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An Investigation into the Location of Horticultural Water Demands

Drivers of Horticultural Development in the Murray-Darling Basin

A REPORT FOR THE

MURRAY-DARLING BASIN AUTHORITY

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1 Executive summary

Almonds, citrus, and table grapes can all be grown above or below the Barmah Choke, but horticulturalists believe they can each be grown more profitably below the Choke.

The people interviewed for this report identified nine key agronomic factors influencing continued horticultural development below the Choke. The climatic and soils data described in more detail in Section 3 of this report support these observations.

In approximate order of priority, the nine key factors driving continued horticultural expansion below the Choke are:

Optimum temperatures and sunlight during the growing season below the Barmah Choke mean that horticulturalists there can deliver premium quality fruit and nuts. In the case of citrus and table grapes, this factor means that they can service a wider range of marketing windows. They can produce varieties for early, mid, and late markets. Crops produced above the Barmah Choke can only service late markets when prices are low and when they must compete with stone fruits.

Less rainfall during the harvest period below the Barmah Choke means that the risks to fruit quality are lower there than they are above the Choke.

Better trafficability after rain is better on Mallee soils than on the heavier soils of the riverine plains. This reduces costs and it reduces the risks to fruit quality. There are patches of suitable soils above the Choke, but generally they would not accommodate the scale of modern developments below the Choke.

Proximity to processing infrastructure favours continued development below the Choke. The cost of replicating this infrastructure above the Choke would be prohibitive. It would also render less capital efficiency because the crop production window would be narrower.

Proximity to services below the Barmah Choke is judged to be superior to that above the Choke. Large-scale horticultural developments need to be located within a 50 kilometre radius of towns with the services they need for repairs and maintenance. Only Albury-Wodonga above the Choke would have the capacity to meet the needs of a wide range of crops. There are seven such towns below the Choke

Proximity to labour is a complex issue. Citrus and table grapes generate approximately 30,000 seasonal jobs for most of the year. There is an existing network of hostels, caravan parks, and on-farm accommodation structures to service their needs below the Choke. Replicating this infrastructure above the Choke would be prohibitive, and it would also be empty for longer periods because of the shorter window of production.

Water availability, trade and reliability have a significant bearing on where developers invest. Horticulturalists below the Choke are conscious of the risk of shortfall, but in the context of all the other risks they must manage, and, given that the risk of shortfall has not yet materialised, this downside risk is seen to be outweighed by the upside benefits of horticultural production below the Choke. For international developers, Australia's water management framework is seen as carrying less risk than the arrangements in the Central Valley of California.

Amenity to attract skilled managers is essential for overcoming well-documented difficulties in attracting tertiary-qualified applications for advertised positions in horticultural enterprises. The closer the position is to a large vibrant town, the more applicants there are for any advertised skilled position. Mildura's central geographical location within the almond, citrus and table grape industries is seen to be an asset in this regard. This is further enhanced by the frequency of short flights to and from Melbourne, Adelaide, and Sydney.

Regulatory and financial approvals processes have traditionally favoured development below the Choke. Banks are reluctant to lend for developments in unproven areas. Horticulturalists below the Choke are aware of recent large-scale developments of citrus and almonds above the Choke, and they are watching these with interest to see how they fare. Historically, the coordinated approach to regulatory approvals in the Victorian Mallee had favoured development there, but less stringent approaches in the other two states have more recently resulted in similar levels of development in each state.

2 Background

The section of the Murray River that runs through the Barmah-Millewa Forest (Barmah-Millewa reach) is different to other reaches of the Murray River. The channel is narrow in this section and under natural conditions water would inundate the forest in winter and spring, which has led to the development of the largest river red gum forest in the world. The Barmah-Millewa Forest is a Ramsar listed wetland, it also contains extensive moira grasslands, and it provides habitat for numerous wildlife species.

However, to maintain the forest's natural values, river operators must avoid flooding it unseasonally (summer) as they deliver water downstream to water users. This limits the volumes they can deliver in the summer months to meet peak irrigation demands.

Given the delivery constraints posed by this narrow section of river, it is often referred to as the Barmah Choke. References made to the Barmah Choke, in this report, refer to the Barmah-Millewa reach as a whole. The Barmah Choke presents challenges to river operators delivering water to irrigators in the lower reaches of the Murray River. This creates a risk of shortfalls, which can occur when demand exceeds the physical capacity of the river to carry the water, or when demands for water unexpectedly spike and there is not enough time to release additional water from dams to meet the demands downstream of the Barmah Choke – particularly in summer.

These risks are not new, and they change over time. Irrigators, and horticultural developers are now well informed that there is an increasing risk that water may not be able to be delivered to users when they want it. Despite this risk being well communicated, permanent horticultural developments, which are highly susceptible to this risk, continue to expand downstream of the Barmah Choke.

For example, from 2018 (when a shortfall was narrowly averted) to 2021, permanent plantings in the lower Murray–Darling increased by 3,445 hectares (ha) in Victoria and 5,520 ha in New South Wales.[1] It is important to note that most of that expansion involved three main crop types – almonds, citrus, and table grapes

In this context, the Murray–Darling Basin Authority (MDBA) is seeking to understand why irrigators are continuing to develop permanent horticultural plantations downstream of the Barmah Choke in the face of uncertain water access. Further, the MDBA is seeking an understanding of the perceived constraints on permanent horticulture upstream of the Barmah Choke.

2.1 Project Objectives

The MDBA has asked for an authoritative report, based on interviews with horticultural developers, to answer the following questions:

1. What factors are influencing the decision of irrigators to develop permanent horticultural properties downstream of the Barmah Choke rather than upstream?
2. What are the perceived constraints on growing permanent horticulture above the Barmah Choke?

