final report

Project code:	B.FLT.8008
Prepared by:	Grant Leslie and Richard Hardy Balmoral Group Australia Valerie Seidel, Dan Dourte, David Osorio, and Justin Pepito The Balmoral Group
Date published:	12 October 2018

PUBLISHED BY
Meat and Livestock Australia Limited
PO Box 1961
NORTH SYDNEY NSW 2059

Water Security for the Australian Feedlot Industry: Solutions and Recommendations

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Executive summary

The purpose of this project was to evaluate current and future feedlot water demands and to better understand the regulatory/policy concerns related to water in order to identify ways to ensure future feedlot water security. The final report combines the analyses from the Regulatory Assessment and the Water Demand estimation to propose recommendations for near-term and long-term feedlot water security in Australia.

Risks to Water Security

A thorough review of all relevant water regulations and policies was completed in order to evaluate water-related regulatory risks. The regulatory review and modelling reveal that there are varying degrees of risk associated with timely access to future water resources. Sources of risk associated with water access entitlements can be broadly categorised into four categories:

- Sovereign risk
- Regulatory risk
- Market risk, and
- Hydrological or resource risk.

These risks manifest themselves through their potential to impact on:

- Access to water under the entitlement
- Tenure and security of the entitlement
- Transferability and liquidity of the entitlement
- Quality of the title of the entitlement, and
- Water allocation announcements.

The degree of risk varies by State and in some cases by catchment. An overview of the State-level situation is provided in the report, and issues warranting careful monitoring are highlighted for action.

Water Demand Estimation

A model of feedlot cattle numbers was developed to project future numbers on feed which was used in conjunction with a cattle water use model predict future feedlot water demands. The head on feed model was developed using historical data regarding livestock on feed and associated water use. Cattle on feed quantities were best replicated using local data on rainfall, exchange rates, feed costs, Asian exports, and a dummy variable demarcating years after 2013 when Chinese imports of Australian meats rose rapidly. Using the coefficients developed from the historical data, forecast data for each variable was used to simulate future conditions and estimate future numbers on feed through 2030. Feedlot operators were interviewed to determine if model estimates and assumptions were reasonable. Some sourcing differences were identified, but in general the model output was deemed realistic and useful for estimating feedlot water needs.

A number of water intake models were evaluated, and the Parker et al 2000 model was selected. Using the Parker et al 2000 model in conjunction with the numbers on feed model, estimated average daily feedlot water requirements were estimated.

Climate projections were evaluated using data and reports from Climate Change in Australia (CCIA; CSIRO and BOM 2015). Four Representative Concentration Pathways (RCPs) were used to estimate future water needs. The RCPs show changes in future maximum temperature from 1% -17% increase, while relative humidity may change up to 30%, depending on RCP and location. The projections were estimated through 2030, and spatially joined to calculate total annual water consumption for 473 feedlots.

The analysis finds that future water use per head increases up to 13% from historical usage depending on the climate scenario (RCP) and location/state. Overall, total feedlot water needs across Australia increase by 14 to 20% by 2030, with about half the increase attributable to economic or environmental factors, and the other half to elevated temperature projections driving up per-head water demand. However, at a State level, the variation is more pronounced, as can be seen in Table 1.

Table 1. Summary of Projected Feedlot Water Demands through 2030 (in ML)

State	2017	2030 RCP2.6	2030 RCP4.5	2030 RCP6.0	2030 RCP8.5
NSW	5,942	6,037	6,121	6,161	6,368
QLD	10,989	12,196	12,343	12,353	12,866
SA	492	811	814	830	835
VIC	1,027	1,699	1,714	1,739	1,774
WA	600	936	936	958	948
TAS	195	219	220	221	225
Total	**19,245**	**21,898**	**22,148**	**22,262**	**23,017**

Source: BGA Work Product

Key Findings and Recommendations:

Recommendations for influencing policy and improving education/training were identified from regulatory and industry research.

1. Water Sharing Plans/Water Resource Plans are in the process of updates currently, and those within The Murray-Darling Basin require submittal for government endorsement by February 2019. This creates some urgency for preparing submissions to protect the interests of feedlot operators in relevant catchments. Information is included identifying those which affect numerous feedlot operators and warrant formal comment to protect the interests of feedlot operators.
2. In a related vein, water reuse may be a cost-effective source for some feedlot operators in future, if town water incorporates proper distribution systems to accommodate this use. Feedlot operators may be able to claim a re-credit to their allocation by using reclaimed water. Water Sharing Plans/Water Resource Plans may be an appropriate venue to validate such arrangements, as many regional utilities will be upgrading plant facilities in the near future.
3. Under the Murray-Darling Basin Water Infrastructure Program announced on 18 July 2018, funding is available for cost share projects to include retrofits or upgrading of on-farm water efficiency projects and off-farm improvements to channel systems stock pipelines and so forth; feedlot operators may wish to aggregate interests to pursue funding in Queensland, South Australia and Victoria.
4. On-farm storage and rainwater harvesting is governed by various regulations that vary by state. Ensuring that additional states do not adopt legislation that reduces feedlot operator flexibility in on-farm storage should be a priority for feedlot operators.
5. High security water, whilst more expensive upfront, provides greater economic certainty for feedlot operators, and should be purchased in the normal course of business. Where only general security water is available, it should be purchased for allocations only.
6. Opportunities for MLA or ALFA to source and supply seasonal forecasts and market information from industry experts to feedlot operators exist. Consistent climate and market information sharing will allow feedlot operators to make timely and informed management decisions.

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1 Background

1.1 Water in Australia: Regulatory Basics

1.1.1 What does a water access entitlement confer?

There is a wide array of different types of water access entitlements between and within Australian jurisdictions. Fundamentally, however, a water access entitlement provides its holder with a number of rights and obligations. The rights conferred by these "water access entitlements" typically encompass conditional rights to access or withdraw water, rather than ownership of the resource itself.

Water access entitlements can be conceived of as comprising several key components (see Box 1) **Please also refer to the full report for specific information of your own State or Territory as Western Australia and Tasmania in particular do not issue permanent entitlements only shorter-term licences.** The full summary regulatory report and the full regulatory report are included in Appendix **9.1 and 9.2.**

Box 1 Rights and Obligations of a Water Access Entitlement

Access to water allocations

Water access entitlements held by end users are typically defined in the form of a unit share of the sustainable yield in a specified water resource, with a specified reliability or probability of delivery. The actual volume of water available to water access entitlement holders in a season will depend on allocation decisions made by the supply authority given the water supply situation at the time. In several States, both the long-term entitlement and the annual allocations made available under them are determined in the context of formal water resource plans developed for specific catchments/basins.

Water Delivery Rights

Water delivery rights have in parts of NSW Victoria and Queensland been unbundled from water access entitlements. Water delivery rights in some cases are now required to have water delivered from its source to the point of delivery (and for which separate charges are payable to the supply authority). In Queensland explicit delivery contracts exist with SunWater. In some parts of NSW and Victoria the water delivery rights are managed by local supply authorities.

Use

Some licences also provide the right to actually use the water under a water access entitlement for defined purposes on specific parcels of land. In other cases, separate site use approvals are required. Site use approvals are designed to ensure that the proposed location and use of water is environmentally sustainable.

Right to transfer

The extent to which the holder of a water access entitlement is able to transfer the entitlement to another party in whole or in part varies across different entitlements and between States. These trading rules are typically specified in other instruments such as primary and subsidiary legislation, water resource plans, and irrigation scheme constitutions.

Obligations

A range of conditions and obligations generally attach to water access entitlements. Typically these include various conditions pertaining to the way in which water can be taken and used, and also financial obligations associated with holding of an entitlement and delivery of water.

In the past, many of these components tended to be “bundled” together within the one license. As discussed further below, however, there is now a trend towards “unbundling” these components into separate instruments and allowing some to be traded separately. Indeed, the extent to which it is tradeable in whole or in part to another party is a key feature of a water access entitlement.

A key implication is that full rights and obligations of a water access entitlement cannot be fully gauged simply by inspecting the water access entitlement instrument itself. Rather, the rights and obligations specified in a water access entitlement need to be read in conjunction with related instruments – such as water resource plans and rules for the relevant region, and site use approvals - that may qualify or enhance these rights and obligations. Another example is water delivery rights that limit the amount of allocation that can be delivered through specified infrastructure that has limited capacity.

1.1.2 What types of water access entitlements are there?

Although there is a progressive move towards conversion to more clearly specified entitlements, there are many different types of water access entitlements in existence and are likely to be for some time.

The existing array of water access entitlements can be usefully seen as having various (not mutually exclusive) dimensions or characteristics, including:

- The use or purpose of the entitlement;
- The source of the water;
- The legal form of the entitlement; and
- The level of devolution in the supply chain.

The use or purpose of the entitlement

Existing water access entitlements for consumptive purposes generally distinguish – explicitly or implicitly – between uses such as irrigation, stock and domestic, urban supply, mining and industrial use. In addition, specific entitlements apply for other non-consumptive uses (principally hydro-electric power generation). At the highest level, a distinction can be made between consumptive and non-consumptive uses of water. In most Australian jurisdictions, allocation of water for the environment has prior right to be satisfied before allocation to consumptive use and is generally defined as environmental flow obligations imposed on supply authorities. These environmental allocations are not tradeable with other uses. However, in additional to this environmental allocation, the various environmental water holders have also purchased other water access entitlements from consumptive users for example NSW general security in a specific Water Sharing Plan. In certain circumstances these water access entitlements and associated allocation owned for the benefit of the environment may be traded by the Commonwealth Environmental Water Holder (CEWH) in accordance with the Water Act 2007 (Cth).

The source of the water

Existing water access entitlements can be distinguished according to the source of water to which they relate. At a generic level this includes regulated rivers and supply systems (i.e. where the flow of the river is regulated by large structures such as dams or weirs), diversions from unregulated rivers and streams (i.e. where the flow of rivers or streams is not regulated by large structures such as dams or weirs), groundwater systems (subartesian and artesian), and overland flows. At a local level, water access entitlements relate to specific water sources.

The legal form of the entitlement

Entitlements to access water may be specified in a variety of legal forms including primary and subordinate legislation, licenses, leases, contracts or agreements, and tradeable instruments. As noted above, the ability to take water or interfere with waterways is generally governed by various forms of licenses that are issued, monitored and enforced by government agencies responsible for water resource management.

The way in which these water access entitlements are recorded or registered varies between jurisdictions, with some having established titling systems similar to land titles and others with less formal departmental registers. In addition, irrigation companies maintain their own registers of water entitlements and shares in their schemes.

The level of devolution in the supply chain

Different types of water access entitlement are held by bulk users, such as urban and irrigation infrastructure operators and individual users.

In urban settings, the level of devolution is generally at the bulk supply level. Urban infrastructure operators hold entitlements to bulk water and are obliged to supply individual domestic and non-domestic customers who themselves have no separate entitlements. Customers only have a contractual right to connection and supply.

In rural settings, irrigation infrastructure operators also typically hold some form of entitlement to bulk water, but individual irrigators often have more clearly defined beneficial entitlements – for example individual water access entitlements and 'shares' in the irrigation company entitlements, and, in some cases, contractual rights to delivery.

2 Project objectives

The goal of this project is to improve the understanding of the regulatory and environmental risks to water security for the Australian feedlot industry, and to recommend the most promising solutions to improve feedlot water security. The objectives include:

- Review State and Federal water regulation/plans to identify current instruments used to allocate surface and groundwater to the feedlot sector.
- Identify current and future water demand within the Australian lot feeding sector and assess if there are any regulatory gaps that limit the sector's water security and the current needs and future growth of the sector.
- Identify state and national based opportunities to address regulatory gaps, inconsistencies and risks to ultimately maximise the lot feeding sector's water security both now and into the future.

3 Methodology

Appropriate methodologies were developed to address each objective, which are addressed in turn.

3.1 Review State and Federal water regulation/plans

For the first objective, a water law legal expert was retained to address state and federal regulatory matters relevant to the meat and livestock industry. The assessment included an overview of commonwealth and state hierarchical authority to adjudicate water issues, and described the current structure of water regulation administration. As the predominant influence to water law affecting the meat and livestock industry falls under the Murray-Darling Basin Plan, the interstate compacts negotiated to achieve the MDB Plan were also reviewed and summarized. Fig. 1 shows the inter-relationships between the states and the Murray-Darling Basin Plan ("The Basin Plan"). An in-depth explanation of the structure of the Murray-Darling Basin Plan Authority and overarching state and federal legal structure of governing regulations is provided in the detailed legal review, which is incorporated herein as Appendix 9.2.

3.2 The Basin Plan

The Basin Plan is a statutory instrument under the Water Act and like statutory regulations it is required to be tabled in both Houses of Parliament and is subject to a motion for disallowance.

The Basin Plan determines the long-term average sustainable diversion limit (SDLs) in volumetric terms that can be extracted or taken annually from the Basin for consumptive use (urban, industrial and agricultural). The diversion limit is determined to be a volume of extraction that will not have a negative impact on the natural environments and the functions of the rivers, waterways, groundwater and wetlands of the Basin. The SDLS are done for each Basin State and the ACT on a water plan by water plan and in some cases zones within water plans for both surface water and groundwater plans. See Map 1 of the MDBA surface water plans and Map2 groundwater plans below.

The MDBA determined that the long-term average environmentally sustainable level of take for surface water in the Basin is 10,873 gigalitres per year. To achieve this level of take, the Basin Plan determined that 2,750 gigalitres surface water per year would need to be recovered from the 2009 baseline diversion level (BDL). In April 2015 the Commonwealth Government legislated that water buy backs would be limited to 1500 gigalitres and the balance of the surface water reduction would need to be achieved through infrastructure efficiencies. If the MDBA Northern Basin Review was approved by Parliament the recovery figure would have been reduced from 2750 gigalitres per year to 2680 gigalitres per year.

For groundwater, the MDBA determined that the environmentally sustainable level of take was to be 3,324 gigalitres per year. The 2009 BDL of groundwater was 2,385 gigalitres per year, therefore diversion levels can sustainably be maintained or increase in all but one of the 66 groundwater units in the Basin.

The Basin Plan came into effect in November 2012. A 7 year period (2012–19) was set for water users and managers to reduce extraction levels, in regions where a reduction was required. Some reduction was achieved prior to the Basin Plan coming into effect in 2012 through water recovery buy back programs operating through 2009–11. The Basin Plan is proposed to be fully operational by 2024.

Since the Basin Plan was foreshadowed, water has been recovered through water entitlement buy backs by the Australian Government. The level of buy backs has caused significant issues within a number of water plans and created stranded asset problems as water entitlements were transferred to the environment from high value water infrastructure. Additional problems were created because the buy back was targeted at lower value general or low security water entitlements with low levels of allocation (volumetric) reliability. This buy back policy was problematic because it focused on the acquisition of water entitlements whilst the reduction was volumetric (allocation). The buy back has created an ongoing shortage of general or low security water for annual crops. The Murrumbidgee has been and continues to be severely affected by the Basin Plan.

The SDLs will commence in 2019 through state government water resource plans. However, the limits for each river valley and groundwater unit may be increased or decreased during the implementation phase of the Plan (2012–19) on the recommendation of the MDBA, depending on the outcomes of infrastructure efficiency programs and new environmental watering regimes.

The MDBA completed the review of the water plans and water recovery in the Southern Basin in October 2016. Total surface water recovery for the 41 affected communities was 1033.9 gigalitres with the net reduction available for consumptive use being estimated at 810 gigalitres.

The MDBA for example proposed the surface water recovery target in the Northern Basin water plans (reduction in water available under the existing State water plans) be reduced by 70 gigalitres from 390 gigalitres to 320 gigalitres.

The Basin Plan also addresses:

- water quality issues in the Basin;
- environmental watering by the CEWH;
- the assessment of State and ACT water resource plans;
- water for critical human needs (availability of drinking water);
- water markets and water trading;
- ongoing review and implementation.

3.3 Status of The Basin Plan

The status of the MDB Plan as at September 2018 is uncertain due to the potential for the change of Government at the next election. From the standpoint of the Australian Lot feeders Association (ALFA) interests, there are key points for monitoring.

Feedlots within the MDB require reliable water supply and would sensibly obtain:

- a water connection to the town mains;
- Groundwater licence and water entitlements;
- High security surface water irrigation water entitlements and delivery rights.

Buy backs of general security water entitlements in the Northern and Southern Basin have placed the production of annual crops and in particular fodder under significant pressure. It is anticipated that the on-market price of allocation water will rise particularly in times where allocation announcements are reduced.

The NWI with the Commonwealth has been signed by all States and Territories. Western Australia and Tasmania have not passed legislation introducing permanent water entitlements and still operate on a temporary renewable licence basis. This creates a significant commercial risk to feedlot owners as the current legislation does not require these licences to be renewed.

