultural use in San Joaquin and overall California, with its population of 25 million recycles 500,000 acre feet (approx 150 GL) of wastewater each year, with the potential to quadruple this amount to 600 GL by 2030.
RECYCLED WATER OPTIONS FOR CARABOODA

The Beenup and Alkimos wastewater treatment plants provide potential sources for the supply of recycled water to the Carabooda area. The details of water availability from these sites are discussed below.

There are two primary options for implementation of the use of recycled water to supplement local groundwater supplies in the Carabooda area:

1. Direct supply to horticultural properties within an area via a reticulated system taking water direct from an appropriate treatment plant, via a metered connection, and subject to a charging regime.
2. Supplementation of groundwater availability through Managed Aquifer Recharge (MAR) of appropriately treated water.

Direct Supply

There are several options for the configuration of a direct supply scheme, depending on the following:

1. The source of recycled water, in terms of configurations involving the Beenup and Alkimos wastewater treatment plants.
2. The location of treatment facilities required in addition to those required to enable discharge the wastewater through an ocean outfall (eg, prior to exit from the wastewater treatment plant, at entry to the precinct, or a combination of both).
3. Whether the supply utility delivers to the boundary of the precinct and a distribution utility reticulates the supply to individual farms, or whether the supply utility delivers from the treatment plant(s) to the farm gate.
4. The form of the reticulation system (e.g., piped [high or low pressure], or channelled).
5. Provision of peaking capacity in the distribution system, or individually on–farm.
6. Security of supply (amount of reserve storage to cover outages).

For the purpose of this analysis, it is assumed that the scheme would comprise:

1. Delivery of Class A standard water from the wastewater treatment plant(s) to the boundary of each farm boundary via a (pumped) pipeline.
2. Water would be stored at the precinct boundary, prior to distribution to horticultural customers, with provision for emergency reserve storage to cover the possibilities of failure of supply (e.g., in the event of a water quality incident in the treatment plant). Peaking storage would be provided on–farm.
3. Water would be reticulated to the boundary of individual farm boundaries via a
gravity pipe system.

4. A constant flow would be provided to the customer, maintained by a constant flow valve.

5. A minimum pressure would be provided at the customer connection.

6. Supply is seasonal (eight non–winter months of the year).

These assumptions are made on Water Corporation advice that this configuration would provide the optimum cost–efficient service. Under this scheme, it would be the individual farmer’s responsibility to provide on–site balancing (peaking) and additional emergency storages to meet their individual needs.

Water Corporation estimates of the costs of such a scheme, based on supplying only the existing precinct (approximately 1000 ha) in Carabooda) have been provided. An additional adjacent area could be serviced, but costs (largely capital costs of pipework) have not been included. The estimates have not included any possible costs required to upgrade the power requirements at the Beenyup wastewater treatment plant site, as the requirement for this was not clear at the time of estimating.

A summary of costs of supply are presented for scheme capacities of 5, 10, 15 and 20 GL/yr in Table 17.

<table>
<thead>
<tr>
<th>Scheme Capacity (GL/yr)</th>
<th>Present Capital Costs* ($M)</th>
<th>Day Operating Costs ($M/yr)#</th>
<th>Net Present Value ($M)#</th>
<th>Full demand realised Cost ($/kL)</th>
<th>50% demand realised Cost ($/kL)</th>
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<td>44</td>
<td>0.8</td>
<td>51</td>
<td>$0.69</td>
<td>$1.22</td>
</tr>
</tbody>
</table>

# For “full demand realised” condition only

- Includes contingency (52.4%), non-directs and replacement mechanical and electrical pump station costs

This analysis demonstrates the sensitivity of cost to the size of the scheme, and allows a comparison of costs with the estimated current cost of self–supply to irrigators in the area (local groundwater), of $0.07/kL.

**Managed Aquifer Recharge**

Managed aquifer recharge (MAR) is a method of adding a water source such as recycled water, to aquifers under controlled conditions. Water can be added to the aquifer by a
number of methods including infiltration via basins or galleries, or by use of injection wells.

MAR has the potential to provide benefits for water resources and environmental management. Benefits include improved maintenance of wetlands and caves, opportunity for storage of water (in times of surplus to meet need in times of demand), a reduction in the risk of salt-water intrusion, increased water availability for irrigation use and potential augmentation of drinking water supplies. The Water Corporation has expressed interest in the opportunity to “bank” surplus recycled water in the Gnangara Mound.

MAR also has the potential to improve water quality through natural processes. It may assist in the removal of nutrients such as phosphates and organics, the degradation of chemicals (such as disinfection by-products) and improve pathogen die-off.

One important aspect of MAR, with respect to utilising the technology in association with a horticultural precinct, is that it provides storage for water delivered during the winter months, when irrigation demand is low, although irrigation demand continues when there is no significant rainfall. Strawberry growers might fertigate up to five times a day. MAR used this way would enable the full yield of a treatment plant to be utilised without the need for an expensive surface storage. Without such storage, the treatment plant would need to dispose of the water inflows through either the conventional disposal to the ocean, or supply to an alternative user.

Utilisation of MAR technology would enable growers to continue with (and expand) use of on–site wells to take groundwater. This has the advantage of growers not being subject to temporary losses of supply through treatment plant or delivery system outages that exceed the design provisions, as would potentially be the case with direct supply. The water would be available year–round, enabling fertigation practices to be pursued, and the requirement to provide on–farm balancing storages would be minimised.

MAR technology can be utilised to raise the level of groundwater available for abstraction, through simply adding water to the underground storage, for removal at any later time (within reason, given the slow movement of groundwater). It can also be used to raise groundwater levels, and watertable levels in particular, in order to offset abstraction and climatic effects where environmental water level criteria need to be met, such as at Gnangara.

In the first instance of simple storage manipulation, the relative spatial locations of the recharge and abstraction points are of much less consequence than where watertable levels at specific locations are to be manipulated. In the latter case, each recharge location will result in an essentially unique set of alternative distribution configurations for the abstraction points. The issue of access rights to the groundwater becomes more complex in terms of the administrative arrangements that would need to apply. Water allocation
systems in Australia have tended to focus on “first use” water, with the principles to be applied to recharged recycled water being slower to emerge.

There is no legislation in Australia that specifically governs the supply or use of recycled water. However, the Rights in Water and Irrigation Act 1914 appears to provide an ability to regulate recycled water once injected into the ground where it becomes “underground water” and the Act does not appear to differentiate between “natural” and other waters.

The EPA is generally supportive of the use of recycled water, but where it is to be managed through technology such as MAR, the Authority has taken a cautious approach, requiring trials and formal assessment under the Environmental Protection Act 1986 prior to application to large schemes (see Section XX for more detail).

The costs associated with supply through MAR would be higher than those of direct supply

**SOURCES OF RECYCLED WATER**

The sources of recycled water potentially available to a horticultural precinct in the Carabooda area are the Beenyup and Alkimos wastewater treatment plants, and these are discussed in more detail in the next sections. The proposed level of treatment would be to produce “Class A” quality water (see Appendix 1). The water could be expected to contain about 15 mg/L of nitrogen and 10 to 12 mg/L of phosphorous. Dissolved salt levels would be about 750 to 800 mg/L, which would eliminate the selection of some salt intolerant crop types to ensure compatibility.

**BEENYUP WASTEWATER TREATMENT PLANT**

The Beenyup Wastewater Treatment Plant serves Perth’s rapidly developing northern suburbs from Quinns Beach south to Scarborough and inland through Dianella and Bayswater to the foothills east of Midland. It is an advanced secondary treatment plant with a capacity of 150 megalitres per day (55 GL/yr) that will eventually be expanded to treat 200 megalitres per day (73 GL/yr), then able to serve a population of 1.1 million people. The treatment process is designed to minimise environmental, public health and community impacts. The current volume treated is about 43 GL/yr.

The wastewater is predominantly from household kitchens, bathrooms, toilets and laundries. Wastewater entering the plant is 99.97% water. The overflow from the sedimentation tanks is the final treated wastewater, suitable for ocean discharge.

Connection of the Beenyup plant to the Carabooda area would require a pipeline approximately 30km in length, and could deliver 20 GL/yr in the short term. This may cause some disruption to landowners along the route, and would require local
Government development approval.

The available volume would be sufficient to irrigate between 1300 to 2000ha of horticulture, depending on crop types, their rotations, and irrigation technology used.

The Water Corporation aspirations for use of the water from Beenyup involve use in a large-scale groundwater replenishment scheme, through managed aquifer recharge of the treated water, to increase the availability of groundwater from the Gnangara Mound for use in the Integrated Water Supply Scheme (IWSS). This proposal is in direct competition with any proposal to use the water to supply a horticultural precinct. The Corporation is currently undergoing a groundwater replenishment trial to examine the feasibility of the proposal.

**ALKIMOS WASTEWATER TREATMENT PLANT**

The Alkimos Wastewater Treatment Plant (AWWTP) is to be established at a site to the west of the potential horticulture precinct. Projected growth in the catchment indicates that approximately 80ML/d (29 GL/yr) will require treatment by 2050 and a capacity of 160 ML/d (58 GL/yr) beyond that point. Ultimately, plant inflows could grow to 160ML/d which is comparable to the projected long term capacity at the Beenyup facility (150ML/d) and the current installed capacity at the Woodman Pt wastewater treatment plant (160ML/d).

Horticulture is the major industry to the east and north of the corridor, and presents a large opportunity for wastewater reuse in this part of the Perth metropolitan area. Based on the Department of Water’s *Water Quality Protection Note, Irrigating Vegetated land with Nutrient-Rich Wastewater* (Vulnerability Category B), this is sufficient to irrigate the following:

- 1,800ha, based on water application of 50mm per week over a 32 week irrigation season (1600mm/yr), or
- 2,400ha, based on a nitrogen application rate of 180kg/ha/yr (1200mm/yr which is limited by the nitrogen content in the water of 15mg/L).

These figures may be modified by supply rates and nutrient demand. However, all of the horticultural areas are adjacent to or hydraulically upstream from Public Drinking Water Source Areas. The potential long term public health effects and social acceptability issues of this option must be fully explored.

For the long term the option of a very high level of treatment (microfiltration and reverse osmosis) could enable injection into the aquifers for storage and reuse. However, this treatment would result in large quantities of brine solution requiring disposal. So for either of the major reuse opportunities, only a portion of the flow is reused. To ensure the continuous safe disposal of treated wastewater, it is proposed to discharge excess treated
wastewater to the ocean via a long ocean outlet.

Alkimos is about 15km closer to the proposed precinct site than Beenyup, with lower energy requirements, capital and operating costs. The shorter distance would also reduce the complexity of planning and approvals and overall project risk.

Being a greenfields site, the additional treatment required can be accommodated into the planning and design of the Alkimos site, rather than retrofitting as would be required at Beenyup. However, the progressive increase in inflows to the plant would not reach 10 GL/yr until almost 2040, with 5 GL/yr anticipated as being available by 2020. 5 GL/yr would be sufficient to support about 350 to 500 ha of irrigated horticulture.

Unlike Beenyup, there are no alternative planned uses for the water from the Alkimos treatment plant, other than consideration of it being a potential source for the Neerabup industrial area.

**CARABOODA PRECINCT**

The availability of Beenyup and Alkimos sources is dependent on urban growth and the related development and use of the treatment plants, along with the establishment of the piping infrastructure required to reticulate the water to the precinct area.

While water from these sources could be utilised to support irrigated horticulture within a precinct in the Carabooda, several factors need to be recognised and addressed:

1. Water from recycling to irrigate horticulture will be insufficient in quantity to replace existing groundwater sources to any substantial extent, at least in the short–term (prior to 2020).

2. Water from recycling to support expansion will become progressively available, but over an extended timeframe (possibly 20 GL/yr from Beenyup plus 5 GL/yr from Beenyup and Alkimos by 2020, with an additional 5 GL/yr from Alkimos by 2040).

3. Water from the Beenyup treatment plant is proposed to be used for augmentation of the public water supply system (IWSS), subject to successful results from the current trial, at a cost of about $1.62/kL, which is comparable with other climate independent sources such as desalination. If water from Beenyup is not available for irrigated horticulture, then water availability from recycling (Alkimos) will be extremely limited and a longer rather than short–term prospect (5 GL/yr by 2020 and 10 GL/yr by 2040).

4. The unit costs of water from Alkimos would be lower than those estimated for the Beenyup plant for similar quantities, but the opportunity for lower unit costs available through a large scale scheme would be compromised because of the lower volumes of water available. Costs for Beenyup range from $0.55/kL for 10 GL/yr (100% of
demand realised) to $1.22/kL for 5 GL/yr (50% demand realised). The costs of water Alkimos could be expected to be about two-thirds of the costs of Beenyup sourced water for similar volumes. These costs should be compared to the costs of direct self-supply of groundwater of $07/kL. Growers have expressed views that similar costs would be acceptable for a recycled water supply, however, higher costs than $0.07/kL would be progressively problematic.

5. The dissolved salt levels of the water delivered, would be about 750 to 800 mg/L as TDS, which will require selection of crops to ensure compatibility (crops with low salt tolerance such as beans, carrots and strawberries may not be suitable).

If any precinct is to proceed the distribution of water from these sources should be related to the ongoing daily needs of the new precinct.

Evaporation in Perth peaks in January and February at about 14 - 15mm per day. On such days a 1000 ha precinct would need at least 140 ML per day to replace evaporation and more water would be needed for cooling. The Water Corporation has indicated possible delivery rates of 45 ML/day so on the hottest days a 1,000 ha precinct would need four times the delivery. For a 1,000 ha precinct average evaporation exceeds the supply capacity of 45 ML per day for all months except June to August. In January/February 2008 there were 16 days in a row when evaporation was equal to or greater than 10 mm. Significant storage would be needed to service a 1000 ha precinct and this cost has not been factored into water pricing. The alternative approach would be for individual farms to install their own storages to provide for peak supply requirements, which directly transfers the storage costs to those growers.

**CODE OF PRACTICE FOR THE USE OF RECYCLED WATER FOR IRRIGATION OF HORTICULTURE**

A draft Code of Practice for the use of recycled water for irrigation of horticulture has been prepared for discussion with stakeholders, in the event of a decision to proceed with plans to utilise such water in a horticultural precinct. The document is presented in Appendix 1. The draft has been based on draft and final guideline documents and codes developed in other States of Australia and overseas. The code has been written primarily as a guide to growers for application anywhere in Western Australia.
7. WASTE STREAMS AND COMPOST

The technology for using recycled solid wastes in agriculture is confirmed to be well established with organic material contributing the only source of fertiliser until chemically compounded fertilisers became available in the 1950s. The composting of Municipal Solid Waste became more common in the in Europe where it was used on vineyards. Poor quality MSW then saw the material lose its market until the 1990s when the desire to minimise the disposal of organic materials into landfill was confirmed. These imperatives have been recognised worldwide and have prompted interest in the composting of organic wastes in Western Australia.

Composts have been recognised as a beneficial amendment for Western Australia’s sandy coastal soils which have a low organic matter content. Significant value has been identified, but the use of compost in horticulture is not widespread in WA. A dedicated horticulture precinct is identified as offering the best opportunity for significant amounts to be used provided high quality standards are maintained.

There is no compelling economic case, at this stage, for diversion of urban organic wastes to compost production. However, there is a government commitment to divert waste from landfill and it is sensible that organic wastes are recycled in some form.

The recycling of organic materials is not new technology. Wine has been grown for millennia in Mediterranean countries, from where it spread with the Roman Empire. For most of this time wine was grown through the use of organic waste products, be it residues from winemaking, other vegetative matter, animal manures or the equivalent of today’s biosolids. These traditional and proven production techniques were applied also wherever wine production was established in the New World (the Americas, Australia/New Zealand), albeit adapting it to local conditions to varying degrees.

An alternative to managing the soils and nutrient supply of vineyards with organic amendments only became readily available during the 1950s and 1960s in the form of chemically compounded fertilisers. This resulted in a gradual shift of many winegrowers to using chemical fertilisers. There was a parallel development which saw the gradual reduction of livestock on wine growing properties, partly due to the use of tractors and partly due to the fact that nutrients contained in manures were no longer needed.

The composting of manure or other organic matter was not a technology widely employed in central Europe before chemical fertilisers were introduced. In fact, early research into composting and the suppressive effects of compost towards soil borne plant pathogens in East Germany in the 1960’s came to a premature end due to the use of compost and organic manures being uneconomical in the face of chemical fertilisers.

However, some local authorities introduced the composting of municipal solid waste (MSW) in the 1960s and 70s and where accessible, vineyards were the prime targets for marketing the low quality MSW compost. It had become apparent, most notably in some of the steep hillside vineyards, that abandoning the addition of organic matter resulted in increased erosion and soil degradation. The use of MSW and sewage sludge compost in
vineyards was researched and monitored to some extent.

However, due to the poor quality of MSW compost (glass, plastics, heavy metals), which resulted in severe marketing problems, all 20 MSW composting facilities in Germany were either closed down or converted to process other materials. The composting of MSW was superseded by a system where the organic waste materials are separated at source and collected separately before being composted. To date this is the best way of guaranteeing the production of compost with as little contamination and impurities as possible.

Compost is not the only organic amendment available to farmers as shown by a survey of German grape growers (Table 18) who have used many organic amendments.

Table 18 Organic Materials used as Soil Amendments

<table>
<thead>
<tr>
<th>Organic material</th>
<th>Proportion of farmers using it</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pomace</td>
<td>91%</td>
</tr>
<tr>
<td>Residues from wine production</td>
<td>42%</td>
</tr>
<tr>
<td>Compost</td>
<td>35%</td>
</tr>
<tr>
<td>Animal manure</td>
<td>23%</td>
</tr>
<tr>
<td>Straw</td>
<td>21%</td>
</tr>
<tr>
<td>Bark for mulching</td>
<td>9%</td>
</tr>
<tr>
<td>Coarse residues from waste paper processing</td>
<td>9%</td>
</tr>
<tr>
<td>Sewage sludge, shredded green waste</td>
<td>0-2%</td>
</tr>
</tbody>
</table>

The European situation concerning organic waste materials changed fundamentally with the introduction of the EU Landfill Directive in 1999 (EU Website). The Directive, among other specifications, requires Member States to substantially reduce landfilling of biodegradable materials in the future. Similar imperatives have been recognised for Western Australian landfill and reported by Paulin in 1999xlviii.

Every West Australian home generates approximately 1.3 tonnes of municipal solid waste (MSW) per household per year; of this waste material 0.71 tonnes is organic material. With some 700,000 domestic residences in Western Australia, this equals 490,000 tonnes of organic material, which traditionally has been disposed of in landfillxlix.

The potential benefits of compost are well established and it is accepted that compost is a valuable resource offering significant agricultural and environmental benefits to farmers and the community because of its unique characteristics, which can offer significant returns to farmers in the form of increased crop yields and improved quality of produce.

- Compost is full of nutrients and trace elements essential for healthy plant growth. As it breaks down, nutrients are released, providing a "slow release fertiliser" for
plants. This reduces the need to use synthetic fertilisers (significant pollutants themselves) by returning valuable nutrients to the soil.

- Compost improves soil structure resulting in increased water holding capacity and nutrient retention of the soil. This reduces the irrigation needs of farms and the potential ground water contamination from synthetic fertilisers.

