Water Market Intelligence

Final Report prepared for the Natural Resources Access Regulator

12 August 2019

AITHER

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Project Overview

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Project context

The Natural Resources Access Regulator (NRAR) is an independent regulator established under the *Natural Resources Access Regulator Act 2017* (NSW). Its core objectives under the Act are to ensure effective, efficient, transparent and accountable compliance and enforcement measures to maintain public confidence in water management in New South Wales (NSW).

To meet its statutory objectives, the NRAR undertakes a prioritised program of activities and specific regulatory projects to respond to emerging issues. The program of activities and regulatory projects is outlined in the publication: *Natural Resources Access Regulator Regulatory Priorities March 2019 – March 2021*. The NRAR takes a risk- and evidence-based approach to assessing and setting its regulatory priorities. Prioritisation occurs on two levels:

- Ecological and hydrological analysis of Murray–Darling Basin (MDB) surface water, coastal surface water and groundwater sources
- Analysis of other information that highlights the potential impact and likelihood of non-compliance.

The NRAR's regulatory priorities are reviewed and updated on an ongoing basis to consider new developments and improvements in data and analytical tools, and to respond to influences such as new technology, community feedback, and environmental and social changes.

Aither has prepared this report to provide the NRAR with a summary of relevant rural water industry information to complement its strategic planning of priorities and operational activities. The report is intended to inform the NRAR's:

- implementation and adjustment of its compliance priorities over the next two years
- design, implementation and continuous improvement of its operational plans, projects and compliance programs.

Project scope

This report provides a high-level summary of the major irrigation industries and their water use across the southern MDB, northern MDB and coastal regions of NSW. It further divides the state into 12 regions that are based upon Australian Bureau of Statistics (ABS) Natural Resource Management (NRM) Zones.

For each of the 12 regions, the report summarises the following components:

- water demand analysis – including major crops in each region, when water is likely to be used, decision making points by major crop types, crop watering rates by major crop types and additional context on the characteristics of each region and its effect on water extraction behaviours.
- water supply and availability analysis – including trend analysis based on historic supply conditions, storage and allocations.
- water market activity analysis – including historic price and trade intensity trends.
- identification and synthesis of key demand, supply and market risks and potential triggers for non-compliance.

Sources and limitations

The analysis in this report is provided at a high-level based on historical data. It aims to identify indicative trends and therefore potential triggers – but is necessarily general in nature.

Land and water use data has been sourced from the ABS, which reports data by NRM regions.

- NRM regions do not align exactly with water trading zones or surface water resource plan areas.
- Data and analyses presented in this report are representative of the general conditions present within regions, rather than being representative of every system within a region (due to scope and information constraints).
- Data is not yet available for the 2018-19 water year; however anecdotal observations have been made (for example, greatly reduced rice crops).

Agricultural production varies annually, geographically and between individual enterprises.

- As such, production information presented in this report is indicative only.
- Aither has consulted a range of sources to provide production information relating to water application rates, production timings and decision-making points, including the NSW Department of Primary Industry (DPI), and various research and development organisations, such as the Cotton Research and Development Corporation (CRDC), Grain Research and Development Corporation (GRDC), Hort Innovation and Sugar Research Australia.
- A full list of references is provided at the end of the report.

Water storage and flow information has been sourced from the Bureau of Meteorology (BoM) and WaterNSW.

Trade data and cumulative seasonal allocations has been sourced from Aither's Water Market Database which is based on trade reported to the NSW water register.

- Trade data for the North Coast, South Coast and Sydney Basin has been sourced from BoM at an aggregated level for all coastal systems within the South East Coast (NSW) drainage division – as defined by the BoM.

NSW has many unregulated and groundwater sources, often with highly complex local take conditions. This report does not address these complex unregulated and groundwater water sources.

Summary of Compliance Triggers

This report provides a high-level summary of the potential water use compliance triggers across NSW, upon the basis of indicative:

- demand for water by various irrigated industries
- supply characteristics around the state
- water market activity.

For the purpose of more detailed trend analysis, this report divides the state into 12 regions within three broadly consistent groups - the southern MDB, northern MDB and coastal regions. However, in principle, the fundamental state-wide compliance triggers are:

- periods in the year when water is used to grow various crops (noting the variations between summer, winter and permanent crops)
- opportunities to capture and store water
- unexpected climatic events such as temperature spikes or rainfall events
- lack of availability of water due to insufficient supply (for example reduced inflows to storages and lower than expected allocation announcements)
- constraints on the delivery of water (i.e. the physical capacity of the system, such as the Barmah Choke or trade / administrative constraints, such as the operation of inter-valley trade (IVT) limits)
- unexpected market activity, such as high prices or low volumes for sale.

For each of these fundamental compliance triggers there are factors that will influence whether non-compliant behaviour will occur (and which are generally beyond the scope of this analysis), such as:

- oversight of the water use, such as the presence of meters or the user being part of an irrigation district
- individual decision-making, such as whether a crop is planted and with what level of water coverage
- the availability of carryover, access to groundwater and on-farm storage
- willingness-to-pay, commodity prices and other farm finance considerations.

As noted in 'Sources and limitations' (page 6), the analysis in this report is provided at a high-level based on historical data. It aims to identify indicative trends and therefore potential triggers – but is necessarily general in nature.

Southern Murray-Darling Basin

Summary of compliance triggers by zone

NRM Zone	Risks and triggers
Upper Murray	• **High water use:** Zone with the second largest amount of water used in NSW (however, this includes a large proportion of water use by Murray Irrigation which from the NRAR's perspective, primarily requires compliance with its bulk licence). • **Historically reliable:** Large headwater storages and historically reliable HS entitlements (more variable and greater number of GS entitlements). • **Interruptible but price sensitive:** Largely lower value annual and semi-permanent crops, therefore interruptible when water supply is limited, but also exposed to higher prices following the decision to plant. • **Summer water use by annual crops:** When water is available (typically GS allocations), annual crops such as rice will be planted and watered over the summer irrigation season.
Lower Murray	• **Moderate to low water use:** The NSW Lower Murray consumes a low volume of water relative to other zones in the MDB. • **Reliable but susceptible to delivery constraints:** The location of the Lower Murray and the existence of trade restrictions such as the Barmah Choke can limit the volume of water available for consumptive use. • **Less interruptible:** The high proportion of permanent plantings (43% of water use in the region) results in a less interruptible demand for water. Permanent plantings require consistent watering throughout most of the year. • **Predominantly summer water use:** Permanent crops require year-round irrigation. However, water use is highest in summer due to the warm climate in the Lower Murray. Crop yield losses will likely be experienced if water is not applied during heatwaves.
Murrumbidgee	• **Largest water use:** Zone with the largest amount of water used in NSW (however, this includes a large proportion of water use by Murrumbidgee and Coleambally irrigation areas which from the NRAR's perspective, primarily requires compliance with their bulk licences). • **Historically reliable:** HS entitlements are among the most reliable water entitlements in NSW. • **Diverse production:** The region supports a high number of annual crops (increasingly cotton, accounting for 40% of water use) and permanent crops (noting the increase in almonds). • **Summer water use by annual and permanent crops:** There is a mix of permanent and annual crops. Due to the warm climate in the Murrumbidgee, water use during summer is high. Crop yield losses will likely be experienced if water is not applied during heatwaves.
Lachlan	• **Moderate water use:** Zone with third largest amount of water used in NSW. • **Less reliable GS:** GS entitlements are historically unreliable. HS has been very reliable since 2010 (however, there are few HS entitlements on issue). • **Dominated by cotton:** Cotton (73% of water use) will be planted and watered over the summer irrigation season. However, watering decisions may be made on the basis of forward contracts (which are particularly prevalent in the cotton industry) despite water scarcity or water price.

Table 1: Summary of compliance triggers in the southern MDB
Note: the analysis in this report is provided at a high-level based on historical data. It aims to identify indicative trends and therefore potential triggers – but is necessarily general in nature.

Northern Murray-Darling Basin

Summary of compliance triggers by zone

NRM Zone	Risks and triggers
Central West	• **Moderate water use:** Lower water use than southern zones, but higher than the coast (however, this includes several private irrigation schemes which account for a significant proportion of entitlements and from the NRAR's perspective, primarily requires compliance with their bulk licences) • **Need for groundwater monitoring:** Accounts for near one third of total water use (depending on surface water availability and rainfall). • **Dominated by cotton:** Cotton (73% of water use) will be planted and watered over the summer irrigation season. However, watering decisions may be made on the basis of forward contracts (which are particularly prevalent in the cotton industry) despite water scarcity or water price. • **Limited permanent crops:** When water is not available / prices are high, there is unlikely to be the same pressure for water as in other zones where there is more permanent cropping.
Namoi	• **Moderate water use:** Lower water use than southern zones, but higher than the coast. • **Need for groundwater monitoring:** Accounts for approximately 40-75 per cent of total water use (depending on surface water availability and rainfall). • **On-farm storages:** Timing and volume of extraction may be different to timing and volume of application to crops as water will be pumped, collected and stored whenever it is available during the year. Therefore the compliance risk may shift from the time of crop water application to the time of water availability for capture. • **Dominated by cotton:** Cotton (75% of water use) will be planted and watered over the summer irrigation season. However, watering decisions may be made on the basis of forward contracts (which are particularly prevalent in the cotton industry) despite water scarcity or water price. • **Limited permanent crops:** When water is not available / prices are high, there is unlikely to be the same pressure for water as in other zones where there is more permanent cropping.
West / Upper Darling	• **Moderate to low water use:** Lower water use than southern zones, but higher than the coast. • **Unreliable:** Stream flows in the Darling River observe seasonal trends and annual variability. • **On-farm storages:** Timing and volume of extraction may be different to timing and volume of application to crops as water will be pumped, collected and stored whenever it is available during the year. Therefore the compliance risk may shift from the time of crop water application to the time of water availability for capture. • **Summer water use by annual and permanent crops:** There is a mix of permanent and annual crops. Due to the warm climate in the West / Upper Darling, water use during summer is high. Crop yield losses will likely be experienced if water is not applied during heatwaves.
NSW Border Rivers / Gwydir	• **Moderate water use:** Zone with the fourth largest amount of water used in NSW (noting the comparative absence of bulk entitlement holders). • **Need for groundwater monitoring:** Accounts for approximately 40-75 per cent of total water use (depending on surface water availability and rainfall). • **On-farm storages:** Timing and volume of extraction may be different to timing and volume of application to crops as water will be pumped, collected and stored whenever it is available during the year. Therefore the compliance risk may shift from the time of crop water application to the time of water availability for capture. • **Dominated by cotton:** Cotton (77% of water use) will be planted and watered over the summer irrigation season. However, watering decisions may be made on the basis of forward contracts (which are particularly prevalent in the cotton industry) despite water scarcity or water price. • **Limited permanent crops:** When water is not available / prices are high, there is unlikely to be the same pressure for water as in other zones where there is more permanent cropping.

Table 2: Summary of compliance triggers in the northern MDB

Note: the analysis in this report is provided at a high-level based on historical data. It aims to identify indicative trends and therefore potential triggers – but is necessarily general in nature.

Coastal Regions

Summary of compliance triggers by zone

NRM Zone	Risks and triggers
Hunter	• **Low water use:** Lower water use than the MDB zones, but higher than other coastal zones • **Low compliance risk:** More reliable rainfall on the coast than in the MDB zones. Irrigation (with typically reliable entitlements) used mainly to supplement rainfall, rather than as the basis for growing. • **Dominated by pastures** – Dairy and hay: Semi-permanent crops allow for a greater degree of flexibility in production, therefore reducing non-compliance risk. • **Low level of information on water use:** Compliance risk due to a lack of information in comparison with zones located in the MDB.
North Coast	• **Low water use:** Lower water use than the MDB zones, but higher than other coastal zones • **Low compliance risk:** More reliable rainfall on the coast than in the MDB zones. Irrigation (with typically reliable entitlements) used mainly to supplement rainfall, rather than as the basis for growing. • **Predominantly summer water use:** Permanent crops require year-round irrigation (dairy accounts for 33% of water use and fruit and nuts account for 28%). However, water use is highest in summer. Crop yield losses will likely be experienced if water is not applied consistently. • **Low level of information on water use:** Compliance risk due to a lack of information in comparison with zones located in the MDB.
South Coast	• **Low water use:** Lower water use than the MDB zones. • **Low compliance risk:** More reliable rainfall on the coast than in the MDB zones. Irrigation (with typically reliable entitlements) used mainly to supplement rainfall, rather than as the basis for growing. • **Dominated by pastures – Dairy and hay:** Semi-permanent crops allow for a greater degree of flexibility in production, therefore reducing non-compliance risk. • **Low level of information on water use:** Compliance risk due to a lack of information in comparison with zones located in the MDB.
Sydney Basin	• **Low water use:** Lower water use than the MDB zones. • **Significant vegetable production:** Vegetables require consistent irrigation during growth. However, water use is highest in summer. Crop yield losses will likely be experienced if water is not applied consistently. • **Low compliance risk:** More reliable rainfall on the coast than in the MDB zones. Irrigation (with typically reliable entitlements) used mainly to supplement rainfall, rather than as the basis for growing. • **Low level of information on water use:** Compliance risk due to a lack of information in comparison with zones located in the MDB.

Table 3: Summary of compliance triggers in the Coastal Regions
Note: the analysis in this report is provided at a high-level based on historical data. It aims to identify indicative trends and therefore potential triggers – but is necessarily general in nature.

Summary of trend analysis

This report analyses the water use of major irrigated agricultural industries around NSW.

Agricultural production varies temporally, geographically and between individual enterprises depending on commodity prices, climatic and weather conditions, operating models, biological characteristics of crops and circumstances specific to individual enterprises. However, there are several demand, supply and market activity trends that exist across most regions.

Demand

- Irrigated agriculture comprises of three classes of crops:
    - permanent crops (almonds, avocados, citrus, macadamias, et cetera)
    - semi-permanent crops (livestock and dairy) and
    - annual crops (cotton, wheat, rice, et cetera).
- Farmers will typically produce multiple crops simultaneously. The same piece of land can be used throughout the year to produce multiple different annual crops (rotational cropping).
- Planting and growing periods shown in the production schedules throughout the report indicate that the crop will likely require water during these periods.
- Water consumption by crops is highest during summer. The biological characteristics of plants require that increased amounts of water are available during warm, sunny weather.
- The relationship between crop, water and land use is determined by the crop's water requirements. For example, in the Upper Murray, rice accounted for 45 per cent of the region's water use in 2017-18 but constituted less than 10 per cent of the region's irrigated land use. This is due to rice's relatively higher water application rate (ES 1).
- Water and land use by annual crops varies annually. This will largely be determined by water availability. In addition, the flexibility of annual crops is due to their biological characteristics, lower establishment costs and lower long-term earning potential per hectare relative to permanent and semi-permanent crops.

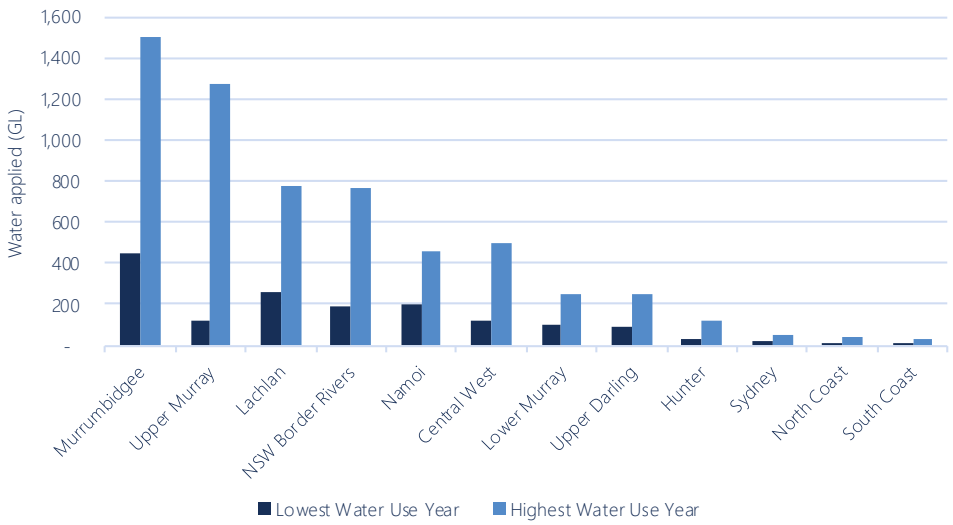
Crop Type	Approximate annual water application rate (ML/ha)
Almonds	12-15
Canola	1-4
Citrus	7-12
Cotton	5-12
Grapevines	3-6
Hass Avocado	3-5
Lucerne	7-13
Macadamia	≈ 5
Maize	6-10
Rice	11-16
Sorghum	≈ 5
Soybeans	6-8
Sugarcane	≈ 1
Wheat	3-5

ES 1 Approximate crop water application rates
Source: Refer Appendix

Summary of trend analysis

Demand (continued)

- Permanent and semi-permanent crops generally have an inflexible demand for water relative to annual crops. This is due to the higher establishment costs, long-term earning potential per hectare and lower tolerance to heat and water stress. As such, permanent and semi-permanent enterprises are more likely to hold higher reliability entitlements (noting that this is ultimately a portfolio / risk issue for individual enterprises).
- Semi-permanent crops such as lucerne and sugar cane can be produced over several years. By way of example, lucerne is a pasture which can be grazed by livestock in-field, cut for hay or baled for silage. In addition, lucerne will continue to grow after being grazed or harvested. Under best practices a farmer can expect to harvest lucerne four times within a year. During winter, growth of lucerne may slow or stop as indicated by the staggered grey lines in the production schedules presented in this report. As such, the timing and decision-making processes of lucerne production can vary significantly.
- In-crop rainfall is an important but sometimes complex demand trigger. Depending on the amount of and the timing of rainfall, farmers may either substitute irrigation with rainfall or complement rainfall with irrigation. Where rainfall is consistent and penetrates the soil to the point of saturation, farmers will likely not irrigate for several days (if not weeks) to reduce the likelihood of waterlogging. Where rainfall is light and does not sufficiently saturate the soil, farmers may compliment rainfall with irrigation to 'top-up' rainfall.
- A shift in the production of one crop to another will results in a change in the production timing and volume of water used. Irrigators (particularly lower value crop irrigators) will consider future water availability prior to sowing. Occasionally, irrigators may wait until an allocation announcement before sowing.
- Total water use by region varies throughout NSW. ES 2 shows the total water for each region in the year of highest and lowest water use since 2006-06. The graph illustrates the magnitude of irrigation and annual variability in water use by region.



ES 2 Lowest and highest recorded irrigation water use by region between 2005-06 and 2017-18.

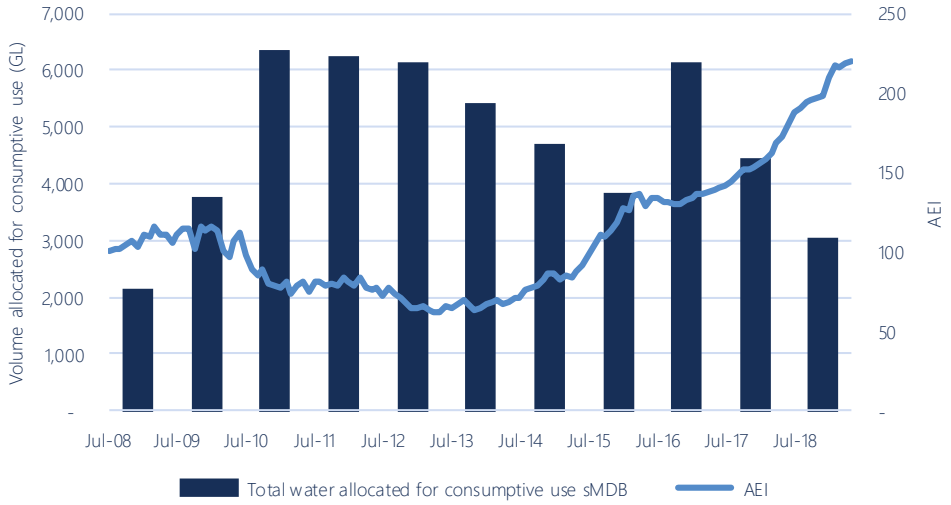
Summary of trend analysis

Supply

- Full or near full allocations often correlate with low allocation prices. During these periods, compliance is unlikely to be an issue as water is abundant and inexpensive to purchase.
- The existence of trade restrictions have an impact on the supply of water within certain regions. Many of these restrictions open and close throughout the water year depending on trade balances. When trade is closed, a price premium for water allocations downstream or within the restricted catchment is likely to emerge. These physical and / or price barriers may increase the likelihood of non-compliant behaviour.

Market Activity

- Spikes in allocation prices often suggest water scarcity which may, in turn lead to water budget shortfalls. During such periods, irrigators may seek non-compliant means to overcome water budget shortfalls.
- High security entitlements in more active markets (such as the NSW Murray and the Murrumbidgee) have experienced a proportionately higher price increase since July 2018. This is likely reflective of the increase in demand for more reliable water, in response to structural changes in the agricultural sector (i.e. transitioning from lower value annual crops to higher value permanent crops) and an extended period of low rainfall and runoff into storages.
- ES 3 shows the volume of water allocated for consumptive use and indexed entitlement price for major systems in the southern MDB. During periods of higher water availability, price is relatively lower such as 2011 to 2014. Since 2014, water has been less abundant, and price has increased.



ES 3 Water allocated for consumptive use and Aither Entitlement Index (AEI), southern Murray-Darling Basin.
Note: Includes all major southern Murray-Darling Basin systems – NSW, Victoria and South Australia.

Southern Murray–Darling Basin

Analysis and context for irrigator decision-making

Analysis and context for irrigator decision-making

Characteristics of the southern MDB

The ABS NRM Zones within the southern MDB include:

- Upper Murray
- Lower Murray
- Murrumbidgee
- Lachlan (included in the southern MDB as it is similar in nature, even though hydrologically it is isolated from the rest of the southern MDB).

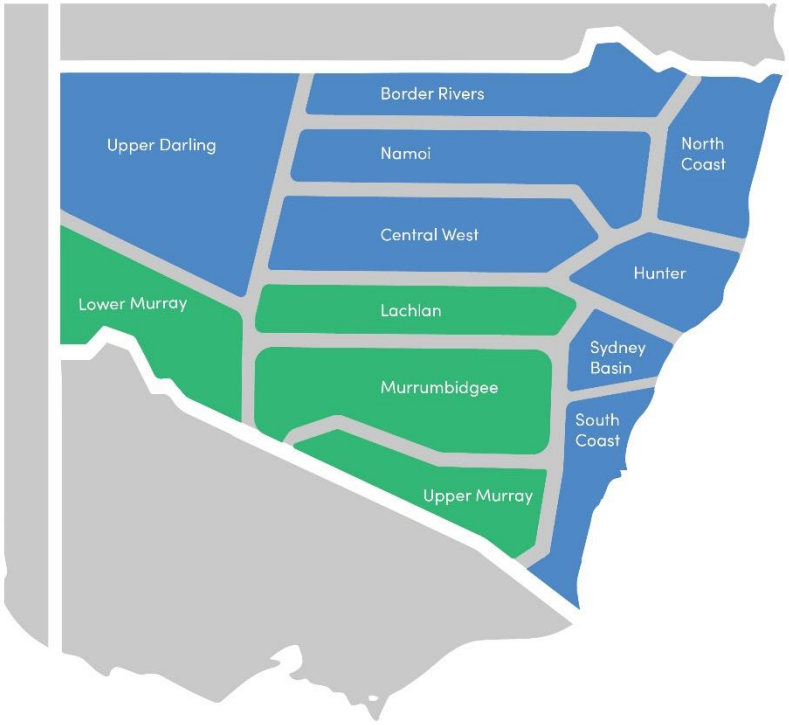
The southern MDB is characterised by highly regulated and interconnected surface water systems which enable trade across different valleys (and states). The reliable water supply provided by large regulating structures throughout the southern MDB means that agricultural enterprises do not — in the majority of cases — require large on-farm storages to ensure water is available to water crops.

The interconnected nature of the southern MDB and regulated water sources also supports Australia's most active and important water market.

In the Murray and Murrumbidgee, large and well-resourced irrigation districts manage and distribute large portions of the water in those catchments.

Groundwater and unregulated water sources also support agriculture in the southern MDB, although not to the same extent as surface water.

There is generally a greater diversity of crops grown in the southern MDB than elsewhere in the state.



Analysis and context for irrigator decision-making

Southern MDB compliance summary

Irrigated agriculture in the southern MDB is extensive, using far greater volumes of water than the northern MDB and coastal regions combined (and with far greater numbers of irrigators), which would in principle suggest the need for more extensive compliance monitoring.

However, the well-developed nature of irrigation in the southern MDB has resulted in relatively sophisticated irrigation use, water trade and water management based on comparatively extensive metering — an important aid to the compliance regime.