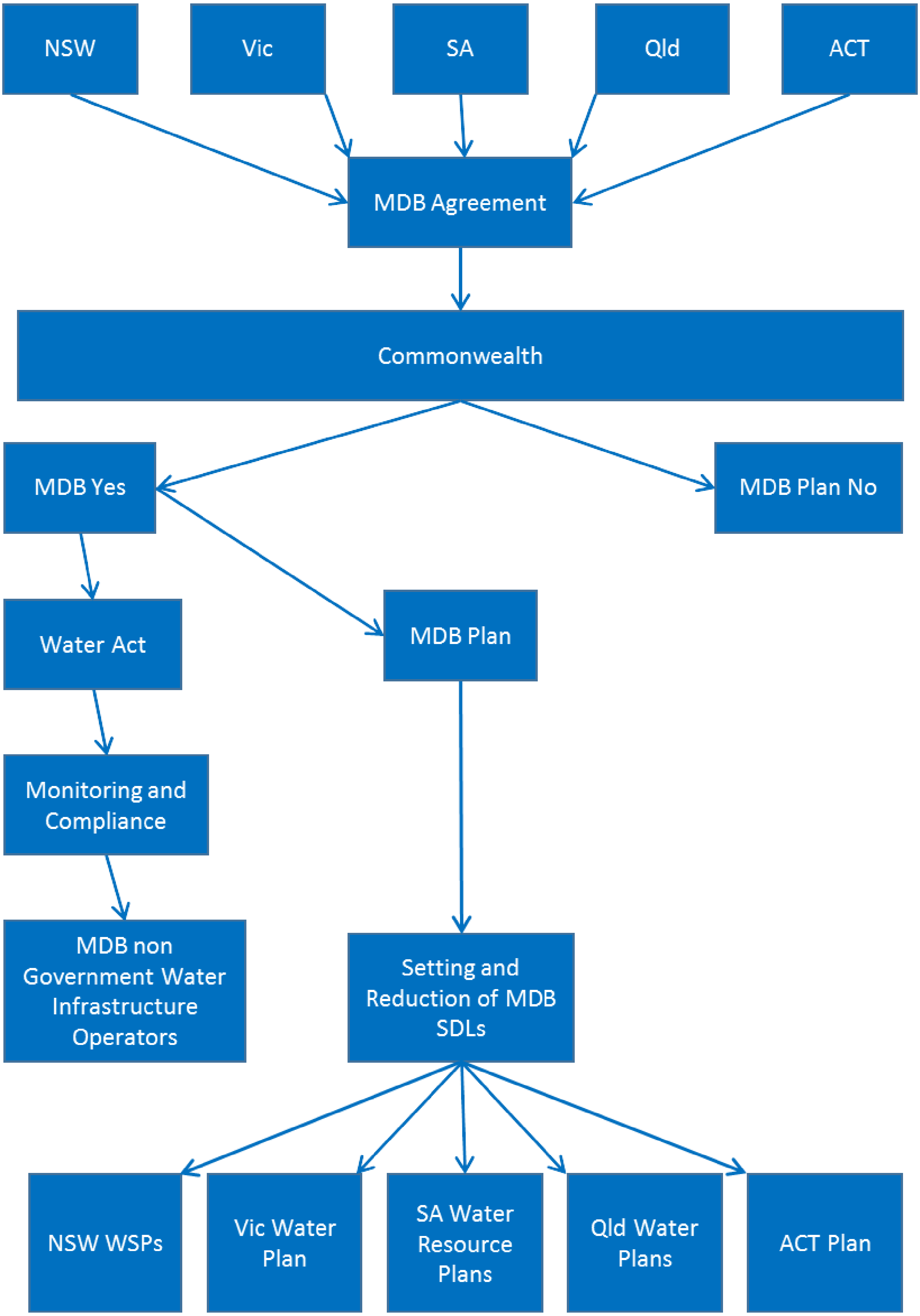

Fig. 1 MDB inter-relationships

Source: BGA Work Product, with Mattila Advisory

3.4 Modelling Current and Future Feedlot Cattle and Water Demand

The second objective was to identify current and future water demand within the Australian lot feeding sector, and assess if there are any regulatory gaps that limit the sector's water security and the current needs and future growth of the sector. To estimate current and future water demand, a model was developed to both quantify and spatially distribute water demand across Australian feedlots. Sections 3.4.1 through 3.4.3 describe the data and techniques used to develop the demand estimates.

3.4.1 Cattle on Feed Model Development

Industry data, reports, and literature on cattle numbers were reviewed to evaluate the important factors driving cattle numbers in Australia and to determine if there were existing models suitable for estimating numbers of Australian cattle on feed. No suitable model was found, and model development proceeded by determining the most relevant determinants to build a model that estimates the number of cattle on feed by state. Numerous environmental and economic factors were evaluated (see all candidate variables in Table A-1 in Appendix 9.3).

The model of cattle numbers on feed was iteratively fitted using various combinations of input variables, with each variable being evaluated in terms of statistical significance (p-value), impact on model performance (R^2, Akaike information criterion (AIC)), and the direction of impacts predicted (for example, does a decrease in rainfall result in an increase in numbers on feed as might be expected holding all other factors equal). This led to a dataset that comprised annual data between 1998 and 2017 for New South Wales, Queensland, South Australia, Victoria and Western Australia. Data sources to compile the dataset include MLA, the Department of Agriculture and Water Resources, the Reserve Bank of Australia, and the Australian Government Bureau of Meteorology. The final model form was a multiple linear regression with variables including: total annual rainfall (in mm), the exchange rate of Australian dollars in U.S. dollars (lagged one period), grain price index (lagged one period), heavy steer prices (MLA – Australia saleyard 500-600 kg C4), beef and cattle exports to Asia, a dummy variable indicating China export significance, and location attributes including variables identifying states for New South Wales, Queensland, South Australia and Victoria. Tasmania numbers on feed were modelled separately because historical Tasmanian numbers on feed were not available.

Several model specifications such as Ordinary Least Squares, Panel and autocorrelation model regressions were tested to reduce model autocorrelation. The best results to estimate the number of cattle on feed (in terms of alignment of the signs of the coefficients with the hypotheses, level of significance of the variables and diagnostics tests) were obtained using Ordinary Least Squares regression analysis. However, having an adjusted R^2 as high as the one in the developed model indicates that some amount of autocorrelation is likely still present in the model. Appendix 9.3 provides further detail on the model inputs and an example of the application of the model.

Given that there was no historical data available for the feedlot in Tasmania, it was not possible to include it in the analytical model. The only available data was the feedlot capacity (16,000 head). Therefore, the process to estimate the cattle on feed was to calculate the ratio of cattle on feed to capacity of the other 472 feedlots, average them and multiply the average of every year by the Tasmanian feedlot capacity. This produced numbers on feed for the Tasmania feedlot that are similar to the average of Australian beef cattle feedlots in terms of capacity utilisation.

3.4.2 Developing Dataset of Future Variables

The production of a future data stream for each of the variables mentioned above involved a multi-step process. Data and reports from Climate Change in Australia (CCIA; CSIRO and BOM 2015), provided rainfall projections to produce state-wide annual rainfall between 2018 and 2030 under different Representative Concentration Pathways (RCPs). These include a low emission scenario (RCP2.6), intermediate emissions scenarios (RCP4.5 and RCP6.0) and a high emissions scenario (RCP8.5). Further explanation on CCIA projections and the method used to produce annual climate projections can be found in the "Future Climate Projections" section.

Forecasts for exchange rate are from the Jacobs (2015) report on Material Cost Escalation from 2016 to 2022. From 2023 onwards, BGA employed a model from Zorzi and Rubaszek (2018) on exchange rate forecasting in advanced countries with flexible regimes (see additional details in Appendix 9.3.1).

The OECD Agricultural Outlook database (OECD 2018) provided projected data up to 2026 for several commodities, including beef & veal, wheat and other coarse grains. First, historical producer prices for beef & veal, were deflated to 2017 dollars. These were compared with the heavy steer prices used in the regression analysis and a subsequent linear regression was run for heavy steer prices as a function of OECD's beef & Veal producer price. A best-fit trend line with a logarithmic functional form was built for the remaining four years. Fig. 2 shows both historical and future prices up to 2030 of heavy steers.

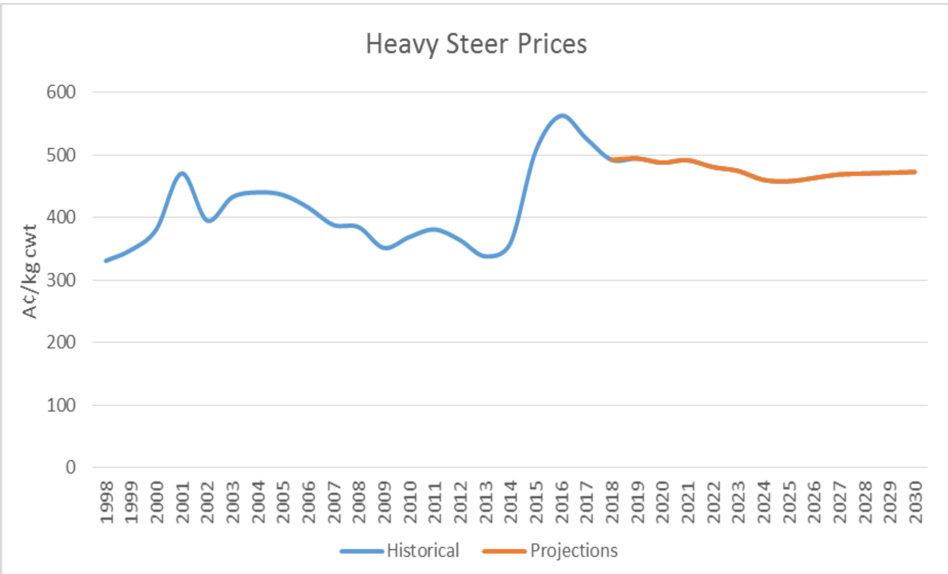

Fig. 2 Heavy steer prices

Source: MLA Statistics Database; OECD-FAO Agricultural Outlook Database; BGA Work Product

This same process took place for wheat and other coarse grains, where a linear regression was built for the grains price index as a function of OECD's wheat and other coarse grain producer prices. The obtained coefficients were then applied in order to estimate the grain price index up to 2026. From 2027 to 2030, a best-fit trend line with a midpoint between cubic and exponential functional forms was used (Fig. 3).

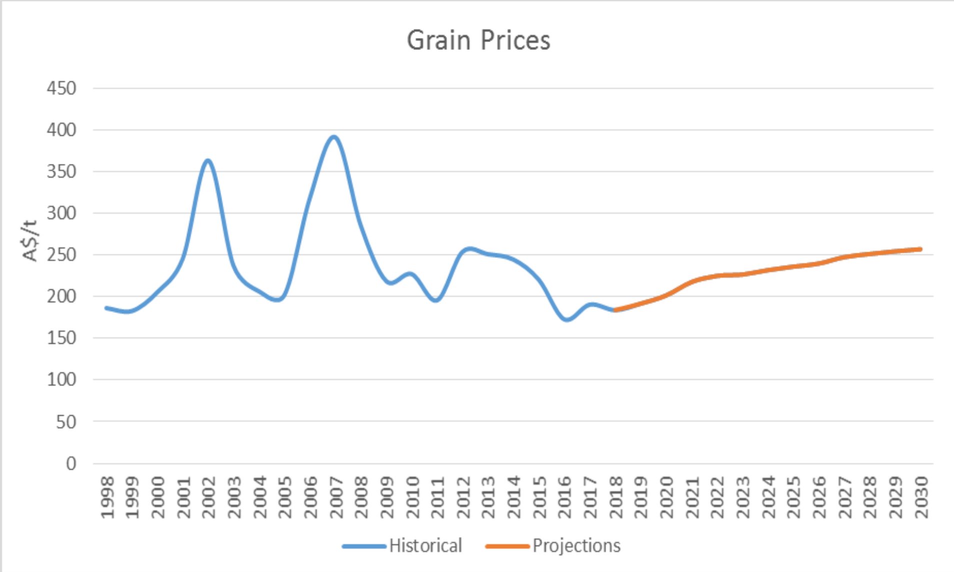

Fig. 3. Grain prices

Source: MLA Statistics Database; OECD-FAO Agricultural Outlook Database; BGA Work Product

Given that there are projections for total Australian beef exports produced by MLA and OECD, average ratios were estimated between the annual beef exports to Asia used in the regression analysis and total beef exports from both data sources for the last ten years. These ratios were then multiplied to the projections of total beef exports up to 2026 (for OECD beef projections) and up to 2022 (for MLA projections). The process to estimate the remaining years was similar as the one mentioned above for heavy steer and grain prices. Since results vary widely between functional forms and time ranges, a midpoint line between results with MLA projections and OECD projections was used. Finally, the obtained forecasts were distributed by state of production based on each state's average share of exports to Asia between 1998 and 2017. Historical and future exports to Asia are shown in Fig. 4.

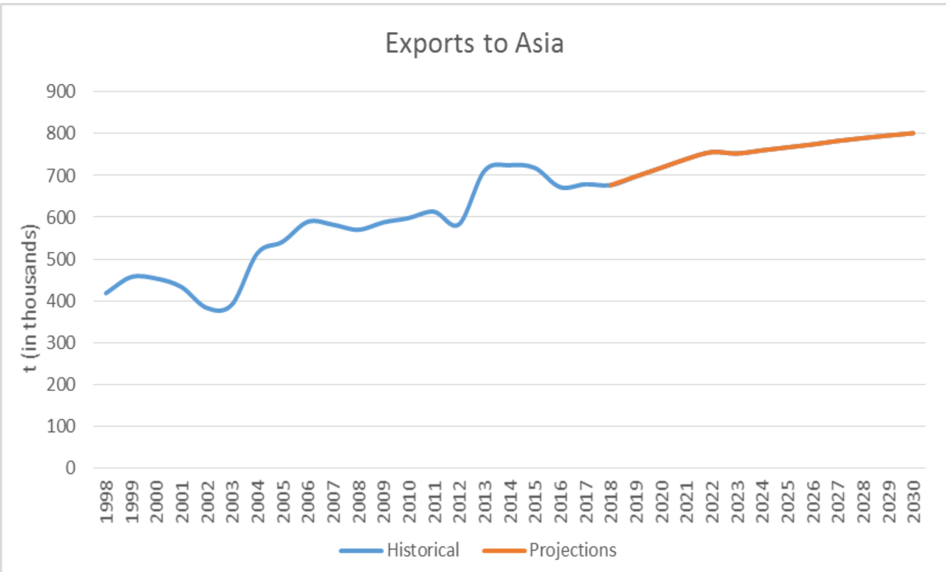

Fig. 4. Exports to Asia (in thousands)

Source: Australian Department of Agriculture and Water Resources Red Meat Statistics; MLA Beef Projections; OECD-FAO Agricultural Outlook Database; BGA Work Product

3.4.3 **Cattle Feedlot Water Demand**

The water demands of beef cattle feedlots were calculated by combining the historical and projected numbers on feed with the results of a daily feedlot cattle water consumption model.

3.4.3.1 Background: water demand model

Several recent feedlot water use assessments were reviewed to evaluate feedlot water usage and to assist with selection of a feedlot water demand model (Davis and Watts 2016, Davis *et al.* 2011, and Davis and Watts 2011). About 90% of feedlot water use can be attributed to direct consumption of water by cattle (Davis and Watts 2016), and the remaining 10% is divided among feed processing, cattle washing, and miscellaneous uses. This water use distribution is consistent with feedback from phone interviews. The most important environmental factors affecting cattle water consumption have been estimated by some to be (in decreasing order of importance): solar radiation, relative humidity, average daily temperature, rainfall, and dry matter intake (DMI) (Sanders *et al.* 1994). A similar study found temperature, relative humidity, solar radiation and wind speed to be the environmental factors with the strongest influence on cattle water consumption (Lyndon 1994).

Numerous cattle water intake models were evaluated based on model performance and data requirements. These models included: Winchester and Morris 1956, Hicks *et al.* 1988, Sanders *et al.* 1994, Parker *et al.* 2000, and Arias and Mader 2008. The models dependent on DMI required too many assumptions about breed and diet to be useful here. The Parker *et al.* 2000 was selected for use in this project based on its high performance in Australian feedlots (Carter 2008) and its low data requirements. Only daily maximum temperature (Tmax) and minimum relative humidity (RHmin) are required. The following equation shows the functional form of the Parker model:

$$DWU = 39.2 - (0.648*Tmax) + (0.0421*(Tmax^2)) - (0.0717*RHmin)$$

Where DWU (L/head/day) is the daily feedlot water use, Tmax is the maximum daily temperature (°C), and RHmin is the minimum relative humidity (%). Based on a graphical evaluation of the Parker *et al.* 2000 water use model, Carter (2008) suggested that the Parker model slightly overestimates feedlot cattle water used. This was based on roughly two years of measured water use at the Wainui Feedlot (Darling Downs, 2007-2008 observed feedlot water use).

3.4.3.2 Historical Climate Data

The model of annual state-specific numbers on feed used historical rainfall data. Both seasonal and annual rainfall totals (averaged for each state) were tested; the annual rainfall totals (mm/year) were used in the final version of the model. State averaged annual rainfall totals for 1998-2017 were retrieved from Australia's Bureau of Meteorology (BOM 2018a).

Historical average monthly Tmax and RHmin data were retrieved from Australia's Bureau of Meteorology (BOM 2018b). Station-based RHmin data were only available as historical, monthly means; this necessitated the use of monthly mean values for the Tmax and RHmin data. The locations of the 473 feedlots were joined to the closest BOM climate stations that had at least 20 years of data. Stations were excluded if the ending period year of the record was before 2009. This resulted in 53 stations being assigned to the feedlots. The average period of record for the stations used was 1950-2015. The impact of this period of record compared to the 1998-2017 period was tested, and it was found that use of the longer historical period of record had a negligible impact on the water use per head.

R code was developed to spatially join the feedlots to nearest stations, bulk download the climate data, and process the climate data into a format that could be readily used for the calculations of feedlot water demand. Resulting locations for historical climate and feedlots can be seen in Fig. 5. Average historical monthly values of Tmax and RHmin were used (from the station nearest to each feedlot) in the Parker model to calculate daily water use values for each month which were then aggregated to yearly totals. The historical values of Tmax and RHmin from station data were used to estimate the historical feedlot water demands; these historical average water demands per head can be considered to be representative of historical and baseline (current) feedlot water demands.