- Compost improves soil microbial activity, which potentially reduces the incidence of plant root diseases. Compost provides nutrients in the soil while increasing organic matter, whereas our current farming systems provide nutrients, but reduce organic matter leading to soil degradation.

In Western Australia the average organic matter in the topsoil ranges from 0.5% to 1.5% with many farmed soils having a sandy texture, especially the soils used for horticulture on the Swan Coastal Plain. This identifies a clear need for municipal solid waste organic material to be recovered and used to replenish the organic material in our poor soils.

For the past ten years the State Planning Strategy has promoted the composting of green waste so it is not disposed of within metropolitan landfill sites or burnt. Land has been allocated for the purpose of composting.

Detailed studies by Paulin (2005) demonstrated that compost made from source separated waste streams consistently increases marketable yield and improved soil quality. Its continued use was shown to build soil nitrogen and carbon, increase soil biological activity and cation exchange capacity, increase water holding capacity, reduce bulk density and stabilise pH. This has led to increased returns and benefits for growers, the environment and the wider community.

Paulin found that when transplanting leafy crops good quality compost elevated plant available nitrogen increasing yields and potentially allowing major reductions in applied fertiliser. Root crops were shown to be sensitive to compost quality and yield and quality increases were not as dramatic. To gain the full advantage of using compost on these crops, the study found it necessary to adjust fertiliser programs to account for the improved soil fertility.

Improved marketable yield and savings in fertiliser were found to be sufficient to return extra dollars particularly on light sandy soils. The greatest benefits arose when the regular use of compost effectively “bullet proofed” the soil against unanticipated climatic events, irrigation or equipment failure and human error that would otherwise have resulted in loss of potential yield.

In spite of successful trials and demonstrations the use of compost by horticulture producers in Western Australia is not widespread, it being seen as more beneficial for vines and tree crops than vegetables or broad acre field crops. Transport will always be an
important issue because of the bulk of compost and its relatively low nutrient content.

The South Metropolitan Regional Council (SMRC) is amongst several local government authorities who have committed to establishing MSW composting facilities to recover the organic material. In association with the Government of Western Australia and Organic Farming Systems the SMRC undertook to develop a market for the MSW based composts. This has been supported by the activities in the City of Stirling with the Atlas Group, but issues associated with glass contamination and elevated levels of some heavy metals continue to raise concern for the long term use of MSW compost in Agriculture. Consequently research by the Department of Agriculture and Food has focussed on the use of compost made from source separated green wastes and animal manures to generate materials better suited to agricultural applications.

In 2001 the City of Stirling began recycling the contents of every household bin put out for disposal by their then 77,000 households. This was seen as a major step in the recovery of recyclables from the waste stream, as the City uses a single bin system for all household waste including recyclables. To this stage the City of Stirling compost is all used on the Atlas farm at Calingiri.

The SMRC trial was viewed as a success with more than 20,000 tonnes of compost used on 46 farms within a radius of about 100km from Perth over a two year period.

The project demonstrated outstanding improvements in soil fertility and crop yields using MSW compost. Soil fertility consistently improved in the area of soil moisture (up to 20% increase), organic carbon (up to 60% increase), pH (consistently reduced acidity) and soil bacterial ratios (aerobic:anaerobic). On broad-acre farms this was represented in obvious soil moisture improvements in the dry 2004 season, and in horticulture by increased soil moisture and retention of soluble nitrogen in the root zone.

The addition of suitable compost to horticultural soils is an effective way to boost a soil’s ability to retain nutrients and water, improve soil chemical characteristics and increase soil nutrient content. An increase in any one of these soil characteristics can lead to improvements in crop performance. It has also been reported (Paulin 1999) that addition of compost to soil leads to large populations of beneficial microbes in the soil at the same time as returning a range of humic compounds to the soil.

Cost benefit analysis of the use of the compost in horticulture showed a positive return in the application to Viticulture, Citrus and Turf farming. However, transport costs have proved to be a significant barrier to their use on broad acre cereal crop farming. In the second year of this project, this was addressed on a small number of properties by examining ways to reduce the volume of compost used (lower application rates), assessing the residual benefits of compost when it was not reapplied in the second year, and pelletising compost. Positive benefits were gained from compost in all three
situations, indicating an obvious need to find cost effective ways to use the compost.

Surveys of farmers participating in the trial showed that 91% had a positive impression of the compost quality, 81% had no problem integrating the compost into their farm management schedule, 85% were prepared to pay freight costs, 86% were prepared to continue to use the compost and 82% would like to trial pelletised compost. Farmers were interested to understand the impact of MSW compost on the soil heavy metal levels. The project showed, after two years of compost application, there was no evidence that repeat applications of MSW compost increases the residual heavy metal levels in soil.

The study found that the market potential for the use of MSW compost within a 150km radius of Perth was 2.5 million tonnes for broad acre farming and 630,000 tonnes per year for horticulture. Considering the supply from proposed MSW facilities is 300,000t, there is the potential for far greater demand than supply in the future. The input cost of compost (with freight costs being a considerable component) will be the biggest hindrance to farmer. One of the key recommendations of the SMRC study was to concentrate bulk compost marketing on the horticultural sector, which has shorter freight distances and higher value crops.

Growers at Carabooda currently use chicken manure from nearby farms in preference to other organic amendments. A dedicated horticulture precinct is more likely to introduce some economies of scale for the production, transport and use of composted MSW and farm wastes. Given that the quality of compost as a soil amendment is always determined by the quality of the inputs careful quality standards would be essential for the production of compost for the precinct.

The costs and benefits associated with the diversion of urban organic waste from landfill and the use of compost that might be produced from such wastes is a complex exercise and probably requires a separate study. This study provides an overview of the issues.

The benefits of diversion from landfill have been studied in Australia with widely differing outcomes. The Productivity Commission rejected the widespread approach adopted in Australia of setting landfill reduction targets on the grounds that a market based solution was better. Under such an approach, the cost of landfill would be internalised into landfill levies with levies established by landfill operators based on best practice environmental standards. Externalities that need to be internalised include the cost of resource depletion, emissions during virgin material extraction, whole of life externalities associated with a product’s use and the downstream effects of pollution such as climate change and groundwater impact.

The Productivity Commission noted that no studies of the true cost of landfill have been undertaken in Australia. This study suggests that is for good reasons – key costs are often cited as climate change impact and adverse rubbish tip site impact on adjoining land
owners (dis-amenity). Climate change impacts are highly uncertain, contentious and widely disputed. Land value impacts is a function of the local land uses and very difficult to generalise.

The most comprehensive study of kerbside recycling and landfill in Australia was conducted by Nolan-ITU in 2001. The findings of this study were rejected by the Productivity Commission. The considered the external cost to be of the order of $5-25 a tonne compared with Nolan-ITU estimate of $200-280 a tonne. The Productivity Commission particularly expressed concern at the cost of greenhouse impact pointing out that estimates are very broad and should be “interpreted with care”.

The Productivity Commission estimate of landfill costs using best practice methods was in the range $127-$147 a tonne.

The costs of landfill and the externalities need to be balanced against the benefits. Landfill provides an income source and a means of rehabilitating old quarries and mines and the methane generated by organic matter breakdown now provides an energy source in many old metropolitan rubbish tips.

The simplistic assumption that waste recycling is better overlooks the fact that waste is not a uniform product stream. Some components such as building rubble and glass have no environmental impact in landfill sites. They can make up a substantial proportion of the waste stream. They also contaminate organic waste streams and reduce the value of any compost as a consequence.

The Southern Metropolitan Regional Council in Perth produces compost for around $65 a tonne and has suggested that they will sell it commercially for around $10 a tonne when volume increases. This compost is suitable for commercial agriculture, but the variability of the waste products makes it unsuitable for use as an organic product.

Taking the Productivity Commission high estimate of $147 a tonne for landfill including externalities and the net compost cost of $55 a tonne suggests that there is a gain to the community of about $90 a tonne in compost production rather than landfill disposal of urban organic wastes.

With such a significant difference, the community could be expected to demand organic waste diversion to compost. The lack of voluntary diversion implies a lack of understanding, lack of confidence in the cost differential, or concern that the diversion may not occur.

Significant risks do seem to be associated at this stage with use of the compost. Quality control is difficult for a product that is collected from houses with highly variable rubbish components. Glass separation has been one of a number of key issues with some compost only suitable for disposal as landfill itself. The sale price and logistics for farmer use have
also created concern with uptake slow possibly due to a lack of research background, but also concerns with potential contamination such as heavy metals.

The cost of landfill in Western Australia may also be significantly lower than the estimate of the Productivity Commission. Gate fees are more like $25 a tonne and with the externality estimate of $5 to $25, the landfill cost might be more like $30 to $50 a tonne – less than the net compost cost.

Clearly, there is considerable uncertainty about the costs and benefits of urban organic wastes to compost for agricultural use. While the compost itself is proving to be a worthwhile addition to poor sandy soils, the overall community net benefit is far from clear. To this concern must be added the conflict that arises with the development of waste treatment facilities. The location of these in urban areas is creating as much controversy as landfill sites.

There is no compelling economic case at this stage for diversion of urban organic wastes to compost production. However, there is a government commitment to divert waste from landfill and it is sensible that organic wastes are recycled in some form. Whether the horticulture sector represents the most suitable outlet justifies further consideration in a study focused on the alternative uses and impacts.
8. ENVIRONMENTAL RISKS

This chapter discusses the environmental risks associated with the use of recycled water to support a horticultural precinct, and the risks associated with a precinct per se.

Water recycling is supported in principle by the Environmental Protection Authority, but any recharge of aquifers will require formal assessment. The EPA has identified key environmental risks to be associated with groundwater contamination, surface and marine water contamination and ecosystem degradation.

Impacts on water quality and the drawdown of groundwater are the main aspects of environmental risk associated with a horticultural precinct, irrespective of the source of water. In addition to potential impacts on environmental values such as wetlands and the marine environment, potential contamination of downstream existing and planned public water supply wellfields is a concern requiring management.

The establishment of a precinct supplied by recycled water will require the drafting of nutrient and pesticide management plans. Particular care will be necessary upstream of the linear wetlands to the east of Wanneroo Road and downstream of the precinct. Fortunately the land and waters impacted by the precinct are not considered to be at risk to the development of acid sulphate soils if lakes are dewatered to any degree.

The Environmental Protection Authority (EPA) has expressed in principle support for water recyclingliii, but has noted that projects involving recharge to aquifers would require formal assessment under the Environmental Protection Act 1986. The EPA believes that substantial work is necessary prior to implementing large schemes if very high levels of treatment such as reverse osmosis and disinfection, were not to be employed. The EPA recommends a staged approach initially involving trials and projects of low risk.

The EPA expects that trials will be necessary prior to the implementation of any large scale recycled water recharge scheme and proponents will be required to undertake a systematic risk assessment of their proposal. The timeframes for a formal assessment, based on current process timings, could be expected to take at least 15 months, and possibly more, given the potential high levels of community concern.

Given the lack of experience with MAR on the Swan Coastal Plain to date, and the site-specific nature of transport and attenuation of contaminants, the EPA has identified the key environmental risks associated with recharge of recycled water as being:

1. Groundwater contamination with nitrogen and phosphorus at levels higher than in the native groundwater, and possibly pathogens, heavy metals and chemicals, depending on the level of treatment applied before recharge. There may be reactions between chlorine in the recycled water and organic matter in the soil forming trihalomethanes, or other geochemical reactions such as mineral precipitation, dissolution, cation exchange and redox reactions.liv Changes in groundwater quality may present potential impacts on subterranean fauna (eg, stygofauna).

2. Surface and marine water contamination may occur where the groundwater migrates
into either surface water bodies or into the marine environment where nutrients may cause eutrophication. The disposal of effluents resulting from treatment of wastewater to produce high quality recycled water may also be an issue in terms of the receiving environment.

3. Ecosystem degradation may occur where groundwater containing recycled water enters wetlands, with particular concern focussed on endocrine disruptors, pharmaceutically active products and personal care products (such as sunscreen and soaps).

The two primary aspects of the environmental risks directly associated with a horticultural precinct are associated with the water resource. These are:

- water quality impacts of the proposed land use on the underlying water resources
- drawdown impacts of groundwater abstraction affecting groundwater dependent ecosystems (GDEs).

Other risks may be associated with local soil conditions such as the potential to develop acid sulphate soils.

The draft Code of Practice for the use of recycled water for irrigation of horticulture (Appendix 1) is aimed at ensuring that use of the water is managed such that the water quality is appropriate for use on food crops, and as such will ensure that most environmental standards are not compromised. Nutrient management is required to ensure that the nutrient content of the recycled water is matched to crop requirements, and should result in relatively low residual reporting of nutrients to the environment. However, this will not guarantee the elimination of residual risks, as there will be a strong reliance on adherence by growers to the required practices, that may be difficult to police. Monitoring of groundwater quality throughout and immediately downstream of the precinct can assist in reducing this risk through providing early warning of untoward levels of water quality parameters.

8.1. WATER QUALITY

The water quality impacts of horticultural practices relate to nutrients and pesticides entering underlying water resources, which can affect both GDEs and use of the water for other consumptive purposes such as public water supplies.

Environmental constraints on water quality in the Swan Valley primarily relate to Ellen Brook and the Swan River as the primary receiving environments for contaminants in local groundwater. Concerns over nutrient levels in the Swan River, of which a major source is Ellen Brook, raise issues that would need addressing if further horticulture is promoted within the valley.
The groundwater dependent wetland areas associated with the western flank of the Gnangara Mound in the Carabooda area would also be considerations in terms of water quality impacts of increasing horticulture. Nutrient and pesticide management plans, provided their implementation can be enforced, can address many of these concerns.

The issue of protecting groundwater catchments that contribute water to the Water Corporation wellfields in the region is more problematic in defining the boundaries of a potential precinct. The Gnangara Public Drinking Water Supply Area (PDWSA) is largely a Priority 1 area in which activities that increase risk to groundwater quality are prohibited. The primary area associated with the potential Carabooda horticultural precinct does not conflict with the areas requiring protection associated with the PDWSA, unless the precinct is extended into the Lake Pinjar area. Land within Lake Pinjar has been progressively purchased by Government as it lies “upstream” of a Priority 1 tongue of land within State Forest 65 that runs along the western edge of the lake (Figure 18).

The Water Corporation has planned a further stage of its Pinjar wellfield in this area, comprising a string of shallow wells running down the State Forest tongue of land. Discussions with Water Corporation indicate that while there are no immediate plans to proceed with this wellfield extension, the Water Corporation does not wish to relinquish the opportunity to develop water from this area in the future. In wishing to maintain this opportunity the Water Corporation would not want to increase the risks to water quality by permitting irrigated horticulture in the Lake Pinjar area.

Land to the west of Wanneroo Road constitutes a Priority 3 area, containing several existing and planned Water Corporation wellfields\(^{v}\). These areas are assigned a Priority 3 category in recognition of the risk to water quality associated with the urban development in the North West Corridor, and the wellfields have been opportunistically located in recognition of this risk. If the opportunity to take water from this area is not taken, the water is effectively lost as it discharges into the ocean, or flows into aquifers that underlie the ocean. There is some potential for groundwater under the proposed Carabooda precinct to be contaminated with nutrients and pesticides, which would take about 20 years to travel downstream into the Priority 3 area. To avoid this risk, robust nutrient and pesticide management plans would need to be developed and implemented within any proposed precinct. It should be recognised that the existing horticultural activities in this area pose a similar risk, and current management is relatively limited.

The Department of Water has statutory responsibility for protection of public water supply catchments and has expressed concern that a horticultural precinct in the Carabooda area will increase the risk of nutrients (from excessive fertiliser use) and pesticides entering the Water Corporation wellfield areas in the North West Corridor resource (pers comm, Department of Water, 26 November 2007). This will increase the
risks of contamination of the wellfield above the risks that were accepted in placing the wellfields in that location.

The Department has also indicated that even if the Water Corporation relinquished its plans for extension of the Pinjar wellfield to the west of Lake Pinjar, this would not necessarily remove the need to ensure protection of water quality to Priority 1 standard. The water may need to be protected to enable an alternative water supply utility to develop the source (pers comm, Department of Water, 26 November 2007).

**8.2. IRRIGATION WITH NUTRIENT RICH WASTEWATER**

The Department of Water requires that irrigation with nutrient–rich wastewater (such as
would characterise the use of recycled water from the Beenyup and Alkimos wastewater treatment plants) should be sited with appropriate buffers to sensitive water resources. Sensitive water resource values cover a range of uses, including public and private drinking water sources, aquifers that sustain important ecological functions such as cave ecology, and wetlands with conservation values. The Department of Water also prohibits the irrigation onto land that is permanently or seasonally inundated or waterlogged (minimum depth to watertable of 2 m is required).

The Department of Water policies generally oppose the use of nutrient–rich wastewater in public drinking water source areas, with the following conditional exceptions:

- where the practice may lower risks to the water resource posed by approved land use activities in Priority 1 and 2 protection areas
- provided the practice does not increase the risk in Priority 3 protection areas.

The Water Corporation proposes a groundwater scheme in the Eglinton area, which is hydraulically downstream of the proposed Carabooda Rural and Agricultural Precinct. While the Eglinton wellfield would be considered a Priority 3 protection area because of risks posed by overlying future urbanisation, implementation of the proposal would require clear demonstration that it could be managed in terms of water quality impacts such that risks to the water supply would not be increased.

The policies also oppose use within the recharge and vegetation buffer zones of natural wetlands with conservation values, and propose that any development proposals that may affect such wetlands be assed in accordance with Part IV of the Environmental Protection Act 1986.

The presence of the chain of linear wetlands immediately to the east of Wanneroo Road, with the proposed horticultural precinct being located immediately upstream (in terms of groundwater flow) of that chain suggests that there would be management concerns regarding the impacts of a precinct located in the area north of Flynn Drive. The Yanchep caves constitute another sensitive water resource, already under pressure from declining water levels on the Gnangara Mound.

Provided the recycled water is treated to an appropriate standard, and/or on–farm management practices are adequate, these features do not constitute total prohibitions for the use of recycled water. However, they will be major considerations regarding the siting of any horticultural precinct in the Carabooda area.

8.3.  ACID SULPHATE SOILS

Acid sulphate soils (ASS) are naturally occurring soils, sediments and peats that contain iron sulphides, predominantly in the form of pyrite materials. These soils are most
commonly found in low-lying land bordering the coast or estuarine and saline wetlands, and freshwater groundwater-dependent wetlands throughout the State.

Acid sulphate soils are benign when in a waterlogged environment. However, when these soils are exposed to the atmosphere through lowering of the water table (temporarily or permanently) or by excavation, oxygen reacts with the iron sulphides in the soil. This oxidation reaction results in the production of sulphuric acid. The acid can cause a breakdown of the soil structure releasing aluminium and other metals, precipitates and nutrients, which remain in the soil until rainfall or groundwater flow is sufficient to leach them out. The acid and metals may then be mobilised into groundwater aquifers, and into nearby surface water bodies with adverse environmental and economic impacts.

Potential environmental and economic impacts include: contamination of groundwater resources by acid, arsenic, heavy metals and other contaminants, fish kills, loss of biodiversity in wetlands and waterways, loss of agricultural productivity; and corrosion of concrete and steel infrastructure by acidic soil and water.

The types of activities which may cause the oxidation of acid sulphate soils include, but may not be limited to:

- Dewatering operations;
- Excavation or other soil disturbance;
- Groundwater abstraction for private or commercial water supplies;
- Groundwater level control by drainage;
- Dredging operations; and
- Land use changes which alter the water balance.