Furthermore, the southern MDB features several sophisticated irrigation districts managed by irrigation corporations (irrigation infrastructure operators) with 'bulk licences'. Given the compliance obligations associated with their bulk licences, these irrigation corporations have incentives to manage water use 'within-district' — supporting the NRAR's compliance efforts in the southern MDB. Therefore, these areas can largely be viewed as 'accounted for' at the bulk level, such that the NRAR's focus could be on those areas outside the irrigation corporations.

Even outside irrigation districts, the southern MDB is characterised by extensive water markets, a wide variety of crop types, dense and populous irrigation areas, and well-established irrigation industries. Collectively this means that water users have greater flexibility than elsewhere in the state when responding to limited supply, and therefore a greater array of water management options to avoid non-compliant behaviour.

However, despite these management options, the risk of non-compliant behaviour in the southern MDB will be increased when:

- unexpected temperature spikes occur — especially in the summer months. All crop types are subject to the pressures of short-term unexpected heat waves. However, annual crop types have more flexibility to not be planted, while permanent horticulture (almonds, citrus, et cetera) or semi-permanent (dairy) will maintain long-term investments through irrigation regardless of water price or budgeted water.
- water allocations are below long-term expected reliability — especially for high security water during dry conditions and amongst less-flexible irrigation enterprises.
- water users have already invested in a crop, and water allocation prices move in excess of their willingness to pay.

Increasing pressures in the regulated surface water market (both the lack of water to purchase and high prices) are increasingly pushing irrigators to seek alternative water sources. These include unregulated water, groundwater, or on-farm water storages. Therefore, water prices should be used as a trigger to not only monitor extraction from regulated sources, but also alternative water sources.

Southern Murray-Darling Basin

Upper Murray

The Upper Murray region extends from the Great Dividing Range in the east, to the Barmah Choke in the west. From a market perspective, the Upper and Lower Murray region are closely linked, however, agricultural and climatic characteristics vary significantly between the two regions.

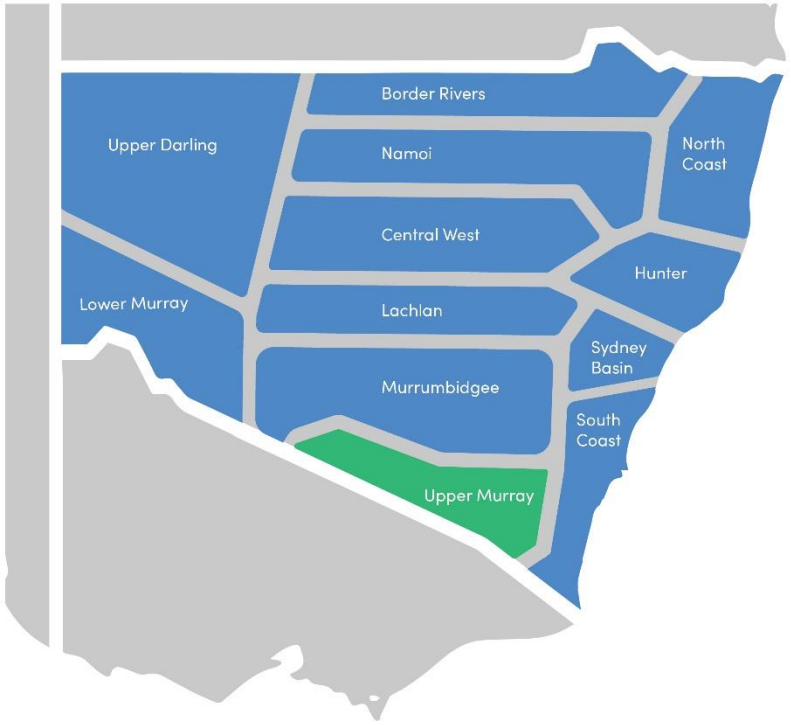
The major tributaries in the region include the Mitta Mitta River in Victoria, and the Geehi, Swampy Plains and Tooma Rivers in NSW.

The region receives good rainfall in the alpine areas, with an average annual rainfall of approximately 1,500 mm in the east, ranging to about 700 mm further west near Hume Dam. With much of the area to the east forested and non-arable, water use is concentrated in urban centres and irrigation areas in the Murray Valley.

Hume Dam and Dartmouth Dam are the major regulated storages on the Murray River, with holding capacities of 3,005 GL and 3,856 GL respectively. Small storages in the Upper Murray include Khancoban Pondage (26 GL) and Geehi Reservoir (21 GL).

The Upper Murray region includes the Murray Irrigation area, to which Murray Irrigation Limited delivers a significant portion of the irrigation water in the catchment.

The main water source in the region is the NSW Murray Regulated River Water Source (which includes the Upper and Lower Murray).



Upper Murray

Demand

Major crops in the region

- In recent years, the major crop has been rice (45 per cent of total water use in 2017-18) (Figure 2), noting that anecdotally, very little rice was planted in 2018-19.
- Pasture and feed for dairy is also a significant user of land and water in the region accounting for approximately 30 per cent of land use (Figure 1).
- Permanent plantings accounted for 3 per cent of water use in 2017-18.
- Other cereals grown in the region include maize, soybeans, wheat and oats.

Extent and location of irrigation

- Australia's largest irrigation water supplier – Murray Irrigation – is located in the Upper Murray region. A canal from Mulwala to Deniliquin supplies water to farmland located with the Murray Irrigation Area north of the Murray River near Finlay and Deniliquin.
- Water is pumped directly from the river or diverted through the irrigation schemes.
- Extensive irrigation also occurs on the Victorian side of the Murray River (not included in this analysis).

Key regional characteristics

- The Barmah Choke is located approximately halfway along the NSW portion of the Murray River and presents a major constraint on irrigation across the southern MDB. The Barmah Choke is a narrow section of the Murray River which restricts the volume of water that can pass through. This has had the effect of limiting the volume of water able to be used downstream of the Choke. River operators have recently used Murray Irrigation's channel infrastructure to bypass the Barmah Choke.
- Major storage inflows in the Upper Murray are shared by Victoria, NSW and South Australia. They are managed by the Murray–Darling Basin Authority (MDBA) on behalf of these states.

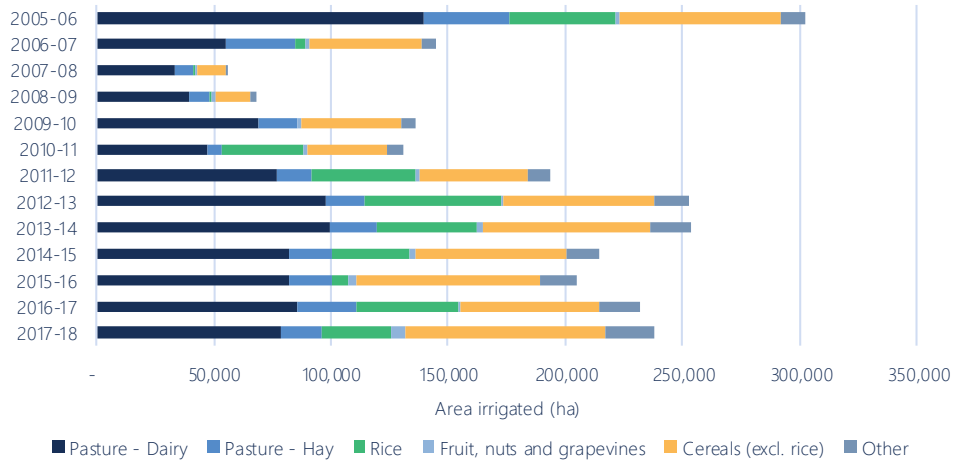


Figure 1 Land use by crop, Upper Murray, 2005-06 to 2017-18

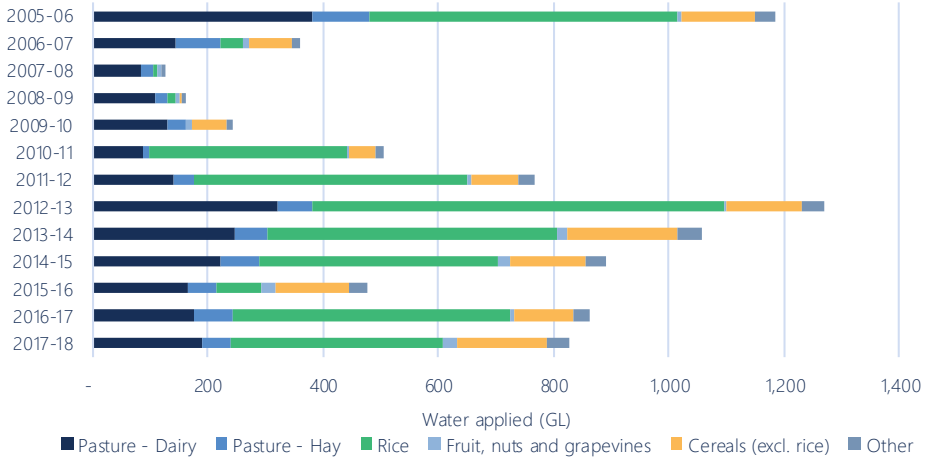


Figure 2 Water use by crop, Upper Murray, 2005-06 to 2017-18

Upper Murray

Demand

Production timings

- The bulk of irrigation water is used during the summer months, when rice and soybeans are grown. Summer crops are often used in rotation with wheat or oats during winter.
- Lucerne, used for pasture and feed, is grown year-round with the possibility to bale or graze two to four times per year (as noted in the 'Summary of trend analysis' above, Lucerne may continue to be grown, or left fallow during winter months – as shown in Figure 3).

Decision making points

- The decision to plant summer crops will occur during August to November. Irrigators will make their decision based on commodity and water price information available at that time.
- Winter crops such as wheat and oats are planted during April to June and the decision to plant will be influenced by in-crop rainfall and soil moisture.
- Demand for pasture and feed in dairy is less elastic and decisions are not necessarily made at any one point during the year. The decision to grow lucerne will be influenced by factors such as herd size, feed prices and water availability.

Demand triggers

- Given the relatively higher level of rainfall received in the Upper Murray, rainfall influences production decisions. Opportunistic production of cereals is influenced by in-crop rainfall around planting. Such crops may supplement in-crop moisture with irrigation.
- The degree of reliance on irrigation water for annual croppers will vary throughout the region.
- High commodity prices will increase the water demand for annual crop types on a year-by-year basis.

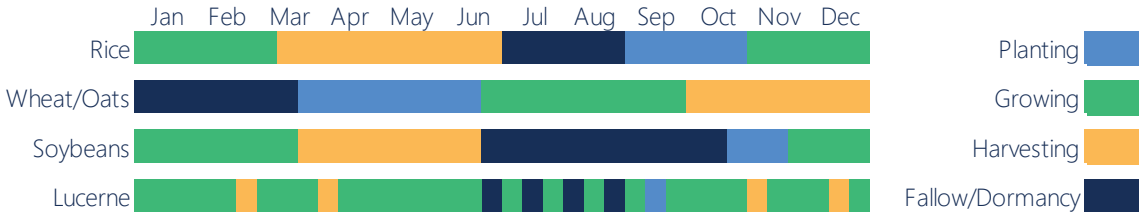


Figure 3 Indicative production schedule of major crops, Upper Murray

Upper Murray

Supply

Seasonal trends in storage

- Hume Dam experiences significant seasonal fluctuation in dam storage volumes. Inflows typically occur from June to October due to winter rainfall, snowmelt and lower releases for consumptive users.
- Storage in Hume has trended downward since 2017-18 and is currently 19 percent full.
- Dartmouth Dam experiences relatively less variability in storage volumes. Dartmouth is used as a more long-term storage, and feeds Hume which is used to meet annual short-term demands.

Allocation/seasonal determinations

- Allocations for NSW general security (GS) entitlements fluctuate significantly and reflect storage volumes in Hume and Dartmouth Dam. During 2018-19 allocations for NSW GS entitlements were 0 per cent.
- Allocations for NSW high security (HS) entitlements are among the most reliable in the southern MDB. NSW HS entitlements have tended to remain between 97 and 100 per cent — with the last three per cent allocated when GS water also exceeds 97 per cent.

Supply triggers

- Storage volumes are the largest determinant of water supply and allocations in the Upper Murray. High winter rainfall and snowfall will likely lead to increases to GS and HS allocations during the water year.
- The water in Hume and Dartmouth Dams is shared between Victoria, NSW and South Australia. Water from Dartmouth and Hume is required to be delivered to the Lower Murray and South Australia in addition to townships and irrigators in the Upper Murray.

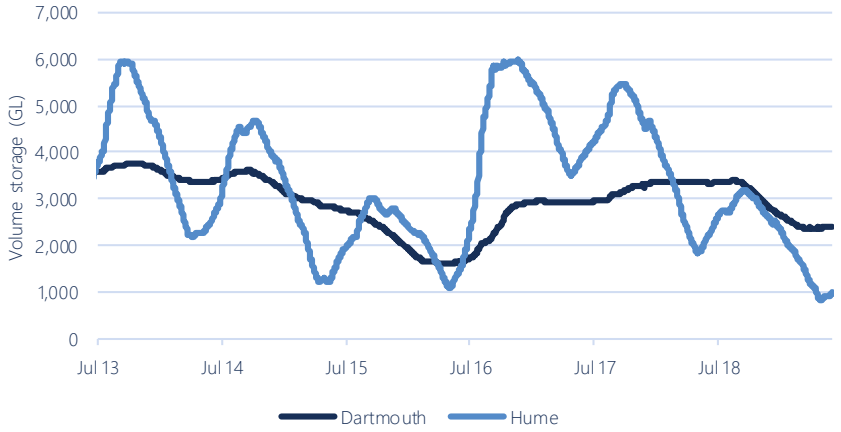


Figure 4 Historical storage volumes of major storages, Upper Murray, June 2013 to June 2019

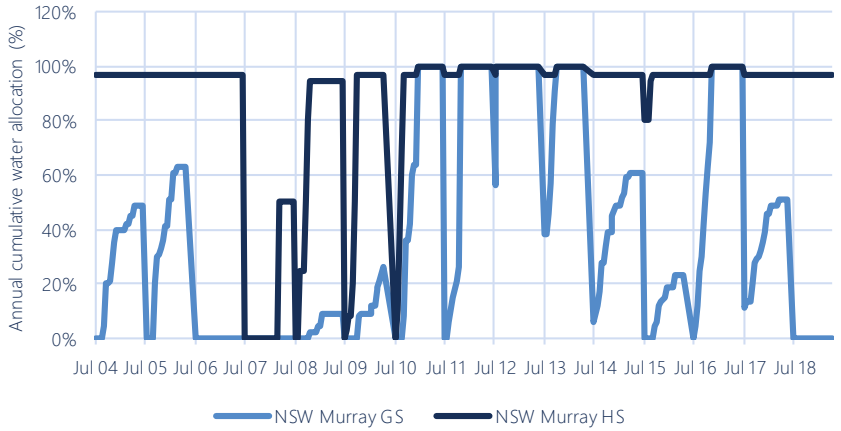


Figure 5 Annual cumulative water allocations

Upper Murray

Market Activity

Allocation price trends

- The NSW Murray allocation market is active, mature and amongst the most liquid markets in Australia.
- The market cannot be considered separately from conditions across the southern connected system, as price movements in Victoria and South Australia will also affect supply and demand decisions in the Upper Murray.
- Movement in allocation prices tends to correspond with storage volumes and water availability. Between May 2017 and May 2019 prices increased by nearly 3,000 per cent (Figure 6).

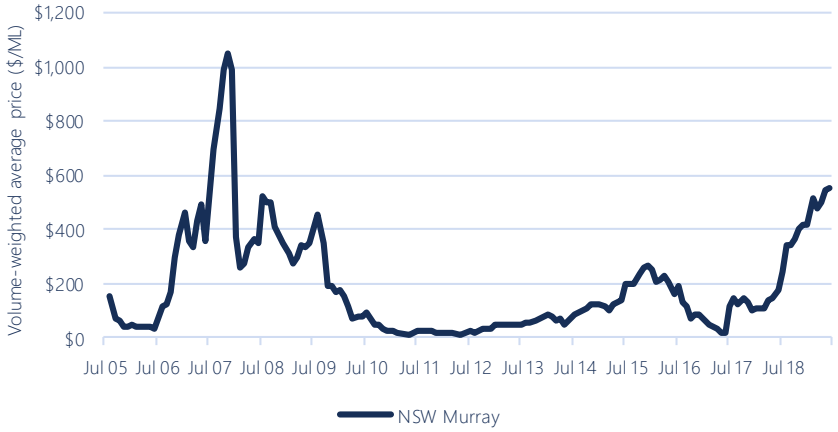


Figure 6 Monthly allocation prices

Entitlement price trends

- The NSW Murray entitlement market is well established and mature. NSW Murray HS entitlements command higher prices than GS entitlements reflecting their higher reliability.
- Since May 2017 monthly volume-weighted average prices (VWAPs) for HS entitlements have increased by over 100 per cent. Comparatively, GS entitlements have increased by 44 per cent over the same period — reflecting short-term concerns about reliability.

Long-term market trends and water use patterns

- There is increasing demand for higher reliability water entitlements which is reflected in the increasing price differential between GS and HS entitlements (Figure 7).

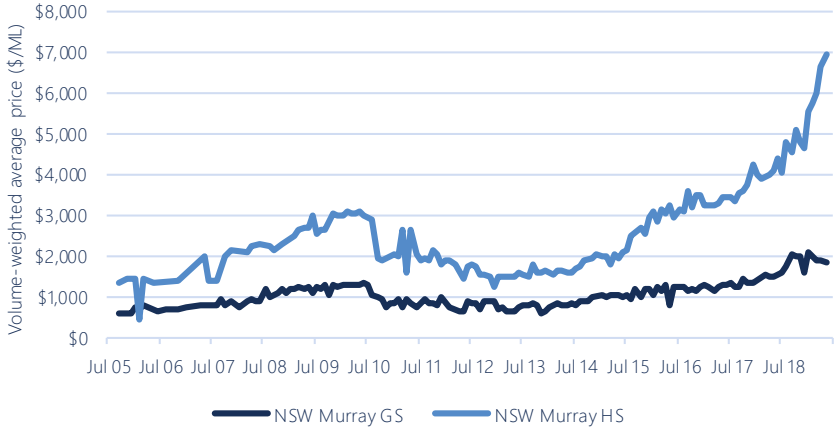


Figure 7 Monthly entitlement prices

Southern Murray-Darling Basin

Lower Murray

The Lower Murray region encompasses the regulated portion of the Darling River below the Menindee Lakes Scheme and the Murray River below the Barmah Choke. The region covers the south-western corner of NSW and a significant part of the MDB. The water within this region is shared amongst three states — NSW, Victoria and South Australia.

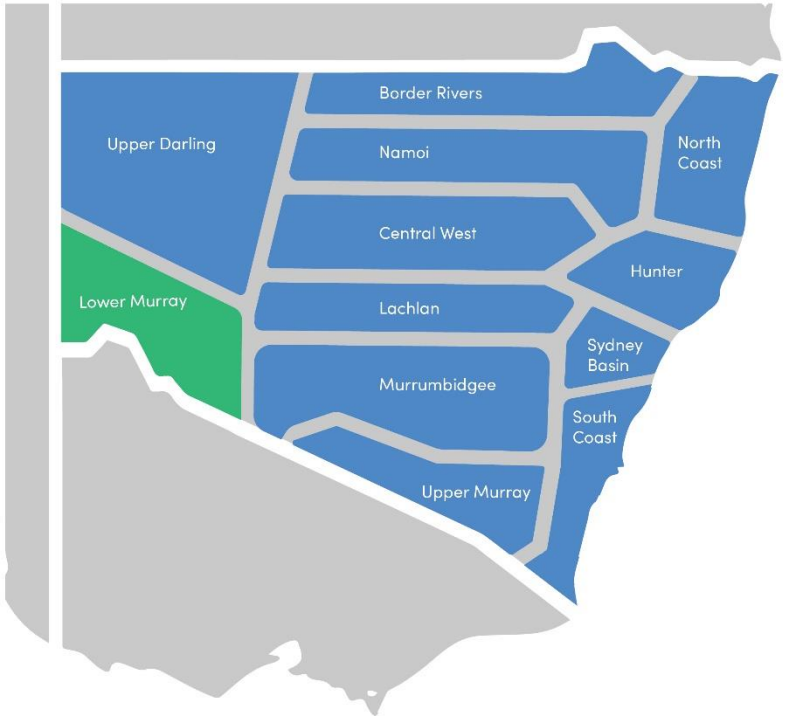
Water markets in this region are highly liquid and trade can occur with a number of other systems (Murrumbidgee, Lower Darling, Victoria and South Australia) pending trade restrictions.

The Lower Darling River is effectively regulated by the Menindee Lakes Scheme, which can store up to 1,730 GL in four main lakes – Menindee, Cawndilla, Pamamaroo and Wetherell. The Lower Murray includes all water from the Darling River at Wentworth, downstream to the South Australian border, but is effectively regulated by Hume Dam (located in the Upper Murray). There are extensive alluvial groundwater systems throughout the region, which are highly connected with the surface water systems. However these groundwater resources are highly saline, particularly those close to the Murray River.

The Lower Darling area has been in a state of prolonged drought in recent years which has largely prevented irrigation from the Darling River in the region. Water availability in the Lower Murray is determined almost entirely by the water delivered from the northern MDB through the Upper Darling.

Water sources within this analysis include the:

- NSW Murray Regulated River Water Source (which includes the Upper and Lower Murray)
- Lower Murray Darling Regulated River Water Source (below Menindee Lakes)



Lower Murray

Demand

Major crops in the region

- A mix of annual cropping and permanent horticulture exists in the Lower Murray.
- When water is available, cotton is a major crop in the region, accounting for 44 per cent of water use in 2017-18 (predominantly along the Darling).
- Favourable commodity prices for permanent horticultural crops such as almonds have led to an increase in fruit and nut production over the past decade.
- Permanent horticulture accounted for 43 per cent of water use in 2017-18 (grapevines accounted for 27 per cent and fruit and nuts 16 per cent of water use within the same period – Figure 9). Unlike cotton, this water usage is non-interruptible.

Extent and location of irrigation

- Irrigation in the region generally occurs within a few kilometres of the Murray River and in pockets along the Darling River.
- Western Murray Irrigation Limited supplies water to three irrigation areas in the district.

Key regional characteristics

- Deliverability issues exist in the region due to the Barmah Choke and the high number of permanent horticultural plantings.
- It is difficult to plan and operate the river in the region due to the time it takes to deliver water from headwater storages to the Lower Murray.
- Trade of water from the Lower Darling to the rest of the southern MDB is closed when water held in the Menindee Lakes is low, and control of the lakes are passed from the MDBA to WaterNSW.

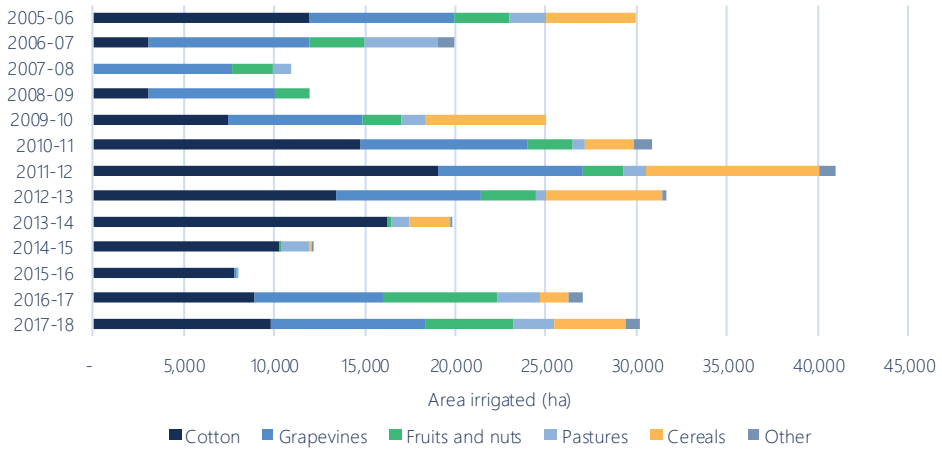


Figure 8 Land use by crop, Lower Murray, 2005-06 to 2017-18

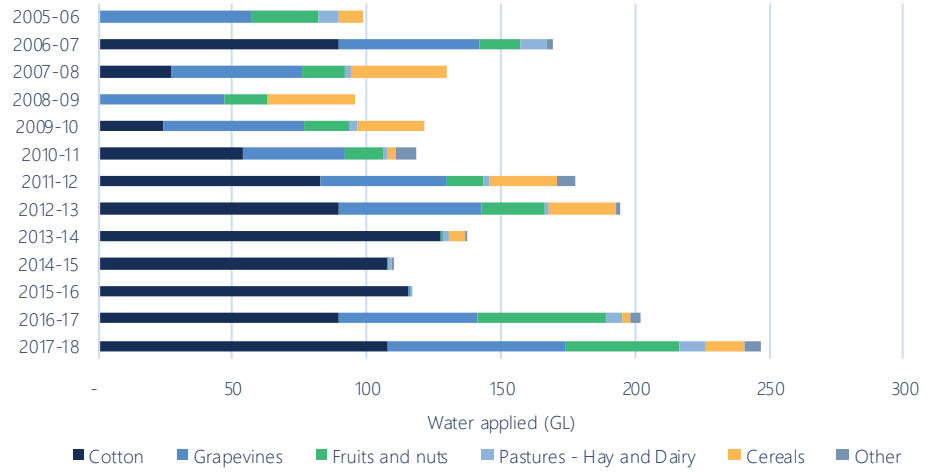


Figure 9 Water use by crop, Lower Murray, 2005-06 to 2017-18

Lower Murray

Demand

Production timings

- Permanent plantings grow year-round; however, water use peaks during summer months when temperatures rise.
- Cotton is grown during summer, often in rotation with wheat or other winter crops.