This project will allow the MDBA to understand the driving factors, constraints, and current trends relating to the development of permanent horticulture in the Murray–Darling Basin. This information will help inform stakeholders and assist with future management decisions.

[1] Figures derived from: https://www.mdba.gov.au/sites/default/files/pubs/phase-1-report-irrigated-crop-area-data-for-the-lower-murray-darling-2003-to-2021.pdf (accessed 25 May 2022)

2.2 Project Scope

The project:

- Focuses on the area downstream of the Barmah-Millewa Forest.
- Assesses the factors influencing horticultural developments downstream of the Barmah Choke by focussing on three permanent crop types: almonds, table grapes and citrus (the three main crops fuelling recent horticultural expansions below the Choke).
- Considers a variety of economic, environmental, and social factors, and it supports anecdotal explanations with quantitative and qualitative data, where applicable.

2.3 Project method

This report is based on the outcomes of semi-structured interviews with relevant people that have worked in horticulture below the Barmah Choke. Most of these were conducted face-to-face in March 2022, but three interviews were conducted by telephone.

The majority of interview participants were selected because they were actively involved in horticulture below the Barmah Choke, they participate in relevant industry associations, or they provide professional advice about site selection and crop production.

Collectively, the participants are involved in the management of at least:

- 28,200 ha of almonds in South Australia, NSW and Victoria (approximately 60% of total almond plantings in the lower Murray-Darling in 2021)
- 1340 ha of citrus primarily in South Australia, NSW, and Victoria (approximately 9% of total citrus plantings in the lower Murray-Darling in 2021)
- 1260 ha of table grapes on the NSW and Victorian sides of the Murray (approximately 10% of total table grape plantings in the lower Murray-Darling in 2021).[2]

Since the aim was to understand why they continued to develop in this region, there were no interviews with horticultural developers above the Choke.

The thoughts and opinions of the different participants were then converted into a narrative describing the apparent consensus of views on the reasons behind the continued expansion of horticulture below the Choke. These views were then tested against available climate and soils data for different regions, with relevant data then being threaded into the narrative.

An initial draft of this narrative was then circulated among the participants for them to review and correct where appropriate. The narrative was then revised and tested with MDBA staff for readability and technical rigour. It was then rewritten as this final report.

[2] Total areas derived from https://www.mdba.gov.au/sites/default/files/pubs/phase-1-report-irrigated-crop-area-data-for-the-lower-murray-darling-2003-to-2021.pdf (accessed 25 May 2022)

3 Factors influencing horticultural development below the Barmah Choke

3.1 Overview

The first thing to note is that each of the three crop types that form the focus of this study, table grapes, citrus, and almonds can be grown to produce harvestable yields in regions both above and below the Barmah Choke.

The question of why these crops are preferentially being grown below the Choke is therefore more an economic question than a technical one. More accurately, it is an agronomic question.

One definition of 'agronomy' is: the relationship between plants, soils, climates, microclimates, and the human inputs necessary to generate economic outputs. Using that definition, our discussions with people actively involved in developing these crops below the Choke identified nine key agronomic factors influencing horticultural development below the Choke.

In approximate order of priority, the key factors currently influencing horticultural development blow the Choke are:

1. Optimum temperatures and sunlight during the growing season
2. Less rainfall during the harvest period
3. Better trafficability after rain and other soil suitability issues
4. Proximity to processing infrastructure
5. Proximity to services
6. Proximity to labour
7. Water availability, trade and reliability
8. Amenity to attract skilled managers
9. Regulatory and financial approvals processes.

Each of these factors is separately discussed in more detail in the following sections. And each of those discussions compares and contrasts the relevance of each factor for the three crop types currently being expanded below the Choke – almonds, citrus, and table grapes.

3.2 Optimum temperatures and sunlight during the growing season

Plant growth rates depend on the amount of heat the plant receives. For each cultivar, if all other plant needs are being met, there is an optimum temperature range for growth. For example, for citrus in Australia, the optimum temperature range for plant growth is generally considered to be between 13°C and 35°C.

An understanding of how much time different cultivars are likely to spend in their optimum growth range during the course of the growing season can help to assess:

- a region's suitability for growing a particular cultivar
- the length of time needed to complete the cultivar's different growth stages
- likely harvest dates.

These assessments have been standardised in many different ways to make use of climatic records for investment assessments and weather observations for seasonal assessments. Typically, these involve adding the maximum and minimum daily temperatures and dividing them by two to get an average. The average is then adjusted in some way to account for the particular requirements of the cultivar in question.

For example, for citrus in Australia all maximum temperatures above 35°C are treated as being equal to 35°C. And 13°C is subtracted from the average to reflect the fact that time below that temperature is not optimal for crop growth.

The adjusted daily average represents the daily 'heat units' useful for crop growth. Results are then added to determine the accumulated weekly, monthly, or yearly heat units. Sometimes heat units are referred to as growing degree days (GDD).

Similar calculations are used to determine the amount of time spent below particular temperatures; these are known as chilling units. Some plants, such as almonds have chilling requirements. Adequate chilling puts the plant through a period of dormancy long enough to promote optimal budburst and flowering. This is important to ensure synchronised flowering between pollinator varieties and the main varieties.

Heat units can be mapped to show regional differences. One such map is shown in Figure 1. The key thing to note in that map is that the optimum climate for growing citrus is represented by the deep-violet band along the Murray River on either side of the South Australian Border. This coincides with the Riverland and Sunraysia regions below the Choke.

By contrast the citrus production regions above the Choke are covered by the brown and dark green bands. Citrus production is possible there, but fruit will be produced in a later and narrower window of marketing opportunities. The implications of this and other climatic and soil factors are discussed in more detail later in this report.