Climatic factors (e.g. reduced rainfall) which alter the water balance may also contribute to the oxidation of ASS.

While some of the lakes adjacent to the existing East Wanneroo horticultural area have been affected by the development of acid sulphate soils the Western Australian Planning Commission\textsuperscript{lvii} has mapped the proposed area as having no known risk of acid sulphate soils developing within 3 metres of the natural soil surface, apart from the lake system found immediately to the west of the existing Carabooda horticultural activity. (Figure 19)
The east Wanneroo land use and water management strategy

notes that preliminary acid sulphate soil investigations in the south east Wanneroo area indicate that ASS occurrences are not as widespread as the broad Department of Environmental and Conservation mapping indicates. Groundwater monitoring indicates the presence of moderately acidic groundwater.

Fortunately ASS are not anticipated to be a significant issue, apart from nearby the western lakes, but where the risk exists the management of groundwater in areas underlain by acid sulphate soils should follow the key principles which have been adapted from the principles for soil management set out in both the National Strategy for managing acid sulphate soils (ARMCANZ, 2000) and the WA State Strategy. These groundwater management principles are:

1. Wherever possible, iron sulphide minerals below the water table should not be disturbed by changes in the elevation of the water table to ensure that these minerals are not exposed to air and allowed to oxidise;

2. Where disturbance is unavoidable, the disturbance should be minimised or otherwise managed to prevent long-term environmental problems caused by the oxidation of iron sulphide minerals. Management measures may need to be implemented not only in the immediate vicinity of pumping bores, but also throughout the area underlain by the cone of depression for the bores (which may extend beyond the development site);
and

3. Where environmental problems have been caused by the oxidation of sulphide minerals caused by either short- or long-term changes in water table elevation, these problems should be remediated wherever possible, or otherwise risk-based management strategies should be implemented to prevent potential impacts on human health and the receiving environment.
9. ECONOMIC FACTORS

A reliable water supply is the key driver for any irrigation enterprise. The Australian Bureau of Agriculture and Resource Economics estimated that 82% of vegetable farms irrigated their crops in 2005. Farmers in the Wanneroo area currently provide their own reticulation by pumping and piping groundwater at a cost of about 10c/kL. Delivery costs for recycled water supplied from both the Beenyup (88 c/kL) and Alkimos Waste Water Treatment Plants are introduced and the need for storage within the precinct is identified. With the delivery costs well in excess of growers’ self supply costs growers must consider what crops can be grown on any given cost. Few vegetables can carry the cost of recycled water that is anticipated for Carabooda from Beenyup or Alkimos. The Beenyup source appears less likely than Alkimos and the Alkimos supply is virtually unavailable until 2020. While recycled water is available to the Werribee Plains area in Victoria at a delivered cost of 21 c/kL the 2007 drought has reduced river flows to the extent that only 8% of allocations could be delivered in March 2008.

Horticulture Australia Limited sees an opportunity for the Australian vegetable industry to supply vegetables far in excess of domestic demand. However, growers are challenged to remain competitive in the face of improved packaging and storage and transport infrastructure that allows increased trade over longer distances.

While Wanneroo has traditionally provided land for small], medium and large enterprises it appears likely that large growers will seek even larger blocks more distant from Perth to ensure their water supplies.

A socio economic analysis was undertaken of various factors important to the Carabooda Precinct. The largest single cost item in this analysis was the community cost associated with lost labour. This was estimated at $20 million and adds to the potentially higher cost for fruit and vegetables of $10 million. Offsetting these costs are higher energy costs of at least $5 million and a wastewater subsidy of $13 million. This simplistic analysis suggests the precinct adds value to the community.

A reliable water supply is clearly the key driver for any irrigation enterprise. Vegetable production in Western Australia and some fruits (such as strawberries) would not be grown without an irrigation water supply.

Across Australia, ABARE estimated that 82% of vegetable farms irrigated their vegetable crops in 2005-06. In general, nearly the entire area of each vegetable crop sown was irrigated on these farms.

Farms that did not irrigate in 2005-06 were generally small with an average area of vegetables sown of around 1 hectare. In comparison, the average area of vegetables sown on irrigating farms was around 41 hectares.

In 2000-01, ABS estimated water use on vegetable farms in Western Australia at 111 GL of water including 66.5 GL of self supply and 44.5 GL of mains water where the latter includes an irrigation scheme. The area irrigated was estimated at 9,000 hectares. This suggests average water use across the sector of 12 ML per hectare.

In Western Australia, the vegetable industry associated with this water use provided a gross value of production of $186 million.
Were the water cost to be set at 10 cents a kilolitre, the cost would have been $11 million or 6% of the value of the output produced.

It has been estimated that wastewater could be delivered from the Beenyup wastewater treatment plant to a precinct at Carabooda for a capital cost of $86.5 million. This would provide an annual allocation of 10 GL with a daily maximum delivery of 45 ML and a scheme life of 50 years. The whole of life scheme cost is put at 88 c/kL. This does not include the cost to store or reticulate the water through the precinct. Growers suggest that storage in the precinct is highly desirable to ensure a large volume of water is available for the very hot days in summer when all growers will want to water to preserve valuable crops. There are no estimates of the reticulation cost at this stage, but depending on the storage requirements and pumping costs, they may be significant.

A supply from the proposed Alkimos treatment plant would be less expensive due to the shorter pipeline distance, but a supply of 10 GL a year is not forecast to be available before 2038.

The estimated water supply cost of 88 cents/kL compares with an estimate of the current value placed on water of 35 cents. Farmers with an allocation have a water supply cost of close to 10 cents.

Clearly growers will not choose to use recycled water unless other options are not available to them or it is made financially attractive for other reasons. Growers might use it under the following conditions:

- The cost was subsidised
- The option carried a long term guarantee of supply
- There is no alternative water supply at lower cost in locations where the same crop can be grown and marketed at similar cost

Growers in a precinct are competing in an industry where the profit margins can be low. Growers in a precinct compete with growers outside the precinct and growers in all other horticulture areas. While water is only one of the cost drivers, an increase from around 10 cents to potentially $1 a kL is a significant jump.

A number of options are available to the government if it seeks to implement a recycled water scheme for horticulture. Commitments it has made under the Council of Australian Government Agreement (COAG) make it hard to directly subsidise the water supply.

An option is to sell Crown land in a precinct for dedicated horticulture use with the land cost set to recover the water supply cost as well as land development costs. For a 2,000 hectare precinct, the water supply cost would represent $40,000 per hectare before any precinct storage or reticulation costs.
Sale of the land has advantages in the application of land use conditions and provides a means of cost recovery. It would almost certainly commit the purchasers to the recycled water supply for irrigation purposes which means that the water supply cost would need to be managed to ensure that the cost did not penalise growers compared with their competitors.

### 9.1. CROP COMPARISONS

Crops vary in their water use requirements and the relative importance of water in the overall cost of production. Summer growing conditions in many areas of Western Australia can be severe with high temperatures and high evaporation conditions. Irrigation water can be urgently needed for plant cooling and crop preservation. The value placed on such water would be very high, but with no water trading in the Gnangara mound area it is difficult to estimate the value growers place on water supplies.

The relative cost of water will vary with the type of vegetable, the season of production, the rainfall and evaporation conditions and the prices achieved for the produce. Such factors will vary significantly between years.

Providing estimates of the returns to different inputs over time (labour, machinery, land and capital) are available, it is possible to partition this gross margin into different sub-components. Brennan (2004) undertook this analysis for some crops in the South West of Western Australia. The residual after a return to the other input components was attributed to a “return to water”, or a “net water margin”. Using similar assumptions, Marsden Jacob Associates developed residual water margins, projected to 2005\textsuperscript{ii}. Many crops had negative returns when this approach was used (Table 19).
Table 19  Indicative estimates of “water margins”

<table>
<thead>
<tr>
<th>Crop</th>
<th>Return ($ / ML)</th>
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<tbody>
<tr>
<td>Potatoes</td>
<td>902</td>
</tr>
<tr>
<td>Carrots</td>
<td>37</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>-216</td>
</tr>
<tr>
<td>Broccoli</td>
<td>-616</td>
</tr>
<tr>
<td>Green Cabbage</td>
<td>-169</td>
</tr>
<tr>
<td>Chinese cabbage</td>
<td>526</td>
</tr>
<tr>
<td>Lettuces</td>
<td>-417</td>
</tr>
<tr>
<td>Oranges</td>
<td>660</td>
</tr>
<tr>
<td>Sweetcorn</td>
<td>62</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>31</td>
</tr>
<tr>
<td>Table grapes</td>
<td>-46</td>
</tr>
<tr>
<td>Nursery</td>
<td>644</td>
</tr>
</tbody>
</table>

Marsden Jacobs suggested that turf farms would be towards the upper end of the range and pasture at the lower end.

Marsden and Jacobs urge caution in the interpretation of these numbers. As net margins, they are highly variable with changes in prices and the costs that make up the gross cost base. For example, costs include a return on land put at 10% and in areas like Carabooda and Wanneroo land prices are high.

Marsden and Jacobs conclude that a gross margin approach to estimating the value of water to agriculture suggests that on average, the residual value to water is only marginally above pumping costs. Further:

“This is not to suggest that agricultural production is not a valuable or valued activity, nor that it lacks profitability. What it does demonstrate is that a snapshot approach to water valuation may generate negative values at a point in time for activities that are profitable in the long term. The results also may reflect the marginal nature of agricultural activities.”

This approach provides two useful messages – it suggests that for many crops that are already making a “loss” on water application any rise in water costs will further reduce the desirability of production. Cauliflower, broccoli, green cabbages and lettuces fall into this category. Secondly, the analysis provides a rough ranking of the sensitivity of crops to higher water costs. High margins are associated with potatoes, oranges, nurseries, Chinese cabbage and probably turf farms. The ranking suggests that these enterprises could withstand higher water costs. Another way of expressing this is that these enterprises would be able to purchase water from other license holders to continue their production – they would be the water buyers were water to be available from other
growers.

An alternative way of valuing water allocations is to look at any increment associated with land sales where a water allocation is assured. Marsden and Jacobs found some variation in the value of water inherent in land sales, but suggested that where groundwater was fully allocated, there was an implied value of $2 to $3 per kL of water entitlement or an annualised value of $0.20 to $0.30 per kL. Marsden and Jacobs derive a best estimate of $0.25 per kL.

While there are many limitations to this analysis it provides an order of magnitude for consideration of water values. It suggests that if water development and on-farm supply costs are, for example, 10 cents a kL, then growers might be prepared to pay $0.35 per kL for a delivered water supply. Current delivered costs for recycled water at Werribee in Victoria are 20.7 c/kL, with no Government rebate. This water is then shandied with river water. In March 2008 while more recycled water could be produced the supply to growers was limited by river flows and growers were receiving only 8% of their allocation. Reduced allocations have encouraged efficient irrigation techniques.

9.2. INDUSTRY TRENDS IN AUSTRALIA

Horticulture Australia has prepared a strategic vision for Australia that provides guidance on the trends in that industry. This section provides a précis of that vision as it is relevant to this study.

The sector faces promising market developments with a rising world population, a trend to greater urbanisation and a growing awareness of the value of vegetables in diet. With increasing disposable incomes there are opportunities for increased fruit and vegetable production.

On the supply side, Horticulture Australian believes that the capacity of the Australian industry to supply vegetables far exceeds domestic demand.

Competition in markets is strongly price-related and exchange rate fluctuations influence the price competitiveness of Australian imports and exports. International markets are dynamic and new low-labour-cost players are providing strong competition. The challenge for Australian businesses is to invest in areas where they can create and sustain competitive advantage against suppliers from other countries.

There are no perceived constraints of overall Australian production. The challenge however will be for growers to remain competitive in the face of improved packaging and storage and transport infrastructure that allows increased trade over longer distances. Horticulture imports are rising rapidly (15% to March 2007), although fresh vegetable imports are not. Rising fuel and transport costs may restrict trade in the future.
Other important trends include the increasing dominance of the large retail grocery chains. These strongly influence market food quality and price. Constantly improving systems of food quality and reporting are driving larger grower enterprises to meet the cost of system development and monitoring. Industry levies to fund research and development and market promotion are becoming even more important in a crowded marketplace and this will favour the farmer innovators and generally larger enterprises.

Farms are growing in size, mechanisation is increasing and the emphasis on bio-security is rising. Farmers do seem to be leaving the industry although statistics are not considered reliable. A small trend to amalgamation has seen farms of less than 50 hectares falling from 57% of the total to just fewer than 50%.

With amalgamation, comes higher income levels and surveys by the Australian Bureau of Statistics show average vegetable farm income rising to $387,000 in 2004\textsuperscript{xiii}.

Water cost may be one factor in the cost of supply.

### 9.3. EMPLOYMENT

In 2001 the resident workforce in agriculture, forestry and fishing was reported as 1,360, exceeding the local job stock of 1,076 by 284. However, horticulture is not a major employer in the region (2% of the local job stock), with the retail trade, education, health and community services and property and business services industries most important, together accounting for more than 50% of all employment. However, Wanneroo has more activity in horticulture than many other local government areas in the metropolitan area, reflecting the peri urban location of horticulture. While employment in agriculture, forestry and fishing is more than the average for metropolitan Perth, it is lower than the proportion for the whole state. Horticultural activity in the City of Wanneroo also supports employment in other parts of Western Australia, including the transport, wholesale, retail and services sectors.

### 9.4. SUPPLY CHAIN

Farms producing vegetable crops and some fruit in the Wanneroo area range greatly in their size and complexity of operation. All ultimately operate through the horticulture supply chain to market, but may use different infrastructure and approaches to the steps along the chain. Plate 7 presents the nature of small ($\leq 4\text{ha}$), medium ($> 4\text{ha}$, but $<20\text{ha}$) and large ($>20 \text{ha}$) enterprises.

Small farms often depend heavily on family labour and management. As farm size increase more mechanisation is likely to be introduced and casual and permanent labour are more essential. Larger farms have often sought land more distant from the metropolitan area and have encouraged a local permanent labour force by supporting their
employees with travel of accommodation. For the small farms direct sale to fresh outlets may be important while larger farms will market through the large retail chains and Market City.

This information should assist the understanding of the different sizes of horticultural enterprises.

Plate 7 Horticulture Farm and Supporting Infrastructure

See plate on the following page.

9.5. SOCIO-ECONOMIC EVALUATION OF PRECINCT

The advantages and disadvantages of creating a horticulture precinct in the Carabooda area can only be evaluated by making assumptions about the future location of horticulture in the absence of such a land reservation. Quantification of the cost implications for the range of impacts associated with a precinct follows.

<table>
<thead>
<tr>
<th>Table 20 Precinct Impacts</th>
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<tbody>
<tr>
<td><strong>Precinct</strong></td>
</tr>
<tr>
<td><strong>Consumer welfare</strong></td>
</tr>
<tr>
<td><strong>Employment</strong></td>
</tr>
<tr>
<td><strong>Water</strong></td>
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<tr>
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<tr>
<td><strong>Energy</strong></td>
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<td></td>
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<tr>
<td><strong>Wastewater</strong></td>
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<tr>
<td><strong>Rural setting</strong></td>
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<tr>
<td><strong>Environment</strong></td>
</tr>
<tr>
<td></td>
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</tbody>
</table>

CONSUMER WELFARE COST

The cost of displacing these commodities from the metropolitan area to consumers can be estimated by multiplying production from the area against the price differential between the Metro price and the cheapest alternative source for those months when the Metropolitan area is the cheapest source area. The challenge is that production is not reported at the Metropolitan markets by source area and volume for many commodities.
Family Casual
Permanent Agent

Family. Plus casuals at peak.

Family plus some permanent and casuals.

Permanent local and some housed on site, some casual is used.

Family, quite mechanised

Mechanical

Family, some machinery

Employee

Mechanical

Family, quite mechanised

Labour intense at harvest, some mechanisation.

Local permanent labour. Mechanised.

Labour Source

Transport

Marketing

Cooling

Packing

Planting

Management

Labour Source

Typical Crops

Labour Source

Light Green

Large (>20 ha)

Blue

Medium (>4 -20 ha)

Red

Small (<4 ha)

Typical Crops

Labour Source

Beans, herbs, cucumbers, hydro gourmet, lettuce, chilli, Asian vegetables,

Family, some casuals

Typical Crops

Labour Source

Beans, herbs, cucumbers, hydro gourmet, lettuce, chilli, Asian vegetables,

Family, some casuals

Typical Crops

Labour Source

Beans, herbs, cucumbers, hydro gourmet, lettuce, chilli, Asian vegetables,

Family, some casuals

Typical Crops

Labour Source

Beans, herbs, cucumbers, hydro gourmet, lettuce, chilli, Asian vegetables,

Family, some casuals

Typical Crops

Labour Source

Beans, herbs, cucumbers, hydro gourmet, lettuce, chilli, Asian vegetables,

Family, some casuals

Typical Crops

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Family, some casuals

Typical Crops

Labour Source

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Family, some casuals

Typical Crops

Labour Source

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Family, some casuals

Typical Crops

Labour Source

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Family, some casuals

Typical Crops

Labour Source

Beans, herbs, cucumbers, hydro gourmet, lettuce, chilli, Asian vegetables,

Family, some casuals

Typical Crops

Labour Source

Beans, herbs, cucumbers, hydro gourmet, lettuce, chilli, Asian vegetables,
Prices are recorded by source area and overall volumes, but frequently not the source volume. Some simplifying assumptions are necessary to provide a broad order of magnitude and the approach used is set out in Appendix 2.

The four most valuable commodities traded through the Perth Metropolitan markets are lettuces strawberries, tomatoes and capsicums.

More than 70 product lines are reported for lettuce varieties and packaging options totalling 8,200 tonnes in 2005-06. The metropolitan area dominates production, but some production also comes from the Gingin and Myalup areas. Over four months in 2006, the metro area averaged close to $3 a crate less than Gingin sales. The total quantity of lettuces sold in these four months (June to September) was 2,800 tonnes suggesting that if ally production had been sourced from Gingin rather than the metropolitan area, the additional cost to consumers would have been about $1 million.

Strawberry sales are not recorded by volume for separate areas. The Metro area was the cheapest source from July to December averaging 50 cents a punnet less than the lowest cost alternative (South West). The total cost assuming that all tonnes from in these months came from the Metro area would have resulted in consumers paying about $5 million extra for strawberries. This estimate provides the upper bound of the potential cost for Wanneroo production displacement– Wanneroo production is less than the metropolitan area as a whole, there is some production from other areas in most months and displacement from Wanneroo might see volume producers relocate to other areas.

Tomato sales are recorded by source and volume and price. The Metro area was the cheapest source in six months out of twelve for 2005-06. Multiplying the volume of sales in these months against the next highest price source (Geraldton) indicated that provided Geraldton could produce an additional 4,800 tonnes in those months at the higher price would cost consumers an extra $1 million in that year.

Around 6,000 tonnes of capsicums are sold a year through the Metropolitan markets. Prices vary widely with type and quality, but generally average from $2 to $3 a kilo over the year. Substantial quantities come from Carnarvon and Queensland as well as metropolitan supplies. No volume breakdown is available on a monthly basis for source of supply. Prices are quoted separately for red, green and yellow varieties and metropolitan sales were cheaper in 2006 than other sources around three months in the year. The price differential (without any weighting by volume) was about 30 cents a kilo or $300 a tonne. For four months a year of sales, this suggests a total cost to consumers of about $0.6 million a year.