Decision making points

- Given the longer-term nature of permanent horticultural crops, production decisions will consider climate outlooks, commodity and water prices over many years.
- The decision to plant cotton will be made during September through to November, or may be influenced through forward contracts.

Demand triggers

- Given the high number of permanent horticultural plantings which require consistent watering during warm weather, high temperatures are a major demand trigger in the region.
- At the same time, consecutive days above 40°C will place high demands on water delivery.

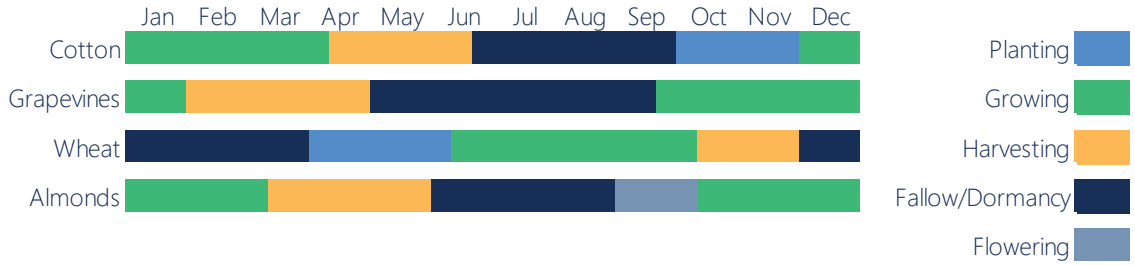


Figure 10 Indicative production schedule of major crops, Lower Murray

Lower Murray

Supply

Seasonal trends in storage

- Dartmouth and Hume Dams are located in the Upper Murray but supply the Lower Murray.
- Lake Victoria is a downstream storage that experiences large seasonal fluctuations, often reaching close to 600 GL by the end of winter and falling to around 100-200 GL through the summer and mid-autumn (Figure 11).
- Over the last six years, the Menindee Lakes has undergone extended fluctuations, starting at around 1,250 GL in 2013-14 and trending downwards until 2016-17 (when storage returned to 1,600 GL), before trending downwards again.

Allocation/seasonal determinations

- Allocations for Lower Darling HS entitlements have typically stayed at 100 per cent, except 2007-08 when allocations were 0 per cent, and the 2015-16 water year when allocations fluctuated between 20 per cent and 80 per cent (Figure 21).
- For the Lower Darling GS entitlements, allocations can fluctuate substantially, although the five years after the 2009-10 water year were characterised by a consistent period of 100 per cent allocations. Last year saw water allocations at 0 per cent for GS entitlements.
- NSW Murray GS and HS entitlements and allocations cover both the Upper Murray and Lower Murray.

Supply triggers

- Rainfall in the northern MDB is the primary determinant of water supply for the Menindee Lakes and is largely dependent on irregular flooding events (which take many months to arrive).
- Lake Victoria, although sitting in the Lower Murray area, is mainly used to manage water delivery to South Australia. It is entirely dependent on water diverted from the River Murray, and effectively functions as a regulated off-river storage. The seasonal trends in storage are produced by its utilisation as a water source for South Australia during times when delivering water via the Murray would be otherwise difficult (such as high irrigation demand or when the Barmah Choke is constrained).
- It takes many days for water to travel from the Hume and Dartmouth Dams to the Lower Murray. This can create issues for river operators in the region, particularly during demand peaks.

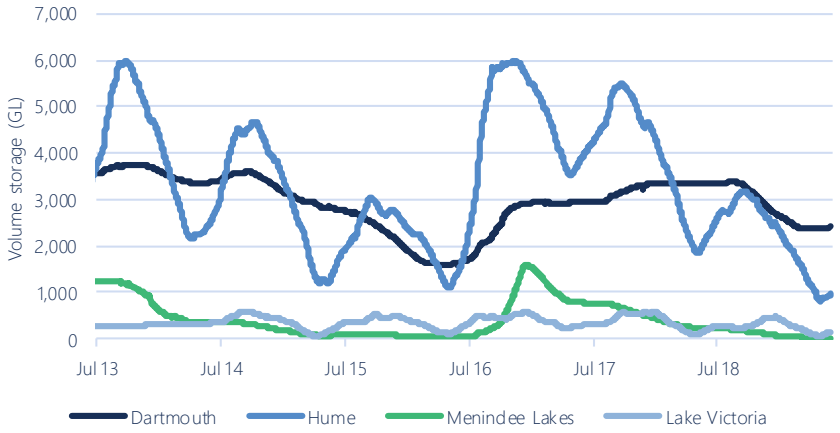


Figure 11 Historical storage volumes of major storages, Lower Murray, June 2013 to June 2019

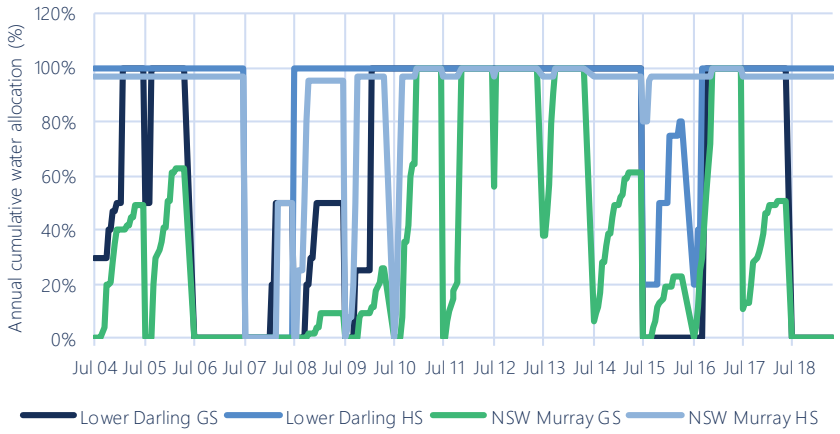


Figure 12 Annual cumulative water allocations

Lower Murray

Market Activity

Allocation price trends

- Lower Darling allocation markets are less active than the Lower Murray due to the lower level of agricultural production in the Lower Darling. However, allocations follow periods of similar monthly VWAPs (for instance between July 2011 and July 2014 in Figure 13).
- Since July 2018, there has been a significant increase in the NSW Murray allocation price, however, the Lower Darling has not observed the same price increase as trade has remained effectively closed.

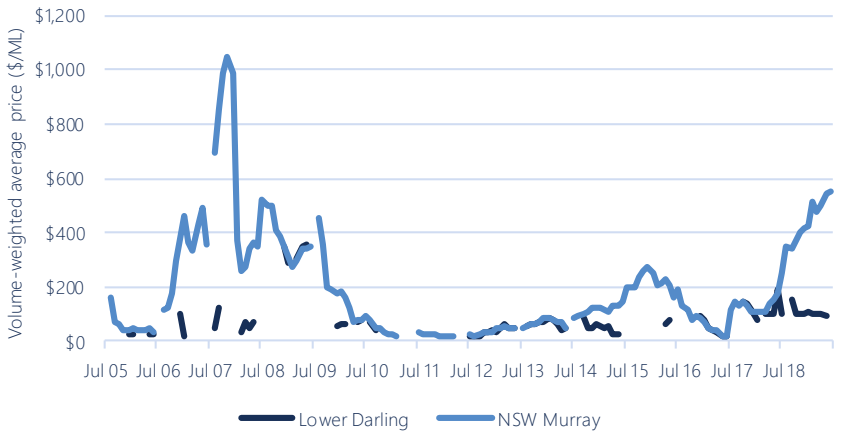


Figure 13 Monthly allocation prices

Entitlement price trends

- Entitlement markets for NSW Murray HS and NSW Murray GS are highly liquid and mature. NSW Murray HS entitlements command higher prices than GS entitlements due to their greater reliability.
- There has been a significant step increase in NSW Murray HS entitlement prices since December 2018 from $4,640 to $6,800 per megalitre.
- GS and Lower Darling HS entitlements have not observed this increase due to their lower reliability.
- There is limited entitlement trade in the Lower Darling due to the low number of individual irrigators along the Lower Darling.

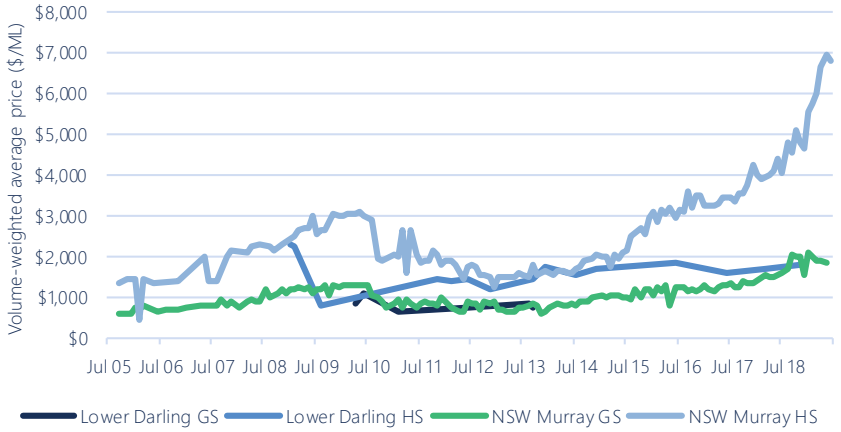


Figure 14 Monthly entitlement prices

Long-term market trends and water use patterns

- There is increasing demand for higher reliability water entitlements which is reflected in the increasing price differential between GS and HS entitlements.

Southern Murray-Darling Basin

Murrumbidgee

The Murrumbidgee region covers a diverse geographic area. Most of the inflow of the catchment occurs in the Great Dividing Range. Average annual rainfall in the region ranges from over 1,600mm in the alpine regions, to around 350 mm on the semi-arid areas of western NSW. Annual stream flow is approximately 4,000 GL (measured at Wagga Wagga), which represents 16 per cent of the MDB's total water.

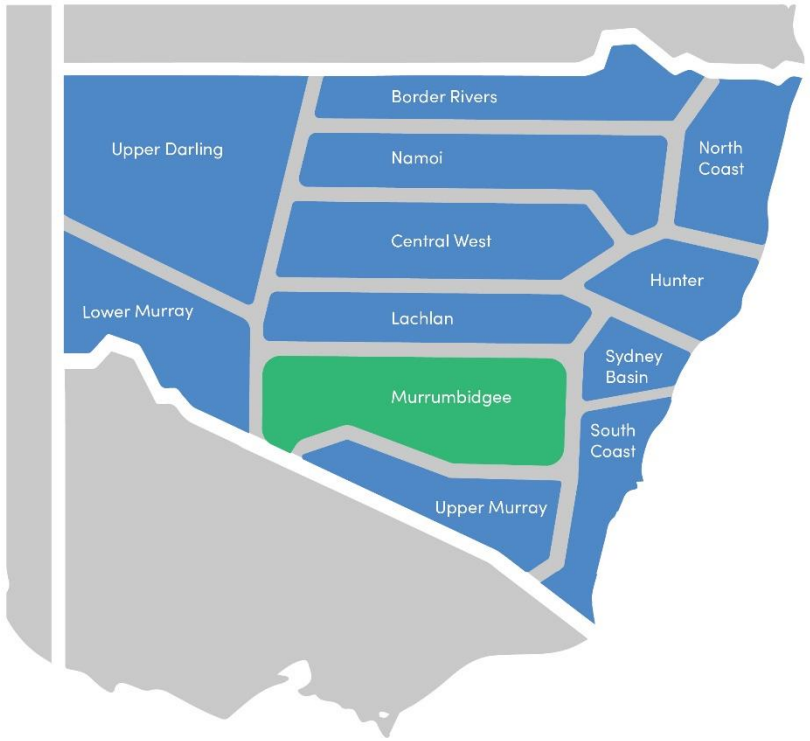
The Murrumbidgee River serves numerous large regional towns — such as Wagga Wagga, Narrandera, Griffith, Hay and Balranald. Agriculture is a primary water user, with the dominant regional crops including cotton, cereals, rice, and grapevines.

The surface water system is regulated by two main storages: Blowering Dam (1,628 GL) and Burrinjuck Dam (1,026 GL). The system also receives transfers from the Snowy Mountains Scheme, notably from Talbingo Dam (921 GL) and Tantangara Dam (254 GL). There are also important groundwater resources, mainly located in the mid to lower catchment, including the Murrumbidgee deep and shallow groundwater sources, which provide important surface water substitution in dry years.

Murrumbidgee Irrigation and Colleambally Irrigation deliver significant portions of the water in the region.

Water sources within this analysis include the:

- Murrumbidgee Regulated River Water Source
- Murrumbidgee Regulated Groundwater Sources



Murrumbidgee

Demand

Major crops in the region

- The Murrumbidgee supports a diverse range of agricultural enterprises — including a mix of permanent horticulture and annual crops.
- There has been an increase in the production of cotton in the Murrumbidgee between 2009-10 and 2017-18. In 2017-18 cotton accounted for 40 per cent of water use in the region and rice accounted for 26 per cent. Cotton is increasingly replacing rice as the crop of choice for annual irrigation enterprises. Water use by annual crops such as rice and cotton varies significantly between wet and dry years.
- In contrast, water use by fruit, nuts and grapevines has remained relatively consistent over the past decade, although there have been changes to the agricultural mix within this zone — such as the decline in grapevines and increase in almonds. In 2017-18 fruits, nuts and grapevines accounted for 12 per cent of water use.

Extent and location of irrigation

- Much of the irrigation within the Murrumbidgee region occurs within the Murrumbidgee Irrigation District and the Coleambally Irrigation District. When combined, this consists of more than half of the water used within the catchment.

Key Regional Characteristics

- Water use is highly tied to the rest of the water market in the southern MDB, with the Murrumbidgee inter-valley trade (IVT) account limiting the volume of water traded into or out of the valley.
- Given the large range of crops in the Murrumbidgee and the prevalence of GS entitlements, water use reflects the respective break-even points for each crop type

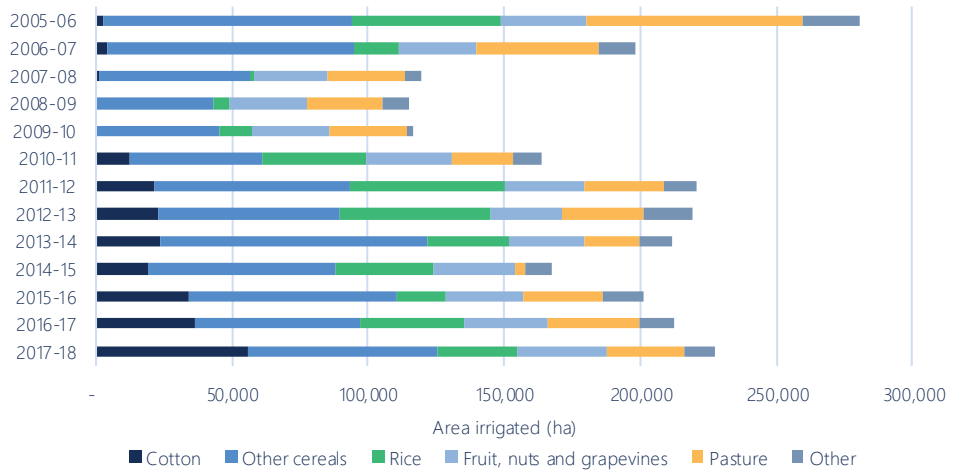


Figure 15 Land use by crop, Murrumbidgee NRM region, 2005-06 to 2017-18

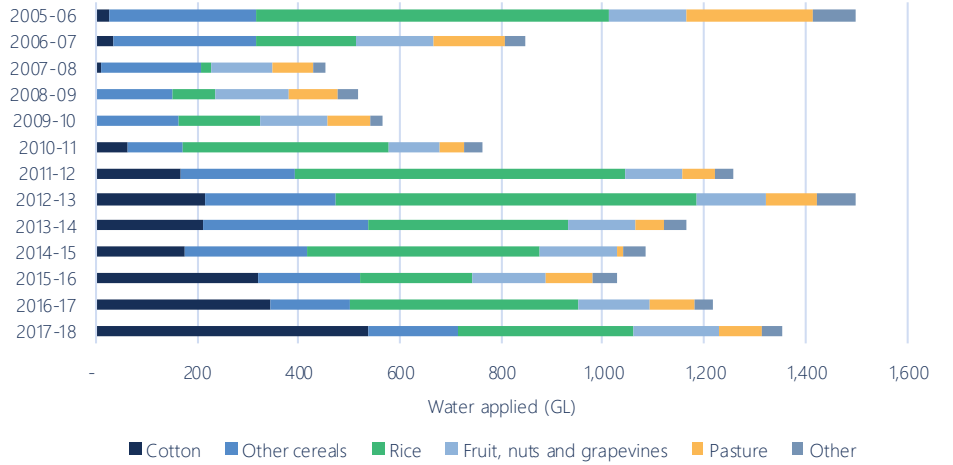


Figure 16 Water use by crop, Murrumbidgee NRM region, 2005-06 to 2017-18

Murrumbidgee

Demand

Production timings

- Summer crops such as cotton, rice and maize are planted during spring and grown during summer.
- Wheat and oats are often used in rotation during winter.
- Citrus trees grow year-round, however many permanent horticultural plantings such as grapes and almonds lose leaves and enter dormancy during winter (and therefore do not require watering).

Decision making points

- Many irrigators watch commodity prices, water prices and climate outlooks leading up to spring in anticipation of sowing summer crops (rice, cotton, maize etc.). Production decisions made during spring will determine whether to plant, the type of crop to plant and hectarage.
- Throughout the growing season (especially summer) annual irrigators watch commodity and water prices, and weather outlooks as this will influence watering periods and the crop's final product.
- Cotton is often forward sold, which has had the effect of slightly decreasing the relative flexibility of water demand (e.g. in comparison to a crop like rice).

Demand triggers

- Crop watering requirements are high for all crops during summer.
- In particular, consecutive days of warm weather (above 40°C) will likely lead to increased water consumption. Conversely, significant rainfall events will likely reduce water demand.

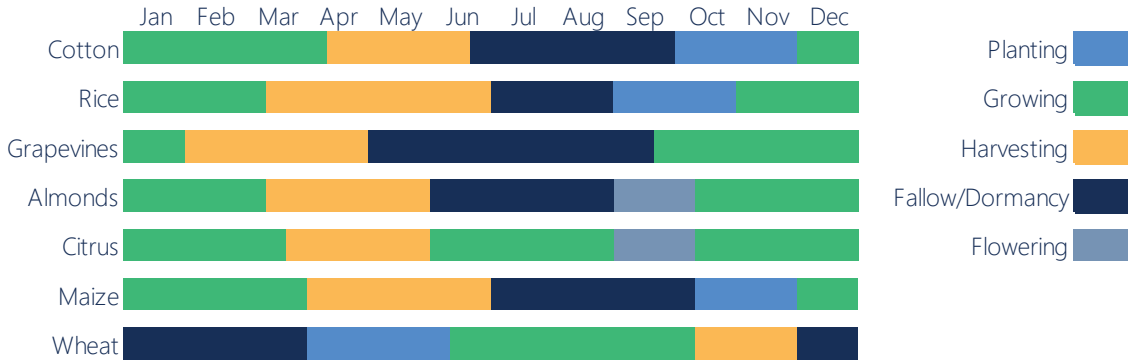


Figure 17 Indicative production schedule of major crops, Murrumbidgee

Murrumbidgee

Supply

Seasonal trends in storage

- Water availability in the Murrumbidgee correlates highly with the rest of the southern MDB; following a regular annual inflow period from May to December, use generally exceeds inflows from around October.
- Sporadic rainfall over the summer period also allows for some supplementary flows throughout peak irrigation periods.
- Groundwater is used extensively throughout the region to support irrigation (particularly in times of reduced surface water availability).

Allocations and seasonal determinations

- Allocations for HS entitlements have been above 95 per cent since 2010.
- GS entitlements are more variable and less likely to receive their full allocation. During dry years such as 2007 to 2010, allocations were less than 25 per cent. GS allocations during 2018 were less than 10 per cent. 100 per cent allocations were announced during 2010, 2011 2012 and 2016 which corresponded with high rainfall and storage volumes.
- Allocations for HS entitlements are amongst the most reliable in the southern MDB. NSW Murrumbidgee HS entitlements have tended to remain between 95 and 100 per cent — with the last five per cent allocated when general security water also exceed 95 per cent.

Supply triggers

- The headwater storage volumes are the primary supply determinant.
- Trade restrictions influence supply in the Murrumbidgee, particularly the Murrumbidgee IVT. 100 GL of net trade out and 0 GL net of trade into the Murrumbidgee is permitted. Once these thresholds have been reached, trade in and out of the Murrumbidgee is not permitted.

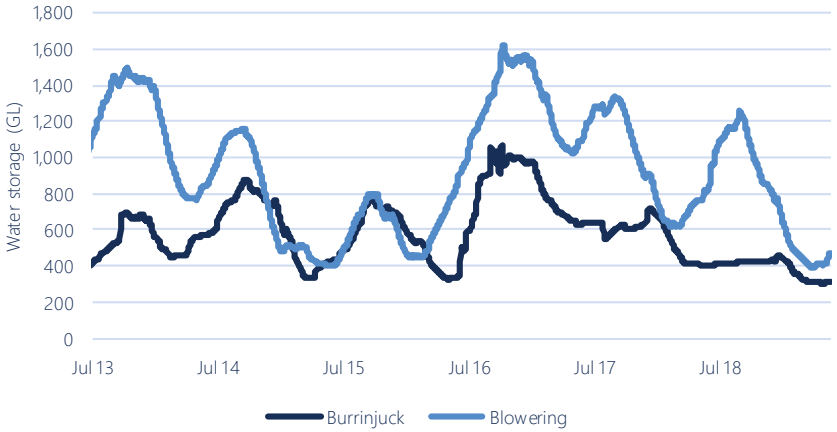


Figure 18 Historical storage volumes of major storages, Murrumbidgee, June 2013 to June 2019

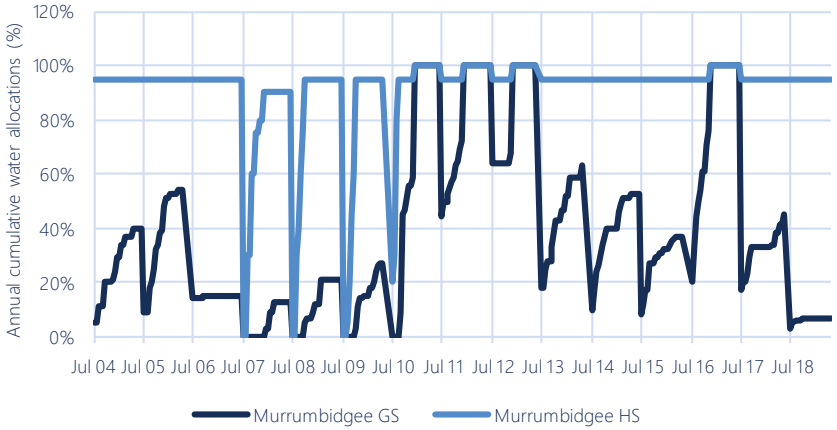


Figure 19 Annual cumulative water allocations, Murrumbidgee

Murrumbidgee

Market Activity

Allocation prices

- Allocation prices have increased from around $10 per megalitre in May 2017 to $550 per megalitre in May 2019. This significant increase in allocation prices reflects the increase in demand for water over the 2018-19 summer, lower 2018-19 GS allocations and drier climate outlooks.

Entitlement prices

- HS entitlement prices have increased 77 per cent to $6,000 per megalitre from April 2017 to April 2019.
- GS entitlements have not increased by the same magnitude; increasing 44 per cent to $2,200 per megalitre over the same time period. The relatively higher price increase can be attributed to the demand for high reliability entitlements in the region.

Long-term market trends

- Historically, the Murrumbidgee has been a net exporter of water to the Murray. Recently, demand for water within the region has increased, meaning that less water is exported to the Murray.
- The emergence of cotton and a recent increase in permanent horticultural plantings has led to a change in the production mix in the region. Favourable commodity prices for cotton, almonds and citrus have meant that lower value crops (relative to per megalitre of water use, such as rice) have been 'priced out' of the water market in recent years.