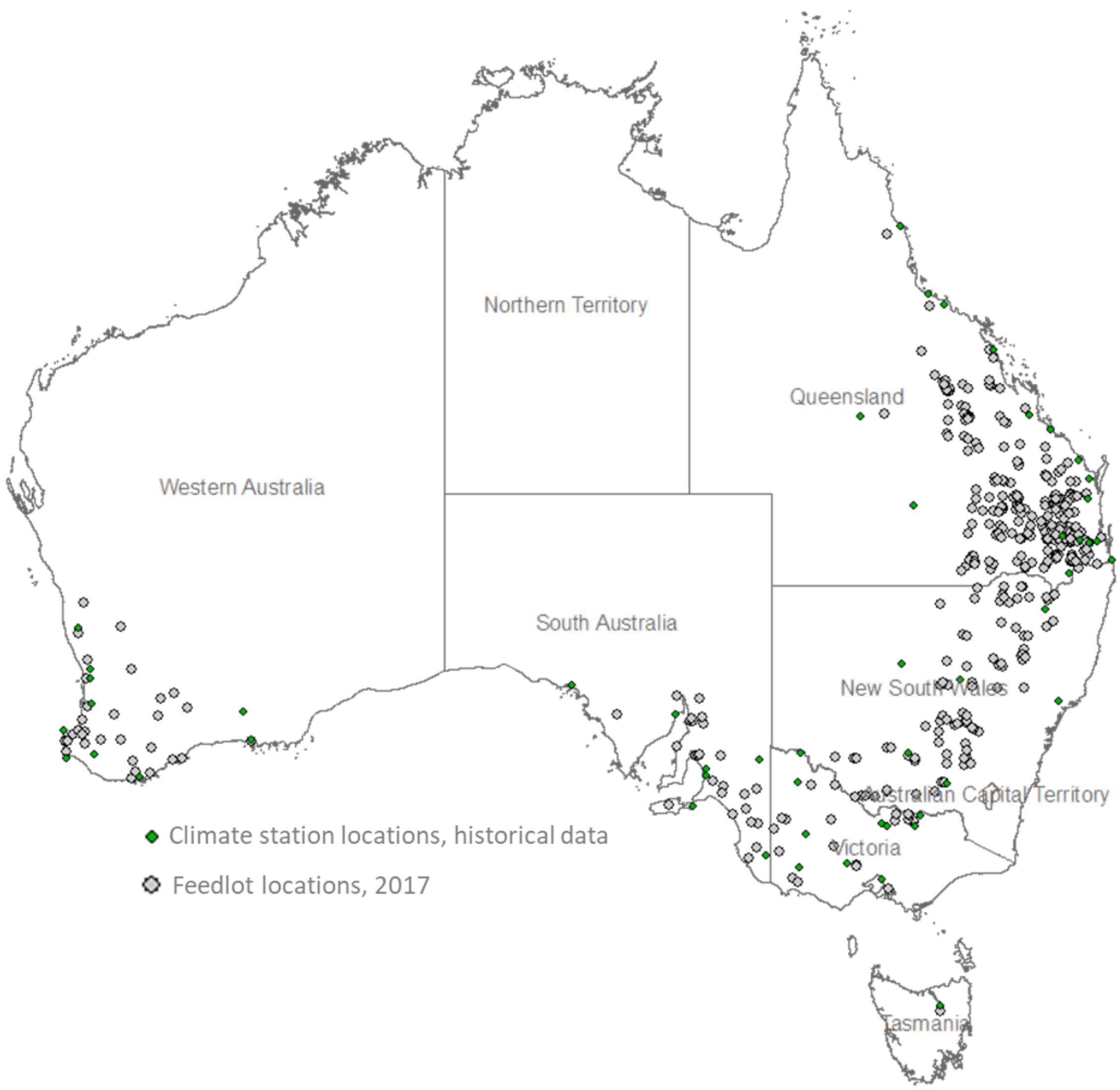

Fig. 5. Historical climate and feedlots locations

Source: BGA Work Product; climate stations from AU BOM; feedlot locations from MLA

3.4.3.3 Future Climate Projections

Projections of future annual rainfall were retrieved and processed to model cattle on feed for the future period from 2018-2030. Projections of future Tmax and RHmin were retrieved and processed to model the daily cattle water consumption from 2018-2030. The data and reports from Climate Change in Australia (CCIA; CSIRO and BOM 2015) were used as the basis for the future climate variables required here. The modelling foundation of CCIA projections is the same as that of the Intergovernmental Panel on Climate Change (IPCC): the CMIP5 models (fifth phase of the Coupled Model Intercomparison Project) were used. The CMIP5 models include about 40 global climate models from 20 climate-modelling groups. CCIA evaluated the skill of all 40 models at predicting Australia's historical rainfall, temperature, sea level pressure, circulation patterns, and other important climate variables. Based on that assessment, eight of the 40 models were selected for use in projecting Australia's future climate.

Projected changes in climate have been made for four different Representative Concentration Pathways (RCPs) in order to account for a variety of possible future land use, greenhouse gas emissions, and aerosols. Each RCP also has unique population, economic growth, and land cover changes (varying vegetation and land surface characteristics) associated with it. These RCPs include:

- RCP2.6: This scenario requires major emission reductions from a peak in 2020 to reach a 2100 CO_2 concentration of 420 ppm (we are presently at about 410 ppm CO_2 concentration)
- RCP4.5: In this scenario, emissions peak around 2040, and CO_2 concentration reaches 540 ppm by 2100
- RCP6.0: Lower emissions reductions are assumed here, and CO_2 concentration reaches 660 ppm by 2100
- RCP8.5: This is the worst of the scenarios in terms of warming potential, assuming little change in energy use and emissions; CO_2 concentration reaches 940 ppm by 2100

The CCIA projections are provided as 20-year averages centred on years 2030, 2050, 2070, and 2090. Part of the goal of this project was to estimate changes in feedlot water demand by 2030; therefore, the 2030 projections (averages of 2020-2039 period) were used here. The results of the eight models for each of the four RCPs were retrieved and processed for use in predicting cattle on feed and cattle water consumption. Results are summarized as average outcomes across the eight models, and separate numbers on feed and water demands are calculated for each of the four RCPs. Annual values for the 2018 to 2030 period were estimated using a logistic smoothing function to produce annual values starting with the monthly, feedlot-specific Tmax or RHmin values historically and reaching the 2030 projections at year 2030.

3.4.3.4 Estimating Current and Future Feedlot Water Demands

There were three main steps in spatially distributing the feedlot cattle water demands:

1) Spatially join the dataset of 473 feedlots to the nearest locations for Tmax and RHmin stations; this was done separately for the historical and projected data as the locations of historical and future data points are different. For the future period, monthly values of Tmax and RHmin were processed to provide average values for the eight climate models for each of the four RCPs.
2) Calculate average daily cattle water consumption (L/head/day) for each month (separately for historical period and future period; using the Parker 2000 model); that value was multiplied

by the number of days in each month, and then all the monthly total water demands were summed to an annual total (L/head/year).

3) Increase the cattle water consumption totals by 10% to account for other non-drinking water uses including washing, feed processing, and others (Davis and Watts 2016).
4) Multiply the feedlot-specific water use values (L/head/year) by the annual-average numbers on feed for each feedlot to produce annual total water consumption for all 473 feedlots in the dataset.

3.5 Interviews to Assess Water Security and Feedlot Priorities

Interviews were undertaken with feedlots owners or managers in order to better understand feedlot water security and other relevant management concerns. Insights about production practices, water consumption and allocations and expected climate change impacts were gathered through semi-structured phone interviews. Interviews took an average one hour, allowing researchers to acquire a depth of understanding of water security matters over the course of the conversations.

Feedlots to be interviewed were identified through a sampling pattern with state representation weighted by percentage of total cattle capacity. The sample pattern was sized at 32 feedlots, or 10% of the feedlot industry with a capacity of 400 or more. This sample included a range of feedlot locations and sizes to get a broader representation of the feedlot industry. The sample pattern included feedlots by state in the following breakdown:

- Queensland 14
- New South Wales 11
- Western Australia 2
- Victoria 2
- South Australia 2
- Tasmania 1

Feedlots were contacted initially via email, using details provided by MLA. This email included an endorsement letter from MLA and ALFA outlining the proposed project and verifying the purpose of the interviewers. This email also included an outline of the proposed interview questions. Where no response was received a follow-up email was sent further outlining the proposed projects. Where no response to the emails were received the feedlots were contacted directly by telephone.

A total of 6 feedlot owners or managers across a variety of states including Queensland (2), New South Wales (2), Western Australia (1) and Victoria (1) with feedlot capacity ranging from 5,000 to 18,500 were interviewed. Given the diversity in feedlot locations, conditions and water regulations the water security issues faced by each vary considerably. This is a small sample size and the chance that the data set is unrepresentative of the broader feedlot industry is high. It is recommended that further interviews are undertaken, ideally face-to-face, with feedlot operators.

There were some factors and issues which were consistent across the feedlots interviewed. This included the majority of water being consumed by cattle in feedlots, consisting of 80 -98% of total water use. Climate change was identified as a major risk factor, particularly in relation to the supply of feed in a drought cycle. A summary of interview insights is provided in Table 2.

Table 2 Water Security Interview Outcomes

State	Water Security Interview Outcomes
Queensland (n=2)	Given the limited response to interviews it is difficult to develop an in-depth analysis of water security for the feedlot industry in Queensland. Anecdotal evidence suggests that water security is a significant concern for the feedlot industry in Queensland, however the interview responses below indicate water security is a low concern. It is recommended that further interviews be undertaken, ideally face-to-face with feedlot operators, to develop a more in-depth understanding of industry concerns regarding water security. Interviewees reported that their level of water security was "Excellent" or between "80%-90%", reflecting the quality of the water sources (the Great Artesian Basin) and the capacity to capture and store water from large rainfall events. Neither interviewee used the entirety of their high security water allocation in an average year, indicating that water security is not currently a limiting factor for production. One operator was utilising produced water from coal seam gas wells near Roma. Both operators noted that during drought water security could become an issue both directly, and through higher feed costs. The ability to maintain the equipment that facilitates water access was noted as an issue. One interviewee noted that the maintenance of pumps and dams affected their ability to reliably access water when needed.
New South Wales (n=2)	The quality of water security in New South Wales varied considerably for interviewees, indicating that it was "Excellent" for one and ranging between "30%-80%" for another. The Great Artesian Basin was considered a high security, high quality water source that required minimal treatment, highlighting its importance as a source of water for many operators. Water from the Great Artesian Basin is also unmetered. However, water security outside of the Great Artesian Basin is highly variable. Another feedlot operator noted that when river levels fell below a certain threshold it cannot be pumped into irrigation channels. This weak link exposes the entire irrigation scheme to climate variability and extreme drought as is currently being experienced in NSW. Interviewees also discussed the difficulties facing feedlots in sourcing both feed and cattle during drought cycles. Operators also noted concerns regarding the potential impacts of Coal Seam Gas production on the ability of groundwater sources to recharge.

State	Water Security Interview Outcomes
Western Australia (n=1)	The feedlot operator interviewed in Western Australia possessed significant rights to capture and store overland flows without limits on consumption. The feedlot is therefore highly dependent rainfall events providing the resources to fill storage, however they require only a handful of storms per year to secure adequate supply, reported as being highly reliable on average. The operator is able to purchase allocations off the open market as necessary to supplement supply. Climate change was identified as a risk factor for water security, especially given the reliance on consistent rainfall.
Victoria (n=1)	The feedlot operator interviewed in Victoria relied primarily on groundwater entitlements, supplemented by high security allocations and therefore noted that their water security situation was very good. However, their ability to access water was limited by the reliability of their equipment to harvest what was needed. Good management practices in maintaining equipment was nominated as a contributing factor in maintaining good water reliability, indicating that the availability of management and maintenance trade skills are a factor determining water security.

Source: BGA Work Product with input from Feedlot Owners / Operators

4 Results

4.1 Current and Future Feedlot Water Demand

4.1.1 Climate Projections

Based on the 8-model means using 2030 projections, the change in annual average maximum temperatures ranges from 1% to 17% depending on combination of RCP and location/state. For RCP2.6 (the most optimistic climate change scenario), it is expected that Tasmania and Western Australia would see the largest maximum temperature increases (10%). In the states with the most feedlots, Queensland and New South Wales, Tmax increases of 7% and 5% are projected, respectively. These Tmax projections rise to 12% and 11% increases in Queensland and New South Wales under RCP8.5. These results are based on the historical station data and projected climate data at locations nearest to existing feedlots. See Fig. 6 for state-specific Tmax change and Fig. 7 for Tmax values at 2030 for station locations across Australia.

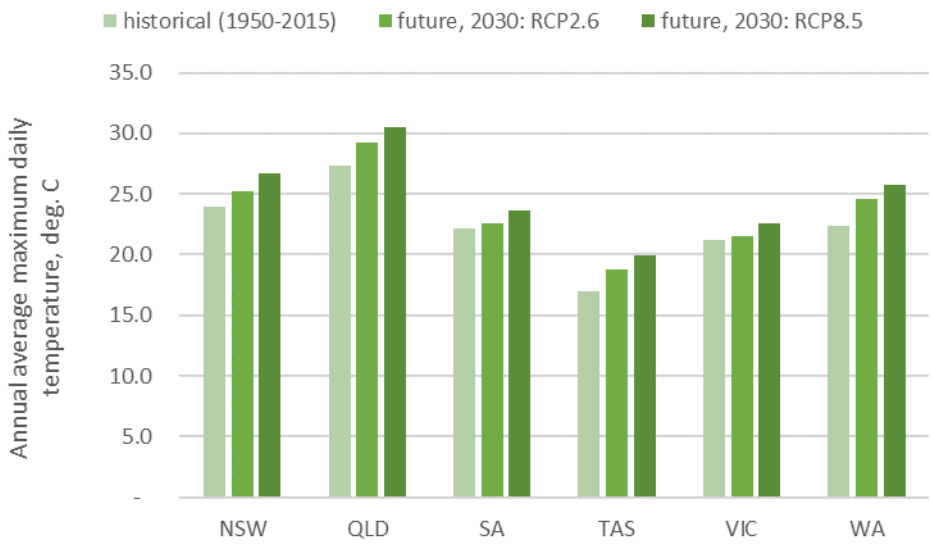

Fig. 6 Estimated maximum temperature by State under various climate models

Source: BGA Work Product, based on data from CCIA; CSIRO and BOM 2015

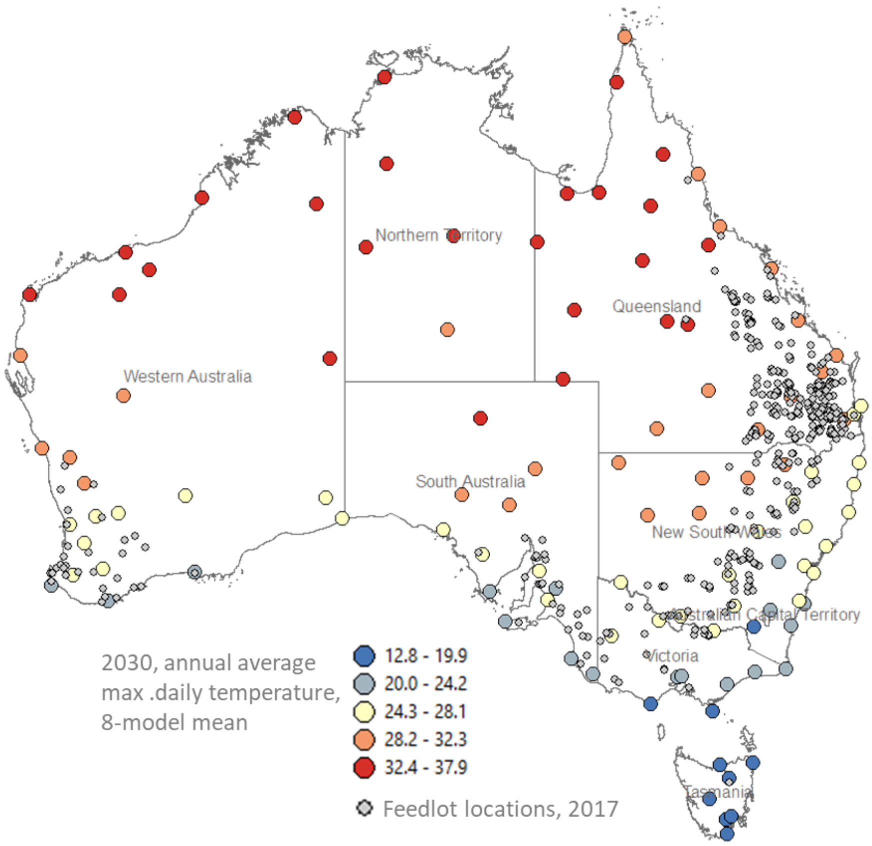

Fig. 7. Feedlot locations and Tmax values at 2030

Source: BGA Work Product; future temperatures from CCIA; feedlot locations from MLA

The projected 2030 values of relative humidity show an increase compared to historical values (Fig. 8). On average, the 2030 RHmin values are about 30% larger than historical. The result of this is a negligible impact from RHmin projected changes on the Parker 2000 cattle water demand results.

Fig. 8. Projected 2030 values of relative humidity

Source: BGA Work Product; future RHmin projections from CCIA

The annual average rainfall is expected to decrease slightly by 2030, compared with historical values (Fig. 9). Under RCP2.6 the biggest rainfall declines are projected in Western Australia and Victoria, 5% and 4%, respectively. In New South Wales and Queensland the biggest rainfall declines are projected to be under the RCP8.5 scenario, with 3% and 4% decreases, respectively. An important rainfall change that is not accounted for explicitly for the purpose of predicting future cattle on feed is the tendency toward more extreme rain events. There is very little change in total annual rainfall being projected, but if more of that rainfall is received in high-intensity events, that can result in water quality problems, erosion, and an increased importance of on-farm storage to manage less reliable surface water withdrawals.