Similar calculations are possible for all crops that might be displaced from the Wanneroo area. The cost for beans and marrow/squashes is small compared to these other commodities as the production volumes are much lower and prices also lower.
The cost to displace all production sold through the Metropolitan Markets based on the prices and volumes suggest an order of magnitude of less than $10 million.

This analysis gives a broad indication of the potential cost of displacing the production from the metropolitan area. The cost of displacing Wanneroo only would be a function of the proportion of each commodity produced in Wanneroo. In 2006, this was around 60% of the planted area for vegetables and strawberries making the upper bound for Wanneroo around $6 million. The cost to consumers must be scaled up to account for sales to retailers outside the market system. With total sales estimated at around about double the Metropolitan market throughput, the upper bound becomes around $12 million.

This rather crude analysis could only be improved with more detailed data on monthly sales for production areas. This data is not available at present, but might be available using a survey approach at the Metropolitan markets.

The result assumes that all displaced Wanneroo production could be sourced from the area that was quoted with the next lowest prices to the metropolitan area. The only quotations are for Geraldton, Gingin and the “South West”. The possibility that production might be increased in other parts of the metropolitan area or any near-urban areas not currently reported has not been factored into this cost estimate.

**EMPLOYMENT**

In 2001, there were an estimated 1,076 jobs in the North West corridor of Perth associated with agriculture, forestry and fishing pursuits. Horticulture may well have represented 800 of these with around 180 fruit and vegetable farms in the 2006 census.

If the farmers shifted to areas such as Myalup and Gingin, labour will be less available and management practices would change to use less labour. Perhaps half of the jobs would be lost in the move to mechanisation. An economy wide loss of 400 jobs at the average wage represents a loss to the community of $20 million in household income.

This labour loss would be offset to the extent that the workers found jobs in other industry sectors. The $20 million thus represents an upper bound to the adjustment cost.

**WATER**

A precinct offers government the opportunity to provide a dedicated wastewater supply scheme. Such a scheme cannot compete with pumped groundwater when the rights to such water are granted by government with minimal management charges and no water use charges. Treated wastewater can only compete when the alternatives are also high cost water sources.

It appears that only the Alkimos WWTP source will be available for a Carabooda Precinct and with 5 GL/yr available by 2020 that would support only 350 to 500 ha of irrigated
horticulture. The plant cannot supply 10 GL/yr (650 to 1,000 ha) until 2040. Supply costs for the recycled water are estimated at around 50 c/kL depending on the level of water treatment and the volume of water storage in the precinct area. These costs should be compared to the costs of direct self-supply of groundwater of $0.07/KL. The Water Corporation will be reluctant to provide treated water at a lower price than potable water and the government will need to subsidise the water cost if it is to compete with pumped groundwater. Even when water is no longer available in this region as a “free” government allocation, horticulture producers will still need to compete with producers elsewhere in the State using low cost groundwater supplies.

Assuming that the cost of on-farm water is around $0.60 a kilolitre and farmers have valued the water at 35 cents (see section 9.1), the subsidy from government will need to be 25 c/kL or $5 million a year for a 20GL supply.

**ENERGY**

This report has calculated (section 12.3) that a horticulture precinct has the potential to increase urban fuel use by nearly 10,000 litres of fuel each working day and increase travel times by 1,725 hours. At current fuel prices, the additional cost to consumers will be around $5 million a year.

This extreme case assumed that the horticulture area was fully in the “face” of urban expansion. In Perth, the urban front tends to stay close to the coastline with lower density development inland. A smaller number of urban residents would be displaced in this situation. The difference in fuel consumption would reflect the expected density of residential development. It could only be calculated on a specific case basis, but would be less than the 10,000 litres a day difference calculated above.

A second comparison is to assume a horticulture area 125km from Perth and similar driving times as Myalup and Guilderton. Total fuel use in this case with very conservative assumptions involves nearly 9,000 litres of fuel and at least 2,000 hours of travel time.

The displacement of urban higher density development with a precinct “embedded” in the urban area creates a green belt, but greatly increases energy consumption and travel times. This calculation has assumed that management practices will not alter.

**OVERVIEW**

Farmers minimise the cost pressures imposed by the location by varying their management practices. Where labour is difficult to obtain or is considered expensive, the farmer tends to use more capital intensive equipment. Planted areas may increase along with plant inputs to increase production and ensure a greater supply and choice in harvesting operations. Larger trucks will be used in transport and regional packing sheds
will be developed by growers to create scale economies. Coordinated transport systems may be developed with for example buses to bring workers to site during busy periods.

The largest single cost item in this analysis has been the community cost associated with any lost labour. This has been estimated at $20 million. It adds to the potentially higher cost for fruit and vegetables of $10 million. Offsetting these costs are higher energy costs of at least $5 million and a wastewater subsidy of $13 million.

This simplistic analysis suggests the precinct has value to the community. The real question that now needs to be addressed is whether the assumptions used are reasonable. Significantly more work is needed to determine that issue and current data sources will not provide the information needed.

In the current full employment economy, job losses will be minimal reducing this community cost significantly. In less prosperous times, the cost will be more important.
10. A COMPARISON OF WESTERN AUSTRALIA'S HORTICULTURE PRODUCTION AREAS

A comparison of Western Australia's main horticultural areas was completed using a multi-criteria analysis. Horticulture areas from Kununurra in the north to Albany in the south were examined for their suitability for the sustainable production of perishable annual horticulture crops in Western Australia.

Readily available water was a distinct advantage to any producing area. The availability of recycled water to the Carabooda was a distinct advantage when costs factors were not considered.

Overall the analysis showed that when many factors are considered differences between areas are not as great as might be expected or in other words Western Australia has many excellent horticultural areas.

When the seasonality of production was examined it showed that production from within the metropolitan area could be replaced by other coastal plain areas to the north and south. However, it remains essential for small areas to be available to cater for the softer lines on the fringes of Perth. Land planning and water allocation can cater for this need.

As part of this study a comparative suitability analysis of the main horticultural areas in Western Australia was conducted. Multi-criteria analysis (MCA) using internet based software (Web-HIPRE) was undertaken with invited experts from the study team and Department of Agriculture and Food. Horticulture areas from Kununurra in the north to Albany in the south were examined for their suitability for the sustainable production of perishable annual horticulture crops in Western Australia. Four scenarios were examined and key results only are presented here.

Readily available water, including recycled water, is a distinct advantage to any producing area as shown by the Carabooda area under the assumption that it is made available to the precinct and Kununurra with its vast surface storage (Figure 20 and Figure 21). No allowance is made for cost in this analysis.

Figure 20 Scenario A – Recycled Water Included (level 1 criteria)
If all areas are considered and recycled water is not available the production areas are far more closely matched (Figure 22 and Figure 23).

Even when the climatic advantages that lead to greater versatility are given higher weights the production areas closest to the metropolitan area are only slightly favoured (Figure 24 and Figure 25). Cool and tropical areas suffer from a more restricted versatility.
The analysis serves to show that, when many factors are considered, the differences between the suitability of the production areas are not as great as might have been imagined. Physical advantages are balanced by economic, social and environmental factors and adjustments can be made.

The analysis did not highlight the effect the availability of labour has on growers’ cropping choices. While Myalup and Gingin cropping experience a relative shortage of labour, Wanneroo has access to an adequate supply. This has led to different crops being grown at the more remote locations, using greater mechanisation and less labour on crops that are suited to that technique. As mechanisation technology improve so also does the number of crops that can be grown with lower labour input.

10.1. SEASONALITY OF PRODUCTION

The ability to supply horticulture crops for an extended period in a year improves the profitability of operations. An extended production period is attained by staggered plantings, different varieties and management practices.

Western Australia is fortunate in being a large State with a very large distance from north
to south. This provides a range of climate types and a changing seasonal pattern from north to south. With a year round hot climate, the Ord River area is able to produce tropical crops for many months of the year. Further to the south, the Broome area is a little more temperate and can produce similar crops although the area is limited by available water supplies. The irrigation area around Carnarvon is more temperate than the northern areas and has an ideal climate for horticulture in the “cooler” months of June through September. Geraldton is the first substantial population centre with a Mediterranean climate experiencing hot dry summers and mild wet winters. Gingin to the north of Perth has become a commercial horticulture area due to a good water supply and substantial areas of sandy soils well suited to large scale irrigation. The metropolitan area with a generally mild climate free of frost closer to the coast allows a wide diversity of fruit and vegetable production. Forms of horticulture are then found in most areas south of the metropolitan area. Coastal areas include Myalup and Capel, Denmark and Albany with inland areas at Harvey, Donnybrook, Balingup, Manjimup and Bridgetown.

Gingin and Myalup are already established as important horticultural areas in Western Australia. Both areas are located on the Swan Coastal Plain that extends from Jurien Bay in the north to Busselton in the south. Horticulture tends mainly to be developed on the Spearwood soils in both areas.

The Shire of Gingin is located to the north of the proposed precinct and has been widely recognised as an important area for future horticulture development and horticulture. By 2001 the shire was already established as the local government authority with the second largest area planted to vegetables. In 1999 van Gool and Runge considered that horticulture could expand by more than 10,500 ha. The same report could only find another 2,500 ha of land for potential expansion in the Wanneroo Shire.

South of Mandurah the coastal plain area of Myalup offers another valuable, if smaller, potential horticultural zone. Most of the better soils within the Spearwood Dunes in the west of the Waroona Shire are covered by pine plantation. Only small pockets of land along the boundary of Lake Clifton have sufficient groundwater for horticulture development and the presence of the lake constrains this development. Further south in the Shire of Harvey van Gool and Runge matched good soils to water availability on the Spearwood Dunes. They identified a potential for another 1,900 ha of horticulture development in 1999.

Vegetable growers are able to produce a wide range of crops around the metropolitan area. The species at Wanneroo that supply more than 25% of State production can be regarded as those best suited to this location. This can be for climatic reasons or due to other factors such as labour demands and proximity to market. The eleven vegetables and strawberries that make up this group can be grown around Perth for most of the year.
(Table 21). The exception is strawberries, tomatoes, beans and marrow/squashes that have a more pronounced seasonal pattern.

<table>
<thead>
<tr>
<th>Varieties</th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
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<tbody>
<tr>
<td>Broccoli</td>
<td>Metro</td>
<td>Gingin</td>
<td>Coastal SW</td>
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<td>Cabbages</td>
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<td>Gingin</td>
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<td>Strawberries</td>
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<td>Metro</td>
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<td>Chinese cabbage</td>
<td>Metro</td>
<td>Gingin</td>
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<td>Beans</td>
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<td>Spring onions/shallots</td>
<td>Metro</td>
<td>Gingin</td>
<td>Coastal SW</td>
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<td>Marrows/squashes</td>
<td>Metro</td>
<td>Gingin</td>
<td>Coastal SW</td>
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Source: Department of Agriculture and Food, 2007

Climatic conditions in Gingin are slightly warmer than the East Wanneroo area, having warm dry summers with the coastal areas on average 4°C cooler than the inland part of the shire. The annual rainfall for Gingin is 763 mm and for Lancelin 621 mm. The annual evaporation for Gingin is 2197 mm, well exceeding the rainfall and demonstrating why irrigation is essential for horticultural crops.

Climatic conditions at Myalup are slightly cooler than those found in the metropolitan area. Rainfall at Myalup is approximated by that at Bunbury at 870 mm where annual evaporation is 1554 mm.

The similarity in climate of the Gingin and Coastal South West locations mean that they generally have a similar pattern of production to the metropolitan area. The same crop can either be grown at Gingin or the Myalup area at much the same time as the metropolitan area.
The Department of Agriculture analysis suggests that Gingin or Myalup plantings could replace Wanneroo production patterns from a climate perspective. There are no crops from a climate perspective that are unique to the metropolitan climate characteristics. For example, celery which is almost entirely grown around the metropolitan area and which can be grown in this area for twelve months a year could be grown in the Gingin area for eight months and in the Myalup area for twelve months. The seasonal production pattern for tomatoes and strawberries is the same across all three areas.

Based on this supply chart, there would be shortages in Perth markets if the supply was confined to these three areas in the following months:

- Strawberries from January to June
- Beans from June to October
- Tomatoes from July to November
- Zucchini/squashes in July and August

All of the 12 varieties of fruit and vegetables in which the Wanneroo area contributes more than 25% of State production can be sourced in the same months from the Gingin or Myalup areas. This assumes of course that land and water is available for such production.

In 2005 the Gingin Ground Water Area (GWA) had 338 GL available per year, of which around 30% or 100GL/yr is unallocated and 20% is reserved for Public Water Supply. The South West Coastal GWA had more than half of its 72 GL/yr resource unallocated. With the potential to freshen the Wellington Dam supply over coming years another significant water supply may be available in that region. Subsequently both areas have been more completely allocated, but some flexibility has been identified.

Pine plantations occupy crown land in the Shires of Wanneroo, Gingin, Harvey and Waroona. Generally these are located on the Spearwood soils, known to be suited to horticulture production. If water can be allocated to these areas as they become available then horticulture can expand onto these new areas. Alternatively freehold land can be associated with water through a licence and dryland crop or pasture can be converted to irrigated horticulture.

Gingin shire farmers have so far tended to concentrate on growing carrots, cauliflower, broccoli and cabbage, celery and lettuce. While carrots can be grown all year round the other crops tend to be grown in the autumn to spring. During the hottest summer months (January to March) growing leafy vegetables in the Gingin shire is more challenging than in the Carabooda area so some summer cropping is constrained. Water use is higher in this area than at Carabooda and Myalup due the higher evaporation and the need for extra cooling irrigations. To balance this restriction the softer crops can be grown further south.
Currently cropping at Myalup is dominated by potatoes, cauliflower, onions and carrots, but it has the potential for a much wider range. The crops that are constrained by the heat of summer at Gingin can be produced at that time at Myalup and further south.

Softer lines of crops such as strawberries, herbs and Chinese vegetables are always likely to be grown in smaller areas on the fringes of Perth. Strawberries are a valuable crop and will find suitable locations and have the capacity to purchase water. They might well be grown on the heavier soils of the Harvey Irrigation District.

With such a distribution of vegetable production there can be continuous supply to match demand. However, it remains essential for small areas to be available to cater for the softer lines on the fringes of Perth. Land planning and water allocation can cater for this need. The nature of the Western Australian horticulture industry is that where supply gaps occur, growers find land in a suitable area to fill that gap provided it is viable.
11. FOOD SECURITY AND FOOD MILES

Food security has become an international, national and local issue. It addresses the need for all people to have access to adequate food to meet their dietary needs. The global focus is introduced and locally the interaction between food security and urban agriculture is raised. The value of maintaining urban production and supporting organic production and fresh markets should not be discounted.

As the price of fuel continues to escalate the awareness of the distance food travels becomes more prominent. However, the concept of food miles has limitations as it does not account for climatic differences and geographic factors that may result in food grown under natural conditions using less energy, even after transport, than the same product grown with heating or other inputs. A newer concept is that of “food print”, or the agricultural land footprint of crops. A diet high in meat can use five times a corresponding vegetarian diet that is low in fat. The theory is that meat eaters take up more land than vegetarians because livestock need more land for pasture than intensive horticulture.

With the increasing dominance of supermarkets as purveyors of food they have begun to respond to these concepts, demanding high standards of their growers. At the same time the demand for organic and fresh foods is growing, generating local interest in both local production, or urban agriculture and fresh markets. Both of these support the concept of horticulture production close to or within the urban environment.

In 1996, countries at the World Food Summit agreed that:

“Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy lifestyle.”

Food security requires an available and reliable food supply at all times. At the global, regional and national levels, food supply can be affected by climate, disasters, war, civil unrest, population growth, lack of effective agricultural practices, and restrictions to trade. Government initiatives that encourage a policy environment based on macroeconomic stability and competitive markets can improve food availability. At the community level, food security is essentially a matter of access to food.

Insecurity can be temporary or chronic. It may vary with age, status, gender, income, geographic location and ethnicity. Poverty is the main cause. Sustainable progress in poverty reduction is critical to improve access to food.

Individuals need access to sufficient, safe and nutritious food. They need adequate health services, and a healthy and secure environment, including a safe water supply. Food security is therefore closely linked to the economic and social health of a nation, society and individual. Australian development assistance addresses these various aspects.

Australia advocates a broad definition of food security based on the principle of self-reliance. This definition takes into account the many factors that impact on food security at a household level, including capacity to trade. Some development activities are
designed specifically for food security purposes according to country and regional program priorities. Regional and multilateral organisations also undertake activities.

Australia’s strategy to meet the food security commitment includes implementing policies and practices to:

- Alleviate poverty and improve physical and economic access of the poorest and most vulnerable to sufficient, nutritionally adequate and safe food
- Ensure agricultural trade is conducive to fostering food security for all, through an open market-oriented world trade system, and assist least developed countries in our region to improve their agricultural productivity and infrastructure
- Promote rural development, including sustainable agricultural, fishery and forestry production and management of natural resources
- Provide technical assistance for developing countries to meet international standards of food quality and safety to export their products
- Enhance women’s access to agricultural credit, natural resources, technology, and information
- Ensure children and other vulnerable groups are provided with adequate food
- Prepare for disasters and emergencies to meet transitory and emergency food requirements in ways that encourage recovery and rehabilitation
- Undertake agricultural research and development
- Improve water governance and delivery systems.

The third point above suggests the need to retain sufficient vegetable production capacity in Western Australia to satisfy local food needs. This leads to the consideration of replacing any production being forced from the East Wanneroo area by urban encroachment. Potential locations include the identified Carabooda precinct or other alternatives discussed in this report.

This food security argument is supported by an English report lxvi that argues that “Health is the Key”, the central consideration of the Nation’s farming and food system. It is argued that England needs a modern, reformed Farming and Food Policy which takes full account of the health of the population and the government’s support for tackling health inequalities and the principles of sustainable development. Both human and environmental health must be considered.

Food insecurity is not just a problem for developing countries. It is defined as that constant feeling of anxiety that comes from trying to provide enough food for yourself or your family. In 2004 a survey of South West Sydney households found that:
• 22% of households experienced food insecurity
• 30% of families with children were food insecure and
• 45% of single parent families were food insecure.

The main contributing factor to food insecurity is living on or below the poverty line. Generally responses to food insecurity in Australia see fresh food and vegetable being sourced from local growers through food distribution networks, community gardens and food banks. Food security is one of the top five priorities in the national and state health department’s nutrition policy. The loss of access to local fruit and vegetables may lessen options for addressing food insecurity.

11.1. FOOD MILES

The concept of “food miles” has arisen from the belief that the true cost of food we buy is not only the price we pay, but also includes the environmental costs of its journey from its origin to our platelxvii. The “food mile” is a measure of the distance food travels from where it is grown or raised to where it is purchased by the consumer. Increasingly in Australia supermarket shelves are stocked with imported food and food products that have been hauled thousands of kilometres. In the past four years Australia has had a 26% increase in imports of fresh produce. Imports now total $300 million per yearlxviii.

The impacts of long distance food may include:

• Environmental – freight, especially by air and road, consumes large quantities of fuel and energy and releases greenhouse gases which contribute to global climatic change. If the environmental impacts of packaging and processing are added then the real costs of the weekly shopping basket can be much greater than otherwise thought.