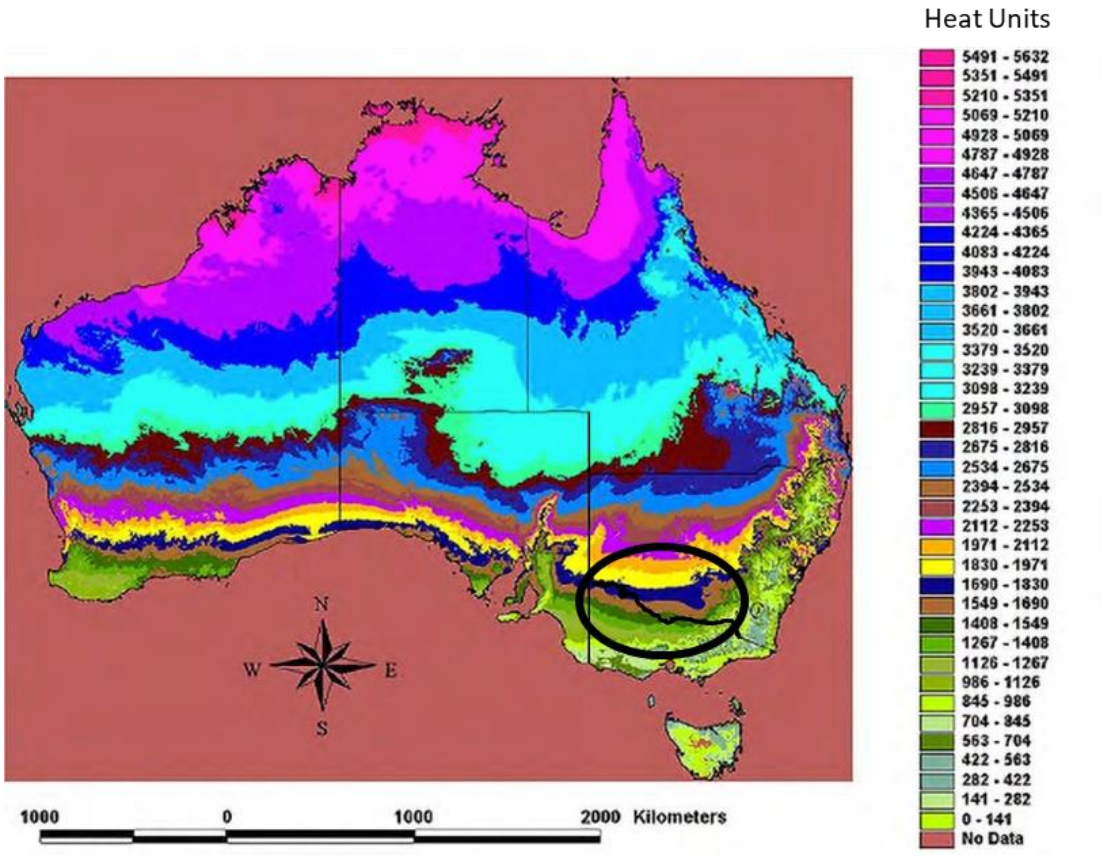

Figure 1: Annual heat units at 13 degrees C for citrus.
Taken from State of New South Wales (Department of Planning and Environment), 2021, https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/218972/Calculating-heat-units-for-citrus.pdf (25 March 2022) Amended for ease of interpretation.

Similar maps have been produced for grapevines using 10°C as the base.[3] They show much the same story for table grapes. The optimum band for growing the three main table grape varieties (Thompson Seedless, Crimson Seedless and Red Globe), and the main early season varieties (Flame Seedless, Menindee Seedless, and Ralli Seedless), straddles the Murray River either side of the South Australian border before sweeping up to the north and away from those reaches of the Murray River above the Choke. The story is similar for almonds.

As briefly discussed above, the Murray Valley regions above the Choke (Cobram and Tocumwal) are on the margins of optimum heat sums. Citrus can be grown there, but the growing season will be longer, and the harvest period will be later. This puts the domestically sold oranges into competition with fresh stone fruits, so prices will be lower. It also places export fruit in the opening part of the northern hemisphere harvest when exported Australian fruit would be exposed to competition from northern hemisphere fruit from countries with lower production costs and lower regulatory burdens.

Similarly, the growing season for almonds and table grapes above the Choke would be longer and harvest would be later. By itself, that is not a big issue for almonds, but, as discussed in the next section, that does increase the risk of being exposed to rain during the harvest period. While the Cobram-Tocumwal region would not be suitable for the three main table grape varieties, other late-season varieties may be suitable, but, again, they would be competing in the late market when prices are lower.

Another thing to note is that heat sums for the Murrumbidgee region are better suited to the production of these three crops than the Murray Valley above the Choke. However, as will be discussed in the next section, the Murrumbidgee also has issues with rain during the harvest season. Importantly though, for reasons similar to the increased risk of rain during harvest, fruit in that region is also exposed to less sunlight during the growing season. Murrumbidgee citrus production is focused more on juice fruit, as the climate and conditions at harvest are less suited to fresh market fruit.

Sunlight is essential for photosynthesis, and photosynthesis is essential for sugar production. Citrus fruits are non-climacteric; they do not develop sugars after harvest. The size and colour of citrus fruit is no guide to the sugar content. Repeat sales and market credibility depend on the citrus industry strictly controlling sugar content in marketed fruit.

The citrus growers interviewed for this report were of the view that it takes longer to get the sugar content high enough to meet industry standards in the Murrumbidgee region, and they must also plant on rootstocks, such as trifoliata, that allow them to develop the necessary sugars. Citrange would otherwise be the preferred rootstock.

Table 1 shows heat units, calculated from Bureau of Meteorology (BoM) data, for citrus and grapevines in Mildura and Echuca to illustrate differences. Citrus calculations are based on a threshold of 13°C [4], all year round, while vines are based on a threshold of 10°C, but just for the growing season 1 October to 30 April.