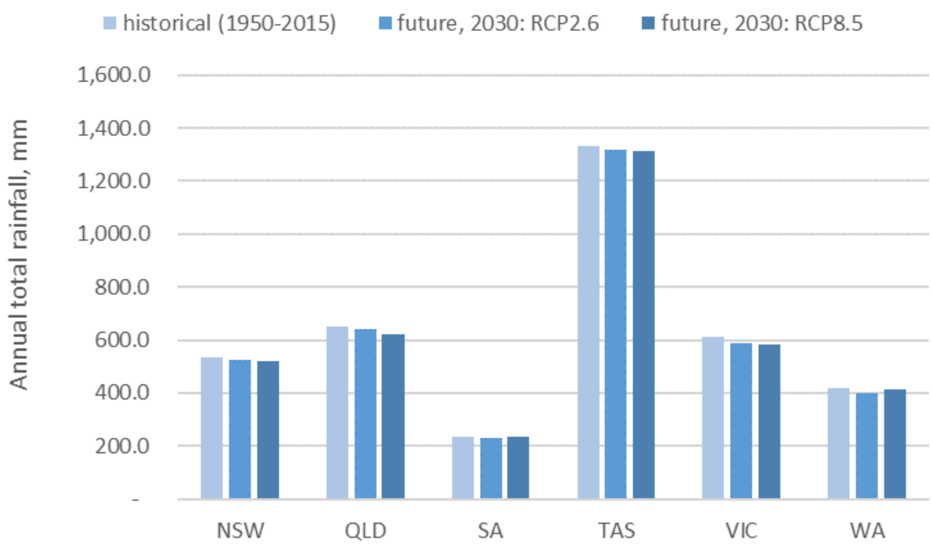

Fig. 9. Annual average rainfall

Source: BGA Work Product; future RHmin projections from CCIA

4.1.2 Numbers on Feed: current and projected

In 2018, there are about the 1.03 million cattle on feed in Australia (ALFA 2018). By 2030, numbers on feed model developed here estimates that cattle on feed in Australia will grow by approximately 8% (to 1.124 million of head) compared to current numbers, based on model results using input variables at their mean values. Fig. 10 shows both historical and future cattle on feed in Australia. State specific numbers can be found in Appendix 9.4.2. Results from all four RCPs lie within a one percent range, where the highest growth is under the RCP6.0 scenario (8.7%), while the lowest is under the RCP4.5 (7.9%). There is uncertainty in the future values of each of the input variables that drive the model of numbers on feed. This means that there is actually a range of possible future estimates of numbers on feed. For example, using conservative estimates of uncertainty in input variables, the 2030 numbers on feed could be around 17% more than current values. For more detail, please see the Sensitivity Analysis section in Appendix 9.3.

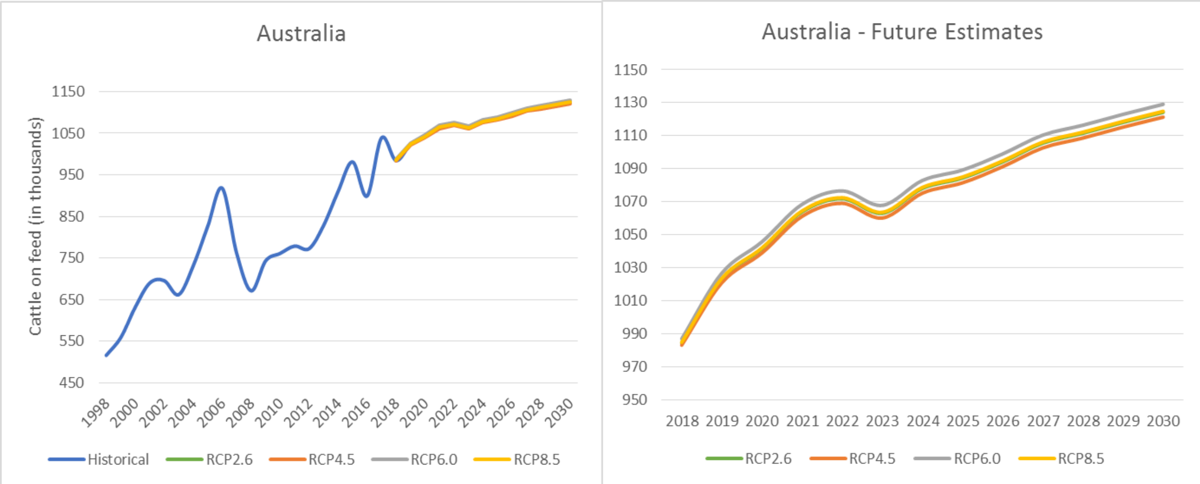

Fig. 10. Historical and future cattle on feed in Australia

Source: MLA Statistics Database; BGA Work Product

At the State level, the estimates show that cattle on feed in NSW and QLD would have an average annual growth rate of around one percent. On the contrary, cattle on feed in South Australia, Victoria and Western Australia will have a significant increase in the next two years and thereafter the numbers will fluctuate within the same levels. Table 3 provides the estimated cattle on feed (in thousands) at the state-level by 2030 for every RCP, while annual state-wide results for each scenario can be found in Appendix 9.4.

Table 3. 2030 estimates of cattle on feed (in thousands)

State	2017	2030 RCP2.6	2030 RCP4.5	2030 RCP6.0	2030 RCP8.5
NSW	328.39	319.59	319.11	321.21	320.16
QLD	574.86	595.83	594.46	596.57	597.24
SA	27.82	45.77	45.58	46.48	45.51
VIC	60.43	97.84	97.65	98.97	98.07
WA	34.36	50.55	49.92	51.14	49.22
TAS	13.16	14.66	14.62	14.73	14.65
Total	**1,039.03**	**1,124.24**	**1,121.34**	**1,129.09**	**1,124.85**

Source: BGA Work Product

There are several recent developments that are not explicitly accounted for in the current model form. The Comprehensive and Progressive Trans-Pacific Partnership (CPTPP) is expected to result in Australia having improved access for beef exports to Canada, Mexico, Japan, and other Asian markets. This and other country-specific tariff arrangements might result in numbers on feed that are higher than projected here. Other global changes could provide pressure in the other direction. Competition from Brazil, Argentina, and Uruguay – nations that are trying to expand their exports to Asian markets – might result in lower than expected beef exports from Australia, driving down the numbers of cattle on feed (MLA 2018).

4.1.3 **Feedlot Water Demands: current and projected**

Considering the 2030 projections, average annual water use per head increased up to 13% from historical usage depending on the RCP scenario and the State (Fig. 11). The annual average water use in Litres per head per day, for the 2030 projections depending on the CP Scenario and the State are shown in Figure 12. Under the RCP2.6 scenario, it is expected that the highest increase in water use per head will be in Queensland and Western Australia with an average increase of 6% by 2030; while the lowest increases will be in South Australia with a 0.1% increase. These rates increase under the RCP8.5, where water use per head will increase by around 11% in Queensland, 9% in Western Australia, 8% in New South Wales and almost 4% in South Australia and Tasmania.

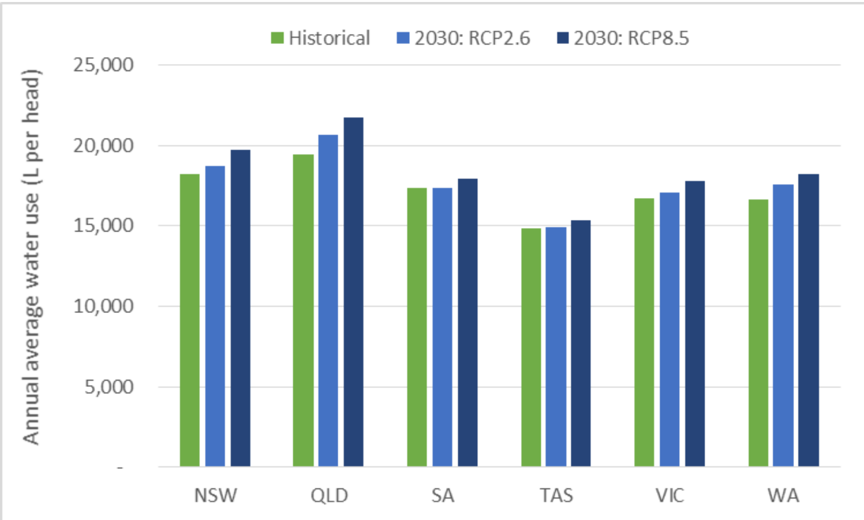

Fig. 11. Annual average water use per head

Source: BGA Work Product

The annual average water use in Litres per head per day, for the 2030 projections depending on the CP Scenario and the State are shown in Figure 12. Under the RCP2.6 scenario, it is expected that the highest increase in Queensland and Western Australia with an average increase of 6% by 2030; while the lowest increases will be in South Australia with a 0.1% increase. These rates increase under the RCP8.5, where water use per head will increase by around 11% in Queensland, 9% in Western Australia, 8% in New South Wales and almost 4% in South Australia and Tasmania.

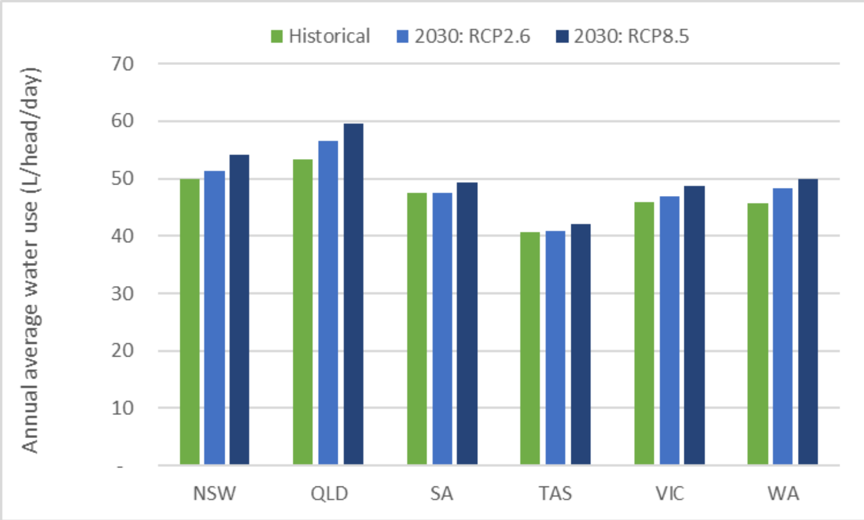

Fig. 12. Annual average daily water use per head

Source: BGA Work Product

Total beef cattle feedlot water use is estimated at 19,245 ML in 2017. By 2030, it is estimated that total water use in Australian feedlots will increase by 14% under the RCP2.6 scenario, 15% under the RCP 4.5 scenario, 16% under the RCP6.0 scenario, and 20% under the RCP8.5 scenario (Fig. 13). This results from the combination of increased numbers on feed and elevated temperatures which increases the per head water consumption.

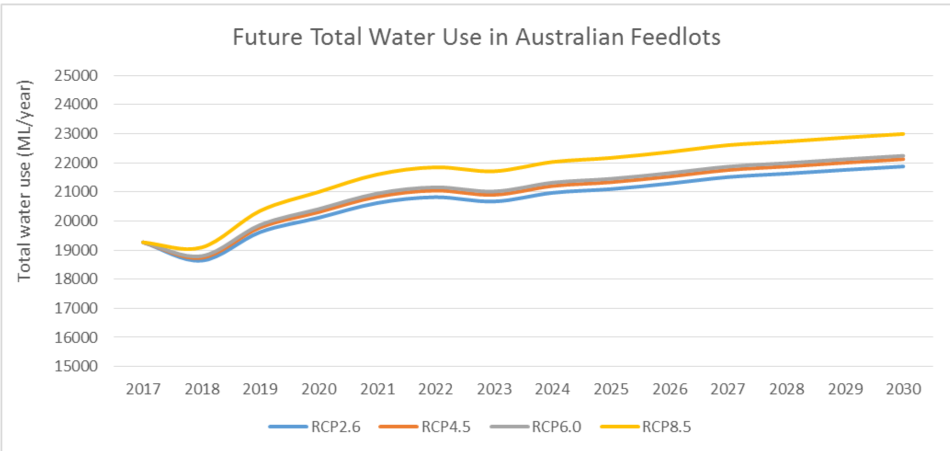

Fig. 13. Future total water use in Australian feedlots

Source: BGA Work Product

At the State level, more than half of total feedlot water use is from Queensland. In New South Wales the share of total water use declines from 31% in 2017 to 28% in 2030, while Victoria has a 3% growth by 2030. Table 4 provides total water use (in ML) at the state-level by 2030 for every RCP and annual state-wide results for each scenario can be found in Appendix 9.3.

Table 4. 2030 estimates of total water use (in ML)

State	2017	2030 RCP2.6	2030 RCP4.5	2030 RCP6.0	2030 RCP8.5
NSW	5,942	6,037	6,121	6,161	6,368
QLD	10,989	12,196	12,343	12,353	12,866
SA	492	811	814	830	835
VIC	1,027	1,699	1,714	1,739	1,774
WA	600	936	936	958	948
TAS	195	219	220	221	225
Total	**19,245**	**21,898**	**22,148**	**22,262**	**23,017**

Source: BGA Work Product

Table 5 provides total water use (in litres per head per day) at the state-level by 2030 for every RCP and annual state-wide results for each scenario can be found in Appendix 9.5.1.

Table 5. 2030 estimates of total water use (in litres/head/day)

State	2017	2030 RCP2.6	2030 RCP4.5	2030 RCP6.0	2030 RCP8.5
NSW	49.9	51.4	52.2	52.2	54.1
QLD	53.4	56.6	57.4	57.3	59.5
SA	47.5	47.6	48.0	48.0	49.2
VIC	40.7	40.8	41.2	41.2	42.1
WA	45.8	46.8	47.3	47.3	48.7
TAS	45.7	48.2	48.7	48.6	49.9
Average	**47.2**	**48.6**	**49.1**	**49.1**	**50.6**

Source: BGA Work Product

4.2 Feedlot Manager Interviews

Given the limited response to interviews by feedlot operators it is difficult to develop an in-depth analysis of water security for the feedlot industry. Given the small sample size there is a high chance that the interviews do not provide a representative view of the broader feedlot industry. Feedback from phone interviews with feedlots in Western Australia, Queensland and New South Wales, suggest that presently the majority of feedlots have good water security and that water is not the main constraint for growth. However, some producers mentioned that this can change if there isn't enough rainfall so that river levels are constantly with low levels during a long period of time. Several producers reported on the importance of on-farm storage of rainfall for feedlot use. Supplies and costs of feed were mentioned as the leading concerns associated with a changing climate. Reliability of water access in a changing climate was also a concern for some of the producers interviewed. It is recommended that further interviews are undertaken, ideally face-to-face, with feedlot operators to provide a broader view of the industry.

5 Discussion

The modelling and regulatory review reveal that there are varying degrees of risk associated with timely access to future water resources.

5.1 Risks to Water Security

The following discussion identifies the general key risks associated with water access entitlements. Sources of risk can be broadly categorised into four groups:

- **Sovereign risk:** The risk that government intervention may attenuate or even annul a water entitlement, either by way of the exercise of ministerial discretion or future legislative change.
- **Regulatory risk:** Varying regulatory regimes result in very different risk management requirements in each state. NSW, for example, has greater volatility and insecurity in the administration of water allocations, resulting in a different outcome for NSW feedlot operators than other states. Currently, dozens of water resource or water sharing plans are in in the process of being updated, and water security could change as a result. The process warrants close monitoring, which may require examination and analysis by industry and legal experts, to provide ALFA and the industry as a whole adequate information regarding potential changes to feedlot water security.
- **Market risk:** The risk associated with variability of the value of water entitlement due to market conditions.
- **Hydrological or resource risk:** Risks associated with, for example, changes in rainfall or the recharge rate of aquifers.

These risks manifest themselves through their potential impacts on:

- Access to water under the entitlement.
- The tenure and security of the entitlement.
- The transferability and liquidity of the entitlement.
- The quality of title of the entitlement.
- Water allocation announcements.

Policy makers can assist feedlot managers to endure volatile water prices through relief payments and loans that directly and indirectly – through other operational cost saving mechanisms - influence their ability to purchase water. Additionally, feedlot managers equipped with more readily available information such as seasonal outlooks can enhance financial management decisions to bear and prepare for volatile price swings. These limitations can include information dissemination, as well as uptake, as many properties span hundreds of acres away from each other; internet access for necessary forecasting tools may be limited by geography and expanse. A more detailed examination of how these risks manifest follow.

5.1.1 Entitlement reliability and price

Australia's climatic variability means that the volume of water under any entitlement may not actually be available in any given season. Differences in the reliability of entitlements to access water in a variable climate reflect in market value.

The level of reliability of a delivery entitlement reflects both:

- The inherent uncertainty associated with the availability of water at the particular

source, for example because of rainfall variability; and
- The storage management policies adopted by the storage operator.

An assessment of the risks of access to water and hence value of an entitlement requires a sound understanding of two factors:
- The specific resource on which the water entitlement is drawn: In catchments where water is fully allocated, the risk of low access is higher compared to catchments where water is not fully utilised. Lower rainfall volatility in a catchment will also contribute to a reduced risk of poor access.
- The resource management policies of the State: Water rights held by South Australian and Victorian irrigators, to include feedlot operators, typically hold a greater proportion of high security entitlements. Conversely, water access entitlements holders in NSW and Queensland have a higher proportion of general (or low) security entitlements.

Within jurisdictions, there are different entitlements with different levels of reliability (i.e. high versus low security entitlements). In broad terms the highest level of security is for urban water use, then stock and domestic (excluding feedlots) then commercial and industrial use (including feedlots), then permanent plantings. General or low security entitlements are primarily used for annual crops.

To some extent, market mechanisms can reduce reliability risk by allowing the purchase of permanent or temporary water as needed. Higher reliability water will generally have a higher value; however reliability can also be increased by purchasing a greater volume of lower reliability water.