• Health – long distance transport increases the time from farm to fork and can reduce the nutritional value as the food contains fewer vitamins and minerals that our bodies need for good health. It is argued that buying local food ensures fresher, more nutritious food, often picked closer to ripening time, and usually with fewer pesticides appliedlxix.

• Social – Australians have little say in the farming practices of other countries – the levels of pesticide used and the wages and conditions of workers. Imported food can come from countries with inadequate environment and health standards and few regulations to protect workers from contamination.

• Cost- the increasing cost of fuel, particularly diesel, adds greatly to the overall cost of food at the retail outlet. The cost of transport from the Eastern States to Western Australia in late 2007 was around $1 per kilogram for refrigerated
product. The opportunity to backload allows product to be sent east for around 20-25 cents per kilogram. The availability of transport will dictate the costs of transport. With world demand for diesel sending prices higher, the costs of transport can only increase, thus increasing the retail price of imported product.

There has been little research on the food miles associated with products on sale in Australia. The Australian Conservation Foundation lists the following figures from overseas studies that may indicate the costs associated with food importation:

- In the USA food for a typical meal has travelled more than 2100km, but the figure is much greater if the meal contains off season fruit or vegetables.
- The energy consumed in food freight often outweighs the nutritional energy in the food itself. It takes around 1000 kJ of energy to ship 170kJ worth of strawberries from Chile to the USA,
- Processed or multiple-ingredient food products may accumulate even more food miles

However, the concept of food miles has limitations as it does not account for climatic differences and geographic factors that may result in food grown under natural conditions using less energy, even after transport, than the same product grown with heating or other inputs.

The newer concept is that of “food print”, or the agricultural land footprint of crops. A diet high in meat can use five times a corresponding vegetarian diet that is low in fat. The theory is that meat eaters take up more land than vegetarians because livestock need more land for pasture than intensive horticulture.

Over the past fifty years the main purchasers and purveyors of food have become the supermarkets. Today they have largely taken over from the greengrocer, butcher, fishmonger and milkman.

In the UK 93% of people shop for most of their food at a supermarket, seeing £7 to £8 of every £10 spent in a major supermarket. Caraher has observed a new consumer awareness of food and climate showing as a move back to farmers’ markets. UK Supermarkets have responded by simulating the farmers’ market in their own premises.

Major UK supermarket chains such as Marks and Spencer and Sainsbury’s demand all producers to be certified to not only GlobalGAP, but also to their own Quality Management Systems. The requirements are becoming ever more onerous for producers with responses required to Marks and Spencer’s questions such as:

- How many miles does product travel to the nearest M&S depot?
- What is the dominant form of transport used?
• Do you know the carbon dioxide footprint per tonne of product produced?
• How many grams of chemical used per tonne of product produced?
• What is your water footprint per tonne of product produced?

The position of supermarkets to supply to customers’ requirements also see them ask questions on Organic products, GMO products (banned), ethical trading, environmental enhancement etc. If any supplier wishes to supply these markets they must pass audit for the particular market’s Quality Management System. Similar obligations (based on food safety and quality parameters) are being placed on Australian producers by both major Australian food retailers.

**ORGANIC FOODS**

While the organic agriculture and food movement maintained sustained growth throughout the mid-twentieth century, over the past two decades it has undergone unprecedented expansion\textsuperscript{lxiii}. With this rapid growth, organics has evolved from a local food movement to an international industry. The organic industry is the world’s fastest growing food sector, with worldwide sales estimated to be worth US$40 billion and growth of between 10 and 30% per year. In Australia, the value of organic production has expanded ten-fold between 1990 and 2000, and is currently valued at around A$400 million. This increase in value reflects rapid growth in the amount of land under certified organic production, which now stands at 12 million hectares in Australia, an increase from 150 000 hectares in 1990. Despite this rapid expansion, organic food production remains around one% of the total value of agricultural production in Australia.

Many European growers started converting to organics three to four years ago\textsuperscript{lxiii}. While there is now a high level of competition for temperate organic fruits and vegetables, exotic and tropical produce have to be imported. This creates an opportunity for Australian suppliers, but export sales are small and domestic demand is strong. There is also a discussion about the “food miles” involved in organics, and whether it is ethical to transport organic foods over long distances. The world organic market is experiencing significant growth. The global market for organic food and drink was valued at USD 40 billion in 2007. The organic market in the United Kingdom (UK) was worth USD 2.0 billion in 2007. The British market is the third largest in the world although market growth rates are slowing after years of growth at 30%. The major catalysts behind the industry growth have been food scares and the advent of Genetically Modified Organisms (GMOs), with the majority of consumers of organic food being tertiary educated, fairly affluent and between 20–45 years of age.

In terms of product sectors, fruit and vegetables make up 45% of the retail sales of organic products. The UK also imports approximately 82% of its organic fruit and
vegetable consumption. Demand in the UK is approximately growing at 40% per year, however supply is only growing at 25% per year. This has meant the UK has been forced to import much of its organic food requirements, leading to considerable opportunities for other producers to capture.

Although production of organic crops is increasing globally, sales are concentrated in the more industrialised nations including North America and Western Europe. There is increasing interests in other regions. In particular, the developed markets of the European Union and Japan offer strong opportunities as growth in demand is currently outstripping supply. The organic food industry is increasingly industrialised, enabling an increase in the scale or organic farming operations and enabling the international trade of organic produce.

While appeasing the currently insatiable demands of organic consumers, this pattern of trade serves to disconnect food eaters from food production by increasing the distance organic food travels, thereby increasing the CO₂ emissions associated with the distribution of organic food. Processing, packaging and other value adding has also intensified the energy consumed in organic food production.

Food processors and supermarkets continue to demand the standardised produce typical of industrial farming systems, denying the seasonal and other variations that organic farming systems traditionally embrace. Many opponents of this industrial organic agriculture model argue that this architecture undermines the contributions of organic food systems to long term sustainable farming and community development.

Australia’s organic industry is currently valued at approximately $350 million dollars, and is growing at approximately 25% per year. Approximately 40% of production is destined for the export market.

Australian consumers are becoming increasingly complex in their decision making and their choices. Greater concern about food safety, convenience, the environment, and genetically modified organisms, has led to organic food being seen as a suitable food alternative which meets these concerns.

Given the above background there are opportunities for Western Australian producers to expand their role in the organic fruit and vegetable markets. Export focussed production is more likely to be developed for Asian markets using highly mechanised production systems. Such systems will be favoured by the long term commitment of large areas of suitable land with guaranteed water allocations to such enterprises.

Many of Western Australia’s soils, including the sands on the Swan Coastal Plain, are old and degraded and so often deficient in nutrients. Organic sources of nutrients are expensive and present a difficult management option for our farmers. The use of compost
would be an important component of organic production on the Swan Coastal Plain.

Given access to sufficient land and water land could be made available to an organic component of any precinct that was developed at Carabooda. A suitable buffer area would be required to guarantee separation from the conventionally farmed area. Local compost would be a key part of organic production. Much of the produce could be sold at organic city markets. Organic growers are allowed to use re-cycled water, if it is produced in an approved way. Such organic production could fit well into the Metropolitan area as synthetic pesticides are not used and there may be restrictions on the use of water soluble fertilisers on conventional farms in future.

**FARMER MARKETS**

Several successful farmers’, grower or fresh markets operate in Perth, all extolling the value of access to “paddock freshness” for their customers. The direct link between fresh markets and growers is a product of proximity and if growers are not located sufficiently close to the markets then that perception of “freshness” may not be sustainable. The establishment of a precinct near to Perth would continue to support access by Fresh Markets to “paddock fresh” produce. Depending on the location of a precinct and population spread a farmer market might establish nearby.

Large supermarkets have introduced tight specifications on their products to guarantee quality and freshness. For example the major supermarkets insist on high levels of quality assurance, such as the Western Australian Department of Agriculture developed SQF 2000 CM, from all of their suppliers. All produce is expected to be grown under an approved quality assurance scheme.

Western Australian National party MLA Max Trenorden is an advocate for consumers wanting quality in the food and he has been scathing about the quality of food in supermarkets. He believes that the supermarkets will become less relevant and that Western Australia can become a world leader in food production.

**URBAN AGRICULTURE**

Churchill Fellow David Mason is a Champion of urban agriculture. He has found that Agriculture in the urban and urbanising situation is a political issue or is increasingly becoming a political issue in developed countries. He found that urban agriculture is a complex and multifaceted discipline, with the complexity predisposing urban agriculture and the people involved in it to not being well understood. In his two month international study of urban agriculture he found that agriculture is able to adapt to changing circumstance brought about by urbanisation, provided the opportunity to do so it provided. He advocates that agriculture in the urban and urbanising situation is a political issue and that those who support the concept must become its political champions.
Mason found many reports of benefits for locally produced food. Most commonly the supporters believe that buying locally produced food:

- Supports the local economy and family farmers; and
- Guarantees better taste, freshness, price and chemical safety

In some cases he found that the promotion of fresh local produce has been able to revitalise communities, such as Ludlow in Shropshire, England. Such communities have been able to extend the food security concept to the grass-roots level. This concept fits with the sense of place felt by some community members for the Wanneroo market gardens and supports access to fresh produce for the Perth metropolitan area.

Mason also found that local food and direct marketing go hand in hand. The greater majority of local food is produced by small growers on small areas associated with cities, towns and villages. Direct marketing is a local/regional response to globalism as well as the increasing evidence that small area agriculture is in the main incompatible with the purchasing mechanisms of major supermarkets. The exception to this is the intensive high-tech production with crops such as mushrooms.

Mason reports a recent study by the South Australian Department of Primary Industries\textsuperscript{xxvii} that suggested the agriculture associated with urban areas accounts for up to 25% of Australia’s total agricultural production i.e. $7 billion of $28 billion. The United States Department of Agriculture estimates that agriculture associated with metropolitan areas accounts for as much as 40% of the county’s total production. While the exact figure is not known it is reasonable to say that there is a lot of local production not catered for by the supermarket system. This combined with the fact that consumers are becoming more discerning of how and where the food they eat is produced, and what constitutes “freshness” is creating its own direct marketing dynamic in which niche marketing is a significant factor.

Mason believes that direct marketing mechanisms offer people the opportunity to utilise their urban fringe lands to produce food to meet an increasing demand. This has many social, environmental as well as economic benefits. However he recognised the chicken and egg scenario – what comes first – the market mechanism or the production. People will not produce, or if they do so, but cannot sell what they produce at a reasonable price, they will not continue to produce. People become tired of looking after areas of land that provide them with no rewardable purpose and when market forces are favourable the ultimate destiny of the land is subdivision. This is certainly the situation in Australia and reflects the history of horticultural development around Perth.

Cities such as Singapore have become extremely urbanised and now seek to preserve their capacity to produce food for their population. The land used for agricultural production
has decreased from 15,000 hectares in the 1960s to the present approximately 1,500 hectares. This land produces about 5% of the total amount of vegetables consumed in the country. This equates to 17,000 tonnes of a total of about 380,000 tonnes. New initiatives include the allocation of productive parcels of land as Agro Technology Parks on the perimeter of the urban areas of Singapore. Farms with a total area of 760 ha generated more than S$221 million worth of produce in 2005. One advantage that has been identified through the location of intensive agriculture production in these parks is that biosecurity is far easier to manage. Some of these peri-urban parks are successfully integrating agriculture with the hospitality industry.

In the Netherlands the survival of important agricultural land has been guaranteed by strict zoning controls under the Spatial Planning Act, first introduced in 1960, but revised continually and then replaced in 2006 by a new Act that recognises changing circumstances and has attempted to better integrate all stakeholders through processes that capture political and social trends.

After reviewing the situation in many countries Mason concluded that in Australia there is a community expectation that governments play a role in land use matters to achieve triple bottom line sustainability for the public good. This expectation has gathered force, focus and legal validity during the 20th Century. That focus has never been as relevant as it is now given the threat of global warming. Australia is traditionally an egalitarian society and that is worth preserving. That sets Australia apart. And in that context it is important that governments in Australia balance free market thinking, economic rationalism and the rights of the individual with the rights of the community in respect to quality of life for all Australians. That balance is fundamental to as many people as possible benefiting from what local agriculture has to offer in the urban and urbanising situation.

He also observed a tension between farmland preservation and the on-going viability of agriculture. Protection is not conducive to innovation. Innovation flows from a need to improve a situation. Farmland preservation is one thing, but having products to meet markets to support on-going viable production from the land preserved is another, and yet both things are vitally interdependent. Innovation has a role to play at all levels of the food chain. Getting the balance right, so that agricultural land has a long term future in the face of urbanisation, is a real challenge.

Finally Mason noted that in Australia the highest rate of urbanisation occurs on the coastal belt and this is where the largest loss of agricultural land is occurring. Western Australia’s Spearwood sands lie close to the coast and benefit from the influence of the Indian Ocean and its cooling sea breezes. The Australian Bureau of Statistics indicated that there was a 10% loss of agricultural land to development in the years 1996 to 2001 in
Mason believes that in the light of predicted global warming effects on inland NSW and inland Australia generally, it is important that government ensures sufficient appropriate coastal land is preserved to at least ensure the food security, and public health needs of current and future generations are secured. The coastal belt of Australia represents a distinct climatic zone. To continue to allow the sterilisation of that zone as a sustainable source of agricultural produce and value added product, with their associated social, economic and environmental benefits would reflect badly on all levels of the Australian community. Mason recommended strongly against this.

Vegetable production from the Perth area has always been important to the State as the region provides an environment well suited to growing crops that prosper in a warm/temperate climate and need ready access to a large labour force. This range of crops includes year-round crops such as broccoli, cabbages, celery, greenhouse cucumbers, leeks, mushrooms, parsnips, Asian greens, and spring onions; spring crops of globe artichokes and strawberries; and warm season crops of capsicums, tomatoes and zucchini. Alternative production areas may be constrained by climatic conditions such as too hot to the north and too cold to the south. Certainly the strong pressure for urban agriculture continues to be exerted in the Perth region.
12. GOVERNMENT INVOLVEMENT IN PROTECTING HORTICULTURAL LAND

Conflict between land use for horticulture and urban uses is not new or unusual. In Western Australia policies have been developed for areas of strategic and regional agricultural significance. Such development pressures have been recognised within the North West Urban Corridor of Perth with the aim to eliminate conflict through planning.

The Carabooda Horticulture Precinct provides an opportunity to eliminate land use conflicts. Government is charged with considering issues such as:

- Food quality and distance to market
- Production methods and labour impact
- Potential for wastewater utilisation
- Energy costs
- Utilisation of urban wastes.

All are considered in this chapter.

Zoning controls have long been used to support the preservation of agriculture in suitable areas close to urban development. While there have been a few attempts to protect areas of high productivity including the Hills Orchard zone in the Shire of Kalamunda and the Swan Valley there has been a general failure to protect areas of prime agricultural land, particularly those used for vegetable growing.

The declaration of the Swan Valley as a precinct for viticulture aimed to protect the industry. Increasingly the industry has expanded to the north and south, but table grapes remain particularly important to the Swan. Growers in the Swan are now not as comfortable with the precinct zoning as options for subdivision have been restricted, cheap labour options are limited and rates are high, not reflecting the rural zoning. The high property rates may affect grower viability while land use and neighbour conflicts are also encountered across the zone. Mixed horticulture and tourism land uses may help to overcome some of these difficulties.

12.1. THE CONFLICT BETWEEN URBAN GROWTH AND HORTICULTURAL LAND

An issues paper prepared by Kininmonth\textsuperscript{lxix} in 2000 recommended amongst other things that comprehensive planning of the protected areas be undertaken to address issues associated with the dispersal of land and water resources, existing land use and ownership, development expectations, land values and rates, land use conflict, environmental management and resource use efficiency. This report also recommended that appropriate policies relating to subdivision, land use and development and land management be prepared for the areas of State/regional agricultural significance. Similar requirements and strategies have been reported for preserving agricultural land in the Peel and South West regions.

More recently the Department of Industry and Resources has published a discussion paper on the economic futures for the North West Corridor of Perth\textsuperscript{lxxx}. This paper recognises
that development pressures are far higher in urban and peri-urban localities than rural and remote centres. The North West Corridor, particularly Wanneroo, has significant (inter-regional export) strength in primary production. One of the major sectors is “horticulture and fruit growing” which is almost solely driven by the strength of the sector in Wanneroo. There is an over representation of employment in the sectors of horticulture, other primary production and wholesaling of farm produce in comparison to metropolitan Perth. In 2001 the resident workforce in agriculture, fishing and forestry was 1,360, with nearly 80% of those having their job locally.

The study reported that horticulture is a well-established industry in the Corridor (particularly in East Wanneroo). However, suitable land for horticulture will diminish as more land is directed to urban development. If horticultural activities are to continue in the Corridor, they suggested that the right balance must be struck between the needs of the horticultural industry (i.e. access to groundwater and land) and urban development (i.e. land for residential and industrial uses). They concluded that consideration should be given to maximising the opportunities for market gardens or vegetable farms.

As horticulture and urban development approach each other the risk of land use conflict becomes strong. This is recognised by the publication of Planning Bulletin 63 that establishes guidelines for managing the potential conflicts. Conflicts are recognised to arise from spray drift, noise, dust and odours. With spray drift the greatest risk, standards using separation and vegetated buffers have been accepted so urbanisation can exist relative closely with horticulture. Other factors are generally intermittent and do not cause serious aggravation.

Traditionally horticultural land in the urban and peri-urban areas has been held under freehold title. This has enabled growers to capitalise on the increasing land values as the urban sprawl has overtaken their location.

Leasehold is accepted by some existing growers for land made available for horticulture provided a reliable water supply is associated with the land for the term of the lease. For some farmers leasing or share-farming are the only options when they enter the industry. If land was to be leased by the government the value associated with the potential for future subdivision could flow to government when it is converted to freehold title.

As has been seen the most prospective secure water resources are recycled water from either the Beenyup Waste Water Treatment Plant (WWTP) or the Alkimos WWTP. Both of these sources have significant lead times before water can be available and are associated with significant capital costs (see section 7.5). The provision of a secure water resource for a horticulture development requires suitable zoning conditions to ensure that the land is used for that purpose.

A large part of the identified precinct is already established as freehold land. It is unlikely
that these growers would agree to a change of tenure. Traditionally horticultural land has
been held under freehold title

While leasehold is accepted for a new horticultural precinct by some of the established
growers in the East Wanneroo and Carabooda areas, they also expressed interest in the
release of freehold land, so increasing capital values could be realised by growers over the
life of the precinct. The value of the land in any precinct will be associated with its
location, water supply, productivity and future opportunity for subdivision for residential
use.

12.2 STRATEGIC ROLE OF AN INTENSIVE HORTICULTURE
PRECINCT

This study has been tasked to determine the strategic and economic advantages and
disadvantages of an intensive horticultural precinct in close proximity to Perth to
potentially replace all or part of the East Wanneroo Groundwater Management Area
horticultural zone. The establishment of such a precinct is an alternative approach to the
historical progressive outward movement of horticultural areas as urbanisation expanded
within the Perth metropolitan area.