[3] An example can be found at http://winegourd.blogspot.com/2018/05/growing-degree-days-maps-of-australia.html (25 March 2022)

[4] Calculating heat units for citrus December 2021, Primefact 749, Second edition Sandra Hardy, Former Leader – Citrus, Tahir Khurshid, Research Horticulturist – Citrus

Table 1: Heat units calculated from BoM data

Location/ BoM site number	Time series	Citrus heat units	Grape vine heat units	Relationship to Choke
Mildura 076031	1957-2022	1768	2357	Below
Echuca 080015	1957-2022	1413	2045	Above
difference		355	312	

Temperatures above the optimum range for plant growth can also be experienced in the Riverland and Sunraysia. Heatwaves can result in fruit damage and plant damage, but cooling sprays are employed to prevent berry damage during periods of excessive heat and low humidity particularly in Table Grapes.

Frosts were seen as being more difficult to manage on the Murrumbidgee Valley and the riverine plains above the Barmah Choke. This is not obvious in the BoM records as shown in Table 2. But this may be an instance where averages are misleading. Microclimates have a large bearing on frost risk and occurrence. One of the people interviewed for this report told us of a climate study, conducted on one of their Mallee orchards, to inform the placement of frost fans, showed significant intra-orchard temperature variability of up to 4°C due to micro-climates. Their view was that weather station data are not a reliable indicator of frost risk or occurrence. It is also possible that, relative to the riverine plains, the undulating Mallee landscapes allow more scope for microclimates with adequate cold-air drainage to minimise or avoid frosts and the need to invest in frost fans to manage frost risks.

Table 2: Average number of days less than 0 degrees C

Location/BoM site number	Time series	July	August	September	Relationship to the Choke
Loxton 024024[5]	1984-2022	4.8	4.1	0.9	Below
Mildura 076031[6]	1946-2022	2.2	1.0	0.1	Below
Balranald 049002[7]	1965-2022	3.0	1.7	0.3	Below
Swan Hill 077094[8]	1996-2022	4.9	3.8	1.2	Below
Echuca 080015[9]	1957-2022	4.5	2.5	0.7	Below
Tocumwal 074106[10]	1970-2022	4.5	2.2	0.4	Above
Griffith 075041[11]	1970-2022	4.5	3.6	0.8	N/A

[5] http://www.bom.gov.au/climate/averages/tables/cw_024024_All.shtml
[6] http://www.bom.gov.au/climate/averages/tables/cw_076031_All.shtml
[7] http://www.bom.gov.au/climate/averages/tables/cw_049002_All.shtml
[8] http://www.bom.gov.au/climate/averages/tables/cw_077094_All.shtml
[9] http://www.bom.gov.au/climate/averages/tables/cw_080015_All.shtml
[10] http://www.bom.gov.au/climate/averages/tables/cw_074106_All.shtml
[11] http://www.bom.gov.au/climate/averages/tables/cw_075041_All.shtml

Table 3:Lowest known temperature

Location/ BoM site	Time series	July	August	September	Relationship to the Choke
Loxton 024024	1984-2022	-4.6	-4.6	-3.2	Below
Mildura 076031	1946-2022	-4.0	-3.1	-1.1	Below
Balranald 049002	1965-2022	-4.8	-2.7	-2.2	N/A

The people interviewed for this project were of the view that the ideal locations for growing Almonds in the Murray-Darling Basin were primarily in South Australia, particularly in the Riverland including Lindsay Point (just on the Victorian side of the border), next best was in the Mallee regions of NSW and Victoria from Lake Cullulleraine to Boundary Bend. After that they listed the Murrumbidgee Valley and west from Boundary Bend to Balranald.

They were not convinced of the potential to go further east than Balranald. In part this was because the production systems were unproven in those areas, and banks were reluctant to lend for unproven systems and locations. They noted however that a large-scale almond orchard was being developed at Katunga, above the Choke, and that everyone would be watching to see how successful that might be. If new production systems could be proven profitable and reliable there, then their outlook might change.

The story for citrus was very similar. Producing fruit for the highest returning markets for the right colour, sweetness, and size was seen as being easier and less risky in the Riverland and Sunraysia. From a marketing perspective they thought there was limited potential to expand on the existing plantings in the Murray Valley above the Choke. They saw difficulties there in achieving colour, sweetness, and shelf-life of equivalent quality to that produced in the Riverland and Sunraysia.

They also noted recent large-scale citrus plantings around Katunga, above the Choke, and they were watching those with interest to see how successful they would be.

For table grapes, few people saw significant potential to go further east. Production would continue to expand in the Mallee regions of NSW and Victoria. The opportunities for growth were seen to be in early-and-mid-season production systems, and these were to be found in the north, not in the east. Eastern areas would produce later season varieties. Mallee-based table grape growers would continue to develop satellite vineyards in St George, Hughenden, Emerald, Alice Springs, and other areas. While there was still potential to develop more in Sunraysia close to existing infrastructure there was little incentive to venture into the Riverland.

Plant breeding efforts for table grapes are also geared towards producing early-and-mid-season varieties for the existing production areas.

3.3 Less rainfall during the harvest period

Rainfall during the harvest period can interrupt the harvest, damage the harvested product, increase the likelihood of pest and disease incursions, affect post-harvest quality, and reduce profitability. These risks can be managed with different techniques, but they can be minimised by growing crops in more arid areas.

Free water sitting on table grape berries can cause the berry to absorb water through osmosis. This increases the turgor pressure inside the berry, which can cause the skin to split, reducing the quality of the fruit and causing it to decay. This risk is managed by spreading plastic covers over the vine rows to keep rain off the berries.