Figure 20 Monthly allocation prices

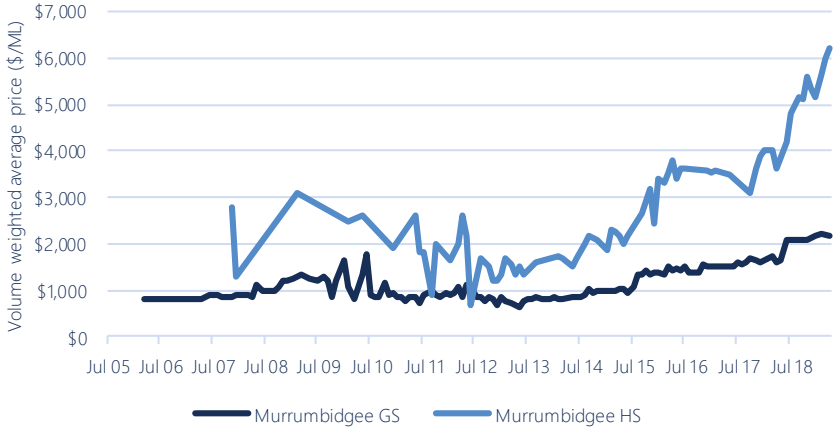


Figure 21 Monthly entitlement prices

Southern Murray-Darling Basin

Lachlan

The Lachlan region stretches across central NSW and is situated in the northern MDB. However, this report includes the Lachlan in the southern MDB as it is similar in nature, even though it is hydrologically isolated from the rest of the southern MDB.

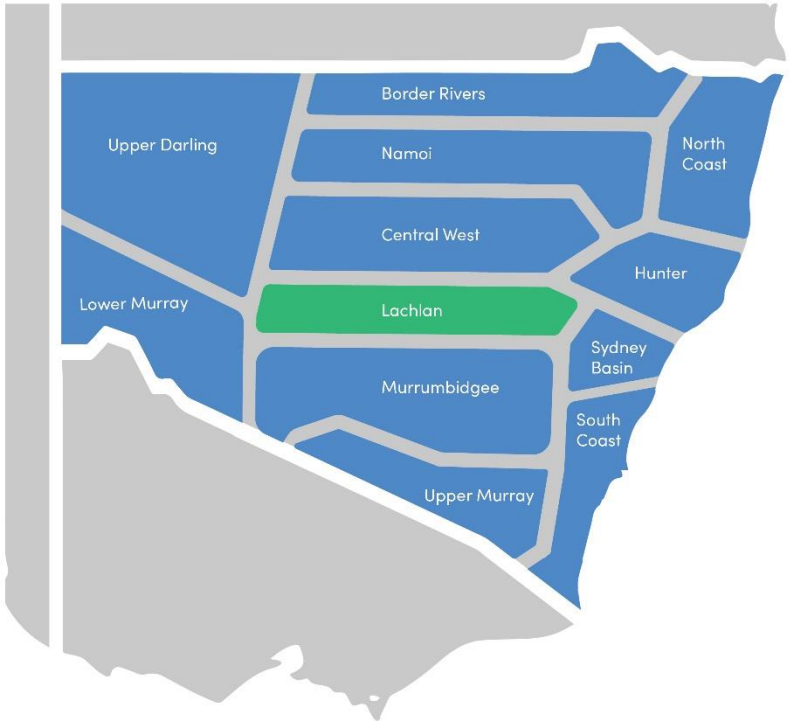
The main tributaries into the Lachlan River include the Abercrombie, Boorowa, Belebula and Crookwell rivers. Average annual rainfall in the region is 600 mm, with 1,100 mm falling in the wetter eastern parts of the catchment, and only 200 mm in the far west. Agriculture is a primary user of water, producing fruit, vegetables, cotton, rice, fodder crops and cereal grains.

The primary storage in the catchment is Wyangala Dam, which regulates the Lachlan River and holds 1,220 GL. Other storages include Lake Cargelligo (36 GL) and Carcoar Dam (36 GL).

Groundwater in the region exists along the Lachlan River from Cowra to Condobolin and near the tributaries of the Lachlan in alluvial deposits. Additionally, large portions of the groundwater in the catchment exist in alluvial aquifers that spread out from Lake Cargelligo through the western parts of the catchment.

Water sources within this analysis include the:

- Lachlan Regulated River Water Source
- Lower Lachlan Groundwater Source



Lachlan

Demand

Major crops in the region

- Most crops grown in the Lachlan region are annual crops.
- Cotton accounted for 73 per cent of water use in 2017-18.
- Permanent plantings accounted for 1 per cent of water use in 2017-18.
- There was an increase in the production of cotton, cereals and other broadacre crops during 2011-12, 2012-13 and 2013-14 following high rainfall and high storage volumes.

Extent and location of irrigation

- Overhead centre pivot irrigation systems are common along the banks of the upper Lachlan. In the mid and lower Lachlan there are fewer centre pivot systems and a higher number of irrigation bays.
- Irrigation generally occurs within a short distance of the Lachlan or its tributaries. Groundwater use is also relatively important as a water source in the region and is often used in conjunction with surface water.

Key regional characteristics

- Rainfall varies significantly from the eastern half of the catchment to the western half of the catchment.
- Unlike the other southern MDB catchments, trade with other catchments is not possible, due to the low degree of hydrological connectivity.

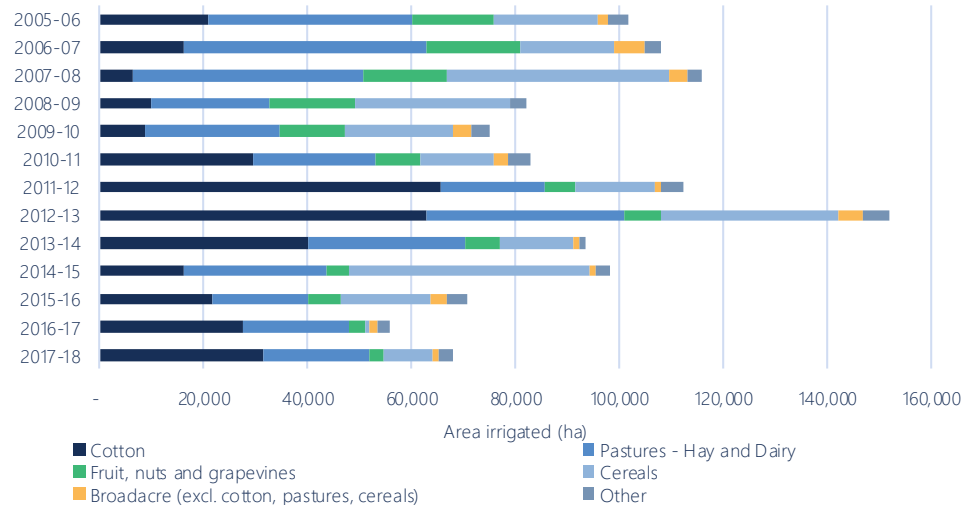


Figure 22 Land use by crop, Lachlan, 2005-06 to 2017-18

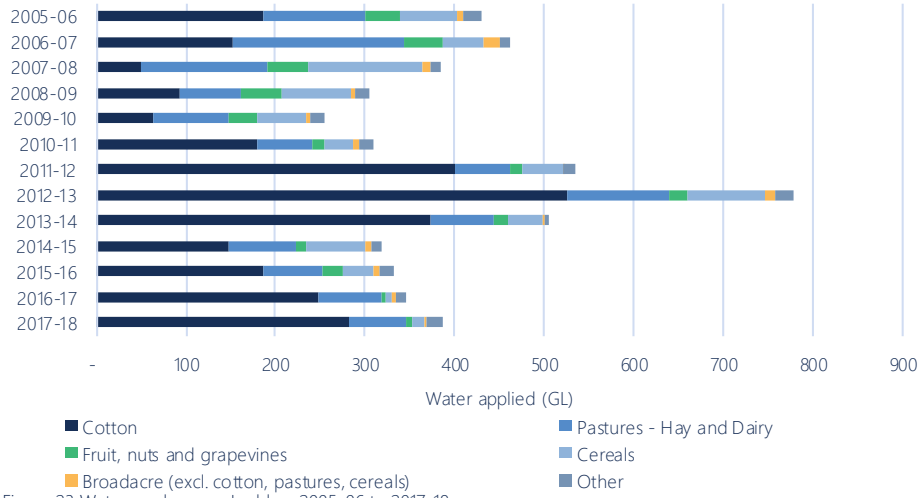


Figure 23 Water use by crop, Lachlan, 2005-06 to 2017-18

Lachlan

Demand

Production timings

- Cotton is grown during summer.
- Wheat and canola are grown during winter and autumn to be harvested in October to December.
- Lucerne and other pastures are typically grown year-round, although growth slows during winter.

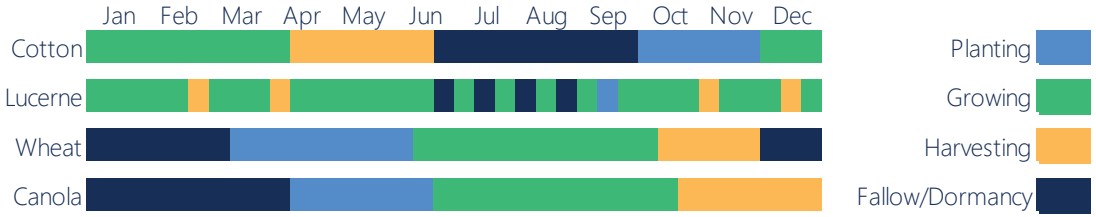


Figure 24 Indicative production schedule of major crops, Lachlan

Decision making points

- The decision to plant summer crops such as cotton will occur during August to November. Irrigators will make their decision based on commodity and water price information available at that time.
- The decision to plant winter crops will be made during March to May and will be influenced by expected rainfall and existing soil moisture.

Demand triggers

- Rainfall or high soil moisture during planting often leads to an increased annual crop planting. Surface or groundwater will often be used to supplement rainfall.

Lachlan

Supply

Seasonal trends in storage

- Since 2013-14, storage levels in Wyangala Dam have increased in the winter months, before dropping throughout summer and autumn. The exception to this has been in the last three water years, where after reaching peak storage at around 1,200 GL, storage levels have steadily declined to a current storage capacity of 27 per cent, or 340 GL.

Allocation/seasonal determinations

- GS allocations in the Lachlan have historically been very low, regularly receiving no allocations – noting the significant exceptions in the 2010-11, 2015-16 and 2016-17 water years.
- Prior to 2010-11, HS allocations were highly variable, but since 2009-10, allocations have consistently been at 100 per cent.

Supply triggers

- Supply for the Lachlan is primarily dictated by rainfall, with a flood event contributing to the high storage levels in 2016-17 and moderate GS allocations.
- Drought in NSW has driven the slow decline in storage levels from 2016-17 onwards.
- Storage volumes in Wyangala Dam are the primary driver of water supply and allocations, with the extent of autumn and winter rainfall determining storage volumes.

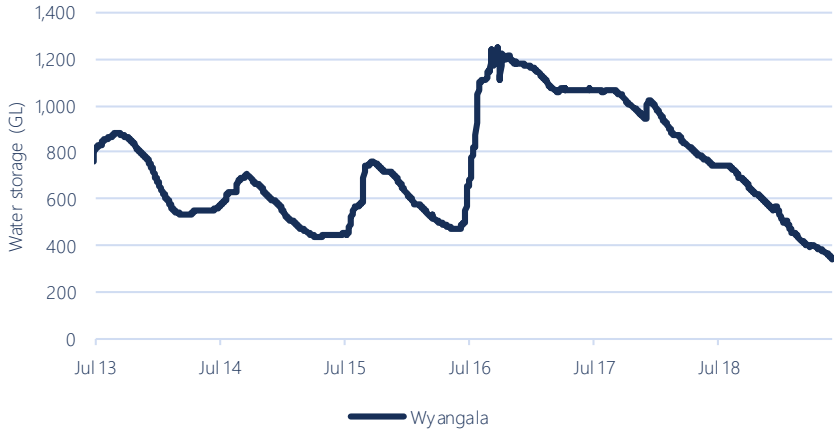


Figure 25 Historical storage volumes of major storages, Lachlan, June 2013 to June 2019

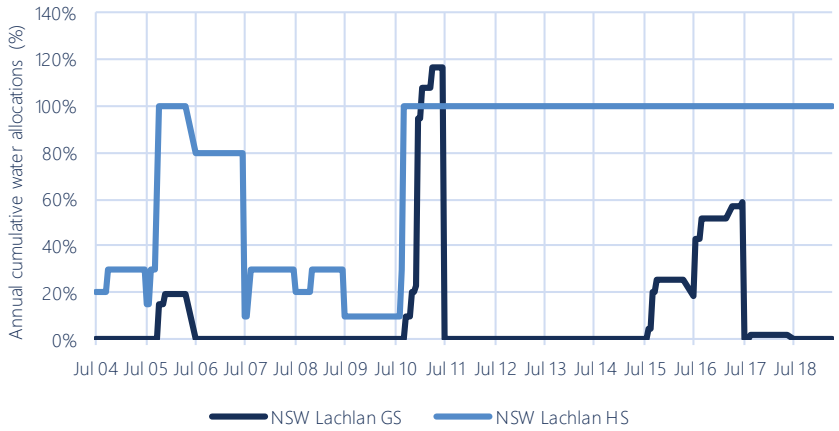


Figure 26 Annual cumulative water allocations

Lachlan

Market Activity

Allocation price trends

- Trade is not possible between the Lachlan and the Murrumbidgee due to a lack of connectivity.
- The VWAP for allocation trade has varied significantly since 2005. Since the last major rainfall events in the Lachlan (which resulted in widespread flooding), the lack of subsequent inflows has resulted in a steady rise in allocation price.
- Prices increased significantly from July 2017 to February 2019 to a high of $360 per megalitre, an increase of over 350 per cent.

Figure 27 Monthly allocation prices

Entitlement price trends

- There are relatively fewer HS than GS entitlements in the Lachlan. HS entitlements are infrequently traded due to the lower number of entitlements. GS entitlements are traded more frequently; however they receive lower prices due to their lower reliability characteristics.
- Between July 2017 and May 2019 HS entitlement prices increased from $2,000 to $6,500 per megalitre (NB due to the relatively low volume of trade, interpretation of such trade data should be done with care).

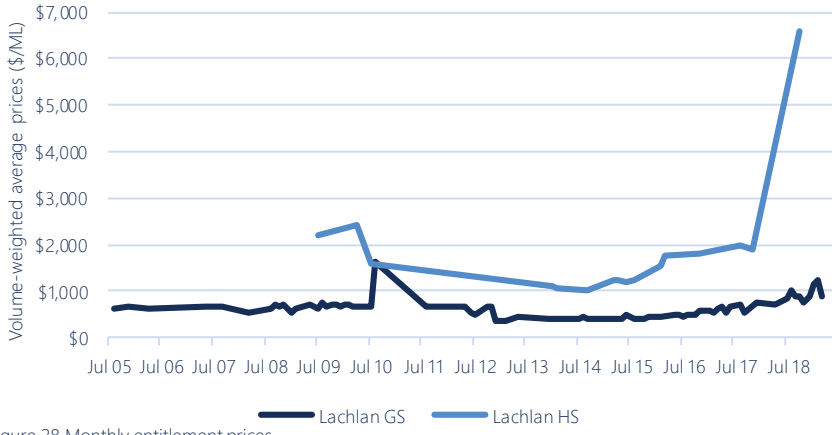


Figure 28 Monthly entitlement prices

Long-term market trends and water use patterns

- The increase in allocation prices since July 2018 and gradual increase in GS entitlement prices may reflect renewed long-term demand for water in the Lachlan catchment.

Northern Murray-Darling Basin

Analysis and context for irrigator decision-making

Analysis and context for irrigator decision-making

Characteristics of the northern MDB

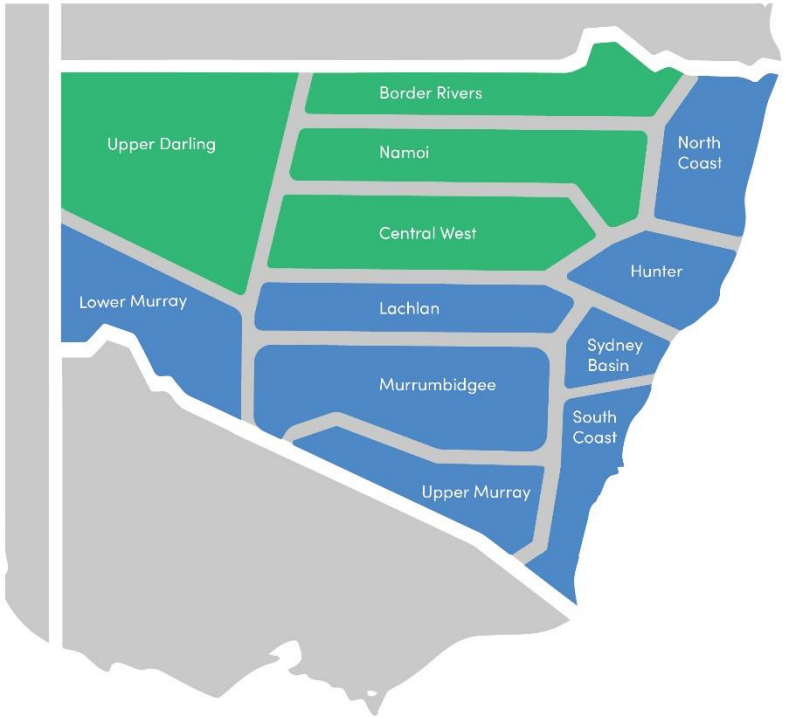
The ABS NRM zones within the northern MDB include:

- Central West
- Namoi
- West / Upper Darling
- NSW Border Rivers – Gwydir.

In contrast to the southern MDB, hydrological connectivity between surface water systems in the northern MDB is limited. This results in variations in market prices and trading activity between systems. Large variations in water supply between and during years, as well as the relatively low number of regulated rivers, has limited the development of water markets in the northern MDB.

In response to the highly variable nature of water supply in unregulated systems, agricultural enterprises in the northern MDB rely on large on-farm storages to secure water needs for crop growing by pumping when water is available in the river or through floodplain harvesting. There tends to be more reliance on groundwater sources in these regions.

Northern MDB regions tend to exhibit more monoculture, particularly for cotton production.



Analysis and context for irrigator decision-making

Northern MDB compliance summary

Irrigation in the northern MDB is significantly sparser and less regular than in the southern MDB. The crop choices are also far less diverse, with the vast majority of agricultural activity being irrigated cotton.

Unlike the relatively regulated southern MDB, the northern MDB is much more climate dependant, with some catchments going for long-periods without viable water availability. Cotton also has a longer growing-period in the northern MDB, which necessitates a longer period of attention each season.

The less regulated nature of the northern MDB regions means that large amounts of irrigation activity occurs across unregulated streams or through floodplain harvesting. This necessarily requires a stronger focus on small-scale local conditions – such as levees and other structures.

Across NSW, water demand in excess of supply is more likely to be a result of *unexpected* temperature spikes — especially in the summer months. All crop types are subject to the pressures of short-term unexpected heat waves.

For market triggers, water users will be more likely to pursue non-compliant behaviours when they have already invested in a crop, and water allocation prices move in excess of their willingness to pay or less allocation is available than was anticipated (or is required).

Northern Murray-Darling Basin

Central West

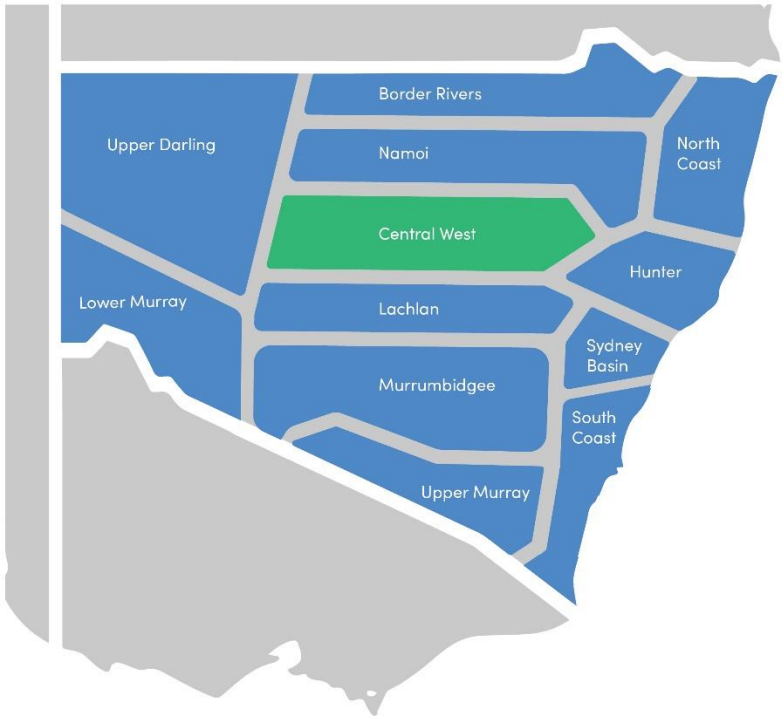
The Central West region incorporates the Macquarie-Bogan and the Castlereagh catchments of the MDB. The three major rivers — the Bogan, Castlereagh and Macquarie rivers — flow from the south east to the north west where they meet the Barwon River near Bourke.

Average annual rainfall in the Macquarie catchment ranges from 1,200 mm in the south-east to around 300 mm in the north-west. Average annual rainfall in the Castlereagh catchment varies from 800 mm in the Warrumbungle Ranges to 400 mm on the Barwon Plains in the north. Agriculture is the dominant water user in the region, with common crops including cotton, pasture, and cereals. Notably, the region is also home to some larger urban centres, such as Bathurst, Orange, and Dubbo.

Burrendong Dam (1,190 GL) and Windamere Dam (353 GL) are the major water storages in the region. Along with several smaller storages, Burrendong and Windamere secure water supplies for town, irrigation and environmental purposes. There are many weirs in the lower reaches of the Macquarie and Bogan rivers that manage irrigation diversions. The region has several private irrigation schemes which account for approximately 40 per cent of all irrigation entitlements in the region.

Groundwater sources include alluvial sediments on the plains of the Macquarie catchment, with the highest yielding aquifers located north-west of Narromine. Across the Macquarie and Castlereagh catchments, groundwater accounts for a third of total water use in the region.

Water sources within this analysis include the Macquarie-Cudgegong Regulated River Water Source.



Central West

Demand

Major crops in the region

- Cotton accounts for around 73 per cent of water use in the Central West.
- Pastures are also a significant water user in the region accounting for 17 per cent of water use and 30 per cent of land use.
- There is a small amount of permanent horticulture which represents less than 1 per cent of the region's land use.

Extent and location of irrigation

- Permanent horticultural crops are mostly concentrated around Orange with grapevines and apples also grown in the region.
- Crops upstream of Dubbo are generally pastures for livestock or cereals.
- Extensive cotton crops are grown downstream of Dubbo.

Key regional characteristics

- Trade between the Macquarie and other systems is not possible due to limited hydrological connectivity.

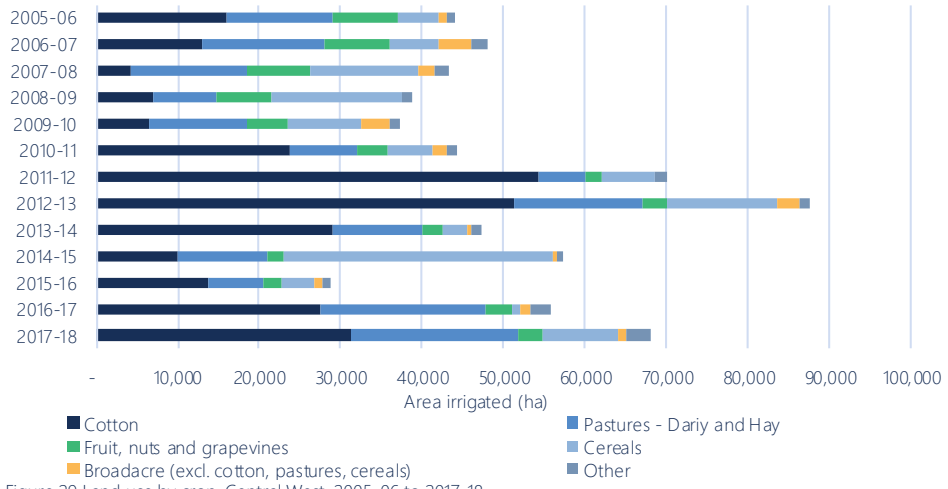


Figure 29 Land use by crop, Central West, 2005-06 to 2017-18

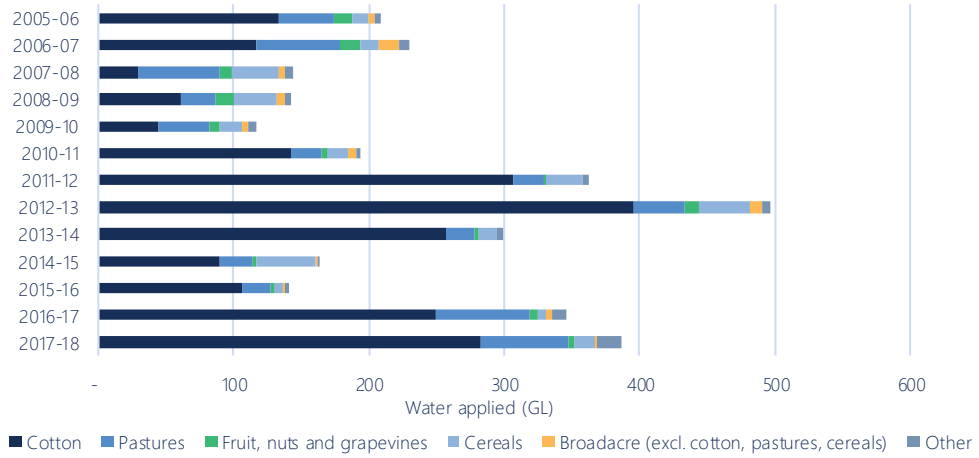


Figure 30 Water use by crop, Central West, 2005-06 to 2017-18

Central West

Demand

Production timings

- Cotton is grown during summer often in rotation with winter crops such as wheat.
- Canola and other winter drops are generally planted in April through to June.
- Grapevines lose their leaves during autumn and enter dormancy during winter, with growth occurring during October through to March.