Horticulture production in many cities occurs in adjacent land areas for a combination of
reasons. The first model of the pattern of agricultural production around cities is ascribed
to J H Von Thunen. His model created prior to western industrialization simplified a
country structure by assuming the:

- City is located centrally within an "Isolated State" which is self sufficient and has
  no external influences
- Isolated State is surrounded by an unoccupied wilderness
- Land of the State is flat and has no rivers or mountains to interrupt the terrain
- Soil quality and climate are consistent throughout the State
- Farmers transport their own goods to market across the land to the central city
- Farmers act to maximize profits

In such a simplified State, Von Thunen hypothesised that development would occur in
rings around the city with four broad categories:

- Dairy and intensive production such as fruit and vegetables wanted for daily
  consumption
- Timber and firewood for fuel and building
- Extensive field crops such as cereal grains
• Broadacre animal enterprises – animals could walk to the city or fibres could be transported without loss

Changes in transport methods such as refrigeration have altered some of the underlying foundations, but the model which essentially balances transport costs against land costs remains highly relevant.

Von Thunen produced a mathematically rigorous formulation in which land rent is a function of the potential value of production less the cost of product transport. The lower the transport cost, the higher the rent that could be paid and hence the higher price that the land could fetch.

Two important assumptions underlie the model – transport cost is an important component in the selling price and a single transport system is used.

A wide range of factors can change the basic ring structure including constraints on land use (government policies), variations in soils and topography, changes in climate and water availability and changes in demand and hence prices. Nonetheless, the Von Thunen model has been remarkably resilient.

Modern refrigeration and handling methods and irrigation systems have done a lot to change the simplicity of the Von Thunen model. Perishable products can now be transported large distances at reasonable cost and with distribution systems for retail supermarkets now often based around airports; international travel is an option for high value perishable commodities.

While the Von Thunen model has limitations, the general philosophy remains highly relevant to the Western Australian situation. Turning the model formulae around, crops will be grown where they can be most cheaply produced taking into account the seasonal conditions, and all cost of production factors including land, labour and water, transport and storage. The model could be applied internationally – in any given month there will be a location interstate or overseas where supplies can be sourced at the lowest price. There are very few examples of fruit and vegetable commodities that can not be transported over some distance precluding international sourcing – perhaps broccoli, spinach, silverbeet, lettuce, berries and figs and some smaller leafy vegetables are possible exceptions.

Subject to suitable seasonal conditions for production, the location of production will be a function of the cost to produce and deliver to market including:

• A return on land
• Labour
• Water
Looking at alternative production locations in Australia, it can be assumed that relatively similar methods of production are used and hence the costs of production associated with chemicals and machinery are similar as are marketing costs. The key determinants for this study thus become land costs, labour, water and transport. With the Von Thunen theory suggesting that land costs are a function of transport costs, these two factors should offset one another making the key variables labour and water. This has been further examined in the consideration of a precinct in this report.

Underlying the study approach is an assumption that the government needs to become involved in establishing and protecting a horticultural area. This involvement is presumably based on a belief that the private sector will not create or maintain such an area or that there are benefits to the community from such a sector that the private sector will not factor into investment decisions. In economics terms, these are arguments about “market failure”. Government intervention in the operation of the marketplace is justified on the grounds that the market will fail to deliver the greatest community benefits. In other words, government involvement will provide an increase in community welfare.

The issues involved with government intervention are examined against the background of the history of horticulture production around Perth. This history adds understanding to the evolution of the industry.

12.2. THE ROLE OF GOVERNMENT

Horticulture as defined previously, is a broad term involving a wide range of activities. They differ markedly in terms of requirements for water, labour, land and desirable market access.

Both fruit and vegetable crops are grown for the domestic market (primarily Perth) and for export. Western Australia has been an exporter of fruit and vegetables for more than 100 years with apples and potatoes early exports. Export commodities are generally produced in substantial quantities to provide economies of scale in transport and storage systems.

In examining the role of government, it is worth segregating the crops that have traditionally been grown close to the city from those that are grown over larger areas in more regional locations. This separation reflects the different land use pressures faced by property owners in the two situations as it is this pressure that underlies the case for a...
dedicated precinct on the Gnangara Mound.

Farmers in all areas adjacent to towns and cities experience land use pressures as urban areas expand and new households seek residential lots. However, in regional areas, the areas of agriculture involved are generally larger and the urban expansion slower allowing for a gradual transition. Country towns away from the coast in Western Australia have generally seen limited population growth and farmers have adapted to any expansion without loss of horticulture capacity. With the larger Perth metropolitan area accounting for more than 60% of the State population, the issue of urban encroachment on agricultural land has been most noticeable there.

This study has examined the crops that are grown in the urban area and Wanneroo in particular. At this stage, it is useful to note that the overwhelming proportion of production is vegetables with smaller areas of nurseries, cut flowers, turf farms and grapes. It is suggested that the focus of this study is on land suitable for vegetables rather than fruit and that for reasons that will be set out later, the other horticulture types need less emphasis. The following sections thus use the term “vegetable farms” rather than horticulture or market gardens.

Generally, land values for vegetable farms are high in comparison with broadacre agricultural land, but low in comparison with urban land prices. Land suitable for urban purposes will thus be sold for this purpose providing the vegetable grower with an opportunity to buy a larger area further from the city, retire or move into another industry. Vegetable growers often view the sale of their land for urban use as justifiable superannuation for a hard working life and this is likely to be factored into land purchase decisions.

Traditionally, vegetable farms have been located close to urban areas due to the demands for labour and fast market access. It has also been the case in dry places like Western Australia, towns tend to be located in areas with water supplies and the same areas are attractive for vegetable farms.

With residential and industrial land users willing to pay significantly higher prices for land than horticulture producers, urban expansion encroaching on vegetable farms areas will always place pressure on the farmers to sell out.

The role for government is to evaluate whether this progression is in the broader interests of the community or whether the dedication of land for such purposes provides greater community benefits. Potential community benefits that have been suggested include:

- Continued access to fresh vegetables
- Employment opportunities
- Landscape scenic values and agri-tourism opportunities
• Utilisation of wastewater
• Lower energy costs in transport
• Opportunity for utilisation of urban organic wastes

Counterbalancing these advantages are:
• Lost regional development opportunities
• Lost water use availability to other sectors
• Higher energy costs for city residents pushed beyond the precinct
• Lost alternative use of organic wastes

The balance of these will depend upon a number of issues including the location of the precinct, the topography and land use constraints, competition for water supplies, source of wastewater and organic wastes and the perspective of the evaluator.

The range of issues involved and the complexity of some of them means that the analysis can only be done on a project basis in which the proposed precinct is directly compared with alternative vegetable farm locations. The final point on the perspective of the analyst requires further explanation. Three levels of overview are hypothesised.

From a local perspective, relocation of activity to another area means a different pattern of land use with a different mix of investment, employment, social and environmental impacts. Jobs in horticulture may be replaced by manufacturing jobs, commercial jobs or jobs involved in providing residential property services such as building services, landscaping etc. Employment in horticulture activities will often be a significant component of local employment on the urban fringe. This employment is pushed out as the urban area expands and may be lost to one local authority, but picked up by the next one further out. The lost jobs will be replaced (with less or more jobs) by the land uses that replace the vegetable farms.

From a State government perspective, employment impacts may not change with location. Unless there are technology changes, provided the same commodities are produced in much the same volumes, employment levels in the industry may not change, but the location of these jobs will. State governments may find such changes politically difficult to handle as a common desire for regional development favours job relocation from the urban area. If the same commodities are still produced with similar employment levels, the State government will be less concerned with these issues. Provided there are still agri-tourism opportunities this will also be less important. The key issues will then be the different environmental impact (if any), energy, wastewater and urban organic waste synergies.

Similarly from a national perspective, unless imports replace Australian production or the
commodity ceases to be consumed, national governments will be less concerned with vegetable farm location other than any different environmental impact including the specific issues of energy, and synergies for wastewater and urban organic waste.

This study has a regional focus in terms of the Gnangara Mound, but a State government perspective. The evaluation of the case for a dedicated horticulture precinct should be reviewed from this perspective which means the key questions should be:

- Can the commodities still be produced at an acceptable quality in the State?
- Will there be a change in production technology that lowers community benefits?
- How does the environmental impact compare between locations?

The assessment of environmental impacts is again a location by location and crop by crop comparison, but in the terms of reference provide for this study, specific attention has been drawn to the impact on:

- Wastewater utilisation
- Energy costs
- Utilisation of urban organic wastes

The issue of food quality in this study is essentially tied to distance to market and perishability as production and packaging and handling methods are likely to be very similar for different growing locations. Any quality issue will be related to the time from harvesting to the consumer. Modern packaging and refrigeration technology has greatly improved food quality and the distance over which most commodities can be transported. Some products remain sensitive and will be reviewed in this report.

The energy issue is examined here.

**12.3. ENERGY IMPLICATIONS OF A HORTICULTURE PRECINCT**

The emphasis on “sustainability” in recent years led to the introduction of the concept of “food miles”. This appears to have been first coined by Tim Lang to “highlight the hidden ecological, social and economic consequences of food production to consumers in a simple way….“lxxii

The concept is still being developed, but the original emphasis on the distance involved in transporting food to market has already been replaced by a more sophisticated evaluation. It is beyond the scope of this study to fully explore the issues, but an overview is important as they are relevant to horticulture location patterns.

The environmental assessment of food consumption chains needs to take into account all of the factors associated with production and harvesting, storage and transport and distribution to consumers. Simplistically, transport and storage over long distances
increase energy use, but this needs to be balanced against the method of production in the alternative locations and the method of product distribution.

In this study, it is likely that the method of food production in alternative locations in Western Australia would be similar. However, limited labour in remote areas favours the use of more mechanised production and harvesting systems. This involves more energy in production, but against this must be balanced the energy consumption of workers involved in production and harvesting activities.

In examining alternative locations for horticulture production, it is also necessary to review the different land use patterns that flow from the location decision.

Preservation of a precinct next to the city means the displacement of the activities that would have otherwise located there. A simplified case study illustrates this point.

**Simplified Case Study Assumptions**

- Flat land with no environmental or topographical limitations on development
- Square precinct on flat land 1,000 hectares in area – 3.2km on each side
- Residential land density average 850 square metres – 11,750 lots in 1,000 hectares
- Horticulture farming – 90 farms from less than 4 ha to more than 50 ha
- Fuel consumption – 12 Litres per 100km for passenger car and 50 Litres diesel for a truck
- Travel time – average 50km per hour in city locations, 70km per hour rural
- Household employment pattern – 1.2 commuting workers per household

Without any topographical or environmental limitations, a square 1,000 hectare precinct will push residential development out from the city by an average distance of 3.16km.

Assuming that the land was used for residential purposes, then with 11,750 lots and 1.2 persons commuting to work for each household, there will be 14,000 people driving to work each day. The additional distance travelled to pass the precinct each working day is thus 89,600km. The additional fuel consumption generated by the precinct is 10,750 Litres a day and the additional driving time involved is 1,866 hours a day.

This fuel use and travel time can be compared with alternative locations. Two alternatives are outlined. In the first case, the horticulture is pushed outside the urban area by the urban expansion. This means an extra 3.2km distance to the centre of the precinct. The expanded city still means that the precinct has houses on its borders and hence immediate access to the urban population for a workforce. A conservative approach is to assume the extra travel distance for all workers and transport from the precinct. With a 1,000 strong workforce and a truck from each property each working day, there would be an additional 6,765km of transport involved (1,000 cars, 90 trucks for 90 farms, a mixture of small to large farms). This suggests total fuel use of 875 Litres and total travel times of 140 hours.
The horticulture precinct has increased total urban fuel use by nearly 10,000 litres of fuel each working day and 1,725 more hours of travel time.

This extreme case assumed that the horticulture area was fully in the “face” of urban expansion. In Perth, the urban front tends to stay close to the coastline with lower density development inland. A smaller number of urban residents would be displaced in this situation. The difference in fuel consumption would reflect the expected density of residential development. It could only be calculated on a specific case basis, but would be less than the 10,000 litres a day difference calculated above.

The third case assumes that suitable horticulture land is not available close to the city. Myalup as one example is 130km from the Canning Vale wholesale markets and Guilderton is 115km. Both are less than 1.5 hours driving time by car and 2 hours by truck.

This case study assumes a horticulture area 125km from Perth and similar driving times as Myalup and Guilderton.

The impact on workers for the horticulture area will depend on where they reside. The practice in rural areas has generally been local recruitment for longer term employment supplemented by casuals such as backpackers for harvesting and processing. Where the local workforce is unable to meet the demand, buses may be used to commute workers from the city or regional centre. This makes calculation of the energy use challenging. A conservative approach is to assume they all come from Perth. This implies a 250km round trip each day for the suggested 500 strong commuter workforce (half local employment assumed). Total fuel use again using a conservative approach of 2 persons in each commuter car would be 7,500 litres plus 12 truck trips (larger trucks or fewer properties than on the urban fringe). Trucks would travel 3,000km a day and use about 1,500 litres of fuel. Total fuel use in this case with very conservative assumptions involves nearly 9,000 litres of fuel and at least 2,000 hours of travel time.

In this scenario, total fuel use is 2,000 litres less than the dedicated precinct, but 8,250 litres more than the horticulture on the edge of the city. Travel times are similarly impacted.

Farmers minimise the cost pressures imposed by the location by varying their management practices. Where labour is difficult to obtain or is considered expensive, the farmer tends to use more capital intensive equipment. Planted areas may increase along with plant inputs to increase production and ensure a greater supply and choice in harvesting operations. Larger trucks will be used in transport and regional packing sheds will be developed by growers to create scale economies. Coordinated transport systems may be developed with for example buses to bring workers to site during busy periods.
Such a decision-making process is confirmed by the establishment of extensive horticulture production operations such as carrots in the Gingin/Lancelin area, using highly mechanised processes under large centre pivot irrigators. In the case of carrots the crop lends itself to mechanised production and bulk transport over long distances. The large local producers have also built accommodation facilities in the area and bus workers to the farms each day. This greatly reduces the fuel estimates provided here.

These examples demonstrate the complexity of energy miles and travel time calculations. They imply that displacement of an urban population with a horticulture precinct is expensive in energy consumption and lost travel time for employees. The key to any difference is the distance to alternative locations, the density of urban development displaced and the distribution of the location of the new workforce. Workforce availability and the energy used in bringing the workforce to the new area appears to be the key energy variable to use in comparison with the precinct base case.

The Carabooda precinct lies north east of the current urban front in the suburb of Butler and within 10km of the coast. As the urban area expands, the area will become attractive to residential development. The timing of this will depend on the rate and pattern of urban expansion and hence the planning policies of government in prescribing the urban land uses. Some concept of the potential impact can be gained by projecting population growth. In 30 years time, the current population will have increased by about 1 million people (1.8% growth rate). The density of population settlement will be a function of government policies on land uses such as parks and reserves, industrial areas, housing density etc. The average density across the Perth metropolitan corridor in 2004 was close to 100 persons per square kilometre. A residential area with some local parks and local services has a density of about 2,300 persons per square kilometre. The difference in density reflects the non-residential land uses in the metropolitan corridor. Assuming a figure half way between these for illustration purposes, the increase in population would require an additional 825 square kilometres of urban area.

Such an area if constrained to within a 5km strip of the coastline would stretch for another 80km north and south of the current urban front. A 10km wide urban strip would require 40km each way. Such large distances would suggest a denser pattern of development with government limits on a linear growth pattern along the coastline. The Carabooda precinct lies within a 10km distance from the coastline and 5km from the existing urban front at Butler. It would be under strong urban pressure well within a 30 year period.

Based on the need to plan for future horticulture areas that have been identified in the Wanneroo Land and Water Plan, current urban planning has identified future urban development areas that do not include the Carabooda horticulture area. Such planning may be sufficient to avoid expectations for future land use changes to residential. This
12.4. PAST AND PRESENT PLANNING STRATEGIES

Western Australia has carefully planned its development under a succession of State Planning Strategies. In the Stephenson-Hepburn report of 1955; “Plan for the Metropolitan Region, Perth and Fremantle” it was stated that of a recorded workforce of 121,544 for the region in 1947, 7,871 (6%) were employed in primary industry (excluding mining). It was also anticipated that this proportion would decrease in the future. Comparisons with Melbourne and Sydney at that time showed 1.6% and 1.2% respectively of their workforce engaged in primary production.

At that time, horticulture was mainly confined to areas of yellow-brown sand at Spearwood, Osborne Park, Balcatta and Wanneroo, with some orchards in the Armadale-Kelmscott area.

The Perth region then produced about 60% of the State’s vegetable production, 70% of the State’s egg production, 50% of the State’s oranges and other citrus fruits, and a considerably higher percentage of the stone fruits while almost all the grapes for both table and other purposes were produced in the Swan Valley.

By 1952 employment in agriculture in the Perth region has decreased to 5,500 or 3.5% of the region’s workforce. At that time there were 700 market gardens, 1000 orchards, 600 vineyards, 1000 poultry farms and 400 grazing, dairy or other farms.

Interestingly the report estimates that 10-11,000 persons would be employed in agricultural holdings when the population reaches 1.4 million.

While the 1955 Stephenson-Hepburn report extolled the virtues of existing market garden areas at Osborne Park and Spearwood and recommended their protection from intruding uses, the only statutory mechanism used since then has been for the Swan Valley.

The 1978 Rural Smallholding Policy prepared by the former Town Planning Board proposed a series of minimum rural lot sizes in the rural zone of the Perth Metropolitan Region which recognised the desirability of maintaining existing identified horticultural precincts to the north and south of Perth as well as orchards in the hills area.

Notwithstanding the report recognised that because of the extensive trading in rural lots, the value of land had risen to a level beyond its value as farmland. As a consequence market gardeners were obliged to relocate.

The study recognised the value of ensuring that vegetables and fruits which did not travel
well except in expensive refrigerated conditions were sourced as close as possible to the
customer to ensure fresh food daily and to keep transport costs as low as possible (p 59).
Other advantages in locating market gardens close to the Perth CBD were seen as a ready
labour pool and the provision of visual and actual green space in an otherwise built up
area.
At that time about one-third of fresh fruit and three-quarters of the vegetable and vine
crops for the Perth market were grown within 40km of the City.
The report recommended the preservation of existing areas which at that time were
Wanneroo, Spearwood, Wattleup and Rockingham. In these areas stringent subdivision
controls were recommended.
The Rural Smallholdings Study concluded that there are two major policies available to
the government in the attempt to limit the rub-off effect of small lots on adjacent farm
land. The first lies in rating changes and the second lies in land use controls.
In respect to land use controls the report recommended that areas of commercial
agriculture should be identified and zoned accordingly in areas not zoned for urban
purposes and Special Rural zones. Development and subdivision should be limited to that
necessary to further commercial and agricultural activities. The Town Planning Board
when considering proposals for subdivision should obtain the advice of the Department of
Agriculture as to the agricultural potential of a unit of land. Horticultural zones could be
designated. The lot size should be determined in consultation with Department of
Agriculture, but development controls should be stringent and limited to those necessary
for agricultural activities.
In respect to land use values the study recommended strict zoning controls, precisely
defining the boundary between different types of rural uses to be used in rural areas to
differentiate between small lot areas and areas of commercial agriculture so that increases
in commercial agricultural land values be limited as far as possible.
From a subdivision perspective the following recommendations were made:

- Except in special circumstances the market garden areas of Wanneroo, Spearwood, Wattleup and Rockingham were to be controlled for subdivision on
  the basis of the lot sizes shown on Map 15 (4, 8 and 20) hectares depending on
  location.
- Strict subdivision controls should be used to preserve the hills orchards areas
  according to the minimum lot sizes suggested on Map 15 (12 hectares).
- The area in the Swan Valley suitable for table grape production is limited. It is
  considered that every endeavour should be made by government and the council to
preserve that part of the area coloured black on Map 15, by (a) ensuring that no subdivision occurs which would militate against this aim, and (b) considering appropriate zoning of the area for viticulture, and restricting other uses. A third issue, that of land tenure, arises from the setting aside of a designated horticulture precinct.