Particular risks of note include:
- The risk that climate change may result in more volatile rainfall patterns or lower regional averages reducing the amount of water available.
- The risk that water may not actually be able to be delivered to the entitlement holder, an entitlement to water may not entitle the holder to have the water physically delivered unless they hold sufficient associated water delivery rights.
- The risk of irrigation distribution infrastructure becoming uneconomic as water is traded out of a channel, pipeline or district, leaving fewer entitlement holders to pay for its ongoing operationand maintenance.
- The risks associated with the ability of the relevant supply authority to finance asset replacement and renewals of infrastructure. Entitlement holders may be asked to contribute to more towards the maintenance of an asset, and if it is not maintained there is the risk of catastrophic asset failure. Government owned infrastructure operators do not typically hold long term financial reserves and infrastructure is more likely in these cases to fail due to the inability of operators to undertake maintenance and renewals.

5.1.2 Water access entitlement security

All water access entitlements in Australia are ultimately subject to attenuation (compulsory government reduction) by virtue of the right to use and control water vesting in the Crown (State). The likelihood of this attenuation being exercised, and whether compensation is payable varies depending on the security of the right.

State legislation typically enables Ministers to reduce the amount of water available to consumptive users in some circumstances, for example during droughts, the precise rules and priorities for doing so are more formally specified in water resource or water sharing plans.

The nominal tenure of a water access entitlement is not necessarily the best measure of its security – more important is the likelihood of renewal and/or attenuation in the future. While the legal powers to attenuate or not renew water rights have not increased in most cases, the likelihood of governments using those powers has shifted substantially.

In several jurisdictions there are now clearly defined processes for renewal or modification of entitlements via formal ten year water plans. It is typically at the government's discretion whether compensation is paid to entitlement holders for any attenuation of entitlements within the period of the plan. Compensation is not payable for any changes when a new plan is developed. Except in limited circumstances in certain jurisdictions, currently compensation is not payable to entitlement holders if governments subsequently do not renew, or otherwise attenuate, their water access entitlements.

The extent of advance notice of any likely changes in water availability in the next plan then becomes critical to assessing the level of risk associated with an entitlement.

5.1.3 **Transferability & liquidity**

The extent and ease with which an entitlement can be traded varies widely between different entitlements and jurisdictions. Generally, only an allocation that is clearly defined in terms of volume may be traded. Some products may be traded on a temporary (allocation) but not a permanent (entitlement) basis. In some cases, only landholders with an ability to use the water on identified parcels of land are able to own an entitlement.

Governmental approval is also often required to finalise a transaction, with scope for considerable bureaucratic or Ministerial discretion in order to protect the interests of third parties or the environment. Rules may specify that trade may only be downstream, or that trade into or between certain zones may not be permitted. The approvals process is more onerous for permanent as opposed to temporary trades. A cautious approach to approving trading in entitlements to groundwater access entitlements has generally been adopted.

Types of transactions that require permission from the relevant authority include:

- **Temporary transfers of seasonal water allocation.** The approvals processes required here are generally relatively straightforward because it only involves the transfer of one off volumetric water.
- **Permanent trades or transfers.** These are the transfer of the rights to access water on a "permanent" basis rather than one off volumetric water so in general permanent trades are subject to stringent approval processes to ensure no adverse impacts on third parties or on the environment.
- **Leasing.** This is currently permitted under legislation in some States. The approval processes for leases are akin to those required for permanent trades of water access licences and the Queensland process in particular is very efficient. In NSW the legislation only provides for the lease of the water access entitlement in conjunction with the

associated land. As a result most NSW leases require the piecemeal transfer of allocation during the period of the lease as the allocation announcements are made.

- **Changes to the specification of the water access entitlement.** These are generally permitted subject to approval processes if there may be an impact on third parties or the environment.
- **Other trades**. State policies and legislation also allow transactions involving a range of parties. These include trades of bulk water access entitlements between water supply authorities and trades between authorities and individuals. Some types of transactions between hydro-power generators (as a theoretically non-consumptive use) and other users are possible under current arrangements.

5.1.4 Changes to Water Allocation Announcements

The timing of allocation announcements and the transparency of the determinations vary by jurisdiction and affect the ability of producers to plan their consumption.

Water allocation announcements for high security water access entitlements in the individual water plan areas and zones in the Murray Darling Basin are announced at the start of the Season (1 July). In Queensland, NSW and Victoria there is a transparent methodology for determining allocation based in most part on dam levels.

We note that South Australian high security entitlements have had a series of allocation announcements in recent years below 100% and that the methodology for determining allocation in SA unlike other MDB States is not transparent.

High Security Irrigation Water Access Entitlements in the Murray Darling Basin - In most instances the full allocation announcement of 100% is made at the start of the season (less environmental water deductions of 5% in some water sharing plans). If the announcement is less than 100% the allocation is then reviewed on a monthly basis and may be increased. Typically an allocation cannot be reduced after it has been announced. However, water allocation in the NSW Murray system and in South Australia was reduced in November 2006 after a higher allocation had been announced in July 2006[1]. During the Millennium drought high security water allocation announcements dropped to an annual average of between 60-85%.

General or Low Security Water Access Entitlements in the Murray Darling Basin - General or low security allocation announcements are highly volatile with allocation announcements in NSW Murray dropping to 0-3% during the Millennium drought.

Other types of entitlements exist and may be available to feedlot owners, in some cases mitigating the risk of uncertain allocation announcements. Feedlot owners should be mindful that the higher the level of reliability of a given entitlement the greater the cost associated with access and allocation. Volumetric costs of urban and town water is many times higher than for allocation associated with high security water access entitlements.

The following broad categories are options for feedlots based on the level of security:

High Security: In order of priority of allocation, these include urban or town water from government owned urban water authorities or councils, water for commercial and industrial use

[1] Australian Bureau of Statistics 1345.4 - SA Stats, Apr 2007

(including feedlots), and high security irrigation (usually owned for watering permanent plantings).

- **Urban or town** water is only available to government water authorities and local councils. Water access entitlements to urban or town water can only be held by a water authority and cannot be sold – it is usually only possible for feedlots to purchase volumetric water supplied through a connection to the mains. Occasionally local councils will allow commercial or industrial users to construct their own pipelines to access water under contract. Under normal circumstances there is 100% reliability for the water delivered from urban water authorities or councils.
- **Commercial and Industrial** is available through government and private water authorities. Except in extreme drought events such as the Millennium Drought commercial and industrial water access entitlements have 100% reliability.

Low Security: These include general or low security irrigation entitlements, usually for watering annual crops.

Purchase of allocations: Relying on the open water market to purchase allocations in order to fulfil consumption needs may also entail significant risk. Purchasing allocations usually requires a works licence (private delivery infrastructure such as a pump). In particular, in NSW allocation accounts are linked to the works licence not the water access licence. The purchase price of allocations varies wildly. In the Murrumbidgee the price varies from less than $100/ML in a full allocation season but exceeded $1000/ML at the peak of the Millennium drought. Due to the fluctuations in the price of allocation it is preferable for feedlot owners to purchase high security water access entitlements.

5.1.5 Climate Risk

The hydrologic or environmental risks to feedlot water security result from the typical seasonal and year-to-year climate variability and from the gradual changes in climate bringing about temperature and rainfall changes that might increase exposure to water security risks. The estimated impacts in terms of changes in feedlot water demand have been explained above in sections 3 and 4.

5.2 Structural Solutions

5.2.1 Increasing On-farm Storage and Water Harvesting

Onsite water storage is a common technique employed by feedlots to manage water security profiles due to any variations in water supply, climate conditions, or to manage any emergency situations. Onsite water storage types vary considerably depending on feedlot, type, location, age, and water security profile.

Further to onsite water storage, a feedlot can augment its water supply by employing rainfall harvesting, through capture of rainfall runoff on the feedlot site. This can be through a range of collection and storage systems, including earthworks to converge and collect overland flow runoff or through a roof rainwater harvesting system as discussed in the text box (Fig. 14). The example below illustrates the potential for covered housing to provide multiple benefits: impervious roof surfaces to enable rainwater harvesting to increase water supply, provide shade during hot seasons to reduce water demand, provide protection from rainfall during cool seasons to keep cattle warm and decrease food intake, and to decrease manure runoff from rain events. The large capital costs associated with covered housing for rainwater harvesting could be partly managed through grants and cost-sharing programs. Among the most affordable ways to collect excess rainfall is through gully dams or other earthworks used to store overland flow.

Regulatory issues relative to on-farm water harvesting are discussed in Section 6.1.1 but it should be noted that NSW has restrictions on water harvesting.

Industry Example – Jalna Feedlot

Jalna Feedlot, a 7,000 head feedlot in Victoria has recently constructed an 8,500 square metre feedlot cover targeting stress reduction in cattle and increased water supply. Stress reduction on animals is a major aspect from both animal welfare and commercial aspects, with feed demands being lower due to the roof providing warmth for the animals. The washing required at the abattoir is lower due to the animals being cleaner when sheltered.

The feedlot cover will be used as part of a water harvesting / water reuse system, with the roof being used to harvest rainwater for use in providing in drinking water in the feedlot. It is estimated that in an average rainfall year, about 4 ML of water can be harvested from the rainfall runoff collected from the feedlot covers.

Fig. 14 Industry Example – On Farm Storage

Source: Stock and Land

6 Conclusions/Recommendations

Changes in Australia's climate are projected to result in increased temperatures and a variety of impacts on rainfall. As early as 2030, a 0.6-1.3 °C increase in Australia's average annual temperature is projected (CSIRO 2015). There is less agreement in the projections of rainfall changes, but for the areas nearest to feedlots in Australia, a 3% to 5% decrease in annual rainfall totals are projected. The temperature and rainfall projections are explicitly accounted for in the models of cattle feedlot numbers and cattle water use (Parker 2000). Two important changes in rainfall dynamics that are not directly accounted for in the estimates of future water demand are changes in extreme rain events (projected to increase) and changes in drought frequency (more frequent, extreme droughts projected). Essentially, most future climate projections indicate more episodic rainfall; this further emphasizes the importance of feedlot management and regulatory initiatives to enhance future feedlot water security.

The regulatory review identified current instruments used to allocate water to the sector, and the caveats and limitations to each jurisdiction's use of various instruments. The second project objective was to identify current and future water demand within the Australian lot-feeding sector and assess if there are any regulatory gaps that limit the sector's water security and the current needs and future growth of the sector. This objective was met through modelling current water demand within the sector, as described in Sections 3 and 4, and projecting future feedlot water demands. Identification of regulatory gaps that limit the sector's water security and potential for future growth was completed in the context of the modelling results and the regulatory review of Phase I. The third project objective was to identify state and national based opportunities to address regulatory gaps, inconsistencies and risks to ultimately maximise the lot-feeding sector's water security both now and into the future.

Combining the regulatory assessment and the projections of feedlot water demands, six key opportunities were identified for realizing improvements in feedlot water security: 1) on-farm storage implementation and regulation, 2) water reuse of municipal supply for feedlot uses, 3) water re-crediting, 4) education and outreach improvements, 5) water purchasing plans, and 6) water resource plans.

6.1 Opportunities to Address Regulatory and Policy Gaps to Maximise Feedlot Water Security

6.1.1 On-farm Water Harvesting Regulation

The legislation regarding onsite water storage and water harvesting varies from state to state and by Water Resource Plans. In NSW the Water Management ACT (2000) Section 54 – Harvestable Rights Orders discusses water harvesting in NSW, stating that rainwater harvesting on a large scale is not allowed in NSW. Runoff harvesting is allowed in Queensland, however there is potential for water harvesting to be impacted by water resource plans specific to regions as they are released. This issue is best described as the Crown owning the rainfall; however, there is potential for rainwater harvesting to be employed in systems depending on its location and management system. This system is difficult to define on a state by state basis and is more influenced by its governing water management plans. The key targets for the Australian Lot Feeders Association (ALFA) and its partners would be to influence legislation that would allow feedlot operators to collect excess rainfall with fewer restrictions and to support rainwater collection at the farm level through cost-sharing or grant programs.

6.1.2 Education and Outreach

Based on interviews, research for model preparation and anecdotal evidence, there is scope for improvement in information sharing. Specifically, in the context of the current drought condition, it is apparent that unequal information is incorporated into feedlot operator decisions, with some operators availed of appropriate information regarding grain prices, water allocations and drought predictions, and others less so. Information-sharing networks are unequal.

ALFA, as the industry peak body, is in the preferred space for disseminating actionable information to feedlot operators. It is recommended that ALFA source relevant information from industry and subject matter experts for distribution to feedlot operators and industry stakeholders. Outlooks or forecasts geared to specific areas are valuable, and could be shared to feedlot operators. Best methods for information dispersal may vary, but operators appear to respond to email communication in a timely manner. Periodic meetings with ample notice were also noted as information-sharing opportunities by stakeholders. Farmers appear to have access to partial information, but lack overall context relating to expected prices, conditions, and regional demand.

Appropriate topics include seasonal outlooks regarding rainfall, temperature, and associated management recommendations (destocking, water storage). As Water Resource Plans evolve through the development phase, pertinent opportunities to engage in the comment period, as further addressed elsewhere herein, will be relevant meetings topics as well. Additionally, under the Murray-Darling Basin Water Infrastructure Program announced on 18 July 2018, funding is available for cost share projects to include retrofits or upgrading of on-farm water efficiency projects and off-farm improvements to channel systems stock pipelines and so forth. Feedlot operators may wish to aggregate interests to pursue funding in Queensland, South Australia and Victoria. Armed with proper information, feedlot operators will be better positioned to identify and recognize their opportunities and issues and communicate appropriately to advance and protect their interests.

6.1.3 Town Water Reuse / Recycling

As Water Resource Plan updates evolve, one issue that warrants monitoring is the planned government expenditure for reclaimed water distribution infrastructure. Suitable infrastructure needs to be extended to within reasonable distances for feedlot operators to access and tie in to systems in order to achieve economic feasibility. An initial review of Water Resource Plan updates underway in NSW finds no mention of water reuse at this time, indicating a potentially overlooked source of future supply for industry. ALFA, as peak body, is in the preferred position to provide guidance for negotiating WSPs as they come under review so that they accommodate feedlot operations within water reuse plans and developments.

The overall cost of tapping into reclaimed water is a function of its reliability and usability for the feedlot operators' needs, in a timely fashion. ALFA is also in a position to disseminate information and tools to its members to assist them in identifying the breakeven point, optimal location, and preferred technology to render water reuse a cost-effective water source. Water infrastructure and subject matter industry experts are well placed to provide both general and specific advice as required by ALFA and feedlot operators.

While regulatory regimes vary, water reuse available from mining operations is a viable, cost-effective water source for feedlot operators and may be suitable for stock. Understanding public concerns and being prepared to address potential barriers raised by stakeholders is an important role for ALFA in protecting feedlot operators from instability in this market.

6.1.4 Water Re-Crediting

Water allocations may be re-credited, whereby water can be returned to the system, if it meets the required quality guidelines whether through managing on-site use or water treatment. Environmental regulators must approve the quality of the resource being returned to the environment, and physical characteristics – salinity, quality etc. – must match the receiving water body. There have been a number of successful instances where regulators have recognized the value of the re-credited flows with slight deviations from required water quality standards.

There are provisions underlying the regulations that appear not to be well-recognised which could benefit some feedlot operators. In NSW Water law, Section 76 – Water allocations may be credited of the Water Management Act (NSW Government, 2000) states that Water Allocations may be re-credited to the water allocation account, to wit:

WATER MANAGEMENT ACT 2000 - SECT 76

Water allocations may be credited

76 WATER ALLOCATIONS MAY BE CREDITED

(1) Water allocations that have been used by the holder of a prescribed access licence may be regained in accordance with this section.

(2) The holder of a prescribed access licence may apply to the Minister for used water allocations to be recredited to the water allocation account for the licence.

(3) An application under this section is to be dealt with in accordance with the water return flow rules.

(4) In this section: "prescribed access licence" means an access licence of a category or subcategory prescribed by the regulations for the purposes of this section.

6.1.5 Water Purchasing Plans

The extent to which Water Licenses or Permits entitle the holder to water security is a function of the license security level, seasonal precipitation and existing infrastructure (e.g., whether proper conveyance structures are in place to transport a required volume of water to a specific site). For the sake of water security, High Security water entitlements have a higher reliability and may be more appropriate for risk planning. Based on interviews, research for model preparation and anecdotal evidence there is scope for refinement in water purchasing plans implemented by feedlots. Specifically, in the context of water purchase methodology and management, it is apparent that purchase of High Security water has a higher reliability and may be more appropriate for managing water security in a feedlot. Distortions in market price for General Security mask the inferior quality of the water access provided by the license for the cost. General Security should be a purchase consideration only when High Security license options are not available, and then only allocations should be purchased.

While general security is cheaper, there is an uncertainty premium associated with General Security water, and a higher risk profile. Over time, the varying supply of water with General Security entitlements likely outweighs the discounted licensing cost. An example of this is the average allocation of water in NSW from 2004 – 2017 being 83% for High Security and 33% for General Security. Additionally, it is worth noting that at the time of writing, in September of 2018, that General Security allocations in the Murray River catchment is zero.

In order to provide an informed decision-making process for water purchases ALFA, as the peak industry body, is well positioned to disseminate information and tools necessary for individual operators to determine the long-term implications for different water purchasing plans. ALFA may facilitate and source information from water market and industry experts that can provide both general and specific advice to feedlot operators.

Methods for water purchasing vary considerably, however it appears that operators do not take a long-term horizon to water purchases. This information would vary considerably depending on market and environmental conditions, and would need to be updated in an ongoing timeline.

6.1.6 **Water Resource Plans**

Water Resource Plans are in place across Australia and are described as Water Sharing Plans in NSW, and are in various phases of update across NSW; Table A-17 in the Appendix provides a summary of the status of 24 water sharing plans in development for renewal or review. The terminology used to describe the Plans varies by state. The Summary Milestone 1 Report provides more detail about the differences across states.