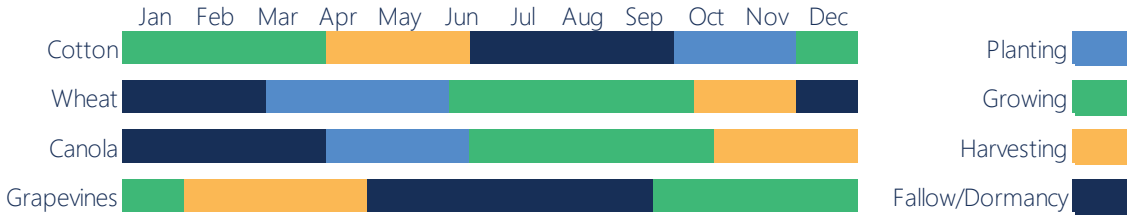


Figure 31 Indicative production schedule of major crops, Central West

Decision making points

- The decision to plant cotton will occur during September to November, whereas the decision to grow winter crops will occur during April to June.

Demand triggers

- In-crop rainfall has a strong influence on an irrigator's decision to irrigate.

Central West

Supply

Seasonal trends in storage

- Storage levels for Windamere Dam have been relatively constant, at or marginally below the 200 GL water mark of a 368 GL total capacity. Windamere Dam is currently at 33 per cent capacity.
- From 2013-14 until 2016-17, Burrendong Dam storage levels ranged between 532 GL and 124 GL, before significantly increasing to around 1,600 GL in 2016-17 with the NSW flood events. Since this peak, it has steadily declined to its current level of 65 GL, or at 5.3 per cent of capacity.

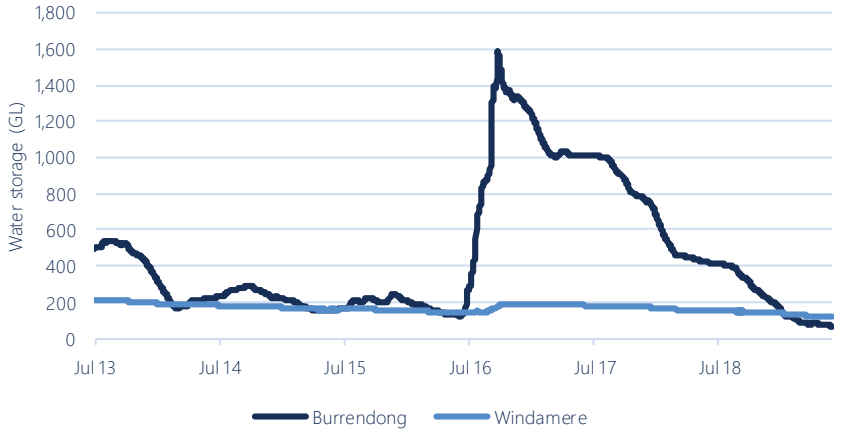


Figure 32 Historical storage volumes of major storages, Central West, June 2013 to June 2019

Allocation/seasonal determinations

- Aside from a short window in 2007, NSW Macquarie and Cudgegong HS allocations have not dipped below 100 per cent (and reached 200 per cent in 2007/08).
- GS security entitlements on the other hand have fluctuated, often remaining at 0 per cent but reaching peaks of 100 per cent in the wet years of 2010/11 and 2016-17.

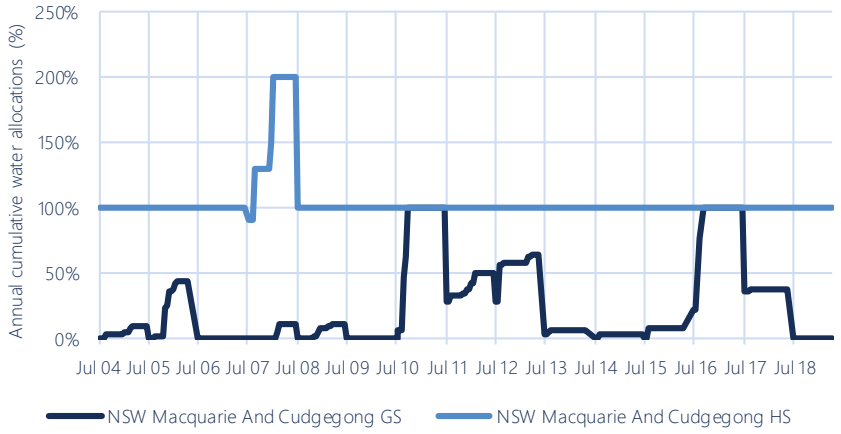


Figure 33 Annual cumulative water allocations

Supply triggers

- Burrendong Dam levels are the primary driver of allocations in the catchment.

Central West

Market Activity

Allocation price trends

- Average monthly VWAPs increased by 75 per cent between July 2015 and Feb 2019.
- Current prices are reaching peaks achieved in 2007-08 during the Millennium Drought years, reflecting the low water volumes in storage.
- Based on available data, prices peak around Jan-Feb each year.

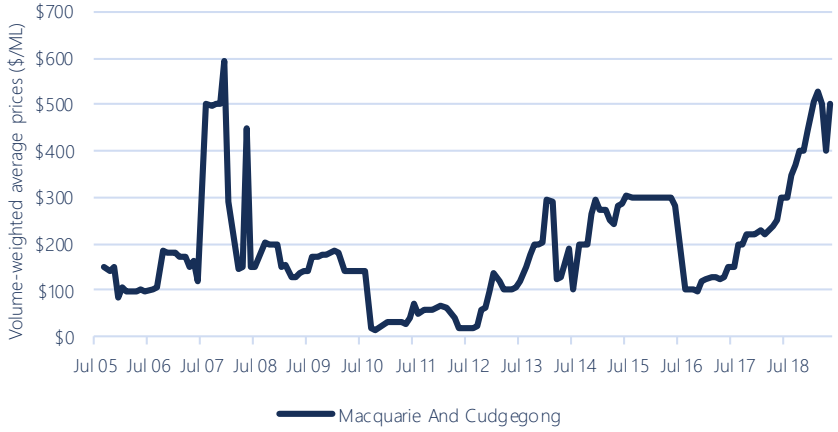


Figure 34 Monthly allocation prices

Entitlement price trends

- Monthly average VWAPs for entitlement trade in the Macquarie-Cudgegong GS market declined from around $1,500/ML in 2005 to $1,000 / ML in 2014. Since October 2014, GS entitlements have recovered from a low of $700 per ML to over $1,700 in May 2019 — an increase of over 146 per cent.
- There is only limited entitlement trade for HS entitlements.

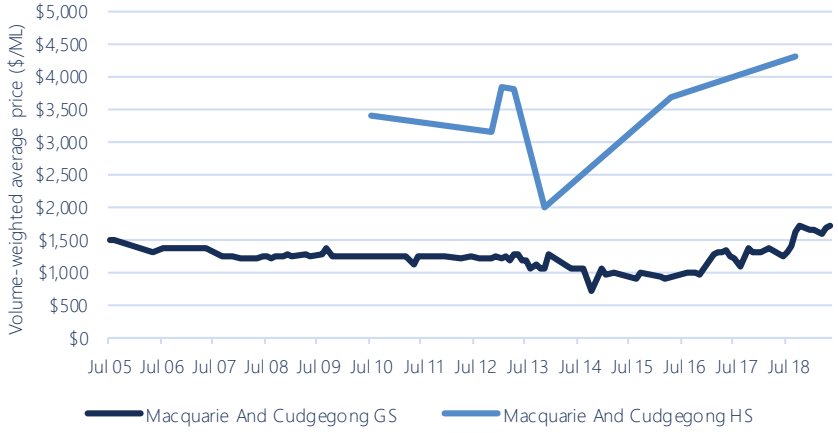


Figure 35 Monthly entitlement prices

Long-term market trends and water use patterns

- Due to the relatively low volume of HS entitlement trade it is difficult to draw conclusions regarding long-term market and water use patterns.
- The variability in annual water use data by crop suggests that water use will continue to vary depending on water availability. As such, it is likely that in wet years annual crops such as cotton and wheat will be grown.

Northern Murray-Darling Basin

Namoi

The Namoi region is located in north-western NSW, spreading westward from the Great Dividing Range. The region consists of the Upper Namoi, Lower Namoi and Peel regulated water sources. Other major tributaries include the Macdonald, Manilla, Mooki, and Cockburn rivers, many of which meet at the foothills of the ranges.

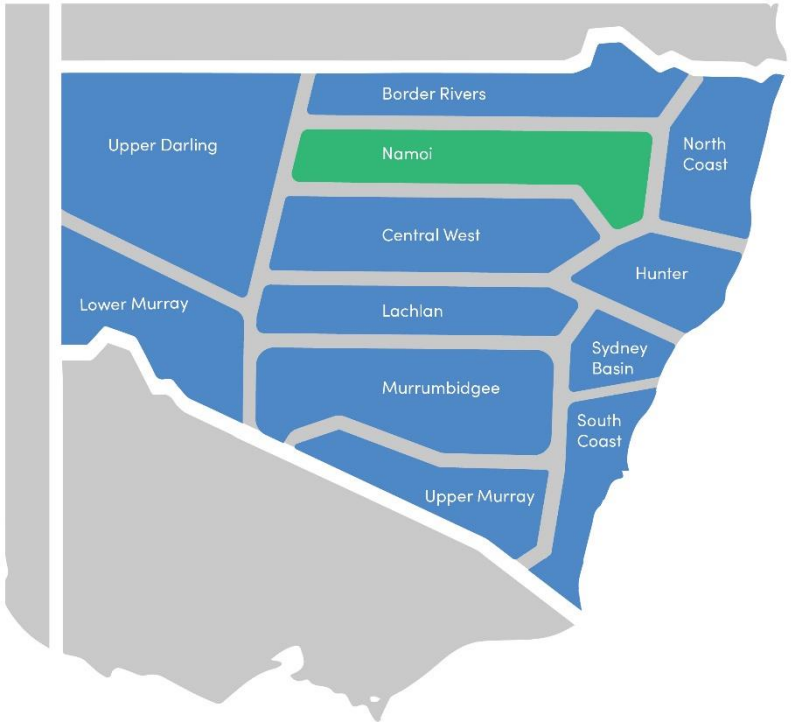
This catchment services the towns of Tamworth, Gunnedah, and Narrabri, and is an area of high agricultural production. Rainfall ranges from 1,000 mm in the higher altitude areas to 400 mm in the lower floodplain country.

Cotton is the dominant irrigated crop in the Namoi catchment, with other important crops including pasture, cereals, and other broadacre crops.

The major storages include Keepit Dam (426 GL), Split Rock Dam (397 GL) and Chaffey Dam (101 GL). There is significant usage of groundwater in the catchment from the Lower Namoi Groundwater Source and the Upper Namoi Groundwater sources. Groundwater usage is relatively high, with groundwater providing anywhere between 40-75 per cent of total water usage depending on rainfall.

Water sources within this analysis include the:

- Upper and Lower Namoi Regulated River Water Sources
- Peel Regulated River Water Source



Namoi

Demand

Major crops in the region

- Agricultural production in the region consists almost entirely of annual crops such as cotton, wheat, oats and other cereals and pastures.
- Production of crops is highly variable between seasons, with water availability being a major determinant.
- Cotton accounts for around 75 per cent of water use in the region prior to 2015-17 noting that ABS reporting boundaries changed leading to an overestimation of cotton production in the Namoi.
- Grain crops, cereals, oilseeds and legumes are often grown in rotation with cotton.

Extent and location of irrigation

- Unlike other regions, irrigated farms may be located several kilometres away from major river and streams in the Namoi. There is also substantial groundwater access in the region.
- On-farm storages are prevalent in the region along with reliable groundwater sources.
- As waterways and streams into the Namoi tend to meander, there are several other billabongs and smaller waterways from which irrigation water is drawn. This is particularly common following rainfall and in the wet season as irrigators look to fill their on-farm storages.

Key regional characteristics

- The eastern fringe of the catchment receives high rainfall, whereas the west receives relatively little rainfall.
- There are numerous anabranches, billabongs and wetlands that meander through the region.

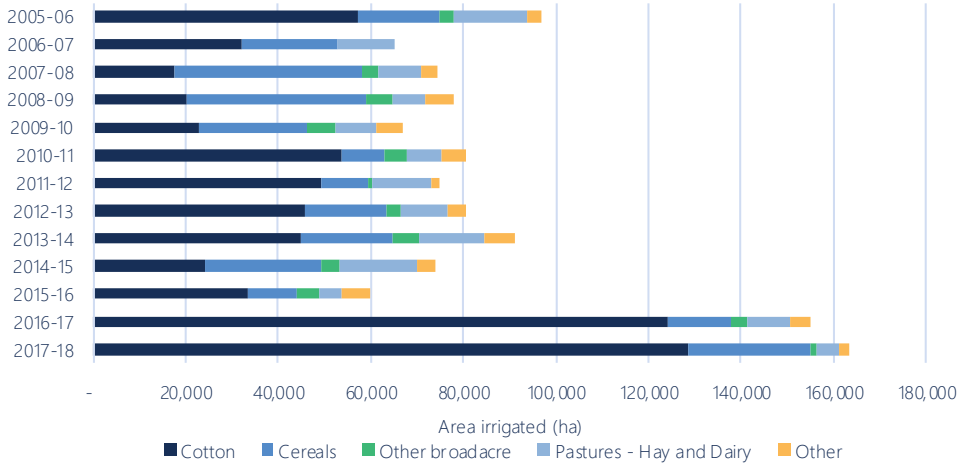


Figure 36 Land use by crop, Namoi, 2005-06 to 2017-18
Note: NRM boundary changes in 2016-17 led to increases in cotton

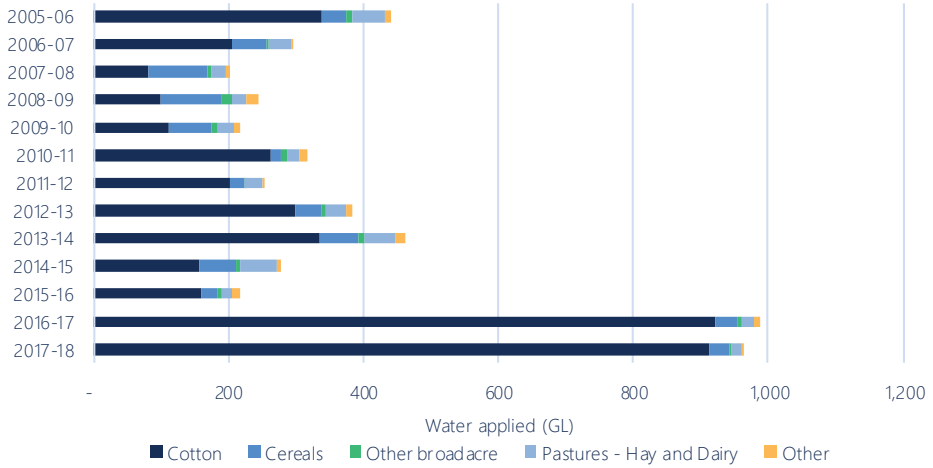


Figure 37 Water use by crop, Namoi, 2005-06 to 2017-18
Note: NRM boundary changes in 2016-17 led to increases in cotton

Namoi

Demand

Production timings

- Cotton is grown during summer.
- Grains, cereals and legumes are grown in rotation either during summer or winter to improve soil biodiversity and maintain soil health.
- Wheat and oats are common winter crops in the region.
- Lucerne for hay is grown from spring with one to four harvests possible.

Decision making points

- The decision to grow cotton will be influenced by water availability and prices for water and cotton. These decisions will be made prior to planting in cotton in spring.
- Winter rotational crops (wheat, oats, legumes, et cetera) will be planted during autumn or following cotton harvest.

Demand triggers

- Low summer rainfalls will trigger greater demand if cotton has already been planted and cotton prices are high.
- Poor rainfall and water availability will have implications for on-farm storage. When on-farm storage volumes decrease, irrigators will likely look to the water market for additional water supplies.

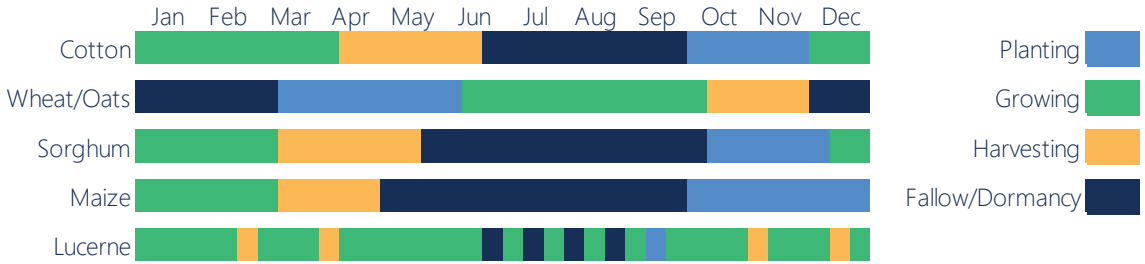


Figure 38 Indicative production schedule of major crops, Namoi

Namoi

Supply

Seasonal trends in storage

- Keepit and Split Rock dams have observed similar storage volumes since 2013-14.
- Notably, the peak volume was highest in 2013-14 for Split Rock, at around 350 GL, and the highest for Keepit occurred in 2016-17 at above 400 GL.
- Driven by severe drought in the region, current storage levels are very low, at 1 per cent for Keepit Dam and 2.3 per cent for Split Rock dam.

Allocation/seasonal determinations

- Peel HS entitlement allocations have generally been at 100 per cent, except for the 2014-15 water year when they stayed at 50 per cent.
- Conversely, Peel GS allocations have been reasonably variable, hitting 100 per cent for periods in 2010-11, 2011-12 and 2016-17 through to 2017-18. However, in 2014-15, GS allocations were at 0 per cent.
- Lower Namoi HS allocations have been consistent since 2004 at 100 per cent. Throughout this time, Lower Namoi GS allocations have generally been low, with sporadic peaks above 100 per cent in 2010-11, 2011-12, and in the wet year of 2016-17.
- Upper Namoi HS allocations have been similar to the Lower Namoi, staying consistently at 100 per cent since 2004. Upper Namoi HS allocations have also stayed relatively stable at 100 per cent, with exceptions between 2007-09 and 2009-10, and in the 2015-16 water year.

Supply triggers

- There are multiple allocation schemes in the region that have, historically, been managed separately. Given these multiple schemes, allocation levels are often driven by the performance of local storages.

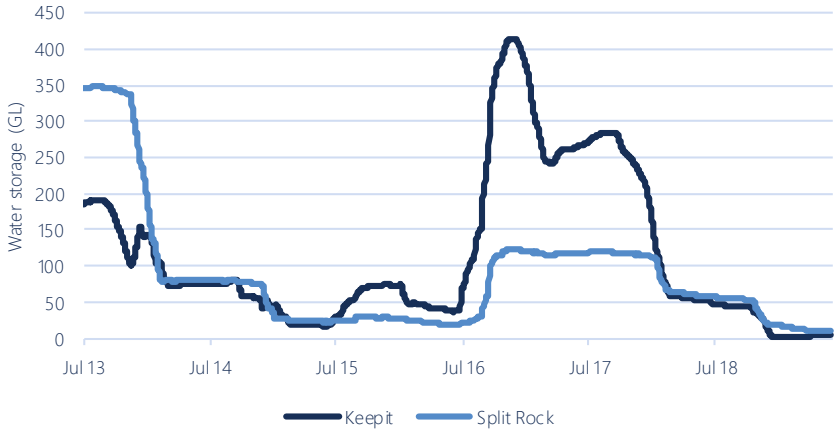


Figure 39 Historical storage volumes of major storages, Namoi, June 2013 to June 2019

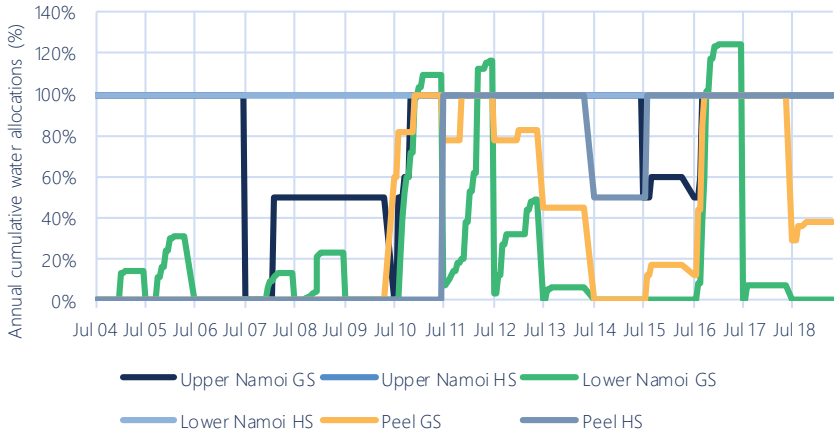


Figure 40 Annual cumulative water allocations (%)

Namoi

Market Activity

Allocation price trends

- Allocation prices in the Namoi display a high degree of variability.
- Generally, there is little differential between Upper Namoi and Lower Namoi allocation prices.
- Peel allocation prices tend to be lower than Upper and Lower Namoi prices.

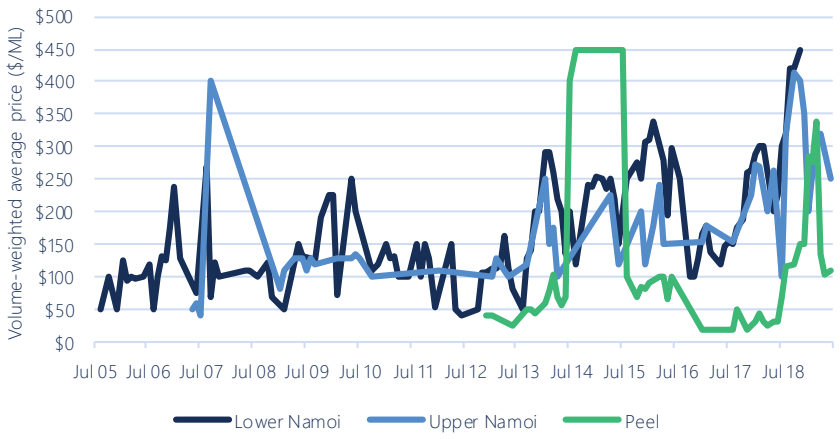


Figure 42 Monthly allocation prices

Entitlement price trends

- There is insufficient trade data for HS entitlements.
- There is a higher volume of trade and higher prices for Lower Namoi GS entitlements compared to equivalent products in the Upper Namoi and Peel.
- Entitlements in the Lower Namoi GS strengthened to $2,900 in December 2018 but have softened to around $2,200 in March 2019.
- Peel GS entitlements are approximately $1,000 cheaper than Lower and Upper Namoi entitlements.