Similarly, free water, either from rainfall or dew, sitting on citrus fruits increases the turgor pressure in the skin. This makes the skin more susceptible to Oleocellosis, a rind injury that can occur when fruit is squeezed or bumped during harvest. It involves rind oil cells breaking and releasing oil that then burns other parts of the rind. This damage can lead to fruit decay. It is managed by interrupting the harvest until the skin turgor pressure is reduced through evapotranspiration. Such interruptions prolong the harvest and cause pickers to go in search of more reliable work.

For almonds, the economic losses associated with rain at harvest are made worse if there are trafficability issues associated with the soils of the orchard floor – trafficability issues are discussed in the next section. The main issue to do with rain during harvest on well-drained soils that remain trafficable has to do with staining of the shell and kernel resulting from nuts being in contact with wet soil. Almonds are a low-moisture food that cannot be stored safely, from either food safety or food quality perspectives, at higher moistures.

The people interviewed for this report cited low rainfall during the harvest period as one of the main reasons for continued development below the Choke. Their perception was that these risks were lower in the Mallee regions of NSW, Victoria, and South Australia.

To some extent this is borne out by BoM data. Table 4 shows the average number of rainy days in each of the harvest months for locations above and below the Choke.

Table 4: Average number of rainy days (> 1 mm) for key harvest months

Location/BoM site number	February	March	April	Relationship to the Choke
Loxton 024024	1.8	1.9	2.6	Below
Mildura 076031	2.0	2.4	2.7	Below
Balranald 049002	2.3	2.6	3.0	N/A
Boundary Bend 76105	2.3	2.5	3.0	Below
Swan Hill 077094[12]	1.9	2.2	2.5	Below
Lake Boga 77025	2.0	2.0	2.5	Below
Echuca 080015	2.4	3.0	3.7	Below
Tocumwal 074106	2.4	3.1	3.5	Above
Griffith 075041	2.7	3.0	3.1	N/A

[12] Swan Hill rainfall record is relatively short – from 1996 onwards. Therefore, nearby Lake Boga which has greater long term record (> 100 years) is shown.

Table 5: shows the average and median rainfall figures for the harvest months at these same locations. It also shows that the differences between locations are greater for median rainfall than they are for average rainfalls.

*Table 5: **Average and median monthly rainfall for key harvest months and total annual***

Location/ BoM site	February average	February median	March average	March median	April average	April median	Annual average	Annual median	Relationship to the Choke
Loxton 024024	18.0	10.9	11.3	5.4	18.3	10.4	256.1	262.8	Below
Mildura 076031	19.2	9.2	19.2	10.8	19.3	12.2	285.4	270.6	Below
Balranald 049002	24.6	12.0	22.0	14.4	23.9	15.5	323.0	312.3	N/A
Boundary Bend 76105	26.1	11.2	18.3	14.1	24.8	15.2	346.0	342.1	Below
Swan Hill[13] 077094	19.1	18.3	16.2	11.2	21.1	10.6	297.0	283.5	Below
Lake Boga 77025	22.1	12.9	22.4	14.3	21.4	16.2	331.9	337.0	Below
Echuca 080015	25.8	13.7	30.8	19.3	32.3	26.6	425.3	415.2	Below
Tocumwal 074106	28.9	17.2	35.2	22.4	32.2	25.2	447.4	440.8	Above
Griffith 075041	28.6	19.2	35.9	17.4	28.4	20.0	398.6	381.7	N/A

3.4 Better trafficability after rain and other soil suitability issues

Perennial horticultural crops are intolerant of waterlogging; therefore, they are not planted on soils that are subject to flooding or waterlogging. They require well drained soils to achieve commercial yields and quality. Good drainage is also needed to enable operational access to the orchard or vineyard following high rainfall.

Poor trafficability following rain is a disadvantage for each of the three crops that are the focus of this report. Because vehicle access must be delayed after rain until vehicles can be operated safely, poor trafficability diminishes the potential for timely harvesting and timely pest and disease control. In the case of almonds, it also means that nuts will remain in contact with wet soils for longer than they would on well drained soils. As discussed in the previous section this creates significant risks for food safety and food quality.

[13] Swan Hill rainfall record is relatively short – since 1996 and this skews average down. Therefore, nearby Lake Boga which has greater long term record (> 100 years) is shown.

Mallee soils generally remain trafficable after rain of average intensity, although there will be exceptions in poorly drained parts of some orchards. There are some patches of lighter freely-draining soils in the Murray Valley above the Choke, but these patches are generally not at the scale favoured for the types of developments that have occurred below the Barmah Choke in recent years.

Most of the soils in the riverine plains of the Murrumbidgee Valley and the Murray Valley above the Choke are clay and silt based; they are heavy, flat, and slow draining. Agricultural vehicles travelling on wet soils in these regions are prone to bogging or sliding away from the desired direction. Sliding vehicles can cause damage to trees, vines, trellises, and irrigation infrastructure. They also create ruts and traffic hazards in the interrow space.

The soil map in Figure 2, which was obtained from the CSIRO Soil Mapp app, indicates that the preferred Mallee soils, which are shown as pink on the map, generally do not extend east of Swan Hill (except for some around Griffith). The upstream areas (upstream/east of Swan Hill) tend to be riverine soils that, in general, are more prone to waterlogging and flooding.

Of the three crops under consideration, almonds are most susceptible to potential economic losses associated with wet untrafficable soils during harvest. These losses accumulate as the duration of orchard inaccessibility increases.

In approximate order of escalation, in response to increasing durations of untrafficable soils, these economic losses include:

- wages lost to down-time
- additional wage and fuel costs associated with spreading or turning over windrowed nuts to facilitate drying
- the cost of relocating nuts from within the orchards to open areas where they will dry better
- the cost of artificially drying nuts
- management costs associated with the separation of stockpiles of wet and dry nuts
- yield and quality losses due to the staining or browning of kernel
- increased hull rot infections because nuts cannot be shaken – causing
    - yield losses in the year of infection
    - spur death causing yield loss in later years
    - increased inoculum potential for similar problems in the future as a result of over-wintering
- loss of product if moist nuts become infected with Ochratoxin A or salmonella.