All Water Resource Plans must be accredited by the MDBA by mid-2019, and require submittal for government endorsement by February 2019. This means industry submissions will need to be completed well before calendar-year end. ALFA will need to monitor the progress of these Plans to identify issues of concern to the feedlot industry, and may seek the advice of industry and subject matter experts in order to identify risks and opportunities. Feedlot operators will need to be prepared to address areas of concern and provide documentation supporting their positions regarding access, security and availability. This will need to happen during the Call for Submissions stage, where the water Sharing Plans are open to review.

Fig. 15, Fig. 16 and Fig. 17 show the overlap of water management plans in Queensland, New South Wales and Victoria Respectively. As only Gwydir catchment appears to be near completion based on the schedule, all of the remaining areas will require additional time before content can be reviewed to identify whether areas of substantive concern have arisen during the WSP development. The key issues to be addressed for each WSP will need to be identified as they become available. A weighted analysis of the key water management areas in each respective state, based on volume of feedlot capacity is shown in Table 6. A summary of water management plans for each respective state and their current status is shown in Appendix 9.6.

Table 6. Water Security Risk Assessment by Feedlot Location

State	Water Resource Plan	Feedlot Capacity
QLD	Great Artesian Basin Plan	**503,386**
QLD	Condamine and Balonne Water Resource Plan	**224,859**
QLD	Fitzroy Basin Water Resource Plan	**110,532**
NSW	Murrumbidgee Unregulated and Alluvial Water Sources	**133,232**
NSW	NSW Border Rivers Unregulated and Alluvial Water Sources	**75,080**
NSW	Lachlan Unregulated and Alluvial Water Sources	**44,993**
NSW	Namoi Unregulated and Alluvial Water Sources	**40,310**
VIC	Wimmera-Mallee (surface water)	**29,300**
VIC	Northern Victoria	**24,374**

Source: MLA Statistics Database, BGA Work Product

ALFA, as the peak industry body is well situated to facilitate access to industry experts in order to identify and optimise onsite water storage and rainwater harvesting opportunities. As Water Sharing Plans are released, ALFA would retain industry experts to identify areas where onsite water storage is viable, using the previously discussed information sharing network. In areas where onsite water storage is constrained by legislation it is possible that submissions could be made to review the Water Sharing Plans. Additionally, as previously noted Water Reuse may need to be elevated as a Water Sharing or Water Resource issue worthy of inclusion in the Plans.

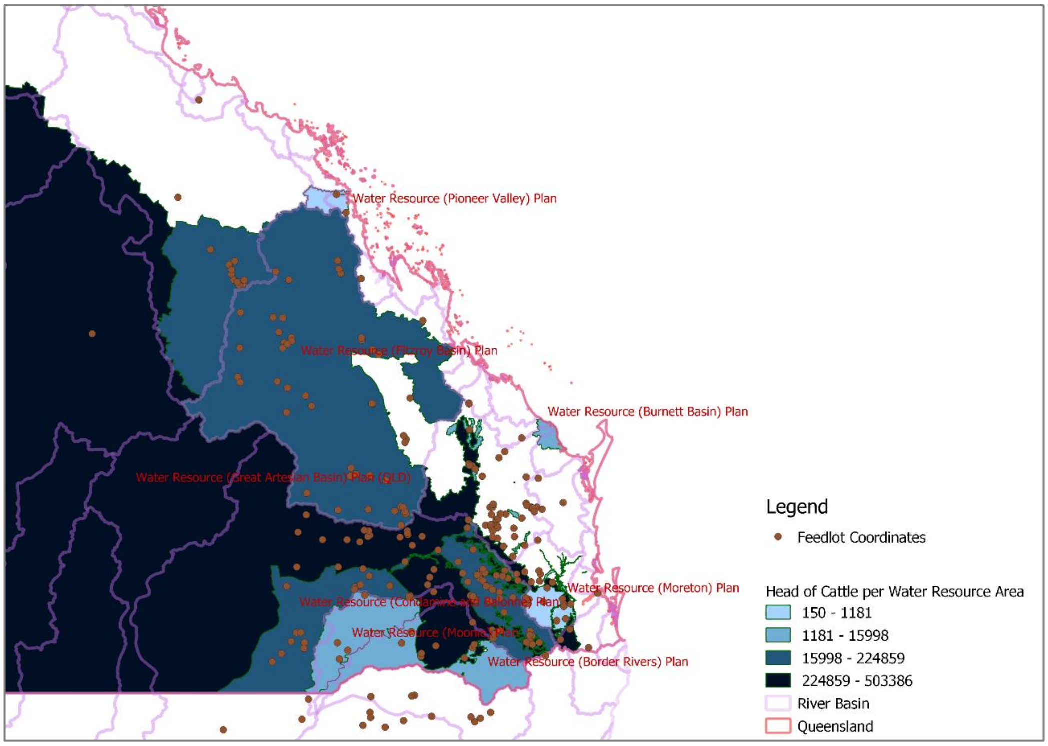

Fig. 15. Queensland Feedlot Locations and Water Resource Areas

Source: Australian Bureau of Meteorology; MLA; BGA Work Product

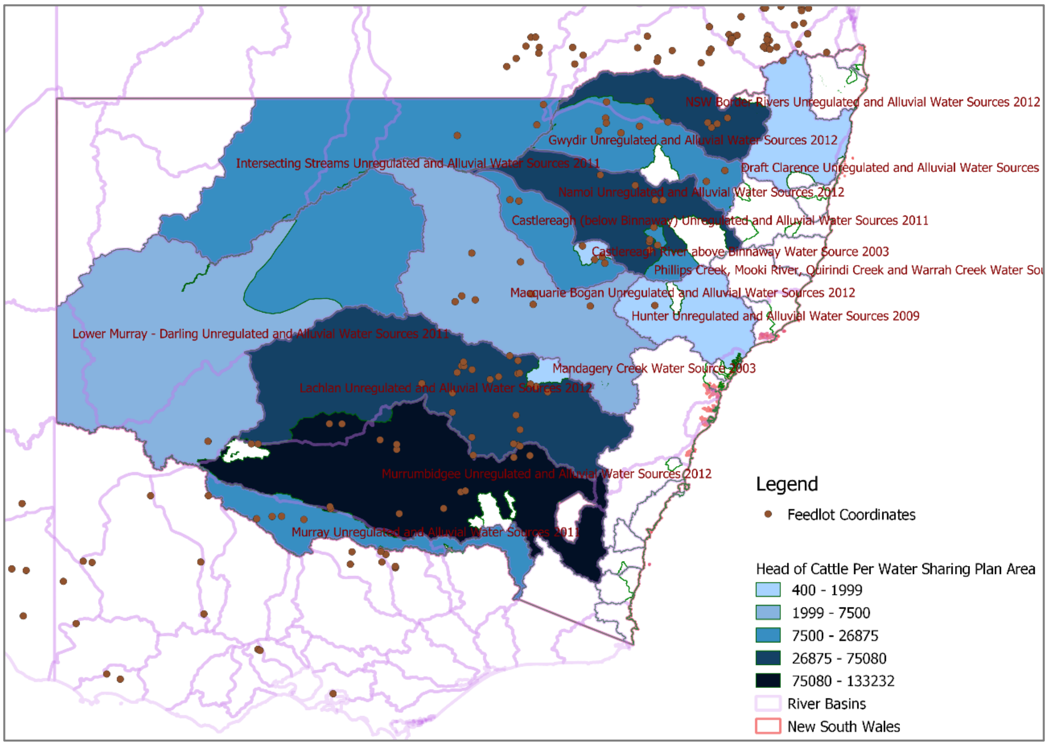

Fig. 16. New South Wales Feedlot Locations and Water Sharing Plans

Source: NSW Office of Water; MLA; BGA Work Product

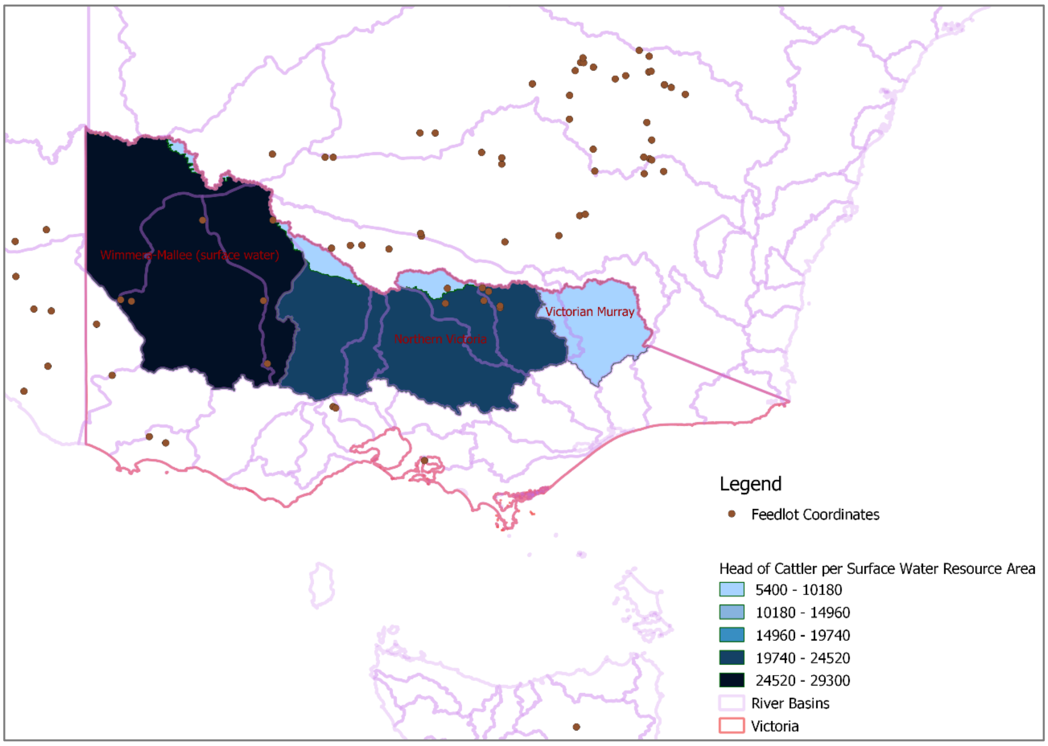

Fig. 17. Victoria Feedlot Locations and Water Resource Plans

Source: Murray Darling Basin Authority; MLA; BGA Work Product

6.2 Risk Assessment

A qualitative risk assessment was developed to characterise legislative and economic and environmental (climate change) risks to feedlot water security, this summary is shown in Table 7. The Phase 1 findings were interpreted to have elevated risks for water access and price for New South Wales, Queensland, and Victoria as a result of the number of feedlots in those states that are in the Murray-Darling Basin.

The relative temperature changes across the states was used to assign risk categories accordingly. With no risk resulting from minimum relative humidity changes, all states were assigned Limited Risk for that category. The greatest rainfall decreases, which result in numbers on feed increases, are in New South Wales, Queensland, and Victoria, the three states having most of the cattle on feed. Moderate Risk for rainfall changes were assigned to those states. Overall, there is elevated risk for feedlot water security in New South Wales, Queensland, and Victoria, resulting from the combination of temperature, rainfall, and location (overlapping the Murray-Darling Basin).

Table 7. Water Security Risk Assessment by Feedlot Location

		Risk Assessment by feedlot location					
Risk category	**Types of Risk**	**QLD**	**NSW**	**WA**	**VIC**	**SA**	**TAS**
Legislative and Economic	Sovereign risk: water access	Moderate risk	Moderate risk	Limited risk	Moderate risk	Limited risk	Limited risk
	Market risk: water price	High risk	High risk	Moderate risk	High risk	Moderate risk	Moderate risk
Environmental	Temperature change	Moderate risk	Moderate risk	High risk	Limited risk	Limited risk	High risk
	Relative humidity change	Limited risk	Limited risk	Limited risk	Limited risk	Limited risk	Limited risk
	Rainfall change	Moderate risk	Moderate risk	Limited risk	Moderate risk	Limited risk	Limited risk

Limited risk | Moderate risk | High risk

Source: BGA Work Product

7 Key Messages

Future feedlot water demands are projected to increase by around 14% to 20% by 2030. About half of the increase can be attributed to elevated temperature projections driving up per-head water demands and about half of the increase can be attributed to increased numbers on feed, resulting from economic and environmental drivers. Several solutions have been identified for potentially providing sufficient water for these increased demands and for managing the substantial seasonal and year-to-year water availability. Identified through regulatory and industry research, these recommendations include:

- Recommendation: improve opportunities for on-farm water harvesting to increase supply. This might be achieved through regulatory influence to limit potential restrictions on on-farm water harvesting and through financial incentives (cost-sharing and grants) to assist producers with implementation of water harvesting.
- Recommendation: expand the educational and training opportunities to include guidance on water purchasing and on utilization of seasonal outlooks, with specific management recommendations associated with outlooks indicating drier than average conditions.
- Recommendation: expanding the utilization of water reuse. This would include research and development to identify most likely locations (combinations of feedlots and water utilities) where water reuse is physically and economically feasible.
- Recommendation: monitor relevant water resource plans and provide submissions and comments to ensure feedlot water use concerns are well accounted for.

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9 Appendix

9.1 B.FLT.8008 Summary of Regulatory Report – See Attachment

9.2 B.FLT.8008 Regulatory Report – See Attachment

9.3 Additional Descriptions of the Analytical Models of Feedlot Cattle and Water Demands

The historical dataset comprises data between 1998 and 2017 for New South Wales, Queensland, South Australia, Victoria and Western Australia. The dataset was built from different sources including, MLA, the department of Agriculture and Water Resources, the Reserve Bank of Australia, and the Australian Government Bureau of Meteorology. Different model specifications were tested, but the final model was obtained using Ordinary Least Squares regression analysis to generate a model of numbers of cattle on feed driven by variables found environmental and economic variables. Variables in the model include total rainfall (in mm), the exchange rate of Australian dollars in U.S. dollars (lagged one period), grain price index (lagged one period; built by multiplying the share of grains in the diet of beef cattle and the respective price of the grain), heavy steer prices, exports to Asia by State of production, and location attributes including dummy variables for New South Wales, Queensland, South Australia, Victoria, and Western Australia. Table A-1 provides a summary of the variables in the model with their respective acronyms.

Table A- 1. Summary of all variables evaluated during model development

Variables	Description
Rainfall Anomalies	State specific percent change from a 30-year climate average from the Bureau of Meteorology. Expectations were that higher anomalies lead to fewer cattle on feed. This variable was not included, as it did not have enough variation between years. Instead, total annual rainfall by state was used.
Total Rainfall	Average annual total rainfall by state (in mm). Data collected is from the Bureau of Meteorology. It is expected that more rainfall decreases the number of cattle on feed.
Maximum Temperature	Annual maximum mean temperature by state. This was estimated with annual max temperature anomalies and averages by state from data of the Bureau of Meteorology. It is not in the final model because the inclusion of the variable caused this and other variables to become insignificant, as reflected in diagnostic tests.
Mean Temperature	Annual mean temperature by state. This was estimated with annual mean temperature anomalies and averages by state based on data from the Bureau of Meteorology. This is not in the final model for the same reasons mentioned above for maximum temperature
Beef Consumption (in Japan, South Korea, USA and Indonesia)	Annual beef consumption in each of the listed countries from the Organisation for Economic Co-operation and Development (OECD) data library. Initially, each country was considered separately, however neither is in the final model because there was too much noise in the data since there are many factors that can make big changes from one year to another in foreign consumption patterns. This lead to change the focus of the model from beef consumption to beef exports.
Beef Consumption in Australia	Annual beef consumption in Australia. The data was national rather than state-specific, but it wasn't included in the final model because consumption patterns in Australia have been relatively steady since 1998 while cattle on feed has been constantly increasing. This resulted in weak explanatory results against cattle on feed

Variables	Description
Exchange rate of AUD in Japanese Yen	Average annual Japanese yen per Australian dollar from Australia's Reserve Bank.
Exchange rate of AUD in US dollars	Average annual U.S. dollar per Australian dollar from Australia's Reserve Bank. Since exports and foreign consumption are important for the Australian beef industry, exchange rate is an important factor to include in the model. Expectations were that cattle on feed decreases as this exchange rate increases. In the final model, this was lagged one period as impacts of changes in the exchange rate won't be immediate.
Cattle prices	Saleyard heavy steer prices (cents per Kg of cattle weight equivalent) from MLA. Historical prices were converted into 2017 dollars to see the real effects. It is expected that the number of cattle on feed increases if heavy steer prices also increase.
Feed Index	Grain prices are an important production input so, in order to incorporate the relevant grains into the model a feed price index (A$/t) was built. This was done by multiplying the share of wheat, barley, oats, and sorghum in the diet of cattle and the respective annual grain price since 1998. The approximate feed grain proportions were 35%, 28%, 15%, and 5% respectively for wheat, barley, oats, and sorghum (Hafi and Connell 2003). In the final model, this variable was lagged one period as it may take some time before the impacts of grain prices can be seen. The expectations were that higher grain prices decreases the number of cattle on feed, which is shown in the final results.
Beef exports (Total, to China and to Asia)	Beef & veal exports by State of production from MLA and the Department of agriculture and water resources. Total exports were discarded because most growth of Australia's exports have been in Asian countries, but these are still small compared to the total. Therefore, exports to Asia provided deeper insight as this variable provides state-specific values and contains the impacts of the expansion in the Chinese beef market in the recent years.
Dummy variable for China	1 for 2013 onwards, 0 otherwise. Initially, the dummy by itself contradicted the hypothesis that cattle on feed increases when exports to China have significantly increased in the recent years. So, this variable was transformed to be an interaction between exports to Asia and the original China dummy to further account for that growth.

Source: BGA Work Product

The econometric model enables to estimate annual future cattle on feed at the State level. Table A-2 provides a summary of the model results, including the diagnostic tests. To estimate annual cattle on feed for individual feedlots, the share of every feedlot's capacity to the respective State total feedlot capacity was calculated. This share was then multiplied by the state-wide cattle on feed for the given year.