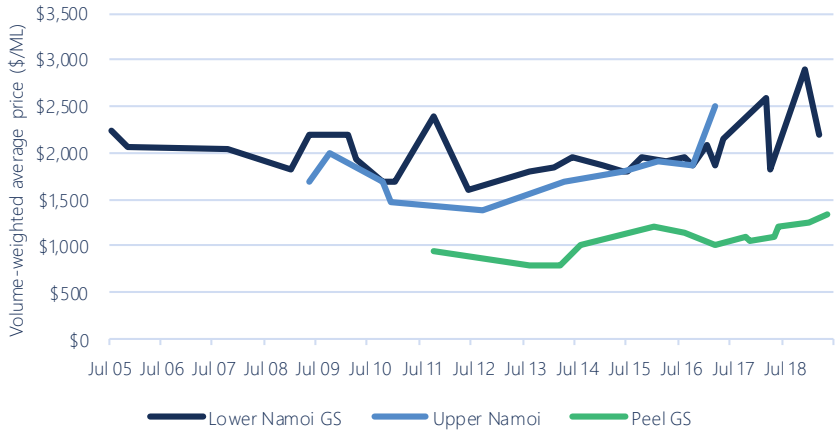


Figure 43 Monthly entitlement prices

Long-term market trends and water use patterns

- Lower Namoi, Upper Namoi and Peel GS entitlements have all trended upward since July 2016.

Northern Murray-Darling Basin

West / Upper Darling

The West / Upper Darling region is located in north-western NSW, north-east of the Menindee Lakes Scheme.

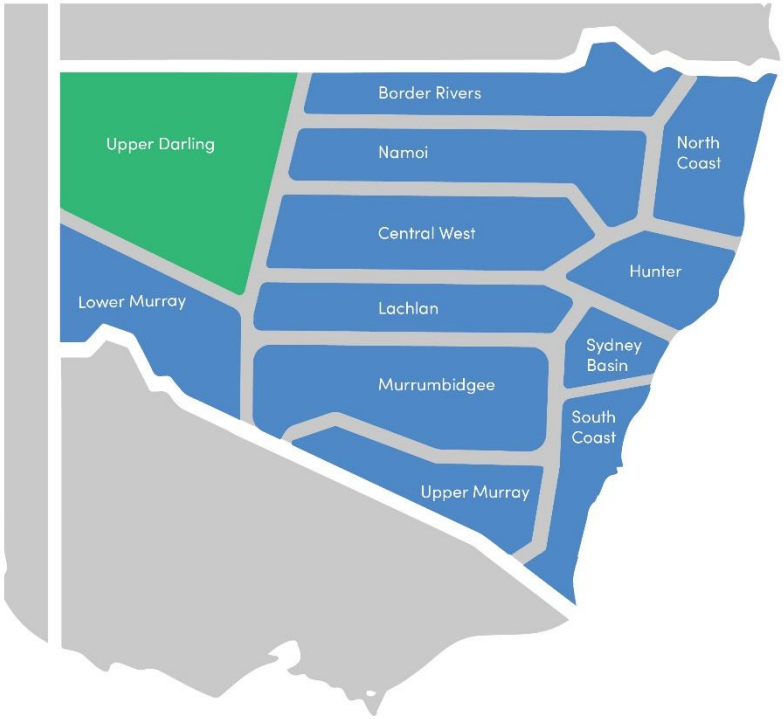
This region includes the Barwon and Upper Darling Rivers. Significant tributaries include the Border Rivers, Moonie, Culgoa, Bokhara, Gwydir, Namoi, Castlereagh, Macquarie and Bogan rivers. The region has low rainfall throughout the year with more intense rainfall in summer, observing an annual average of 330 mm.

Urban centres within the region include Collarenebri, Walgett, Brewarrina, Bourke, Cobar and Wilcannia.

Agricultural activity in the area is primarily livestock agriculture, including beef and sheep grazing on pastoral land. The Barwon-Darling is considered an unregulated river above the Menindee Lakes Scheme. There are some groundwater resources in the Darling Alluvium located near the Darling River, as well as in aquifers associated with the Lachlan Fold Belt and the Great Artesian Basin.

Water sources within this analysis include the:

- Barwon-Darling Unregulated River Water Source



West / Upper Darling

Demand

Major crops in the region

- Irrigation in the Upper Darling is relatively small compared to other regions.
- There are concentrated pockets along Barwon–Darling River which support a mix of cotton and permanent horticulture.
- Permanent horticulture accounted for 43 per cent of water use in 2017-18.

Extent and location of irrigation

- Compared to other systems in the northern MDB and southern MDB, the Upper Darling consumes much less water.
- Given the arid and dry climate, the majority of irrigated farmland is located near streams and waterways.

Key regional characteristics

- Most of the region's water is generated upstream.
- On farm storage is prevalent in the region.

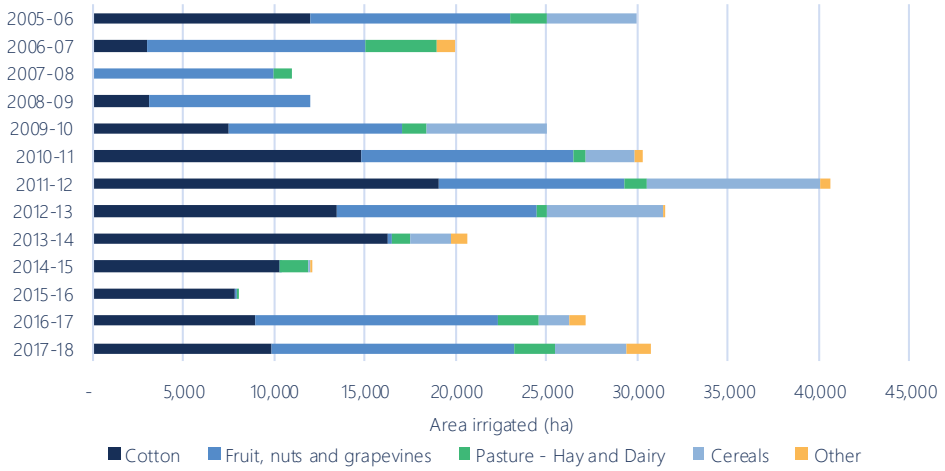


Figure 44 Land use by crop, Upper Darling, 2005-06 to 2017-18

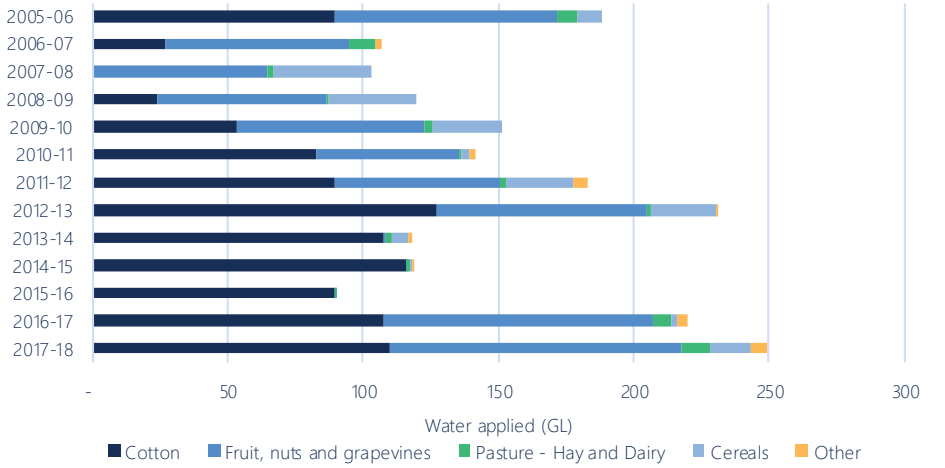


Figure 45 Water use by crop, Upper Darling, 2005-06 to 2017-18

West / Upper Darling

Demand

Production timings

- Cotton is grown in summer and grain crops, cereals, oilseeds and legumes are grown in rotation, or land may be rested during winter.
- Of the relatively small number of permanent plantings, grapevines are dominant. They enter dormancy during winter with growth and water required during summer.

Decision making points

- As cotton is planted during spring, many production decisions will be made at this time.

Demand triggers

- Low summer rainfalls will trigger greater demand if cotton has already been planted and cotton prices are high.
- Consecutive warm days will require permanent horticultural crops such as grapevines to be irrigated.

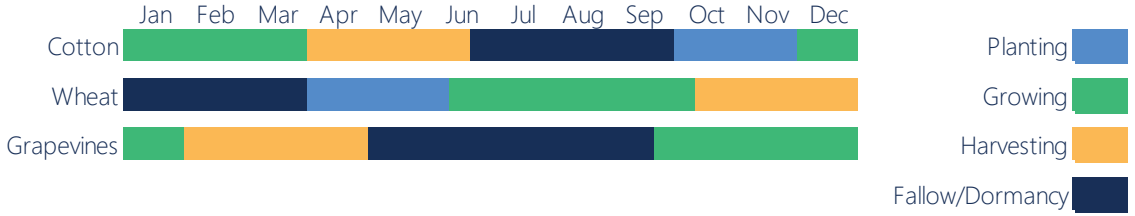


Figure 46 Indicative production schedule of major crops, Upper Darling / West

West / Upper Darling

Supply and Market Activity

Seasonal trends in storage

- Rainfall in the Upper Darling is low. Inflows to the region generally come from the east through the Barwon, Culgoa and Paroo rivers.
- There are few major public storages in the region. Private on-farm storages tend to be more prevalent.
- In lieu of reliable storage data, observed flows in the Darling River at Wilcannia show the long-term variability in stream flows. The high flows during 2016-17 are notable in comparison to the relatively low flows between July 2013 and June 2019.

Supply triggers

- The principal determinant of water supply in the Upper Darling is rainfall upstream.
- Given the prevalence of on-farm storage, irrigators can manage flow and supply variability to an extent.

Entitlement price trends

- Analysis of market activity in the region is limited due to the limited volume of allocation and entitlement trade.
- There has only been limited amounts of trade in the Barwon-Darling entitlement market.
- Prices vary greatly, such that it is not possible to discern any specific market trends.

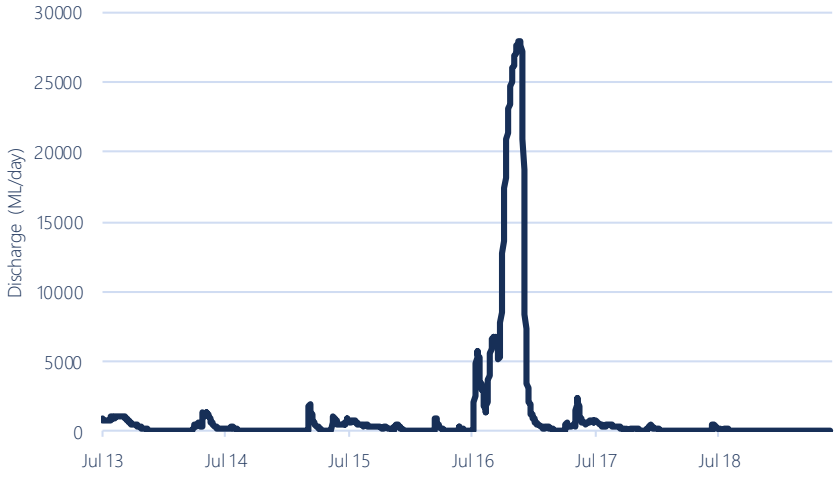


Figure 47 Observed Darling River flow, measured at Wilcannia.

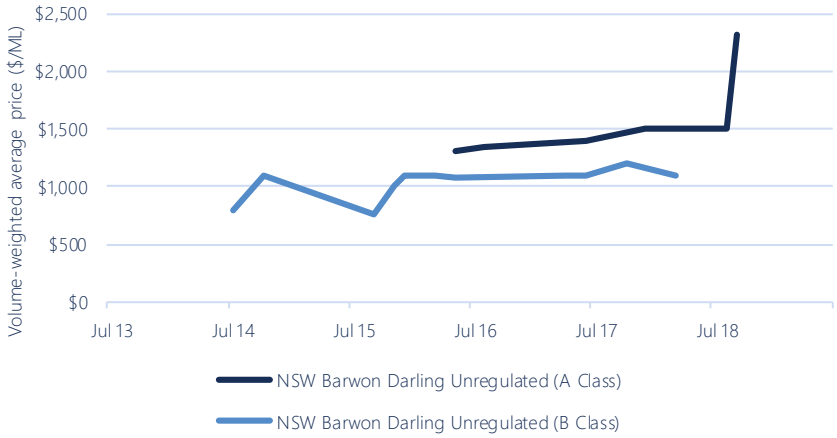


Figure 48 Monthly entitlement prices

Northern Murray-Darling Basin

NSW Border Rivers - Gwydir

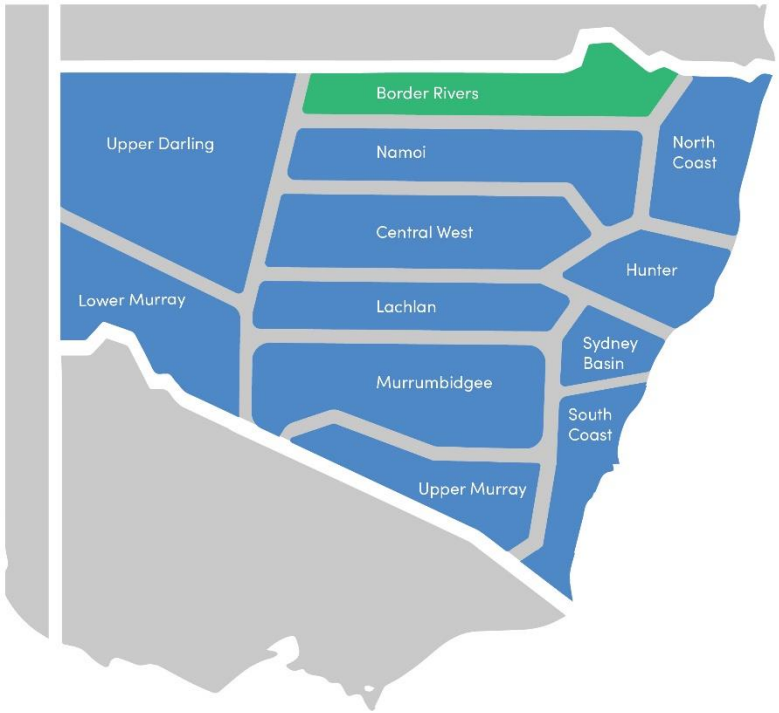
The NSW Border Rivers – Gwydir region comprises the NSW Border Rivers catchment and the Gwydir catchment in northern NSW. Straddling the NSW and Queensland border, the NSW Border rivers include the Dumaresq, Macintyre and Severn rivers. The Gwydir catchment, located south of the Border Rivers catchment, includes the Mehi and Gwydir rivers.

Average rainfall across the eastern half of the NSW Border Rivers - Gwydir is 800 – 1,100 mm, with an average of 400 – 500 mm across the western half. Rainfall is summer dominant.

The annual streamflow of the Macintyre River is 130 GL (measured at Wallangra) and 336 GL for the Gwydir River (measured at Bundarra).

Agriculture is the primary user of water in the area, with cotton production particularly common across both catchments.

Pindari Dam (312 GL), Glenlyon Dam (261 GL) and Lake Coolmunda (69 GL) are the major water storages for the Border Rivers catchment. Copeton Dam (1,364 GL) is the main storage for the Gwydir. Groundwater extraction occurs in both catchments and is a major source of water in the region.



Water sources within this analysis include the:

- Gwydir Regulated River Water Source
- Border Rivers Regulated River Water Source

NSW Border Rivers - Gwydir

Demand

Major crops in the region

- Cotton dominates the region's agricultural production.
- In 2017-18 cotton accounted for 77 per cent of water use in the Border Rivers-Gwydir region.
- Permanent plantings accounted for 4 per cent of water use in 2015-16, prior to the land use boundary changes.
- Other crops such as wheat, oats and pastures are often used in rotation with cotton, or the ground may be left to rest.

Extent and location of irrigation

- Irrigated farmland is extensive along waterways, as are accesses to water such as anabranches and billabongs.
- In the region's west, irrigated farmland become more scattered along waterways.

Key regional characteristics

- In the mid- and western reaches of the region, on-farm storage is prevalent.
- Agricultural production in the region fluctuates annually in accordance with water availability.

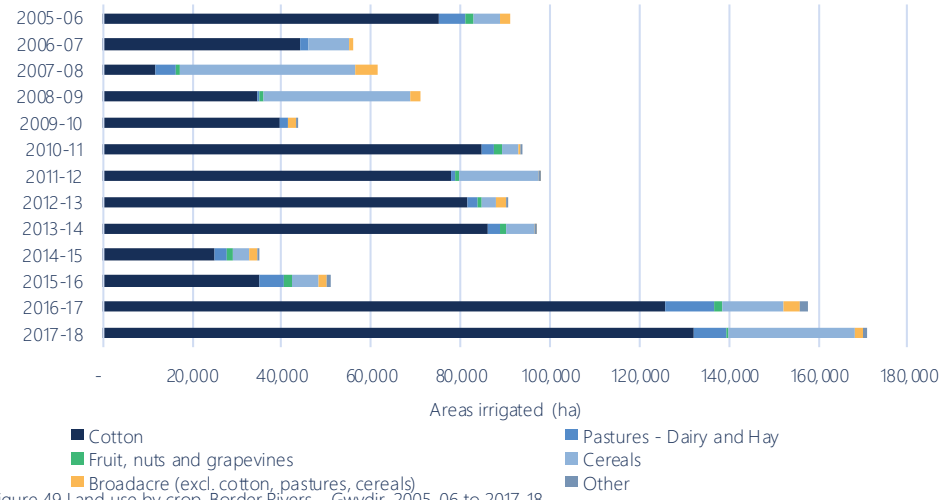


Figure 49 Land use by crop, Border Rivers – Gwydir, 2005-06 to 2017-18
Note: NRM boundary changes in 2016-17 led to increases in cotton

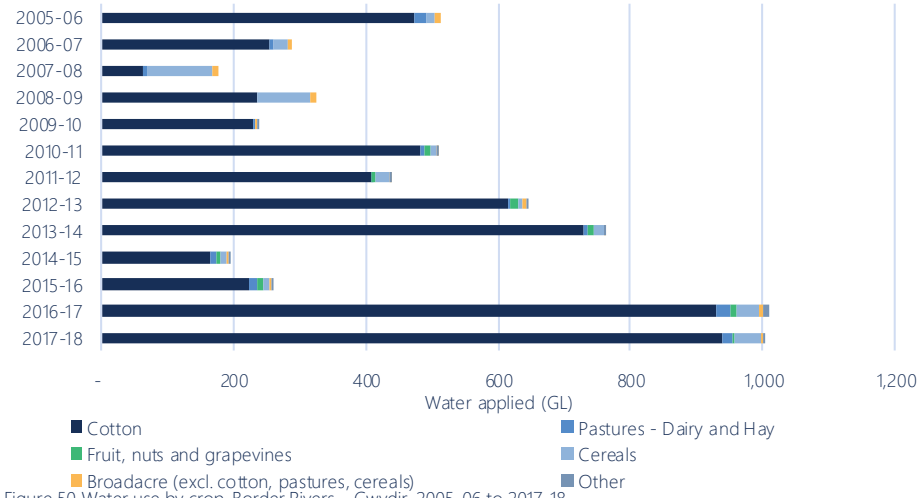


Figure 50 Water use by crop, Border Rivers – Gwydir, 2005-06 to 2017-18
Note: NRM boundary changes in 2016-17 led to increases in cotton

NSW Border Rivers - Gwydir

Demand

Production timings

- Cotton is grown in summer and grain crops, cereals, oilseeds and legumes are grown in rotation; or, lan- may be rested during winter.
- Of the relatively small number of permanent plantings, grapevines are dominant. They enter dormancy during winter with growth, and water is required during summer.

Decision making points

- As cotton is planted during spring, many production decisions are made at this time.

Demand triggers

- Low summer rainfalls will trigger greater demand if cotton has already been planted, and cotton prices are high.

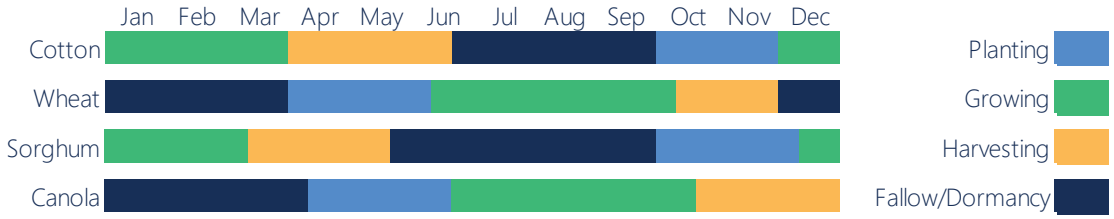


Figure 51 Indicative production schedule of major crops, Border Rivers – Gwydir

NSW Border Rivers - Gwydir

Supply

Seasonal trends in storage

- There are no clear seasonal trends in the NSW Border Rivers storages, but over the last five years the Copeton, Pindari and Glenlyon dams have followed broadly similar volume trajectories.
- Each of the three dams had localised peaks in the storage volumes in June 2013, before having a period of low volumes through to 2016-17. At this point, storage volumes increased, before flattening out and decreasing through to the current water year.
- Currently, all the dams have reasonably low storage volumes, with Copeton Dam at 9.3 per cent , Pindari Dam at 5.5 per cent, and Glenlyon at 9 per cent.

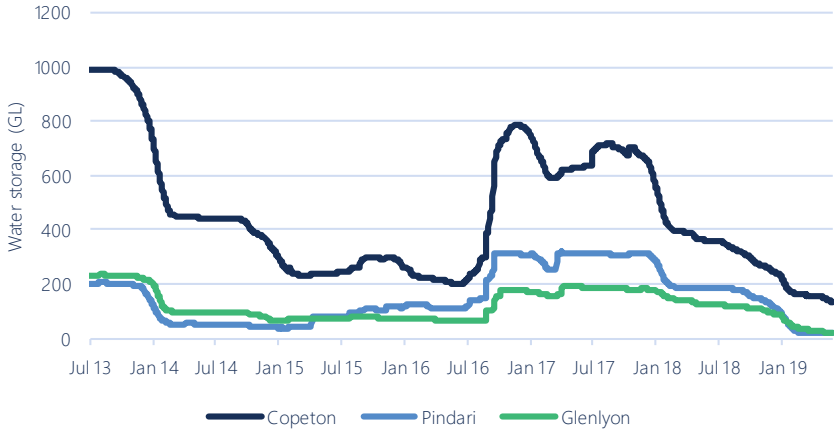


Figure 52 Historical storage volumes of major storages, Border Rivers – Gwydir, June 2013 to June 2019

Allocation/seasonal determinations

- The Gywdir GS allocations have generally been low with sporadic peaks, notably in 2010-11, 2011-12 and 2012-13, when allocations spiked at around 80 per cent, 300 per cent and 160 per cent, respectively.
- The Border Rivers GS A allocations have broadly stayed around the 100 per cent mark, with short exceptions in 2010-11, 2014-15 and 2015-16.

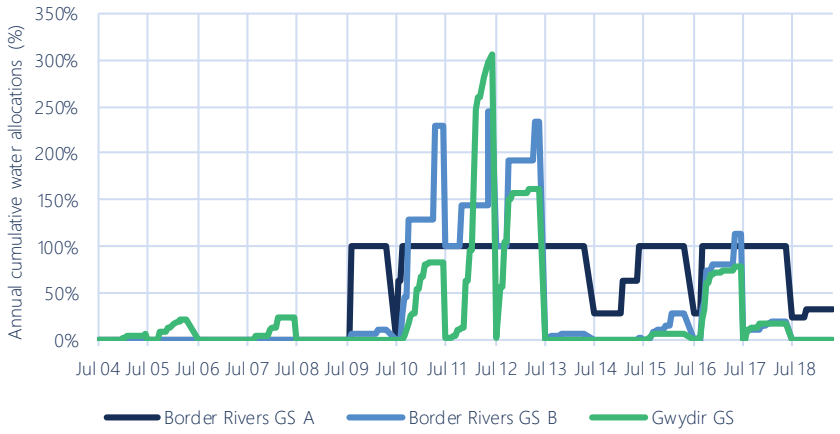


Figure 53 Annual cumulative water allocation

NSW Border Rivers - Gwydir

Market Activity

Allocation price trends

- Monthly allocation prices trends are not consistent between the Border Rivers and Gwydir, beyond sharing more intensive summer trade.
- Prices for both Border Rivers GS and Gwydir GS increased by approximately 55 per cent between February 2018 and February 2019.

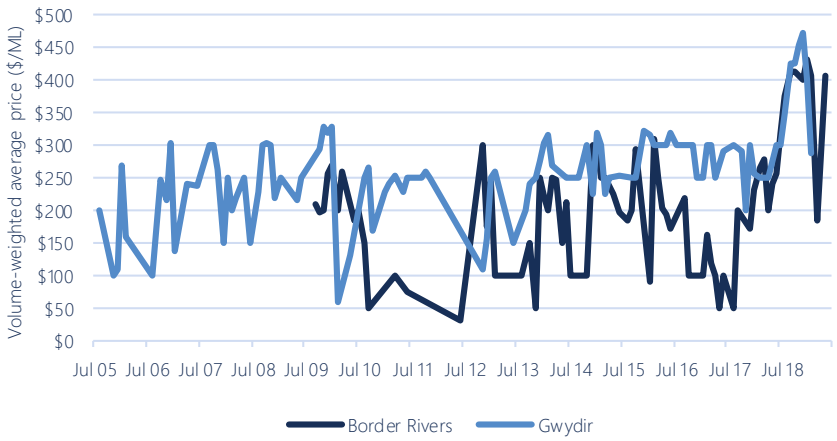


Figure 54 Monthly allocation prices

Entitlement price trends

- There are limited entitlement trades recorded for Border Rivers GS products (prices only recorded between July 2011–July 2018, with only 11 VWAPs each for GS A and GS B entitlements).
- Prices for GS A class entitlements enjoy a premium over Border Rivers GS B and Gwydir GS entitlements. GS A are between $3,000 and $3,850 per megalitre compared to $2,000 to $2,572 for Gwydir GS and $1,800-$2,250 for Border Rivers GS B.