At local government level it was recommended that local authorities prepare planning schemes which should provide for Horticultural zones. The lot size should be determined in consultation with Department of Agriculture, but development controls should be stringent and limited to those necessary for agricultural activities.

In 1996 the State Planning Strategy\textsuperscript{lxxxiii} embraced significant economic growth provided the growth:

- Is balanced with conserving and enhancing the natural environment; and
- Provides a better quality of life for present and future population.

That strategy recognised particularly high land use pressure on the Swan Coastal Plain surrounding Perth, and at the same time recognised priority agricultural areas at Wanneroo and Carabooda. The strategy also provided a development framework that was guided by environmental, community and economic principles. With increasing pressures for development and ever scarcer resources these principles remain just as relevant today.

The preservation of land for intensive agriculture and downstream processing featured in most regions with the strategy to protect prime agricultural land and intensive agriculture infrastructure from incompatible development. The locations currently identified with potential for further horticultural development near Perth (Carabooda, Gingin) and in the South West (Myalup) are as identified a decade ago, but the pressure on the essential resources of land and water have increased considerably in the past decade.

Land use planning processes have not always considered the strategic importance of agricultural land in the Perth region and have tended to follow the market rationalist view driven by urban property development processes. These processes logically target high quality agricultural land\textsuperscript{lxxxiv} because this land also has high suitability for urbanisation and the land use planning process has generally failed to provide any impediments or clear signals relating to the future of these areas. While there have been a few attempts to protect areas of high productivity including the Hills Orchard zone in the Shire of Kalamunda and the Swan Valley there has been a general failure to protect areas of prime agricultural land, particularly those used for vegetable growing.

The Department of Agriculture’s 1999 Land Use Planning Policy and Procedures Manual\textsuperscript{lxxxv} reported a strategy for the Perth Region was to protect prime agricultural land and intensive agriculture infrastructure from incompatible development. This was to be
supported by the action of ensuring that the main market gardening areas of Wanneroo and Carabooda are identified and protected.

Freehold landowners including horticulturalists have an expectation that as the urban area extends towards their property that it will be rezoned for urban development, with a consequent capital gain over and above that which could be expected over time as horticultural land.

While farmers in the regional areas of the State have had to grudgingly accept that their farms can’t be traded piecemeal (i.e. subdivided and sold in smaller or part parcels), no similar limitations have been experienced by metropolitan growers.

Accordingly if the Government is to provide freehold lots with access to a Government financed and subsidised (either fully or partially) recycled water scheme, it is reasonable that the Government would expect that such lots would have restrictions placed upon their disposal to subsequent buyers to ensure that any future capital gain (either partially or fully) is recouped to assist in recovering the initial outlay.

While leasehold arrangements would be possible, this is unlikely to be attractive to buyers who would be seeking to use the property as security against which they would seek to raise loans for capital expenditure.

Another option is that which currently applies to the transfer of units in retirement villages where the developer retains part or all of the capital gain when a unit is sold on, in return for a reduced entry fee.

If freehold tenure was to be the preferred option it would need to be made clear to buyers that there was no foreseeable prospect of a rezoning for the land. This could be enforced by way of restrictive covenant on the title.

12.5. LESSONS FROM THE SWAN VALLEY HORTICULTURE PRECINCT

Initially the declaration of a Horticultural precinct in the Swan Valley was intended to protect the viticulture industry. This industry has since expanded both North (starting in Carnarvon) and south (to Margaret River), with increased amounts of crop now produced outside the Swan. The spread of production allows for an extended production and marketing period. The Swan Valley still produces half the volume of table grapes in the state and has at least half the total number of commercial table grape growers. Returns for table grapes in recent years have been excellent. Swan Valley crimson seedless and dawn seedless command record prices during March, April and May. The wine industry is in a similar situation, with much of the premium product produced in the cooler areas further south.

Many growers are no longer as comfortable as originally with the precinct zoning as their
options for subdivision have been restricted. Older growers who wish to leave the industry have difficulty disposing of their land under the current zoning. Properties are becoming difficult to handle because of shortage of family or other cheap labour. Options for sale are dictated by the zoning and vineyards must be sold as they are or can be converted to lifestyle blocks, losing the production potential as a result. Alternatively, for a limited number of enterprises hospitality activities may piggyback on the producing vineyard.

Rates within the precinct are high, recognised as being more equivalent to city rates than rural, so the rural zoning is not reflected in the rates, but this is not a new situation. Opportunities to downsize and reinvigorate the properties are limited because of the zoning. The high property rates are affecting grower viability. Land use and neighbour conflicts are also encountered across the zone.
13. EAST WANNEROO REPLACEMENT SCENARIOS

Historically horticultural land has been developed on the fringes of the urban area of Perth. Land for horticulture has been taken up as freehold broadacre land on the fringe of the city and increasing land values associated with urbanisation have allowed the horticulture producers to purchase larger areas further from the industry or retire on the land sale income.

The precinct identified at Carabooda by the Western Australian Planning Commission is already well developed, with about 1,000 ha of the 1,800 ha area under freehold and more than 60% cultivated. These established horticulture producers will have land use expectations that need to be taken into account in any land use scenarios. Three scenarios are discussed, including the Carabooda Precinct, continuing small production areas on the fringe of the metropolitan area and a larger commitment to horticulture production to the north and south of the metropolitan area. Advantages and disadvantages for each are introduced.

Three development scenarios are introduced for consideration as approaches to addressing the pressure being exerted on horticultural land in East Wanneroo (Plate 8).

Plate 8 Development Scenarios

See plate on the following page.

13.1. CARABOODA PRECINCT

A potential precinct has been identified by the Western Australian Planning Commission. This precinct has a total area of just under 1,900 ha, of which about 60% is held as freehold title. Approximately 60% of the freehold land in the precinct is cultivated.

Groundwater in the Perth North region is fully allocated and new enterprises can only establish in the area by purchasing a water allocation with land or from another water license holder. An expansion in horticulture activity in the precinct can only occur if the present allocation is not fully utilized or external water supplies become available.

This study assumes that the existing allocations are being fully used, that the existing self supply continues for established growers at Carabooda, and that the only water supply available to the new component of the precinct is recycled water from the Alkimos waste water treatment facility. The use of recycled water has been confirmed to be accepted for vegetable production by local farmers through this study and also by the consumers of vegetables where nearly 80% of respondents to a local survey indicated they found the irrigation of fruit or vegetables by recycled water to be acceptable or highly accepted. Only 8% considered it to be unacceptable or highly unacceptable. Conditions that influence the availability of this water are:

- 5 GL of recycled water will be available from the Alkimos by 2020, expanding to 15 GL/yr by 2050.
- This availability limits the new area that can be developed from 330 ha in 2020 to
1,000 ha in 40 years.

To develop any new land within the precinct, pine plantations occupying about 800 ha may need to be harvested and the land allocated for agriculture. If similar proportions are cultivated as the current area, a maximum of about 500 ha is likely to be cultivated.

The recycled water available by 2020 would allow an expansion in the horticulture area of 330 hectares. This could come from unused existing land or from new land taken out of pine trees. Any future expansion beyond the 800 ha of pine plantation would have to be accommodated on suitable land to the north and east of the precinct. For this land to be available agreement must be obtained from the Water Corporation and Department of Water to allow development to the east of a surveyed, but undeveloped public water supply bore line (Pinjar Stage 2 Groundwater Scheme).

The land currently under pine plantations lies to the east of the coastal strip that is the priority for urban expansion as identified by the Western Australian Planning Commission. Land can be allocated to organic vegetable production with required buffers. Buffers around the precinct can be made available for industry infrastructure such as cool rooms and packing sheds. Other land uses in the buffer might include nurseries, and turf farms, and when excess recycled water is available it could be used by the nurseries and turf farms.

The projected daily rate of supply of recycled water is to peak at 45 ML/day under current design specifications. This is not sufficient to water the planned area on a hot summer day, especially when cooling is required and on-site storage in the precinct or farm would be essential. Assuming the supply rate of 45 ML/day and evaporation experienced over the past year undersupply is an issue for significant periods over summer each year for any area of 500 ha or over. If an area of 500 ha is irrigated and 45 ML supplied each day there is a deficiency of water in five months of the year (November to March). If 750 ha is irrigated the system will be deficient at some time in each month from October to April. As the areas increase the daily supply rate must be higher or storage of water must be factored into the design of the precinct (Table 22).

<table>
<thead>
<tr>
<th>Precinct Cropped Area</th>
<th>% Days Undersupplied at 45 ML/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>330</td>
<td>0</td>
</tr>
<tr>
<td>500</td>
<td>21</td>
</tr>
<tr>
<td>660</td>
<td>35</td>
</tr>
<tr>
<td>1,000</td>
<td>64</td>
</tr>
</tbody>
</table>

These conditions present the opportunity for best practice irrigation techniques to be adopted. Such systems can be professionally designed. During winter when supply can
exceed demand water could be used for local Managed Aquifer Recharge, supplementing the security of the self supplied farmers in the established part of the precinct. If groundwater can be made available to the new precinct it would be possible to shandy the waters, so improving some aspects of the quality of water applied to the precinct.

Three days of storage is specified in South Australia for a wastewater recycling scheme. In addition to the $1200 connection charges imposed on users of recycled water on the Northern Adelaide Plains, the capital costs to growers of configuring their irrigation systems have been estimated by growers to be several tens of thousands of dollars. The water charge in the Adelaide Plains is close to 12 cents a KL for most farmers.

If government installs the storage then the cost of water at delivery to farms will be higher than the projected cost of 88 cents/KL for Class A water delivered to the precinct boundary from Alkimos, and certainly far higher than water currently pumped from underground sources by freehold farmers in the precinct. Wastewater recycling for irrigation purposes has been subsidised by government in Victoria and South Australia to meet other government policy objectives – the same certainly appears to be required for this precinct, but more detailed consideration is required to test this view.

Advantages of the establishment of the precinct include:

- The long term commitment of the land and water to horticulture production;
- The use of recycled water for a productive purpose;
- Encouragement of efficient irrigation techniques;
- Retention of the horticulture “sense of place” for wanneroo for at least several decades;
- The opportunity to use separated recycled urban waste as high quality compost, so reducing landfill and improving water and nutrient holding characteristics of the sandy soils;
- Potentially more secure production of vegetables for perth;
- The opportunity to contain horticulture within a relatively small area., so environmental management practices can be well planned and organised;
- Ready availability of labour; and
- The opportunity for family based horticulture enterprises to access city based advantages such as education for their children.

Disadvantages include:

- Slow and limited availability of recycled water;
- Loss of recycled water for other uses such as groundwater aquifer replenishment
to increase availability for higher value uses such as public water supply;

- Subsidised public irrigation schemes are contrary to objectives of the coag water reforms and national water initiative;
- Government subsidy reducing other government programs;
- The long time frame for development;
- Increased energy consumption as a consequence of the inclusion of an agricultural area within an urban area;
- Establishment of an agricultural area in an urban area and subsequent pressures for rezoning; and
- Potential for contamination of downstream groundwater, affecting uses such as coastal public water supply schemes.

13.2. CONTINUED EXPANSION ON THE FRINGE OF THE METROPOLITAN AREA

Since Perth was first established horticulture has always been located on the fringe of the metropolitan area, with the established areas eventually overtaken by urban expansion. The horticulture production has then moved towards or beyond the new city boundary. Suitable land is generally not a limiting factor for horticulture in Western Australia and hence this form of agricultural development will continue as long as the areas on the urban fringe have access to water. Water is available beyond the urban fringe to the north of the city and expansion in this direction is occurring as can be expected.

This approach preserves horticulture adjacent to the urban area, but in time will push the farming beyond the Wanneroo area. Crops better suited to mechanisation will tend to be located on larger farms at a greater distance from the metropolitan area and in more permanent locations. This is already happening in the Gingin and Lancelin and Myalup areas.

Hydroponic production will become increasingly important in future, especially with tomatoes, cucumbers lettuce, flowers and strawberries. A total of 17% of tomato crops in Australia are already produced by this system. This system needs less land than conventional crops and produces 50 t of crops per ML of water compared with 8 t for conventional cropping. Such efficiency could be encouraged in small metropolitan developments. Hydroponic growers can also use reverse osmosis to desalinate poor water and therefore operate in areas which are unsuitable for conventional growers. The climate can also be moderated to optimum temperatures. Hydroponics needs high initial expenditure and may not be suitable for a lease situation and using wastewater. However, hydroponic growers need a good supply of labour and the climate around Perth helps
reduce costs in moderating the temperatures. Within this scenario consideration could be given to allocating a separate, smaller freehold precinct in the metropolitan area for hydroponic growers. This could be located on poorer cheaper land, not within a groundwater area if an alternative source is available, but within 15km from the coast and possibly south of the Swan River. Many advantages and disadvantages of horticultural plots on the fringe of urban expansion are common to those of the first scenario. Additional advantages include:

- Retention of intact urban areas;
- Encouragement of highly productive techniques such as hydroponics on smaller areas and water sources such as local water treatment plants; and
- Change can be evolutionary and responsive to the full range of relevant factors rather than being managed in a manner that may be contrary to relevant economic and social factors.

Disadvantages include:

- Higher energy costs for the producers as they shift further from the wholesale markets in the city;
- Inability to use recycled water unless small developments use small scale water treatment plants; and
- Inability to use compost to reduce landfill.
- Increasing distances for the workforce.

13.3. A STATE COMMITMENT TO HORTICULTURE EXPANSION

Western Australia is experiencing concerns over water supplies for the future as is the rest of Australia. However, several of the significant groundwater resources are reported to have valuable reserves that might be used for horticulture without compromising other future demands or uses. Large horticulture supplier groups in the Eastern States are under pressure from restricted water supplies and are looking to the possibility of establishing independent production operations or joint ventures in Western Australia to reduce their Eastern States’ exposure. To do this, significant areas of suitable land and associated water resources must be dedicated to horticulture production, without the pressure of urban expansion. Areas to the north and south of the expanding metropolitan area can satisfy this need.

The Gingin Shire is already established as an important production area for horticultural crops, especially carrots. Similarly the Harvey Shire is establishing as an important location for vegetable production. Vegetable production can be further expanded in both
of these shires thus reducing the need for production within the metropolitan area. The Swan Coastal Plain is well suited to vegetable production and neither shire is too distant from the marketing hub of Perth.

To the north and south of Perth, suitable areas can be developed using unallocated groundwater or by trading or releasing other allocated resources. The use of managed aquifer recharge in the metropolitan area to generate public water supplies may enable the release of reserves to the north and south of the city for other purposes. If a commitment of water is made for horticulture production this water will be associated with suitable freehold land as the value of horticulture production will exceed other dryland uses in the area.

This approach requires a major commitment by the State to the horticulture industry. Developments should be encouraged to the north of Perth in the Gingin - Lancelin area by allowing water allocations of 10 – 15 GL/yr for each 1,000 ha of horticulture land, and south in the Myalup area, allowing similar allocations. This study has not identified actual tracts of land that might be used, rather indicating options and suitability. There is a need for long term planning to designate precincts in the West Gingin and Myalup areas for use in the next 50 years.

Indications were given in Chapter 6 that in the Gingin Groundwater Area, no single management sub-area with the exception of the Wedge Point sub area has greater than 10 GL/yr currently available for additional allocation there is water is distributed across the sub-area in the superficial formations. A 10 GL/yr allocation to horticulture will allow the development and annual irrigation of up to 1,000 ha of horticultural land. Smaller developments of less than 1000 ha should also be encouraged. This distributed nature means that development is more conducive to self-supply than a public reticulated scheme. If at least some of the water currently allocated to the public water supply reserve be made available as a result of the development of other metropolitan sources (desalination, water trading, managed aquifer recharge) then horticulture developments can be encouraged where the water can be abstracted.

Similarly in the South West Groundwater Area, the Myalup sub-area is virtually fully allocated. While the Department of Water allocation rules for this area have been consequently set to limit use to 4000 kL/yr/ha to ensure the required abstraction distribution, a distributed approach to abstraction partnered with horticulture could ensure the safety of the water resource although supply would be more expensive than normal self-supply.

To develop these more remote areas for larger scale horticulture areas, land must be identified that can be associated with the available water and horticulture production encouraged on those areas for the long term.
Spearwood and Bassendean soils are suitable for development in both locations, but Spearwood are preferred. The areas have similar seasons, but by establishing major horticulture areas to the north and south of Perth microclimatic differences can be accommodated and production from the old Wanneroo and Spearwood horticulture areas can be largely replaced with the new areas.

Some soft leafy lines and labour intensive crops can be accommodated by retaining small urban horticulture plots in the north and south of the metropolitan area as described in the second scenario. The underground sources can be supplemented by managed aquifer recharge with recycled water to replace the water taken for horticulture.

Establishment of the new areas to the north and south of Perth, while retaining small horticultural nodes on the fringe will reflect particular advantages include:

- The long term commitment of important areas of land and water to horticulture production;
- The establishment of a larger scale future for horticulture in western australia;
- Encouragement to establish large scale mechanised production to increase the size of the horticulture industry;
- Encouragement of efficient irrigation techniques;
- More secure production of vegetables for perth;
- The opportunity to increase vegetable exports;
- The opportunity to contain horticulture within a relatively small area in metropolitan perth, so environmental management practices can be well planned and organised; and
- Will enable the locations and types of horticultural production to be responsive to the market.

Disadvantages

- Inability to develop a wastewater recycling scheme;
- Limited availability of labour dictates alternative labour supply approaches are required;
- Accelerates trend to larger scale mechanized production due to reduced labour availability in rural areas;
- Inability to reduce landfill thorough the use of compost; and
- Higher energy costs for producers in transporting goods to market and labour to fields and packing facilities.
14. CARABOODA PRECINCT AND ALTERNATIVES

This study has examined the feasibility of establishing a dedicated horticulture precinct located at Carabooda in the north of the Wanneroo local government area. It has also examined alternative horticulture locations and trends in the industry that would affect such a precinct. The precinct has been suggested as one approach to overcoming the impact of urbanisation and displacement of existing horticultural land in East Wanneroo. Many factors impact on the possible establishment of a horticultural precinct in the area indicated at Carabooda. In the following pages these factors are identified and related management issues are addressed.

This chapter outlines some advantages and disadvantages of the precinct.

14.1. CARABOODA PRECINCT ADVANTAGES

With escalating fuel prices the world may face a food crisis in the future as food prices increase. This study has not considered the impact of rising fuel prices in detail as that would be a separate and major study, well beyond the scope of the current analysis. The impact of rising fuel prices is manifold and would reflect local and international relativities. This study has noted that most of the United States’ salad vegetables are grown in California and then transported throughout the country. Perth and the nearby coastal plain areas are well suited to horticultural production and given long term access to sufficient water supplies could prove nationally important.