Table A- 2. Summary of model results

Ordinary	least squares regression			
LHS=NUMFEED	Mean =	151.7935		
	Standard deviation =	159.9498		
----------	No. of observations =	100	DegFreedom	Mean square
Regression	Sum of Squares =	2.48E+06	10	248215.5
Residual	Sum of Squares =	50654.8	89	569.1552
Total	Sum of Squares =	2.53E+06	99	25583.94
----------	Standard error of e =	23.85697	Root MSE	22.50662
Fit	R-squared =	0.98	R-bar squared	0.97775
Model test	F[10, 89] =	436.1122	Prob F > F*	0
Diagnostic	Log likelihood =	-453.275	Akaike I.C.	9.2855
	Restricted (b=0) =	-648.877	Bayes I.C.	9.57207
	Chi squared [10] =	391.205	Prob C2 > C2*	0

Variable	Coefficient	Standard Error	t	Prob. |t|>T	95% Confidence Interval		Mean of x
Constant	43.19	31.78	1.36	0.18	(19.96)	106.34	
RFTOT	(0.07) ***	0.02	(3.15)	0.00	(0.12)	(0.03)	490.21
AUDLAG	(28.23)	21.16	(1.33)	0.19	(70.28)	13.82	0.77
FEEDLAG	(0.07)	0.04	(1.53)	0.13	(0.16)	0.02	242.92
NSW	144.37 ***	12.83	11.25	-	118.88	169.86	0.20
QLD	58.79	40.70	1.44	0.15	(22.09)	139.67	0.20
SA	(25.87) ***	8.69	(2.98)	0.00	(43.14)	(8.61)	0.20
VIC	(23.00) **	10.70	(2.15)	0.03	(44.25)	(1.74)	0.20
HSPRICE	0.09 **	0.04	2.09	0.04	0.00	0.18	408.93
ASIAEXP	0.99 ***	0.13	7.66	-	0.73	1.25	112.22
CHINA	0.08*	0.04	1.90	0.06	(0.00)	0.16	35.06

*****,** and * refer to significance at the 1%, 5% and 10% level, respectively**

Source: BGA Work Product

The following example is provided to demonstrate model operation. For instance, assume a feedlot in Chinchilla, Queensland, with a capacity of 30,000 cattle. By 2030, under the RCP2.6 scenario, Queensland will have an annual average rainfall of 645.22 mm, beef exports to Asia are estimated to be almost at 495 tonnes of shipped weight, and the price of heavy steer is estimated to be at 472.64 A¢/kg cwt. Since grain prices and the exchange rate were lagged in the econometric model, 2029 values are used to estimate the 2030 number of head. In 2029, the grain price index and the exchange rate are estimated to be at 257.21 A$/t and 0.54 U.S. dollars per Australian dollar, respectively. Applying the coefficients to this example produces an estimated 595,831 cattle on feed in Queensland and 27,312 cattle in the feedlot. In 2030, the water use per head estimated with the Parker (2000) model is 20,534 (L/head/year). This number multiplied by the cattle on feed for this feedlot gives a total feedlot water use of 561 ML per year. A summary of the attributes for this feedlot in Queensland are provided in Table A-3.

Table A- 3. Application of the model

Variable	Estimated Value in 2030	Coefficient	Product
Constant		43.19	43.19
RFTOT	645.82	(0.07)	(46.34)
AUDLAG	0.54	(28.23)	(15.25)
FEEDLAG	254.67	(0.07)	(17.24)
QLD	1.00	58.79	58.79
HSPRICE	472.64	0.09	42.79
ASIAEXP	494.88	0.99	490.83
CHINA	494.88	0.08	39.05
Cattle on feed (in thousands)			595.83
Cattle on feed			**595,831**
Feedlot Capacity			30,000
Feedlot Capacity in QLD			654,469
Share			4.6%
Estimated cattle in the feedlot (Share*Cattle on feed in QLD)			**27,312**
Estimated water use per head in the feedlot (L/Head/yr)			20,534
Total feedlot water use (L/yr)			560,816,821
Total feedlot water use (ML/yr)			**560.82**

Source: MLA Statistics Database; BGA Work Product

9.3.1 Future Dataset Details

To develop future projections of exchange rates for the period from 2023-2030, BGA employed a model from Zorzi and Rubaszek 2018 on exchange rate forecasting in advanced countries with flexible regimes. In conjunction with the European Central Bank, the authors developed a model that examines regularities empirically observed in their datasets. Assuming purchasing power parity (PPP) holds in the long-run, the authors observe that real exchange rates are mean-reverting through nominal rate adjustments, thus implying the possibility of forecasting the former. The idea further incorporates "half-life" parameters that reflect the half amount of time needed for the exchange rate to adjust back to its long run past average. The authors ultimately impose a reasonable pace at which the law of PPP is restored. Zorzi and Rubaszek 2018 developed the equation below to easily calculate the whole forecasting path:

$$\Delta ner^{f}_{t+h,h} = \rho^{h}(rer_t - \overline{rer})$$

Where "p" is a monthly calibrated parameter to be consistent with a 3-year half-life adjustment to the mean, "h" represents the number of projection horizons (in this case, number of months), "ner" is the nominal exchange rate, "rer" is the real exchange rate, "t" subscript denotes the time period, and "f" denotes a forecasted value.

9.3.2 Sensitivity Analysis

A sensitivity analysis was done to assess how the estimates of cattle on feed change when the future annual values of the input variables are increased (and decreased) by 10% and then by 25%, as shown in Table A-4. This process involved changing the values of variables of one at a time (OAT), while the other variables were left unchanged. The table below summarises the percent change of cattle on feed from the estimated 2030 value (from all variables at nominal values) under the RCP2.6 scenario (8.2%). This OAT sensitivity analysis increased or decreased each variable by 10% and 25% while the other variables were kept at nominal values. Results showed that, in this particular model, estimates of cattle on feed are more sensitive to changes in exports to Asia, while less sensitive to changes in the exchange rate.

Table A- 4. One-at-a-time sensitivity analysis of model variables; % change relative to 2030 projections using mean values of projected input variables

2030 cattle on feed % change		
	10% change	25% change
Total Rainfall	± 1.7%	± 4.2%
Exchange Rate	± 0.7%	± 1.9%
Grain Prices	± 0.8%	± 2.1%
Heavy Steer Prices	± 2.1%	± 5.2%
Exports to Asia	± 8.4%	± 20.9%

Source: MLA Statistics Database; BGA Work Product

9.4 Cattle on Feed Estimates

9.4.1 Annual Cattle on Feed by RCP

Table A- 5. Annual estimated cattle on feed under the RCP2.6 scenario (in thousands)

State	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NSW	294.64	301.57	304.70	308.71	309.99	308.28	311.13	312.26	314.07	316.19	317.27	318.47	319.59
QLD	515.67	531.01	543.14	556.60	565.38	562.11	568.33	572.73	577.81	583.83	588.02	592.09	595.83
SA	38.57	43.10	43.42	44.35	43.16	42.01	43.73	43.76	44.47	45.28	45.30	45.54	45.77
VIC	78.30	85.13	87.56	90.55	90.95	89.52	91.94	92.64	94.01	95.61	96.26	97.08	97.84
WA	44.61	48.99	49.10	49.82	48.45	47.34	48.97	48.92	49.56	50.27	50.22	50.38	50.55
TAS*	12.74	13.32	13.56	13.86	13.94	13.81	14.03	14.12	14.25	14.41	14.49	14.58	14.66
Total	**984.53**	**1,023.12**	**1,041.48**	**1,063.89**	**1,071.86**	**1,063.06**	**1,078.13**	**1,084.42**	**1,094.18**	**1,105.58**	**1,111.56**	**1,118.15**	**1,124.24**

*** Tasmania's estimates are not based on the analytical model; these were calculated as described in the "Cattle on Feed Model Development" section**

Source: MLA Statistics Database; BGA Work Product

Table A- 6. Annual estimated cattle on feed under the RCP4.5 scenario (in thousands)

State	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NSW	294.40	301.21	304.28	308.27	309.53	307.82	310.66	311.79	313.60	315.72	316.80	318.00	319.11
QLD	514.99	529.98	541.94	555.31	564.05	560.76	566.97	571.37	576.45	582.46	586.65	590.72	594.46
SA	38.47	42.96	43.25	44.17	42.97	41.82	43.53	43.56	44.28	45.08	45.11	45.35	45.58
VIC	78.21	85.00	87.40	90.38	90.77	89.33	91.75	92.45	93.83	95.42	96.08	96.89	97.65
WA	44.30	48.52	48.55	49.22	47.83	46.71	48.34	48.29	48.93	49.64	49.59	49.75	49.92
TAS*	12.72	13.29	13.52	13.82	13.90	13.77	13.99	14.07	14.21	14.37	14.45	14.54	14.62
Total	**983.08**	**1,020.95**	**1,038.94**	**1,061.17**	**1,069.06**	**1,060.21**	**1,075.26**	**1,081.53**	**1,091.29**	**1,102.68**	**1,108.67**	**1,115.25**	**1,121.34**

*** Tasmania's estimates are not based on the analytical model; these were calculated as described in the "Cattle on Feed Model Development" section**

Source: MLA Statistics Database; BGA Work Product

Table A- 7. Annual estimated cattle on feed under the RCP6.0 scenario (in thousands)

State	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NSW	295.45	302.78	306.11	310.23	311.56	309.88	312.74	313.87	315.69	317.81	318.89	320.09	321.21
QLD	516.04	531.56	543.79	557.29	566.10	562.84	569.07	573.47	578.55	584.57	588.76	592.83	596.57
SA	38.92	43.63	44.03	45.01	43.84	42.70	44.43	44.46	45.18	45.98	46.01	46.25	46.48
VIC	78.87	85.98	88.56	91.61	92.04	90.63	93.06	93.76	95.15	96.74	97.40	98.21	98.97
WA	44.91	49.43	49.62	50.37	49.02	47.92	49.56	49.51	50.15	50.86	50.81	50.98	51.14
TAS*	12.78	13.37	13.62	13.93	14.01	13.88	14.10	14.18	14.32	14.48	14.56	14.65	14.73
Total	**986.96**	**1,026.77**	**1,045.73**	**1,068.44**	**1,076.57**	**1,067.84**	**1,082.95**	**1,089.26**	**1,099.03**	**1,110.43**	**1,116.42**	**1,123.00**	**1,129.09**

*** Tasmania's estimates are not based on the analytical model; these were calculated as described in the "Cattle on Feed Model Development" section**

Source: MLA Statistics Database; BGA Work Product

Table A- 8. Annual estimated cattle on feed under the RCP8.5 scenario (in thousands)

State	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NSW	294.92	302.00	305.20	309.24	310.55	308.85	311.70	312.83	314.64	316.76	317.84	319.04	320.16
QLD	516.38	532.07	544.37	557.92	566.75	563.50	569.74	574.14	579.22	585.24	589.43	593.50	597.24
SA	38.44	42.91	43.19	44.11	42.91	41.75	43.47	43.50	44.21	45.02	45.05	45.28	45.51
VIC	78.41	85.31	87.76	90.77	91.17	89.74	92.16	92.86	94.24	95.83	96.49	97.31	98.07
WA	43.94	47.99	47.94	48.56	47.15	46.02	47.65	47.59	48.23	48.93	48.89	49.05	49.22
TAS*	12.74	13.31	13.55	13.86	13.94	13.80	14.03	14.11	14.25	14.41	14.48	14.57	14.65
Total	**984.83**	**1,023.58**	**1,042.01**	**1,064.46**	**1,072.46**	**1,063.66**	**1,078.74**	**1,085.03**	**1,094.79**	**1,106.19**	**1,112.17**	**1,118.76**	**1,124.85**

*** Tasmania’s estimates are not based on the analytical model; these were calculated as described in the “Cattle on Feed Model Development” section**

Source: MLA Statistics Database; BGA Work Product

9.4.2 Annual Cattle on Feed by State

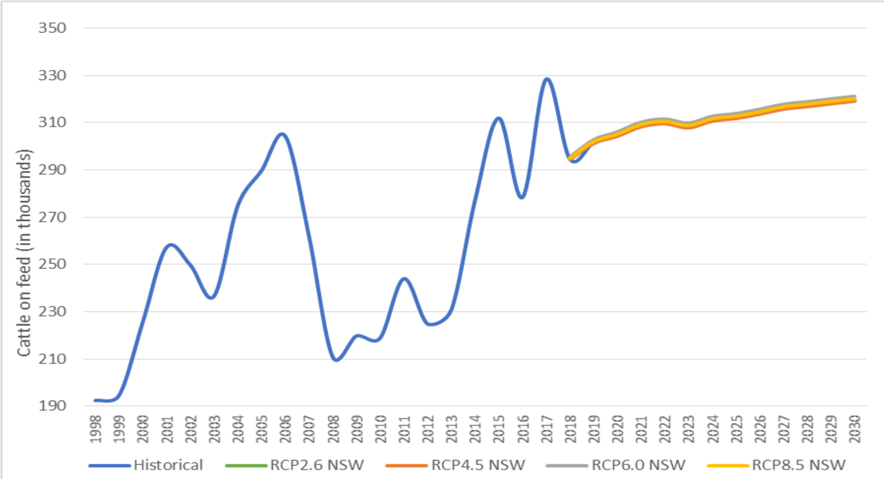

Fig. A- 1. Cattle on feed in New South Wales

Source: MLA Statistics Database; BGA Work Product

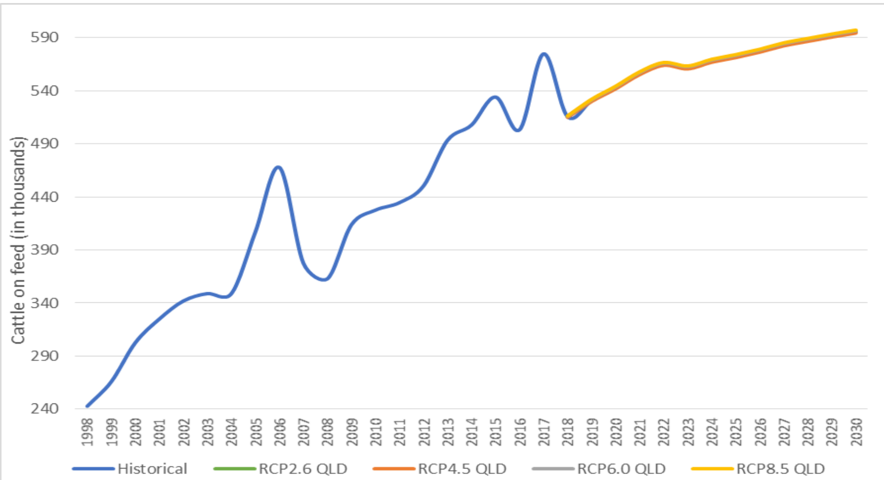

Fig. A- 2. Cattle on feed in Queensland

Source: MLA Statistics Database; BGA Work Product

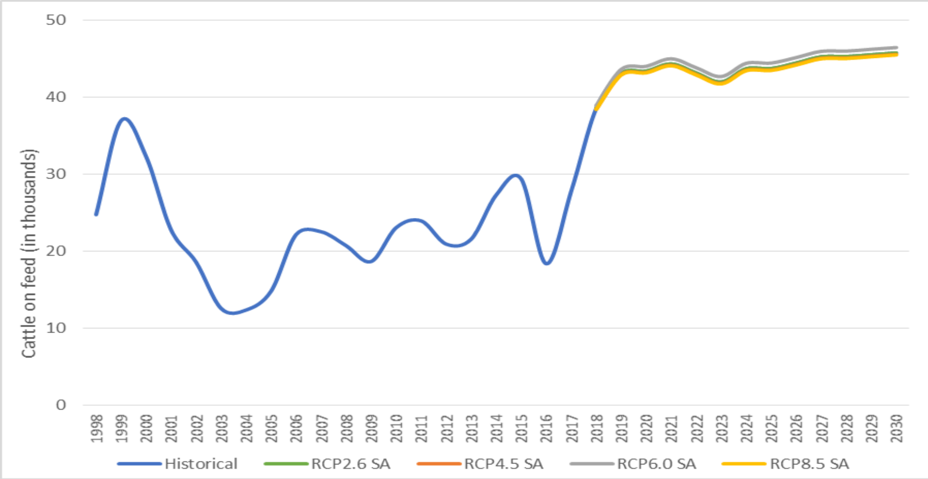

Fig. A- 3. Cattle on feed in South Australia

Source: MLA Statistics Database; BGA Work Product

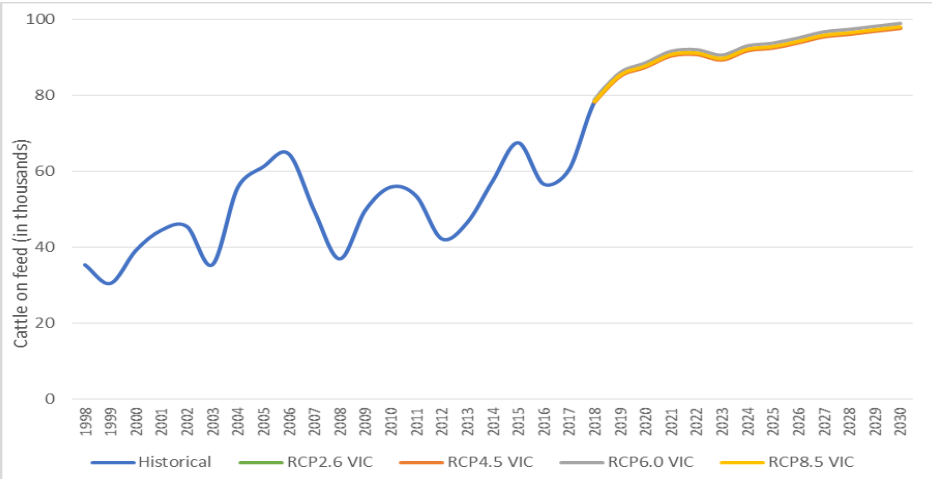

Fig. A- 4. Cattle on feed in Victoria

Source: MLA Statistics Database; BGA Work Product

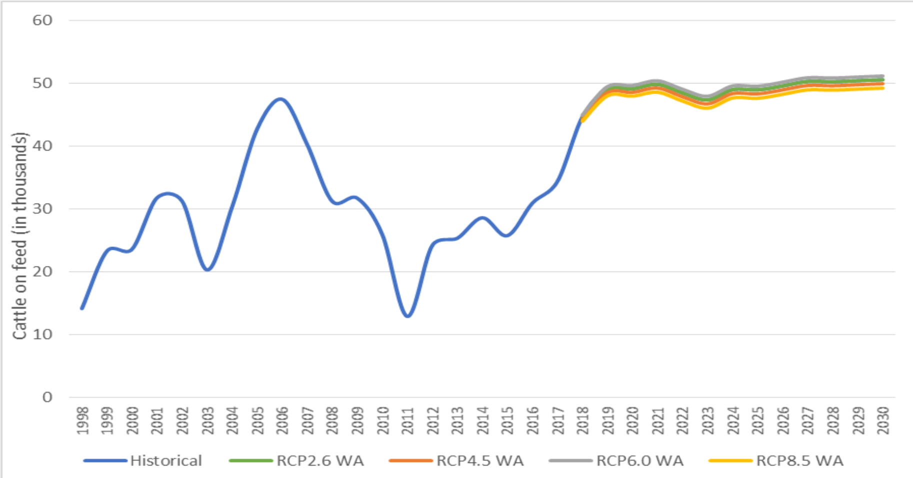

Fig. A- 5. Cattle on feed in Western Australia
Source: MLA Statistics Database; BGA Work Product