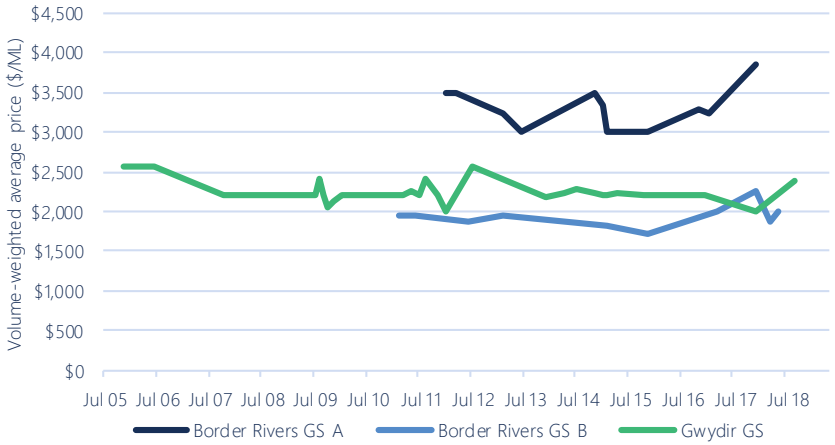


Figure 55 Monthly entitlement prices

Long-term market trends and water use patterns

- Since July 2018, allocation markets have observed a step increase in price, while entitlement markets have also observed a gradual increase over the same period.

Coastal Regions

Analysis and context for irrigator decision-making

Analysis and context for irrigator decision-making

Characteristics of coastal regions

The ABS NRM Zones within the coastal regions include the:

- North Coast
- Hunter
- Sydney Basin
- South Coast

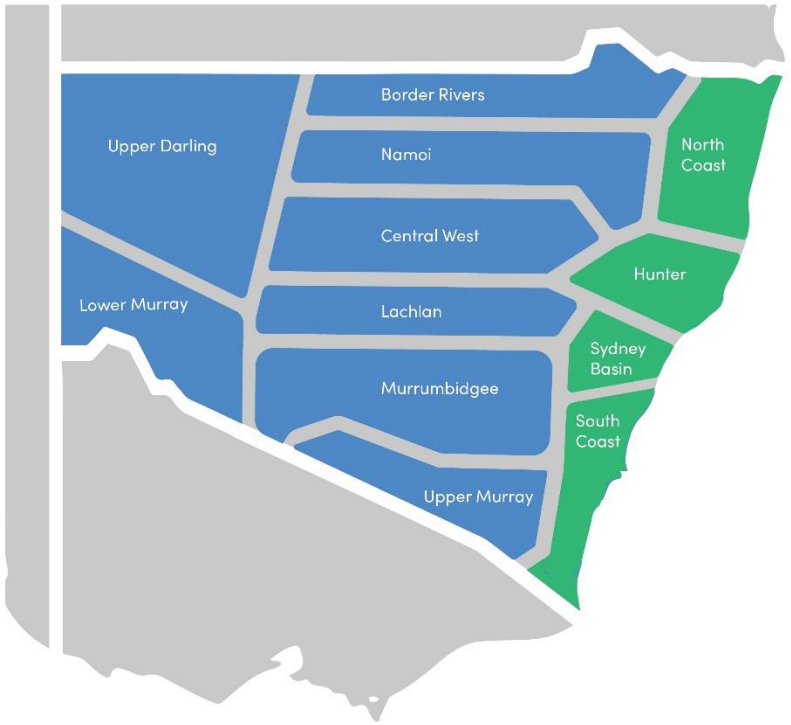
Coastal regions tend to comprise numerous surface water systems with limited connectivity to other systems.

Within the coastal regions there are three distinct characteristics:

- the Sydney Basin is influenced by urban water demand
- the Hunter is a regulated system with significant irrigated agriculture
- the North Coast and South Coast are both largely unregulated, aside from the Richmond regulated water source and Bega-Brogo regulated water sources, respectively.

Rainfall in coastal regions is generally moderate and more reliable compared to MDB regions (due to the presence of the Great Dividing Range). Reliable rainfall and the widespread use of on farm storages also contributes to lower reliance on irrigation to meet water needs, except during dry periods.

Water markets are generally underdeveloped outside of the Hunter region, and reliance on groundwater systems is low.



Analysis and context for irrigator decision-making

Coastal regions compliance summary

The coastal regions are significantly smaller in size, in the volume of water used, and the number of irrigators compared to either the northern or southern MDB. The water courses along the coast are also significantly more numerous and varied. The nature of Australian weather systems means that the systems are more regular, being fed through off-shore climate, rather than larger climatic systems such as the Indian Ocean Dipole. This water availability is unlikely to result in non-complaint behaviour.

There is less data available on irrigation along the coastal regions, which is a shortcoming that could be addressed by the NSW Government / NRAR. However, many of the same principles are likely to apply as for irrigators in the MDB.

Across NSW, water demand in excess of supply is more likely to be a result of *unexpected* temperature spikes — especially during the summer months. All crop types are subject to the pressures of short-term unexpected heat waves. Over whole seasons, annual crop types have more flexibility to not plant, while permanent (almonds, citrus, et cetera) or semi-permanent (dairy) horticulture will maintain long-term irrigating investments by using water they do not immediately own.

For market triggers, water users will be more likely to pursue non-compliant behaviours when they have already invested in a crop, and water allocation prices move in excess of their willingness to pay.

Increasing pressures in the regulated surface water market is increasingly pushing irrigators to seek alternative water sources. These include unregulated water sources, groundwater, or on-farm water storages. The NRAR should continue to monitor long-term water prices as an indication of the importance of regulating these alternative water sources.

Coastal Regions

Hunter

The Hunter region is situated east of the Great Dividing Range and north of the Sydney Basin. The major river in the catchment is the Hunter River, which is fed by numerous tributaries including the Goulburn, Peterson and Williams Rivers.

The region supports a range of important water users due to its large population and significant industry. Water users include a major water corporation (Hunter Water), local councils, major NSW power generators (whom provide most of the NSW's electricity), major coal mines and high-value agriculture.

The average annual rainfall is about 870 mm across the catchment. Rainfall averages around 1,100 mm on the coast, and decreases inland, with less than 600 mm annually falling in parts of the upper Hunter.

There are two major headwater storages on the Hunter River, Glenbawn Dam and Glennies Creek Dam, with capacities of about 750 GL and 283 GL respectively. The region also has groundwater resources in the Tomaree Sandbeds and the Tomago Sandbeds, which provide accessible aquifer volumes of 16 GL and 60 GL, respectively.

Water sources within this analysis include the Hunter Regulated River Water Source.

Hunter

Demand

Major crops in the region

- As with other coastal regions, irrigation water is often used to supplement rainfall.
- Pastures for livestock is the main water user in the region.
- In 2017-18, pasture for dairy accounted for 70 per cent of water use, followed by pasture for hay which accounted for 22 per cent of water use.
- The region is also known for its wine industry, although grapevines accounted for only 4 per cent of the region's water use.

Extent and location of irrigation

- Irrigation occurs along the banks of the region's many streams and waterways.
- Irrigated pastures and centre pivot systems are located downstream of Lake Glenbawn along the banks of the Hunter River.
- Other tributaries to the Hunter (such as the Williams River) also support irrigation.

Key regional characteristics

- Historically, the region supported a large vegetable industry around Maitland. However, land prices have increased recently which has disrupted agricultural production in the region.

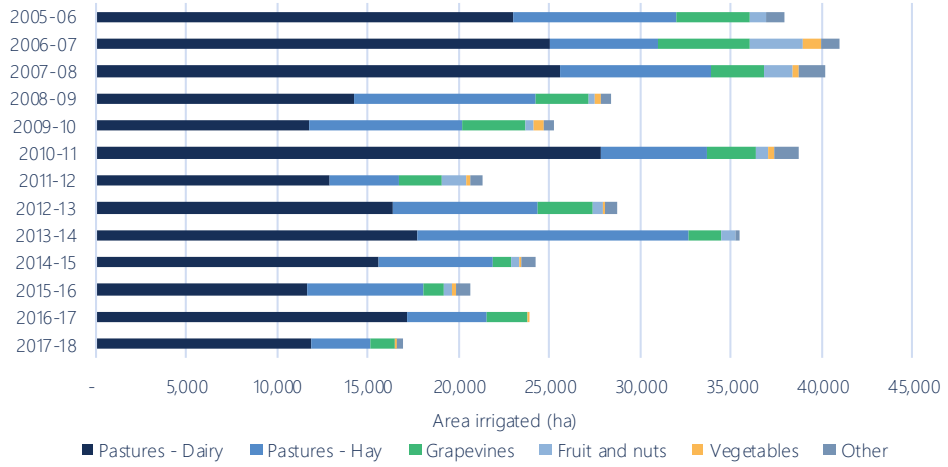


Figure 56 Land use by crop, Hunter, 2005-06 to 2017-18

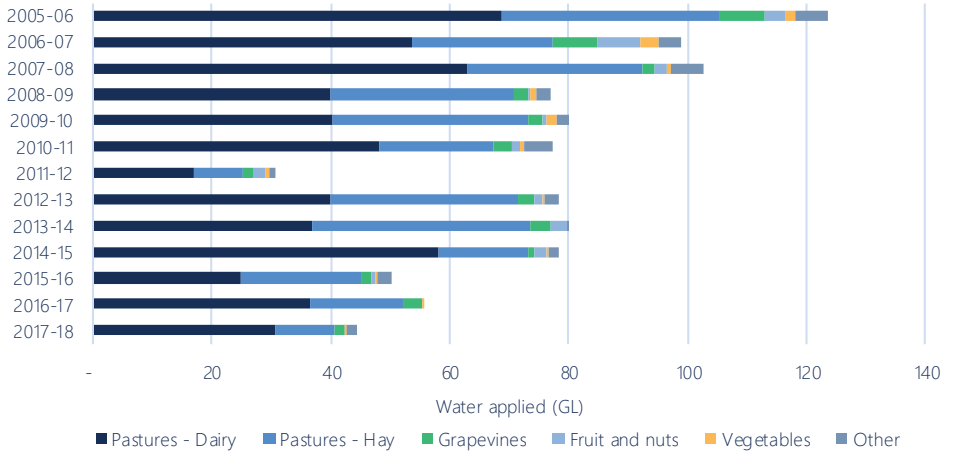


Figure 57 Water use by crop, Hunter, 2005-06 to 2017-18

Hunter

Demand

Production timings

- Lucerne for pasture or hay is grown year-round.
- Grapes in the Hunter region tend to be irrigated only to supplement rainfall.

Decision making points

- Clear decision-making points in the production cycle are limited, as many decisions regarding pasture and feed will relate to herd size and expected rainfall throughout the year.

Demand triggers

- The onset of drought and periods of dry weather that lead to the deterioration of pastures and feed will likely result in increased demand for water to irrigate pastures.
- Periods of low rainfall will likely lead to increased water use as irrigators look to supplement rainfall with irrigation.

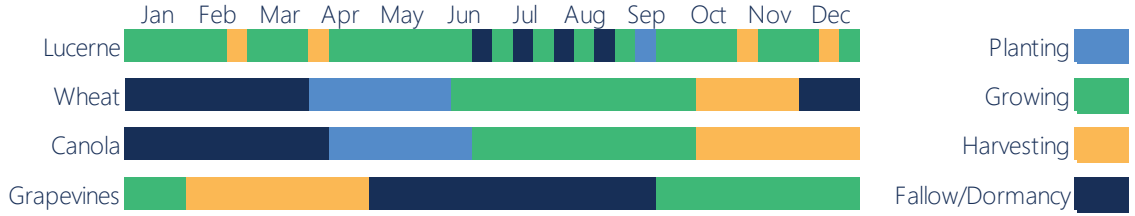


Figure 58 Indicative production schedule of major crops, Hunter

Hunter

Supply

Seasonal trends in storage

- Lostock Dam has had a roughly consistent level at around 20 GL since the 2015-16 water year, with volumes often decreasing throughout summer each year and jumping back up to 20 GL in mid-autumn.
- Glennies Creek Dam has similarly had mid-autumn increases to storage volumes, but has shown a general downwards trajectory from 250 GL in 2015-16 until current levels at around 150 GL.
- Glenbawn Dam has not had any seasonal storage changes but has been steadily decreasing in storage volume since 2016-17 when it reached 700 GL (to its current level of just under 400 GL).

Allocation/seasonal determinations

- Cumulative water allocations in the Hunter have regularly been 100 per cent, with the only major exception in the last fifteen years being the 2006-07 and 2007-08 water years, where allocations sat between 0 and 35 per cent.

Supply triggers

- Rainfall in the upper reaches of the Hunter Valley, or near storages, is the principal supply trigger.

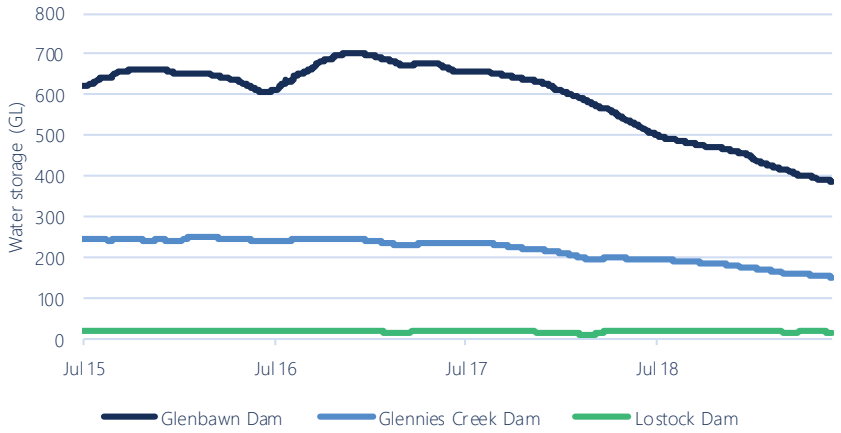


Figure 59 Historical storage volumes of major storages, Hunter, June 2013 to June 2019

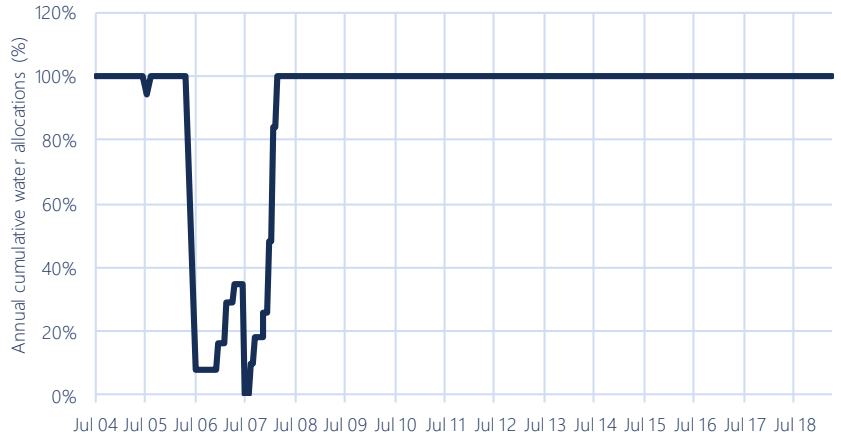


Figure 60 Annual cumulative water allocations, July 2004 to present

Hunter

Market Activity

Allocation price trends

- Allocation markets in the Hunter are relatively inactive compared to other water markets in the MDB.
- Monthly prices for allocation water peaked around $1,000 per ML during 2007 when allocations were 0 per cent but have otherwise remained generally consistent below the $50 per ML mark.

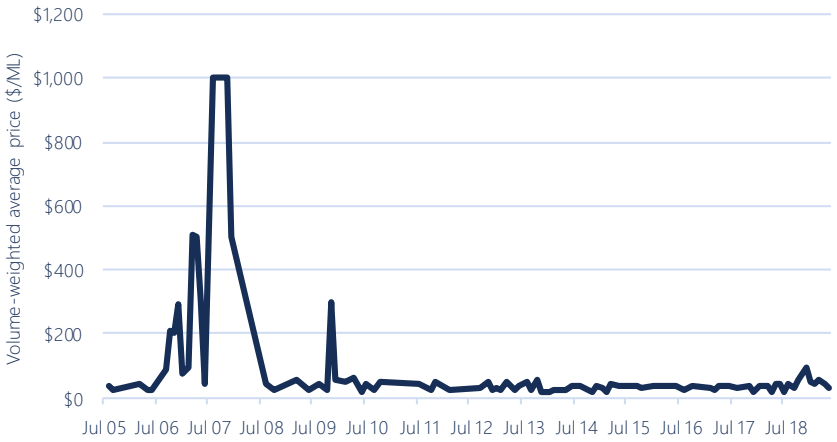


Figure 61 Monthly allocation prices

Entitlement price trends

- HS entitlements are traded infrequently, such that there is insufficient data to report on.
- GS entitlements, by comparison, are traded more frequently. The monthly VWAP for Hunter GS varies markedly.

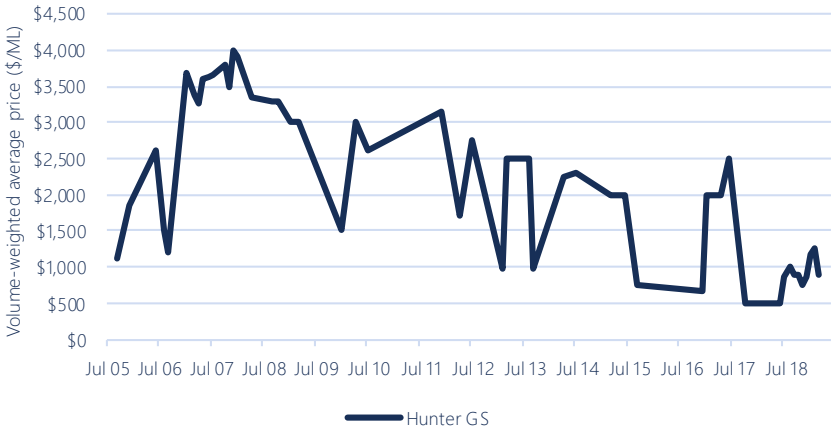


Figure 62 Monthly entitlement prices

Long-term market trends and water use patterns

- There has been a gradual downward trend in entitlement prices over the last 15 years.
- Additionally, the relatively inexpensive price of water on the allocation market, coupled with reliably high allocations suggests that the Hunter has not seen demand out-strip supply to the same extent as in the MDB.

Coastal Regions

North Coast

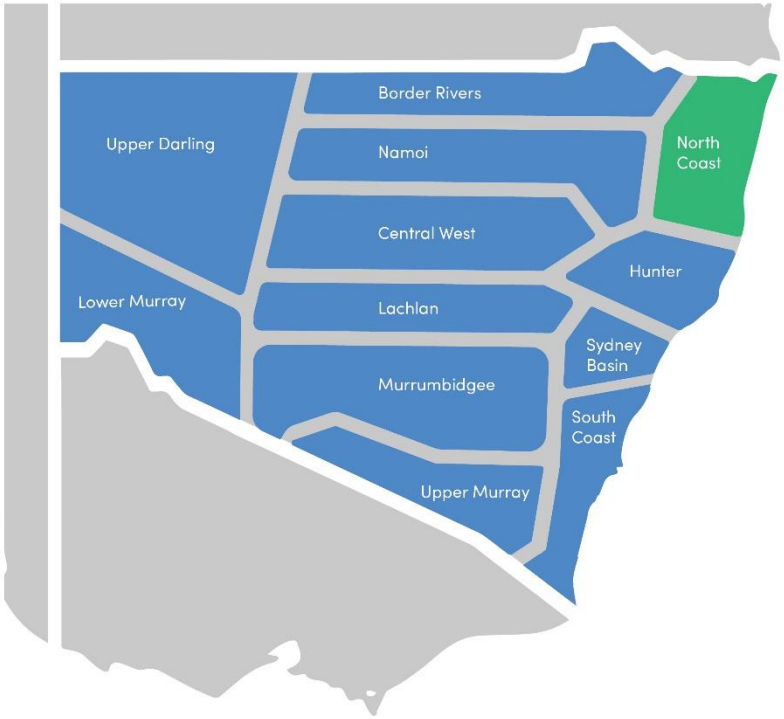
The North Coast region is located east of the Great Dividing Range, extending south of Port Macquarie to the Queensland border. The region is comprised of several discrete river basins. The Clarence River is the most significant river in the North Coast region in terms of annual discharge into the sea. Other river basins include the Tweed, Brunswick, Richmond, Bellinger, Nambucca, Macleay and Hasting basins.

In the Tweed Basin in the north of the region, rainfall is high, receiving annual averages between 1,600 mm and 2,000 mm. In the lower North Coast areas adjacent to the Hunter region, annual average rainfall varies from 980 mm to 1,700 mm, with the higher rainfall occurring from January to March.

The urban areas in this region are mainly smaller coastal towns, with larger urban areas including Port Macquarie, Coffs Harbour, Grafton and Byron Bay. The main industries in the region are livestock grazing, horticulture, fishing and aquaculture, timber production, and tourism.

Aside from the Richmond catchment, which is regulated by several small storages to support irrigation and urban water use, catchments within the North Coast are largely unregulated. On farm storages are also widespread, meaning that irrigation water is generally only used for supplementary purposes during hot summer months. There are several groundwater sources in the region, including aquifers near Newcastle, Grafton, Port Macquarie, Port Stephens, the Manning River and Lismore.

There are a large number of small water courses on the north coast, rather than a single large water course.



North Coast

Demand

Major crops in the region

- As with other coastal regions, irrigation water is often used to supplement rainfall.
- The region supports highly diverse agricultural production.
- A large dairy industry exists in the Northern regions. Dairy accounts for around 33 per cent of water use in the region.
- Fruit and nuts are also a major water user in the region accounting for around 28 per cent of water use in the region. Macadamia orchards account for a significant proportion of fruit and nut production in the region.
- Sugar cane production accounts for a small amount of land use in the region.

Extent and location of irrigation

- Livestock production occurs throughout the region.
- Macadamia orchards tend be concentrated in the north of the region above Ballina.

Key regional characteristics

- A significant amount of land is occupied by State and National Parks containing natural vegetation.
- There are a high number of short streams and waterways that meet the coastline.

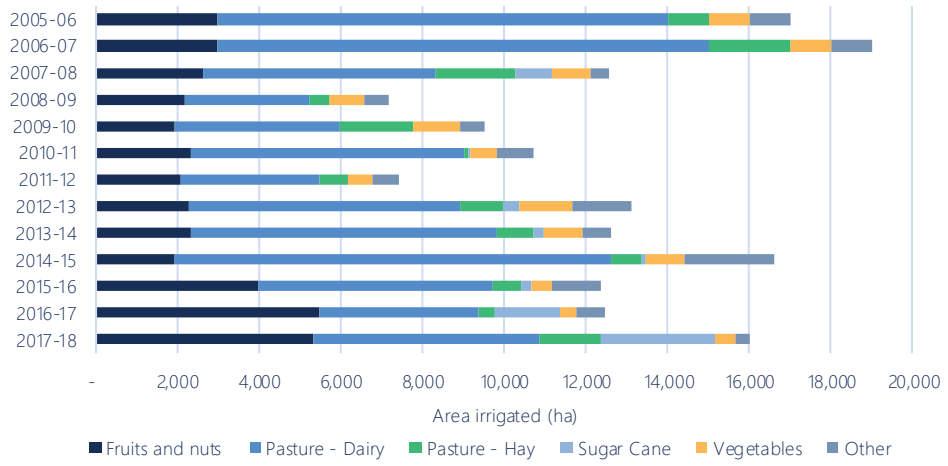


Figure 63 Land use by crop, North Coast, 2005-06 to 2017-18

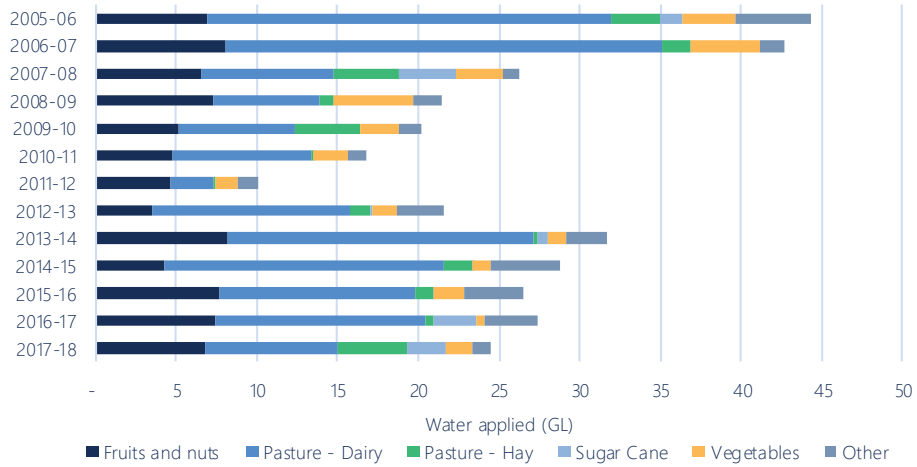


Figure 64 Water use by crop, North Coast, 2005-06 to 2017-18

North Coast

Demand

Production timings

- Macadamias grow year-round; however crop water requirements are highest during summer.
- Wheats and oats are grown during summer.
- Sugar cane is planted in autumn and winter and can grow for around three years; it can be harvested once per year.
- Lucerne is grown year-round with the possibility to graze or bale two to four times per year.
- Avocadoes are a permanent planting and grow year-round. The Hass variety are generally harvested between March and August.