Site accessibility is important for citrus also as citrus has a limited shelf life, and it is important that harvest is not delayed. Heavy wet soils pose challenges for workers accessing trees safely and scaling ladders when the surface is slippery following rain.

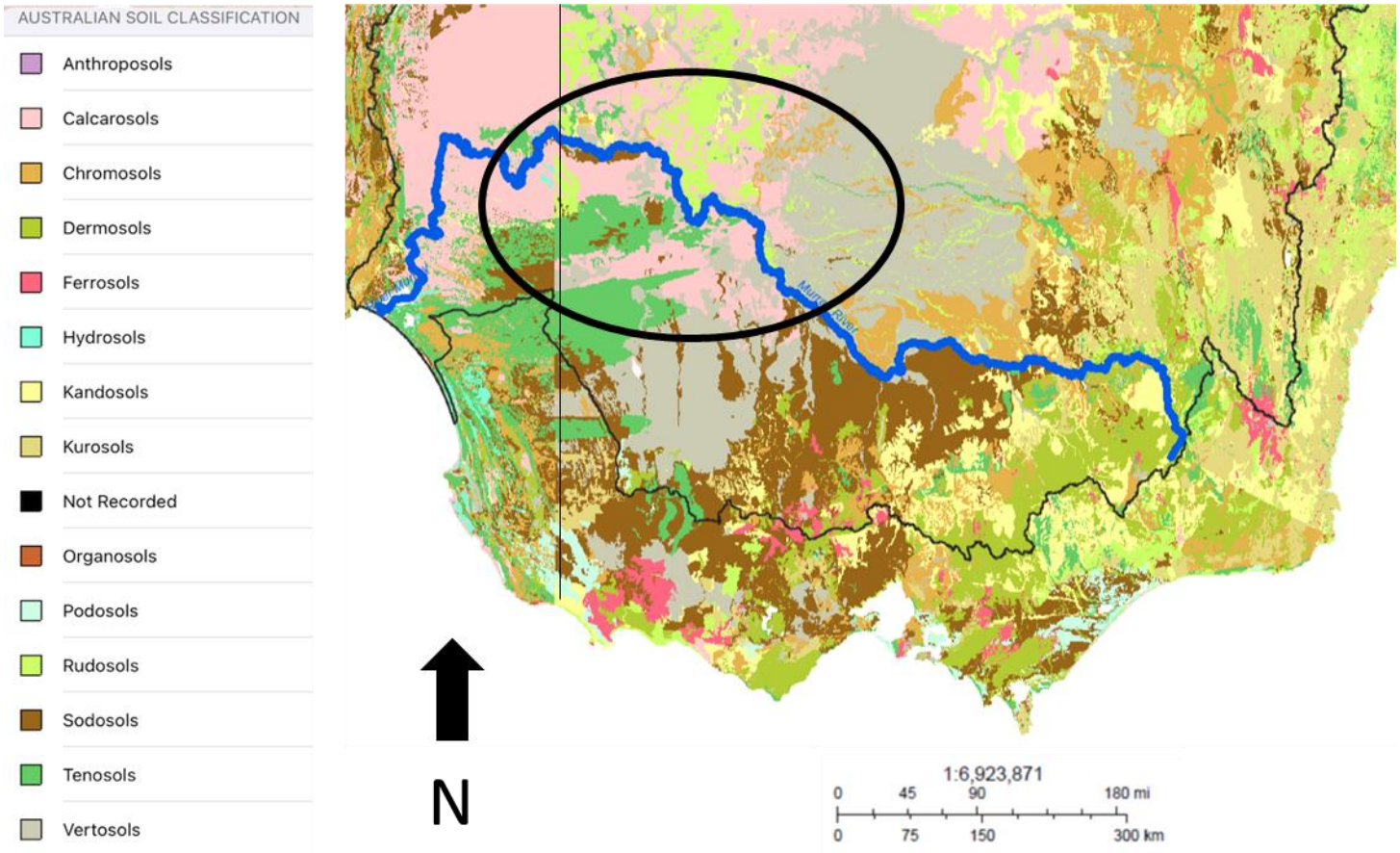

Figure 2: Soils of south eastern Australia (source CSIRO Soils Mapp App)

3.5 Proximity to processing infrastructure

While there is spare capacity in existing processing infrastructure for citrus and almonds, it makes economic sense to develop further horticultural plantings close to that infrastructure. Similarly, it makes economic sense to expand processing infrastructure in proven growing regions.

Existing citrus processing infrastructure located downstream of the Barmah Choke is being incrementally expanded as current plantings mature; the capital required to replace this infrastructure in new regions would be prohibitive.

A new almond processing plant has just been built at the centrally located Wemen, and other facilities are being transferred there. There is some concern however that there is not enough existing capacity to service recent plantings. Almond planting in Euston in NSW expanded after the new Robinvale Bridge was opened making access to Wemen more viable.

Table grape packing and storage infrastructure is built in quantum units to match new plantings.

3.6 Proximity to services

The people interviewed for this report believe that large-scale horticultural developments need to be located within a 50 kilometre radius of towns with the services they need for repairs and maintenance.

Mildura, Robinvale, Griffith, and the Riverland (Renmark, Berri, Loxton, and Waikerie) are regional hubs with the necessary skilled businesses to service a wide range of horticultural crops. Albury-Wodonga is probably the only location with similar capacity (albeit in different industries) above the Choke.

Mobile phone coverage is also essential for management communication, and, with the rise of autonomous farm machinery, internet connectivity is also increasingly being seen as important.

3.7 Proximity to labour[14]

The comparatively high cost of labour, seasonality of work, and reliance on seasonal workers, combined with the continued consolidation of the production base into larger corporate and private farming businesses, make the horticultural labour sector a complex issue.