There is genuine concern about food miles and pesticide residues in some other countries and quarantine prevents many fresh foods from entering Australia. This provides encouragement for Western Australia to remain self sufficient in fruit and vegetable production. The metropolitan area can continue to be an important supplier especially of vegetables and has the advantage of good labour supplies compared with more remote country areas. Some growers have requested a metropolitan precinct, helping to replace land that is being lost to horticulture in the north and south of the metropolitan region. Part of a metropolitan precinct could be reserved for the production of organic foods.

Several factors support the establishment of the precinct at Carabooda.

- The precinct preserves horticulture production closer to the city centre.
  - The horticulture “feel” of Carabooda is preserved.
  - The precinct may present the opportunity for some production to become even more intensive using greenhouses and shade houses. However, such developments may not be desirable near to future urban development.
- The Wanneroo local government area had an estimated irrigated area of 2,500 hectares in 2005 including fruit, grapes, vegetables, cut flowers, nurseries, and
turf farms. The more perishable vegetable crops and strawberry plantings occupied about 700 ha from 2001 ABS figures. Production of the latter crops will have increased in the past six years so an allowance of 1,000 ha of new productive land may be reasonable for the future. Some of this production has already relocated to the identified precinct area. Replacement of present vegetable and strawberry plantings with growth in population suggests a new precinct area of between 1,000 and 2,000 ha of productive land. By way of example, the Werribee Irrigation District near Melbourne uses recycled water on 2,086 ha of market gardens.

- The Carabooda area has ideal growing conditions for many vegetables and some fruit over an extended season.
  - Other horticulture production areas also experience excellent conditions for vegetable crops, perhaps with some seasonal differences from the Carabooda area.
- Recycled water is an option for secure future water supply under the expected long term drying climate conditions.
- The use of recycled water will help the government to achieve its 20% recycling target.
  - There are alternative uses for recycled water;
    - Industry; and
    - Managed Aquifer Recharge.
- Established infrastructure is already partly developed so it can service the newly developed area as well.
- “Fresh” markets favour the location of production areas as close to the market as possible so they can have direct access to the growers.
- Growers who are already established in the Carabooda area provide some basis for locating other growers nearby to help consolidate services to the industry.
  - Advisory services,
  - Agricultural supplies.
- Establishment of the precinct can provide the impetus to consolidate further infrastructure to service horticulture in the precinct and so provide better service to small growers.
  - Certainty of production from the precinct for several decades will encourage the establishment of infrastructure,
Packing and cooling facilities are most likely to be developed where production is consolidated.

- The precinct will minimise interaction with urban expansion and so minimise conflicts with surrounding landholders.
  - Buffer zones will be needed for odour, dust and spray drift.
  - Downstream monitoring will be needed to ensure the environment is not affected by operations.
- The industry consolidation provided by establishment of a precinct justifies the maintenance of the rural zoning for a longer term.
  - This raises the issue of the adverse impact on established producers who might be planning to sell their landholdings when they increase in value as a consequence of urban expansion.
  - When the precinct is surrounded by urban expansion in the future the argument for urbanisation will be stronger.
  - Werribee Plains Irrigation District is located adjacent to the Western Treatment Plant, guaranteeing the lowest possible supply costs (Figure 26).

Figure 26  Werribee Plains Showing the Horticultural Precinct and Encroaching Urban Land

- The Adelaide Plains area includes a mix of urban, industrial and rural development and some of the small townships in the region continue to grow (Figure 27).
Establishment of a precinct can provide the basis for regulating best practice irrigation management standards that will improve efficiency of irrigation by all growers and save water.

- One approach is to use certified irrigation design, installation and practice promoted by Irrigation Australia. They support the following principles.
  - Use of recycled water for irrigation (urban & rural).
  - Rain-fed water (dams) and groundwater needs to be given a commodity value in addition to cost of supply value.
  - Water for irrigation needs to go to the highest value uses.
  - The opportunity costs of “locking” large volumes of recycled water into lower value uses for 20-30 years must be considered.
  - A Precinct creates an environment to raise the “bar” on irrigation standards: design, installation, maintenance, scheduling, Water Use Efficiency and to link to State Water Plan initiatives.

- The concentration of horticultural enterprises into a precinct consolidates the opportunity to use compost to improve soils and reduce landfill.

- Removal of pine plantations in the surrounding area is planned over the next 25 years. The removal of pines reduces water use on the Mound with most of this being re-allocated for environmental improvement.
• Suitable soils are available for expansion of the existing growing area, onto Spearwood soils lying to the north and east of the designated precinct.

• The precinct is the last significant land opportunity on the Gnangara Mound before the Yanchep National Park.

• The precinct may guarantee certainty of location and water supplies to the growers of intensive and small farming vegetable crops for up to 50 years.

• Small farms are often family operations with the family desiring access to services such as education for their children to a standard only available in the city.

  o Vietnamese families are prominent small farm vegetable growers, some using market gardening as an entry level industry on their arrival in Australia.

  o Vietnamese farmers usually involve the family, but seek opportunities for their families to gain an education, and so tend to stay close to the metropolitan area.

• About 1,000 persons are directly employed in the horticulture industry in the North West Corridor. If the production falls it is likely some of these will leave the industry and may not easily find similar relatively unskilled employment in other local industries.

  o A precinct that introduced more services and intensive production techniques might create increased employment from that reported at this time.

14.2. DISADVANTAGES

Other factors do not support the establishment of the Carabooda precinct.

• Establishment of the precinct will preclude urbanisation of that area for the long term because of the need to guarantee recovery of costs associated with new services and infrastructure possibly recycled water.

  o If urbanisation develops beyond the precinct there is a significant and ongoing additional cost of transport for commuters living beyond the precinct who could be housed within the precinct if it was located further from the city centre.

  o The precinct will need to be preserved for a long time if it involves new infrastructure for water recycling in which case it will be “embedded” within the urban area for a long time – it will not be a peri-urban area.
• Crops that will be grown in the precinct can be grown elsewhere in WA and Australia and transported to the Perth market.
  o Some retailers believe they will lose freshness if this happens.
  o In the USA the Salinas and San Joaquin Valleys provide much of the production of salad vegetables for the whole nation, built on established postharvest and transport infrastructure.
  o Infrastructure will have to be improved for postharvest and transport if crops are grown at greater distances, but greater mechanisation will result.
  o The mechanisation of crop production is increasing, but is favoured for crops suited to larger scale production.
  o Increasing the scale and mechanisation of horticultural crop production can be encouraged by establishing large horticultural precincts well beyond the urban sprawl (Gingin/Lancelin and Myalup have been suggested), ensuring sufficient land and water for the growth and mechanisation of these precincts.
  o Both small and large lots should be allocated in the precinct as some of the crops grown in the Wanneroo area are grown using labour intensive techniques that are not easily mechanised. Traditionally these have been produced on small family vegetable farms.

• Recycled water may have a cost more than 10 times the current cost and significant storage and reticulation challenges need to be addressed.

• Recycled wastewater has a range of uses and some are considered to have higher values than agriculture irrigation.

• The potential wastewater stream from Beenyup may have already been committed to aquifer recharge and the Alkimos plant is more than 20 years away from supplying any reasonable water volumes.

• Recycled water will not be available quickly enough to satisfy the displacement of horticulture production in the East Wanneroo area. Subdivisions already under way will consume around 300 ha of horticultural production in the next five years. Recycled water may not be available for more than ten years and then its availability will increase slowly over time.

• Recycled water will be difficult to sell to established growers without a government subsidy. The most promising option appears to be the development and sale of a new area of land incorporating a recycled water supply.
• The precinct may concentrate practices (sprays, fertiliser application) that can lead to pollution and environmental damage.
  o This management issue must be addressed by carefully regulating nutrient applications and monitoring the impact of vegetable farming in the area, and by allocating sufficient buffers in the precinct to ensure separation of activities.

• Recycled water will give a guaranteed supply for decades to come, but will lead to an estimated on farm price of at least $0.90/kL and this is 9-10 times higher than is currently paid under self-supply circumstances.
  o Water will be delivered to the precinct at a cost of from $0.66 to $0.88 per kL.
  o Substantial storage will be needed to allow extensive watering on hot days.
  o New shared infrastructure will have to be installed within the precinct to distribute water to farms.
  o A new water supply business or cooperative would need to be established to manage the precinct water supply.
  o On farm water supplies may require further storage, pumps and piping.
  o Best practice design and installations should be encouraged
15. EVALUATION CRITERIA

There is a case for a precinct if the State Government chooses to direct a wastewater treatment scheme towards agricultural water use. However, the cost of recycled water will be high and it may be difficult for growers to compete with growers with established self-supply water sources without some form of subsidy on the supply of water. The provision of subsidised irrigation schemes is contrary to a major thrust of the national water reform agenda that has been in place (and largely implemented) since the mid 1990s. Re-cycled water may be treated more leniently.

The timeline for development of recycling may not meet the immediate needs of producers seeking to relocate from the existing east Wanneroo area. The Water Corporation has specific plans for use of the Beenyup plant water in the Integrated Water Supply Scheme (IWSS) if the current trials are successful. Recycled water from the Alkimos plant appears the most likely source.

The development of a new area of unallocated Crown land well ahead of the urban frontier with a wastewater supply incorporated into the land sale price is one option. Land release can then be matched to the timing of water supply availability. With suitable land use conditions attached as caveats, the land should be able to be protected from urban encroachment. This opportunity is best suited to the proposed Alkimos plant where economies of scale might be achieved by incorporating wastewater treatment into the plant design.

Careful evaluation of the costs and benefits of such an option is necessary on a case by case basis. The cost of delivered water and land must be assessed against other horticulture location options along with detailed consideration of the social and environmental impacts.

Horticulture has traditionally been located on land zoned rural on the fringe of the expanding urban area of Perth. Horticultural production can continue on the urban fringes provided sufficient water is available for irrigation. The options for large horticultural developments will tend to lie at greater distances from the city centre, dependent on the availability of water for irrigation. If water that has so far been reserved for future urban use can be reallocated to horticultural production in locations such as Gingin/Lancelin and Myalup then large scale and mechanised production could be concentrated in those areas. Smaller intensive farms could continue to operate closer to the city, growing specialty crops that are most perishable and labour intensive.

There are many factors to consider in determining which scenario or scenarios might be supported and these are summarised in Table 23.
Table 23 Evaluation Criteria

<table>
<thead>
<tr>
<th>Factor</th>
<th>Scenario 1: Carabooda Precinct</th>
<th>Scenario 2: Metropolitan Fringe</th>
<th>Scenario 3: Regional Commitment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Favoured crop types</td>
<td>Leafy greens, perishables, large volume crops</td>
<td>Perishable, labour intensive crops will be grown on small areas.</td>
<td>Broadacre, mechanised crops with low labour requirements.</td>
</tr>
<tr>
<td>Food Security</td>
<td>Long term production in metropolitan area is guaranteed</td>
<td>Small areas in metropolitan area will be pressured by future urban expansion.</td>
<td>Long term production in two substantial areas will be guaranteed.</td>
</tr>
<tr>
<td>Area of Horticultural</td>
<td>Area of up to 2,000 ha close to Perth guaranteed for decades.</td>
<td>Small areas (hundreds of hectares) under pressure from urban expansion.</td>
<td>Areas of more than 2,000 ha guaranteed for decades.</td>
</tr>
<tr>
<td>Fresh Markets</td>
<td>Close to fresh markets</td>
<td>Close to fresh markets, but less production.</td>
<td>Distant from grower markets.</td>
</tr>
<tr>
<td>Urbanisation Pressures</td>
<td>Urbanisation pressures likely in the time frame of water availability, but can be protected by zoning</td>
<td>Ongoing urbanisation pressures, small areas, owners wish to superannuate their land.</td>
<td>No pressure for urbanisation</td>
</tr>
<tr>
<td>Land Availability</td>
<td>Pine plantation land available.</td>
<td>Limited land amongst urban developments, water must be traded or dedicated to horticulture to preserve activity.</td>
<td>Land available for purchase, water allocation may be traded or released from reserves for other purpose.</td>
</tr>
<tr>
<td>Future urbanisation pressure on land</td>
<td>Likely to be under strong urban pressure well within the 50 year lifespan of the wastewater delivery system</td>
<td>Continue to move with urbanisation pressure</td>
<td>No pressure from urbanisation.</td>
</tr>
<tr>
<td>Labour</td>
<td>Labour readily available close to operations, supports labour intensive crops.</td>
<td>Labour readily available close to operations, allows labour intensive crops.</td>
<td>Labour scarce, but can be overcome by providing housing, transport, and by mechanisation of crops. May need to import specialised labour</td>
</tr>
<tr>
<td>Labour Community Cost</td>
<td>Labour employed in the precinct and does not have to find other employment.</td>
<td>Loss of labour to the precinct region may cost up to $20 million annually.</td>
<td>Loss of labour to the precinct region may cost up to $20 million annually.</td>
</tr>
<tr>
<td>Employment</td>
<td>Employment in northern corridor horticulture will be maintained, location will move to Carabooda.</td>
<td>Employment in metropolitan horticulture will diminish.</td>
<td>Employment in metropolitan horticulture will diminish, increased employment in regional locations.</td>
</tr>
<tr>
<td>Supply Chain Characteristics</td>
<td>Existing supply chain will support the precinct. Some handling facilities may be</td>
<td>Existing supply chain will support the growers.</td>
<td>Existing supply chain will support the precinct. Remote producers will establish</td>
</tr>
<tr>
<td>Characteristics</td>
<td>developed at the precinct growers.</td>
<td>their own infrastructure to supply retailers and central markets.</td>
<td></td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-------------------------------------</td>
<td>---------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Cost of fruit and vegetables</td>
<td>Fruit and vegetables retain relative metropolitan cost Fruit and vegetables retain relative costs Fruit and vegetables may cost up to $10 million more annually.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Availability</td>
<td>Limited availability. Can use part of allocation freed by urbanisation, or trade for allocations. Water is available, but areas are spatially separated. Medium sized distributed developments are favoured. Less irrigation required in the south than north.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Recycling</td>
<td>No or limited contribution to recycling strategy. No contribution to recycling strategy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recycled water on produce</td>
<td>Not applicable. Not applicable.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subsidy of water to farmers</td>
<td>No subsidy required. No subsidy required.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recovery of subsidy costs</td>
<td>No subsidy. No subsidy.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water cost to growers</td>
<td>A relatively low cost if self supply is continued. A relatively low cost if self supply.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy costs</td>
<td>Lower energy costs Lower energy costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental pressures</td>
<td>Distributed production leads to less intense environmental pressures, distant from Perth.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compost Recycling</td>
<td>Limited possibility for compost as small areas. Only compost manufactured on-site will be used.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compost Recycling</td>
<td>No case for the use of organic waste in compost for small areas. Only compost manufactured on-site will be used.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horticultural Sense of Place</td>
<td>Horticulture preserved close to the city for the term of the precinct. Horticulture preserved close to the city. Horticulture will not be as active close to the city</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seasonal impacts</td>
<td>Continues the well established annual metropolitan production cycle. Continues established annual metropolitan production, but limited by area. Production affected by climatic differences to north and south of Perth. Eg Lettuce – winter production to the north and summer to the south.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport or freight</td>
<td>A relatively low cost in all locations at 2 – 5 cents per unit. A relatively low cost in all locations at 2 – 5 cents per unit. A relatively low cost in all locations at 2 – 5 cents per unit. Larger vehicles used.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
16. CONSULTATION

This feasibility study was enabled by extensive consultation with many groups and individuals. Amongst those who provided information to the study are officers or individuals from the following organisations:

- Department of Agriculture and Food;
- Department of Water;
- Department of Planning and Infrastructure;
- Department of Environment and Conservation;
- CSIRO;
- Landcorp;
- Water Corporation;
- Wanneroo and Carabooda horticulture producers;
- Market City;
- Major Australian vegetable and fruit retailers;
- Sumich Group;
- Carine Fresh Market;
- Southern River Water, Victoria;
- Irrigation Association of Australia;
- Swan Catchment Council;
- Harvey Water;
- Ms Dianne Guise, Member for Wanneroo;
- Rural Solutions, South Australia.

Information was also collected through participation in forums such as:

- Gnangara Sustainability Strategy,
- State Water Recycling Strategy;
- Cedar Woods Group;
- Department of Agriculture and Food;
- Department of Environment and Conservation pine plantation Site Tour;
17. REFERENCES


xi FAO Yearbook 2005-06

xii Sing Ching Tongdee, Thai Fresh Fruit Traders and Exporters Association: http://www.agnet.org/library/eb/545/

xiii Australian Horticulture Fact Sheet, Department of Agriculture and Food, December 2005


xv The Perth metropolitan population growth rate will vary over time but this reflects recent trends

xvi McArthur, WM (1991) Reference soils of Western Australia. Published by Department of Agriculture, Western Australia for the Australian Society of Soil Science Inc (WA Branch)


xviii Western Australian Water Resources Council (1992) Horticulture on the Swan Coastal Plain; a review of water needs and land availability.

xix The Integrated Water Supply System (IWSS) is the integrated combination of surface and groundwater sources and their distribution system that services Perth, Pinjarra, Mandurah, Harvey, Waroona and the Goldfields and Agricultural Water Supply.


xxii Department of Water, Department of Agriculture and Food, Department of Planning and Infrastructure, Department of Environment and Conservation 2007, Gnangara Sustainability Strategy – Managing land and groundwater for the future, brochure issued October 2007.

xxiii M. McGuire (Dept of Water ) 2007, pers comm 1 November.


xxvi J. Connolly (Dept of Water) 2007, pers comm (2 November 2007).


xxxi Reproduced from CSIRO (2005).


xii Monterey Regional Water Pollution Control Agency (undated) Monterey County Water Recycling Projects.


xlv Fertigation refers to the use of distributing fertilisers to crops through the irrigation system. The practice utilises water as the transport medium, and is undertaken independently of water demand, particularly in the wetter months.

xlv Monterey Regional Water Pollution Control Agency (undated) Monterey County Water Recycling Projects.


l Western Australian Planning Commission (1996) State Planning Strategy

li Western Australian Planning Commission (1996) State Planning Strategy


liii Environmental Protection Authority 2005, *Strategic Advice on Managed Aquifer Recharge using Treated Wastewater on the Swan Coastal Plain*, Section 16(e) report and recommendations of the Environmental Protection Authority, Bulletin 1199, Perth, Western Australia, October 2005.


lv Priority areas west of Wanneroo Road are not shown on the map as the Gnangara Land Use and Water Management Strategy study did not consider the coastal strip.


lviii Western Australian Planning Commission, 2007, *The future of east Wanneroo – Land use and water management in the context of Network City*, report prepared by the Western Australian Planning Commission and Department for Planning and Infrastructure, Perth, Western Australia, August 2007.


lx ABS Water Account 2000-01. Catalogue 4610

lxi Marsden Jacob Associates, Gnangara Economic Values, 2007


lxiii ABS catalogue 7121


lxvi Lang, T and Rayner, G. ( )


lxviii AUSVeg CEO quoted in The Land August 2005.

lxix Sydney Food Fairness Alliance (2008) *Understanding Food Miles*.

lxx www.aefonline.org.au


lxxiv


lxxviii Rural Press - Hawkesbury Gazette - 1st October 2003

lxxix Kininmonth (2000) *Agriculture in the Perth Metropolitan Region - The importance of agriculture in the Perth region*


lxii See iii

Western Australian Planning Commission (1996) State Planning Strategy


http://www.naiad.net.au/?q=node/108

http://www.naiad.net.au/?q=node/57