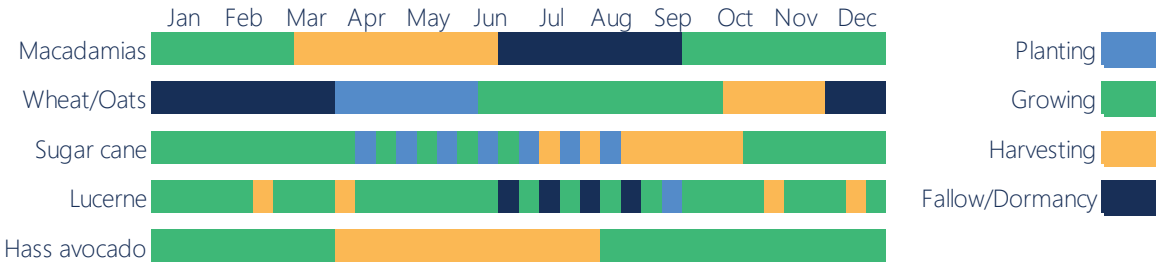


Figure 65 Indicative production schedule of major crops, North Coast

Decision making points

- There are few distinct decision-making points in the production cycle due to the year-round or semi-permanent nature of crop production in the region.

Demand triggers

- The onset of drought and period of dry weather that lead to the deterioration of pastures and feed, will likely result in increased demand for water to irrigate pastures.
- Permanent horticultural crops such as avocados and macadamias require consistent watering. Periods of reduced rainfall will lead to additional irrigation requirements.

North Coast

Supply

Seasonal trends in storage

- Toonumbar Dam has typically hovered at storage volumes of around 11 GL, with dips throughout the spring-summer periods in 2013-14, 2014-15 and 2016-17.
- Currently Toonumbar Dam is at 66.8 per cent capacity.
- The Malpas Dam on the other hand has not been prone to seasonal fluctuations. The storage capacity dropped from just above 12 GL in 2012-13 to a localised low of around 7 GL in 2014-15. Significant inflows around July 2015 and July 2016 saw storage volumes return to above 12 GL, but since summer of 2017-18, storage volume has been decreasing to its current level of around 6 GL.

Allocation/seasonal determinations

- Given that the market data for coastal regions is presented at an aggregated level (except for the Hunter region), analysis of allocations is not possible.

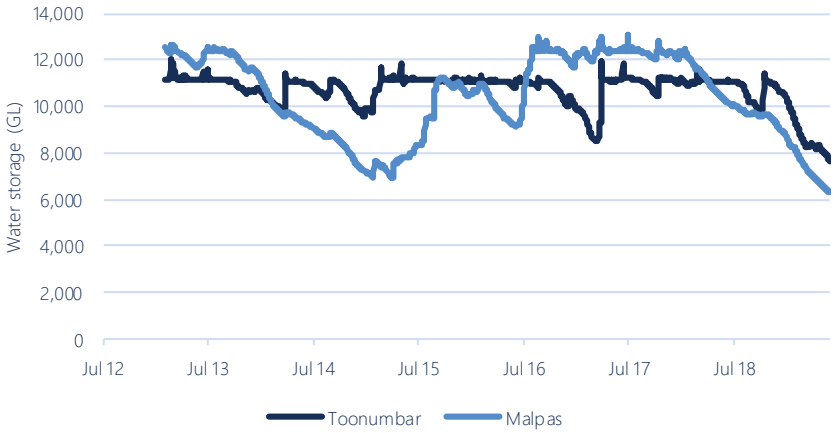


Figure 66 Historical storage volumes of major storages, North Coast, June 2013 to June 2019

North Coast

Market Activity

Coastal water markets are generally relatively less mature than water markets located within the MDB. Water trade data for coastal systems is less readily available. As such, price and volume of trade for allocation and entitlement prices is presented at an aggregated level for all NSW coastal systems — it includes trade data for regulated and unregulated systems within the South East Coast (NSW) drainage division defined by the BoM. The BoM's definition of South East Coast (NSW) drainage division includes all coastal NSW from the border with Queensland along the Great Dividing Range to the Victorian border.

Allocation price trends

- Monthly allocation trade volumes have tended to increase and become more consistent since July 2017.
- Prior to July 2018 monthly allocation prices tended to remain steady at around $30 per megalitre.
- Monthly allocation prices have increased to $60 per megalitre in March 2019 from $30 per megalitre in July 2017.

Entitlement price trends

- Monthly entitlement prices display a high degree of variability between months.
- Since 2011-12 coastal entitlement prices have trended downward.

Long-term market trends and water use patterns

- There has been an increase in permanent horticulture land use over the past 4 years. Permanent horticultural crops such as macadamias and avocados require reliable irrigation.

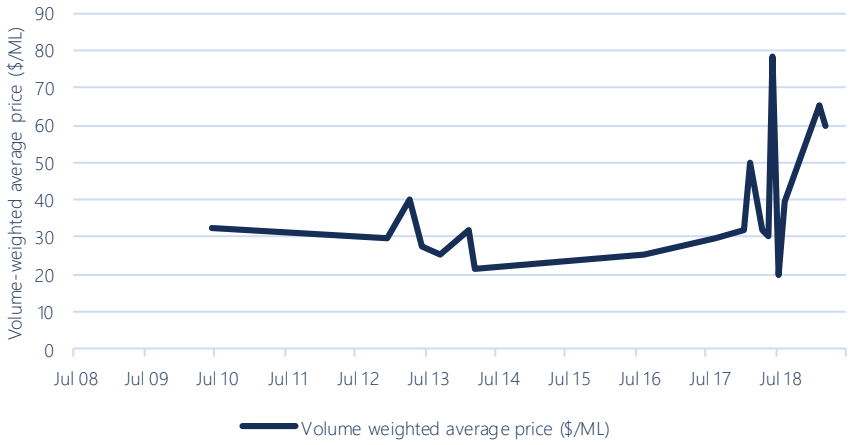


Figure 67 Monthly allocation prices, aggregated NSW coastal systems.

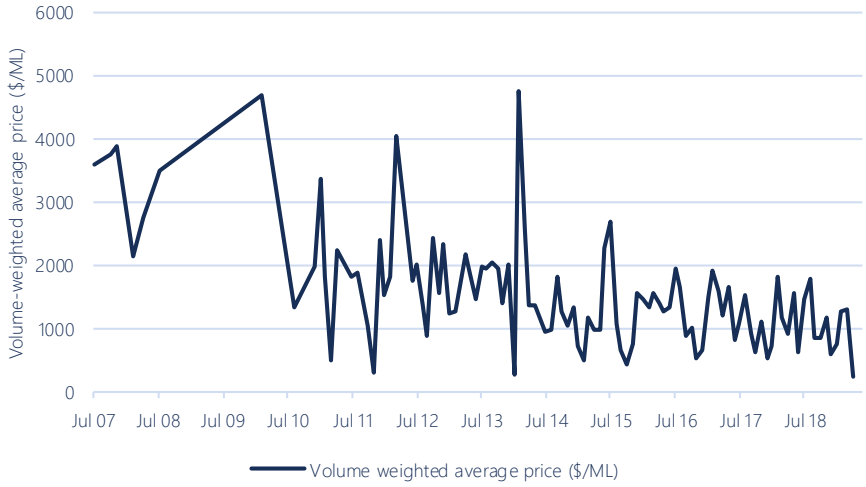


Figure 68 Monthly entitlement prices, aggregated NSW coastal systems.

Coastal Regions

South Coast

The South Coast region is located east of the Great Diving Range, extending south from below Sydney to the Victorian border. The region incorporates several heavily forested catchments, including the Wollongong, Shoalhaven, Clyde, Moruya, Tuross, Bega, Towamba catchments, and part of the East Gippsland catchment.

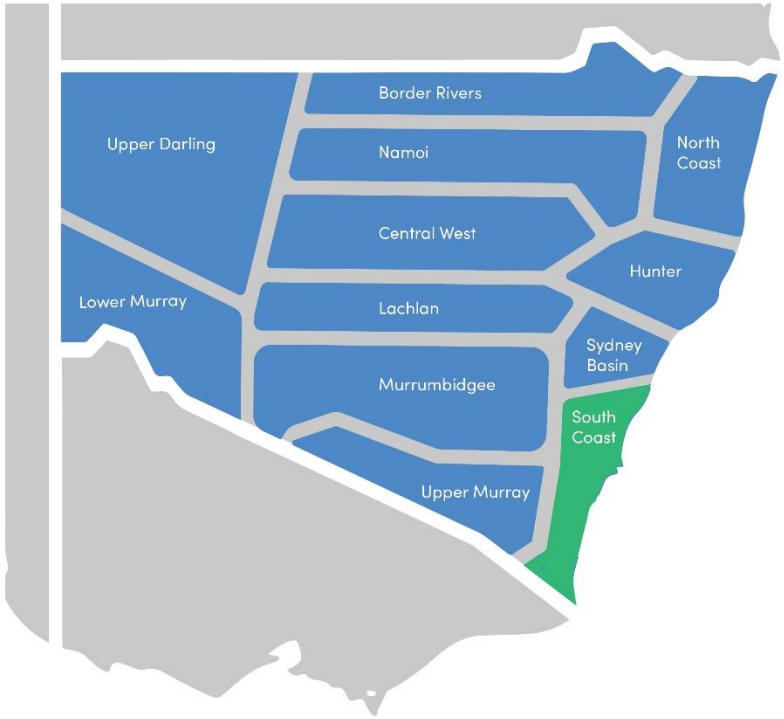
Major rivers include the Shoalhaven, Clyde and Bega rivers. Rainfall in the Bega catchment varies from an annual average of 800 – 1,100 mm. Further north around Ulladulla, annual rainfall is averages around 1,100 mm.

Significant industries include livestock, dairy and cropping agriculture, horticulture, tourism, and mining, especially in the northern areas near Wollongong. The major population centres in the region include Nowra, Ulladulla, Batemans Bay and Bega.

Most of catchments in the South Coast are unregulated, aside from the Bega River downstream of Brogo Dam (8.9 GL), which provides water for irrigated dairy and urban use.

There are some groundwater resources in the region, including the Lachlan Fold Belt Coast Groundwater source, the Sydney Basin – South Coast Groundwater Source and the South East Coastal Sands Groundwater Source.

There are a large number of small water courses on the South Coast, rather than a single large water course.



South Coast

Demand

Major crops in the region

- Pastures — especially for dairy — dominate agricultural production in the region.
- Water use for dairy pastures accounted for 66 per cent of the region's irrigated water use in 2017-18.
- Water use for dairy pastures was significantly higher between 2005-06 to 2008-09, since then the region has observed a decrease in dairy pasture water use.
- Other crops in the region include vegetables such as potatoes and pastures for hay.

Extent and location of irrigation

- The extent of irrigation in the South Coast is relatively small.
- Irrigation occurs along the many waterways in the region such as the Bega and Tuross Rivers.

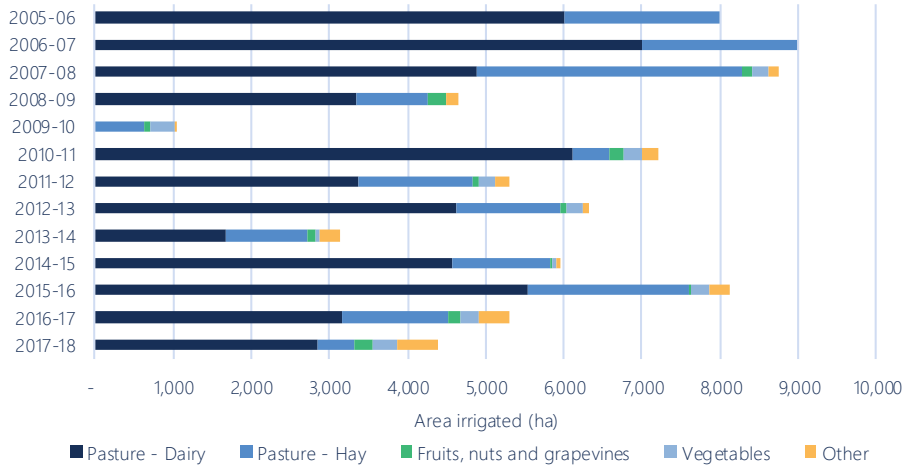


Figure 69 Land use by crop, South Coast, 2005-06 to 2017-18
Note: Pasture data unavailable for 2009-10 from the ABS

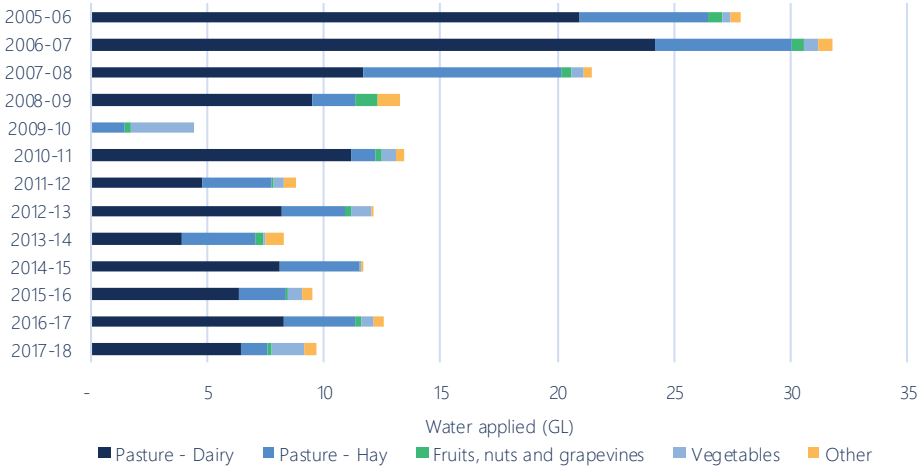


Figure 70 Water use by crop, South Coast, 2005-06 to 2017-18
Note: Pasture data unavailable for 2009-10 from the ABS

South Coast

Demand

Production timings

- Lucerne for pastures is grown year-round although growth slows or stops during winter — particularly in frost prone regions.
- Potatoes can be planted in either winter or late summer for a late spring or winter harvest respectively.
- Wheats and oats are planted in autumn for harvest in November to December.

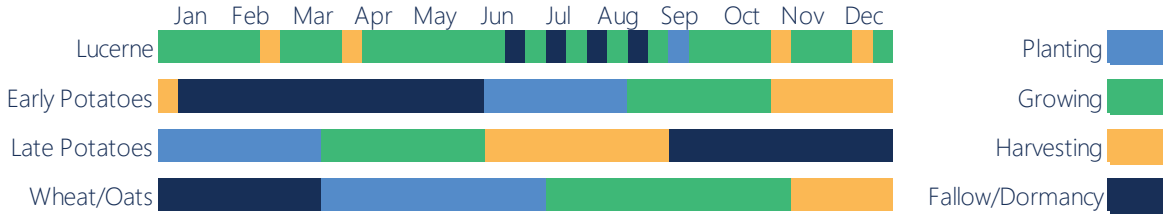


Figure 71 Indicative production schedule of major crops, South Coast

Decision making points

- There are fewer distinct decision-making points in the production cycle due to the semi-permanent nature of dairy production.
- Irrigators will however often rotate between wheat, oats and potatoes.

Demand triggers

- Irrigation is used to supplement rainfall in the region.

South Coast

Storage and Market Activity

Given the largely unregulated nature of water systems in the South Coast, analysis of storage volumes and market activity is limited.

Coastal Regions

Sydney Basin

The Sydney Basin region comprises the Greater Sydney and Central Tablelands NRM Zones. The region includes the Sydney metropolitan area and the Greater Sydney region, which is an area of high population density. The Hawkesbury–Nepean, Parramatta and Georges Rivers are significant waterways in the region.

Within the metropolitan Sydney area, annual rainfall averages range from 1,500 mm in the south-east to 900 mm in the south-west near Campbelltown. The major users of water include the agricultural industry supported by the Hawkesbury–Nepean River system and metropolitan Sydney (Sydney Water Corporation).

The main storages include the Warragamba (2,027 GL), Nepean Dam (67 GL), Avon Dam (146 GL), Cataract Dam (97 GL) and Cordeaux Dam (93 GL).

The region encompasses several groundwater sources.

There are a large number of small water courses, rather than a single large water course.

Sydney Basin

Demand

Major crops in the region

- The Sydney Basin supports a highly diverse agricultural production mix.
- Vegetables account for 30 per cent of irrigation water use in the Sydney Basin. This includes a mix of indoor, undercover and outdoor production systems. Mushrooms, lettuce and Asian vegetables are common vegetables grown in the Sydney Basin.

Extent and location of irrigation

- Irrigated farmland is located along the Nepean and Hawkesbury Rivers to the south and west of Sydney.

Key regional characteristics

- Irrigated agricultural production is mixed with residential, commercial and industrial land use.
- Increasing demand for residential housing and lifestyle farmland is leading to an increase in land prices. In time this will likely lead to a decrease in agricultural production in the region.

Production timings

- Given the high number of smaller and diverse agricultural enterprises, it is difficult to determine production timings in the region.
- Irrigators will generally grow several types of vegetables simultaneously.
- Vegetables are a higher value crop and require reliable irrigation.
- Lucerne and pastures will grow year-round with irrigation used to supplement rainfall.

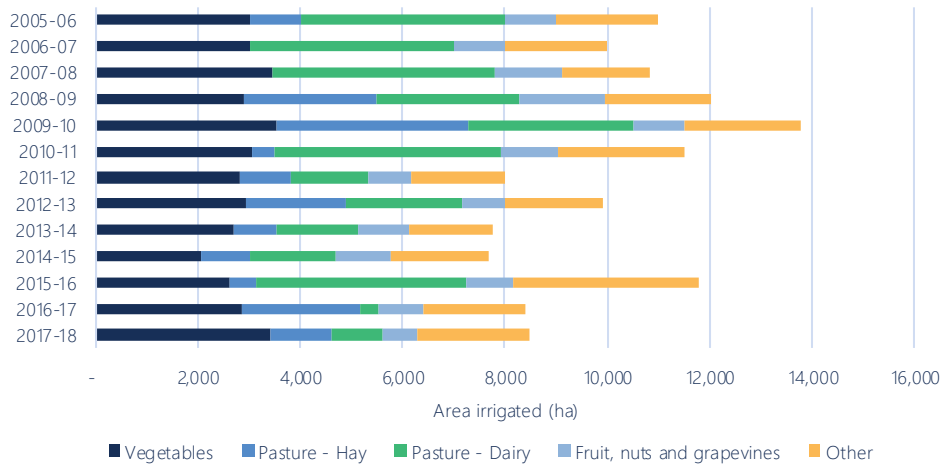


Figure 72 Land use by crop, Sydney Basin, 2005-06 to 2017-18

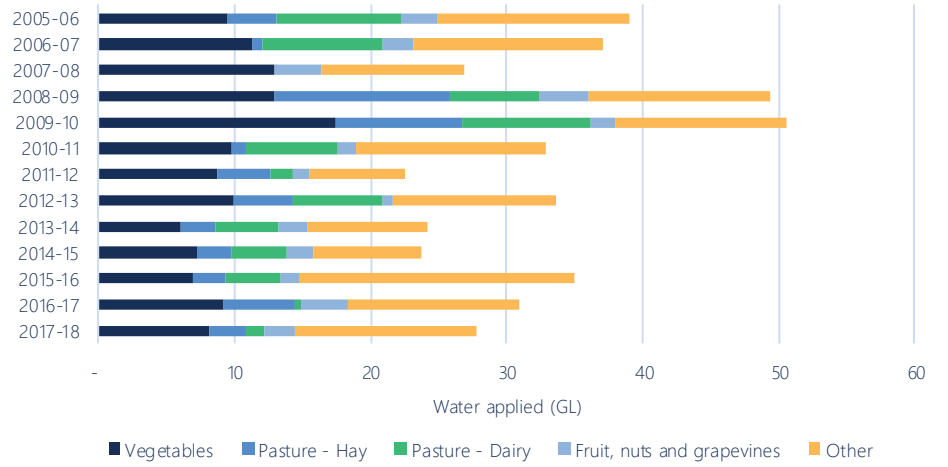


Figure 73 Water use by crop, Sydney Basin, 2005-06 to 2017-18

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Appendix

Table 4 Crop-specific information sources

Crop Type	Source
Almonds	NSW Department of Industry (DPI) 2016, Almond industry expansion, NSW Department of Industry, viewed 20 June 2018, <https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/586435/almond-industry-expansion.pdf>
Canola	Grains Research and Development Corporation (GRDC) 2009, Canola best practice management guide for south-eastern Australia, Grains Research and Development Corporation, viewed 20 June 2018, <https://grdc.com.au/__data/assets/pdf_file/0016/202615/grdccanolaguide.pdf>
Citrus	NSW Department of Industry (DPI) 2016, Australian mandarin production manual, NSW Department of Industry, viewed 20 June 2018, <https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/820624/australia-mandarin-production-manual.pdf>
Cotton	Cotton Research and Development Corporation (CRDC) 2019, Australian Cotton Production Manual 2019, Cotton Research and Development Corporation and CottonInfo, viewed 20 June 201, <https://www.crdc.com.au/sites/default/files/pdf/ACPM%202019%20final.pdf>
Hass Avocado	NSW Department of Primary Industry (DPI) 2003, Agfacts: Avocado Growing, NSW Department of Industry, viewed 20 June 2018, <https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/119739/avocado-growing.pdf>
Lucerne	NSW Department of Primary Industry (DPI) 2003, Agfacts: Lucerne for pasture and fodder, NSW Department of Industry, viewed 20 June 2018, <https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0010/164737/p2225pt1.pdf>
Macadamia	NSW Department of Primary Industry (DPI) 2005, Primefacts: Macadamia culture in NSW, NSW Department of Industry, viewed 20 June 2018, <https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/75740/Macadamia-culture-in-NSW-Primefact-5---final.pdf>
Maize	Grains Research and Development Corporation (GRDC) 2017, Grownotes: Maize, Grains Research and Development Corporation, viewed 20 June 2018, <https://grdc.com.au/__data/assets/pdf_file/0019/244225/GRDC-GrowNotes-Maize-Northern.pdf>
Potato	NSW Department of Primary Industry (DPI) 2004, Agnote: The potato industry in New South Wales, NSW Department of Industry, viewed 20 June 2018, <http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/127194/Potato-industry-NSW.pdf>
Rice	NSW Department of Primary Industry (DPI) 2018, Rice growing guide 2018, NSW Department of Industry, viewed 20 June 2018, <https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/829330/RGG-accessible-22Aug2018.pdf>
Sorghum	Grains Research and Development Corporation (GRDC) 2017, Grownotes: Sourghum, Grains Research and Development Corporation, viewed 20 June 2018, <https://grdc.com.au/__data/assets/pdf_file/0014/322124/GRDC-GrowNotes-Sorghum-Northern.pdf>
Soybeans	Grains Research and Development Corporation (GRDC) n.d., Grownotes: Soybeans, Grains Research and Development Corporation, viewed 20 June 2018, <https://grdc.com.au/__data/assets/pdf_file/0025/370654/GrowNote-Soybean-North-01-Paddock-prep.pdf>
Sugarcane	Sugar Research Australia 2014, Irrigation of Sugarcane Manual, Sugar Research Australia, viewed 20 June 2018, <https://sugarresearch.com.au/wp-content/uploads/2017/02/Irrigation-Manual-F-LowRes2.pdf>
Wheat	NSW Department of Primary Industry (DPI) 2017, Irrigated wheat in southern cropping systems, NSW Department of Industry, viewed 20 June 2018, <https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/832578/IRRICAC-wheat-web-access.pdf>