Industry publications show that existing citrus orchards in NSW, Victoria, and South Australia, which are overwhelmingly in the Riverland, Sunraysia and Griffith, account for 71% of national citrus production in Australia. Existing vineyards in the same regions account for 87% of Australia's table grapes, with 70% of Australia's table grape production in Sunraysia alone.

According to work done by industry to understand the impact of Covid 19 restrictions on the labour market, citrus and table grapes are the most labour intensive horticulture industries in these regions, requiring approximately 30,000 seasonal workers for harvest periods across

[14] References for this section can be found at the following websites (accessed 25 May 2022)
https://citrusaustralia.com.au/wp-content/uploads/Citrus-Australia-Submission-to-the-targeted-update-of-agricultural-sector-occupations-in-ANZSCO.pdf
https://consult.abs.gov.au/standards-and-classifications/anzsco-targeted-update-2021-proposed-changes/
https://consult.abs.gov.au/standards-and-classifications/anzsco-targeted-update-2021-proposed-changes/supporting_documents/AGRICULTURE%20Occupation%20Groups_Proposed%20Changes%20v1.5.pdf
https://citrusaustralia.com.au/wp-content/uploads/Citrus-Australia-Submission-to-the-National-Agricultural-Workforce-Strategy.pdf
https://immi.homeaffairs.gov.au/what-we-do/skilled-migration-program/recent-changes/new-horticulture-industry-labour-agreement

extended periods of the year. Citrus harvest season in southern Australia is May to October, table grapes is November to May.

Almonds are less labour intensive than citrus and table grapes, but the scale of production requires orchards to be divided into a minimum of 200 ha units (the suggested ideal size is 400 ha) with a set of tractors, workers, and implements dedicated to each unit. The development and redevelopment phases of production are also labour intensive.

Seasonal horticultural workers in the Riverland and Sunraysia are made up of a mix of local and transient workers. Many transient workers move between the same commodities each year. Relocating these industries above the Choke, where harvests would all be condensed into the late part of the season, would not only alter the market window it would also alter and shorten the window that annual workers would normally be consistently available for growers.

Accommodation, household supplies, and other social services must also be located within reasonable commuting distance from vineyards and orchards.

The Riverland and Sunraysia have many hostels, labour hire companies, caravan parks, and on-farm accommodation that rely on transient workers each year. If most horticultural production were to shift above the Choke, this infrastructure would need to be available above the Choke to accommodate large groups of workers for shorter times, and they would need to sustain being empty for longer periods than the existing facilities below the Choke.

3.8 Water availability, trade, and reliability

The major almond growing enterprises mostly have orchards in NSW, Victoria and South Australia and they hold water entitlements in each state. They also maintain a portfolio of held and leased entitlements with the balance of their water use being dependent on water allocation trade. One advantage of holding water entitlements from each state is that if trade from Victoria to NSW is closed in either direction, they can trade to their South Australian holdings first and then back to whichever of the states they need water in.

Victorian high reliability water shares are seen as having similar long term reliability as South Australian entitlements, even though they are seen as having been less reliable in recent years. NSW high security licences are seen as being the highest reliability entitlements, though the transaction costs in moving water interstate from NSW are seen as being more prohibitive than the transaction costs involved in trading out from the other states

Groundwater availability in the Murrumbidgee Valley is seen as providing a hedge against low surface water allocations. The trade-off is that the groundwater is more saline than the surface water, and this poorer quality water results in lower yields.

Given the deliverability risks associated with the Barmah Choke, further developments in South Australia are being seen as more attractive because of the influence of Lake Victoria (supported by the Menindee Lakes when available to the MDBA) and the series of weir pools in South Australia.

When the MDBA has access to significant volumes of water in Menindee lakes, river operators use the water available from Menindee in preference to the upper storages, which store water more efficiently because they lose less to evaporation. This means that the upper storages are used only to provide the minimum flows needed to meet expected demands at Mildura weir. Under these conditions there are minimal extra flows available in the Murray River to buffer against a spike in demand; this increases the risk of a delivery shortfall in Victoria and NSW but not in South Australia.

The expansion of horticulture below the Choke is reliant on trade of water from other parts of the system, including the tributaries (noting the Barmah Choke trade rule, does not allow any net trade from above to below the Choke). This has put pressure on other parts of the connected river system. For example, in 2020 the Victorian Department of Environment, Land, Water and Planning announced changes to the Inter-Valley Trade rule between the Goulburn and Murray rivers due to the degradation of the lower Goulburn River. Options for changes to this rule could have significant/detrimental impact to the regions below the Barmah Choke, as each results in less water availability, and therefore an inability to meet the water requirements of permanent plantings during dry sequences.

Lack of transparency about intervalley trades from the Murrumbidgee to the Murray compounds these problems. The future impact of redeveloping existing licenced properties from low-water-use horticultural crops (such as some wine grape varieties) to higher-water-use crops (such as citrus) also needs to be considered in determining the location of future demands and their relationship with delivery risks.

Many interview participants expressed concern regarding the ability now to trade allocation from the Murrumbidgee and Goulburn to the Murray. The difficulties involved in accessing allocations from Goulburn high reliability water shares that were tagged to properties on the Murray, in Trading Zone 7 – as a result of the recent changes to the Goulburn to Murray trading rules – led one major horticulturalist to sell the majority of their Goulburn entitlements.

Everyone interviewed for this report was conscious of the risk of shortfalls, but because it is a risk that has not materialised in the horticultural areas, it is not perceived to be as significant as all the other risks they must contend with. A more tangible risk is the risk of low allocations. Everyone is conscious that horticulture now accounts for a much larger percentage of average annual irrigation water use than it did during the Millennium Drought. A repeat of those conditions would therefore see much more horticultural land being dried off than previously.

Some of the people interviewed for this report were able to put deliverability risks into a much broader perspective. International companies will continue to develop new orchards, or purchase existing orchards, in Australia, given the complexity of risks surrounding water availability in the Central Valley of California, which at the moment looks worse than the situation in Australia. They look favourably on Australia's strong water entitlement and water trade protocols.

International companies are also conscious of counter-seasonal benefits as well as different reflections of the *La Nina/El Nino* cycle (wet conditions here versus dry conditions there and vice versa). They have demand they need to meet and being in both hemispheres helps to manage supply risks for their markets.

3.9 Amenity to attract skilled managers

For the international firms involved in horticultural developments, the ease of access to the region, and the amenity offered by Mildura's accommodation houses and restaurants, is a decided advantage. They can fly from the US to Melbourne and then to Mildura and still be only an hour away from being on farm.

More broadly there are always vacancies in skilled and managerial roles. There are also fundamental gaps in applied research roles which present real challenges for recruitment, progression and job security.

The citrus industry's' submission to the Targeted Update of Agricultural Sector Occupations in ANZSCO (Australian and New Zealand Standard Classification of Occupations) states:[15]

- A lack of understanding about the career opportunities in horticulture, and a lack of supportive pathways to an apprenticeship or full-time role where they can progress through leadership roles, results in little interest from students. Their perception of agriculture and regional areas is based on stereotypes driven by city centric media [focusing on struggling farmers and the like].
- Evidence from grower surveys in 2020 indicated that just 4 to 11 per cent of job applications received for horticulture roles were made by Australian citizens or permanent residents.
- The further a harvest job is from both a capital or regional city, the fewer the number of applications from Australians, with only three per cent applying for jobs more than 200 kilometres from a regional city, and 11 per cent applying for jobs more than 100 kilometres from a capital city.
- Sponsoring [the immigration of] a skilled worker is an expensive and arduous task, generally starting at between $20,000 and $40,000; it is certainly a measure of last resort after all other options to find a suitable Australian worker have been exhausted.

Semi-skilled workers are frequently used to fill skilled positions. Most of them do well in those jobs with adequate training, but their lack of tertiary education means that it is difficult to promote them into management positions. This means there are no obvious career paths for them.

Mildura, Griffith, and the Riverland (Renmark, Berri, Loxton, and Waikerie) are attractive regional centres that help to attract skilled workers. Mildura in particular has the scale, the vibrancy, the connectivity, the social services, and the social capital to support careers and opportunities for skilled workers. Importantly, Mildura also offers careers and opportunities for their families.

3.10 Regulatory and financial approvals processes

Until 2009 the overwhelming majority of new horticultural developments below the Choke were planted in Victoria. In part this had to do with Victoria's one-stop-shop approach to the various development approvals processes. Expansion was subdued between 2009 and 2015 largely because it was offset by properties, especially wine grape properties, being dried off in response to the water allocation shortages during the Millennium Drought.

Between 2015 and 2021 the overall rates of expansion were similar in each of the three states.[16] In part this had to do with an increasing scarcity of easy sites to develop in Victoria, and in part it had to do with the relaxation of approvals processes in NSW and South Australia.

The Almond Board of Australia is concerned that this continued expansion is adding to the probability and potential consequences of a delivery shortfall. It has called for *"a moratorium on state governments in the Murray Valley issuing new water use licences that threatens the future capacity to deliver water to existing irrigators."*[17] The Australian Table Grape Association and Citrus Australia Limited support that request.

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[15] https://citrusaustralia.com.au/wp-content/uploads/Citrus-Australia-Submission-to-the-targeted-update-of-agricultural-sector-occupations-in-ANZSCO.pdf (accessed 25 May 2022)

[16] https://www.mdba.gov.au/sites/default/files/pubs/phase-1-report-irrigated-crop-area-data-for-the-lower-murray-darling-2003-to-2021.pdf (accessed 25 May 2022)

[17] https://australianalmonds.com.au/wp-content/uploads/2020/08/2020_Almond_Insights.pdf?v=6cc98ba2045f (accessed 25 May 2022) page 8

The Victorian Government has responded to these requests by not issuing anymore 'extraction shares' on the approvals necessary to divert water from new pump sites. In effect this means that in the event of a shortfall, irrigators without extraction shares would have to cease pumping while other irrigators were rationed. Other governments have not yet responded.

While generally supportive of Victoria's approach, industry groups think this cap on extraction shares need to be backed up by a cap-and-trade system, to create a market in extraction shares, so that irrigators can take more responsibility for managing their own risks.

Several of the people interviewed for this report also noted that it is easier to obtain finance for horticultural developments in proven production zones like those below the Choke. It is harder to obtain finance for developments in unproven production zones such as those above the Choke. Recent large-scale developments above the Choke appear to have the scale to cover risks internally without putting the banks at risk. If those plantings prove successful, this calculus may change.

4 Conclusions

Horticultural developers are conscious of shortfall risks, but in the context of all the other risks they contend with, and in the absence of that risk having yet been materialised in horticultural areas, shortfall risks are seen as being outweighed by significant advantages.

Optimal temperatures and sunlight during the growing season, and the lack of rainfall during the harvest period, allow horticulturalists below the Barmah Choke to service premium markets. Mallee soils are also more suitable for these permanent crops because they drain better than the soils of the riverine plains; this allows for a faster return to trafficability after rainfall, this in turn improves the control of pests and diseases.

As such, horticulture will continue to expand below the Barmah Choke in the short to medium term. In the long term, another drought on the scale of the Millennium Drought, accompanied by low allocations, will result in significant areas of horticultural plantings being dried off. Depending on commodity prices at that time, some different crop types will be more prone to being dried off than others. In a repeat of recent commodity prices, wine grapes would likely be most affected while table grapes might be least affected.