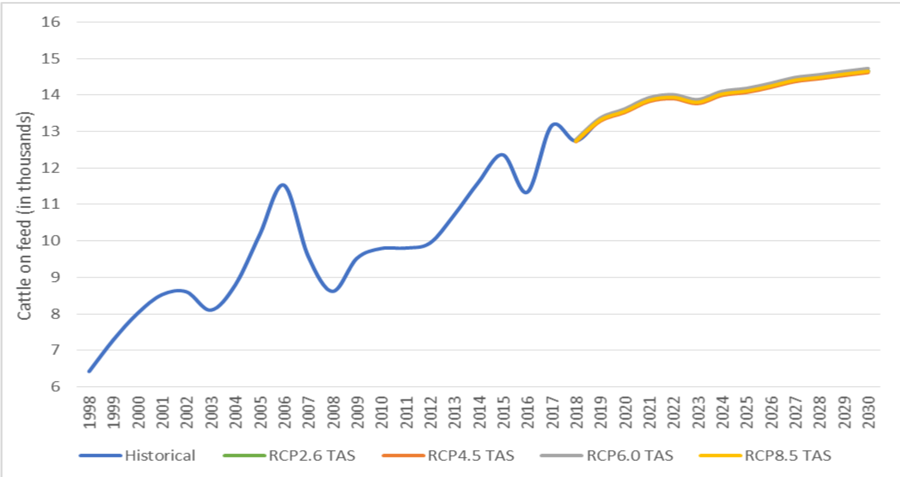

Fig. A- 6. Cattle on feed in Tasmania

Source: MLA Statistics Database; BGA Work Product

9.4.3 Annual Cattle on Feed by Feedlot

Separate Document: Estimates are in the “Australian cattle on feed and total water use by feedlot” document

9.5 Feedlot Water Demand Estimates

9.5.1 Water Use per Head by RCP

Table A- 9. Average annual water use per head under the RCP2.6 scenario (in L per head)

State	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NSW	18,459.1	18,601.6	18,679.0	18,719.2	18,739.7	18,750.1	18,755.2	18,757.9	18,759.2	18,759.8	18,760.1	18,760.3	18,760.5
QLD	20,028.1	20,334.7	20,495.6	20,578.0	20,619.7	20,640.6	20,651.1	20,656.4	20,659.0	20,660.4	20,661.0	20,661.3	20,661.7
SA	17,345.2	17,355.0	17,363.6	17,368.8	17,371.7	17,373.2	17,373.9	17,374.3	17,374.5	17,374.6	17,374.7	17,374.7	17,374.7
VIC	16,877.0	16,974.0	17,027.6	17,055.7	17,070.1	17,077.4	17,081.0	17,082.8	17,083.8	17,084.2	17,084.5	17,084.6	17,084.7
WA	17,100.7	17,341.2	17,468.2	17,533.3	17,566.3	17,582.9	17,591.2	17,595.4	17,597.5	17,598.5	17,599.0	17,599.3	17,599.6
TAS	14,862.4	14,880.3	14,891.9	14,898.3	14,901.7	14,903.5	14,904.3	14,904.8	14,905.0	14,905.1	14,905.2	14,905.2	14,905.2
Average	**17,445.4**	**17,581.1**	**17,654.3**	**17,692.2**	**17,711.5**	**17,721.3**	**17,726.2**	**17,728.6**	**17,729.8**	**17,730.4**	**17,730.7**	**17,730.9**	**17,731.1**

Source: MLA Statistics Database; BGA Work Product

Table A- 10. Average annual water use per head under the RCP4.5 scenario (in L per head)

State	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NSW	18,593.4	18,810.1	18,926.2	18,986.2	19,016.7	19,032.1	19,039.8	19,043.7	19,045.6	19,046.6	19,047.1	19,047.3	19,047.6
QLD	20,161.1	20,541.7	20,741.5	20,843.8	20,895.6	20,921.6	20,934.6	20,941.2	20,944.5	20,946.1	20,946.9	20,947.3	20,947.7
SA	17,414.8	17,460.8	17,487.9	17,502.5	17,510.0	17,513.9	17,515.8	17,516.8	17,517.2	17,517.5	17,517.6	17,517.7	17,517.7
VIC	16,957.2	17,099.0	17,176.4	17,216.6	17,237.1	17,247.5	17,252.7	17,255.3	17,256.6	17,257.3	17,257.6	17,257.8	17,257.9
WA	17,184.4	17,471.8	17,623.4	17,701.2	17,740.6	17,760.4	17,770.4	17,775.4	17,777.9	17,779.1	17,779.7	17,780.0	17,780.3
TAS	14,931.0	14,987.8	15,020.0	15,037.1	15,045.8	15,050.3	15,052.5	15,053.6	15,054.2	15,054.5	15,054.6	15,054.7	15,054.8
Average	**17,540.3**	**17,728.5**	**17,829.2**	**17,881.2**	**17,907.7**	**17,921.0**	**17,927.6**	**17,931.0**	**17,932.7**	**17,933.5**	**17,933.9**	**17,934.1**	**17,934.3**

Source: MLA Statistics Database; BGA Work Product

Table A- 11. Average annual water use per head under the RCP6.0 scenario (in L per head)

State	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NSW	18,594.4	18,811.1	18,927.1	18,987.1	19,017.5	19,032.9	19,040.6	19,044.4	19,046.4	19,047.3	19,047.8	19,048.0	19,048.3
QLD	20,137.7	20,505.3	20,698.3	20,797.1	20,847.1	20,872.2	20,884.8	20,891.1	20,894.3	20,895.8	20,896.6	20,897.0	20,897.4
SA	17,407.4	17,449.5	17,474.7	17,488.3	17,495.3	17,498.9	17,500.7	17,501.6	17,502.1	17,502.3	17,502.4	17,502.5	17,502.5
VIC	16,963.4	17,108.5	17,187.5	17,228.7	17,249.6	17,260.2	17,265.5	17,268.2	17,269.5	17,270.2	17,270.5	17,270.7	17,270.8
WA	17,173.5	17,454.7	17,603.1	17,679.2	17,717.7	17,737.1	17,746.8	17,751.7	17,754.1	17,755.3	17,755.9	17,756.3	17,756.6
TAS	14,922.5	14,974.3	15,003.8	15,019.4	15,027.4	15,031.5	15,033.5	15,034.6	15,035.1	15,035.4	15,035.5	15,035.5	15,035.6
Average	**17,533.2**	**17,717.2**	**17,815.7**	**17,866.6**	**17,892.4**	**17,905.5**	**17,912.0**	**17,915.3**	**17,916.9**	**17,917.7**	**17,918.1**	**17,918.3**	**17,918.5**

Source: MLA Statistics Database; BGA Work Product

Table A- 12. Average annual water use per head under the RCP8.5 scenario (in L per head)

State	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NSW	18,919.0	19,318.4	19,530.9	19,640.4	19,695.9	19,723.9	19,737.9	19,744.9	19,748.4	19,750.2	19,751.1	19,751.5	19,751.9
QLD	20,515.2	21,095.2	21,400.4	21,556.7	21,635.9	21,675.7	21,695.6	21,705.6	21,710.6	21,713.1	21,714.4	21,715.0	21,715.6
SA	17,628.6	17,788.5	17,874.4	17,918.7	17,941.3	17,952.7	17,958.4	17,961.2	17,962.7	17,963.4	17,963.7	17,963.9	17,964.1
VIC	17,188.0	17,461.2	17,608.1	17,684.2	17,722.8	17,742.3	17,752.1	17,757.0	17,759.5	17,760.7	17,761.3	17,761.6	17,761.9
WA	17,383.8	17,784.8	17,996.7	18,105.5	18,160.6	18,188.4	18,202.3	18,209.2	18,212.7	18,214.5	18,215.3	18,215.8	18,216.2
TAS	15,077.5	15,220.2	15,298.4	15,339.3	15,360.1	15,370.7	15,376.0	15,378.6	15,379.9	15,380.6	15,380.9	15,381.1	15,381.3
Average	**17,785.4**	**18,111.4**	**18,284.8**	**18,374.1**	**18,419.4**	**18,442.3**	**18,453.7**	**18,459.4**	**18,462.3**	**18,463.7**	**18,464.5**	**18,464.8**	**18,465.2**

Source: MLA Statistics Database; BGA Work Product

9.5.2 Annual Total Water Use by RCP

Table A- 13. Annual total water use under the RCP2.6 scenario (in ML)

State	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NSW	5,439	5,629	5,721	5,814	5,847	5,819	5,875	5,898	5,932	5,973	5,993	6,016	6,037
QLD	10,182	10,671	11,015	11,340	11,546	11,492	11,626	11,720	11,825	11,949	12,035	12,119	12,196
SA	682	763	769	785	764	744	775	775	788	802	803	807	811
VIC	1,343	1,469	1,516	1,570	1,578	1,554	1,596	1,608	1,633	1,660	1,672	1,686	1,699
WA	801	893	902	919	896	876	907	906	918	931	930	933	936
TAS*	189	198	202	207	208	206	209	210	212	215	216	217	219
Total	**18,637**	**19,623**	**20,124**	**20,634**	**20,838**	**20,691**	**20,988**	**21,117**	**21,308**	**21,530**	**21,649**	**21,778**	**21,898**

Source: MLA Statistics Database; BGA Work Product

Table A- 14. Annual total water use under the RCP4.5 scenario (in ML)

State	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NSW	5,474	5,685	5,789	5,888	5,925	5,898	5,955	5,978	6,014	6,055	6,076	6,099	6,121
QLD	10,239	10,763	11,127	11,465	11,678	11,626	11,764	11,859	11,966	12,092	12,180	12,265	12,343
SA	683	765	772	789	768	747	778	778	791	806	806	810	814
VIC	1,348	1,478	1,527	1,583	1,591	1,567	1,610	1,623	1,647	1,675	1,687	1,701	1,714
WA	800	892	901	918	894	874	906	905	917	930	929	932	936
TAS*	190	199	203	208	209	207	211	212	214	216	217	219	220
Total	**18,734**	**19,783**	**20,319**	**20,851**	**21,065**	**20,920**	**21,223**	**21,355**	**21,550**	**21,775**	**21,895**	**22,026**	**22,148**

Source: MLA Statistics Database; BGA Work Product

Table A- 15. Annual total water use under the RCP6.0 scenario (in ML)

State	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NSW	5,493	5,715	5,824	5,926	5,964	5,937	5,995	6,019	6,054	6,095	6,116	6,139	6,161
QLD	10,246	10,773	11,139	11,477	11,690	11,639	11,776	11,871	11,978	12,104	12,191	12,275	12,353
SA	691	777	785	803	782	762	793	794	806	821	821	825	830
VIC	1,361	1,497	1,549	1,606	1,616	1,592	1,635	1,648	1,672	1,700	1,712	1,726	1,739
WA	811	908	920	939	916	896	927	927	939	952	951	955	958
TAS*	191	200	204	209	211	209	212	213	215	218	219	220	221
Total	**18,793**	**19,871**	**20,421**	**20,960**	**21,178**	**21,035**	**21,338**	**21,471**	**21,665**	**21,890**	**22,010**	**22,141**	**22,262**

Source: MLA Statistics Database; BGA Work Product

Table A- 16 Annual total water use under the RCP8.5 scenario (in ML)

State	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
NSW	5,579	5,854	5,992	6,111	6,157	6,133	6,195	6,220	6,257	6,300	6,322	6,346	6,368
QLD	10,450	11,103	11,540	11,922	12,160	12,114	12,261	12,362	12,475	12,606	12,697	12,785	12,866
SA	692	779	788	807	786	765	797	798	811	826	826	831	835
VIC	1,371	1,517	1,574	1,635	1,646	1,622	1,667	1,680	1,705	1,734	1,746	1,761	1,774
WA	804	900	911	929	905	885	917	916	929	942	941	945	948
TAS*	192	203	207	213	214	212	216	217	219	222	223	224	225
Total	**19,088**	**20,356**	**21,013**	**21,617**	**21,868**	**21,732**	**22,052**	**22,192**	**22,395**	**22,629**	**22,755**	**22,891**	**23,017**

Source: MLA Statistics Database; BGA Work Product

9.5.3 Annual Total Water Use by Feedlot

Separate Document: Estimates are in the “Australian cattle on feed and total water use by feedlot” document

9.6 Water Resource Plans

Table A-17 Australian Water Management Plans

Water resource area	Status at May 2018	% completion	Stage of WRP development	Next phase	Next phase date	Completion date
ACT						
ACT (SW)	Late assist phase	60	Progress in developing draft material, providing to the MDBA for review, and updating draft material	Assess phase	Feb-19	Jun-19
ACT (GW)	Late assist phase	60	Progress in developing draft material, providing to the MDBA for review, and updating draft material	Assess phase	Feb-19	Jun-19
NSW						
Gwydir (SW)	Assess phase	60	Progress in developing draft material, providing to the MDBA for review, and updating draft material	Accreditation phase	Aug-18	Oct-18
Macquarie-Castlereagh (SW)	Late assist phase	40	Progress in developing draft material, providing to the MDBA for review, and updating draft material	Assess phase	Jul-18	Jan-19
Lachlan (SW)	Late assist phase	40	Progress in developing draft material, providing to the MDBA for review, and updating draft material	Assess phase	Jul-18	Jan-19
Gwydir Alluvium (GW)	Late assist phase	30	Some early draft material available to the MDBA for review	Assess phase	Jul-18	Jan-19
Lachlan Alluvium (GW)	Late assist phase	40	Progress in developing draft material, providing to the MDBA for review, and updating draft material	Assess phase	Jul-18	Jan-19
Macquarie-Castlereagh Alluvium (GW)	Late assist phase	30	Some early draft material available to the MDBA for review	Assess phase	Jul-18	Jan-19
NSW Border Rivers Alluvium (GW)	Late assist phase	30	Some early draft material available to the MDBA for review	Assess phase	Jul-18	Jan-19
Namoi Alluvium (GW)	Late assist phase	30	Some early draft material available to the MDBA for review	Assess phase	Aug-18	Jan-19
Murray Alluvium (GW)	Late assist phase	30	Some early draft material available to the MDBA for review	Assess phase	Aug-18	Jan-19
Murrumbidgee Alluvium (GW)	Late assist phase	30	Some early draft material available to the MDBA for review	Assess phase	Sep-18	Jan-19
NSW Border Rivers (SW)	Late assist phase	30	Some early draft material available to the MDBA for review	Assess phase	Oct-18	Feb-19
Barwon Darling (SW)	Late assist phase	30	Some early draft material available to the MDBA for review	Assess phase	Oct-18	Apr-19
Namoi SW (SW)	Assisted phase	30	Some early draft material available to the MDBA for review	Late assist phase	Dec-18	Jun-19
Murrumbidgee (SW)	Assisted phase	30	Some early draft material available to the MDBA for review	Late assist phase	Dec-18	Jun-19
NSW Murray Lower Darling (SW)	Assisted phase	30	Some early draft material available to the MDBA for review	Late assist phase	Dec-18	Jun-19
Intersecting Streams (SW)	Assisted phase	10	Preliminary planning begun	Late assist phase	Dec-18	Jun-19
Darling Alluvium (GW)	Assisted phase	30	Some early draft material available to the MDBA for review	Late assist phase	Dec-18	Jun-19
Western Porous Rock (GW)	Assisted phase	10	Preliminary planning begun	Late assist phase	Dec-18	Jun-19
Eastern Porous Rock (GW)	Assisted phase	10	Preliminary planning begun	Late assist phase	Dec-18	Jun-19
NSW GAB Shallow (GW)	Assisted phase	10	Preliminary planning begun	Late assist phase	Dec-18	Jun-19
Lachlan and South West Fractured (GW)	Assisted phase	10	Preliminary planning begun	Late assist phase	Dec-18	Jun-19
New England Fractured Rock (GW)	Assisted phase	10	Preliminary planning begun	Late assist phase	Dec-18	Jun-19
QLD						
Warrego Paroo Nebine (GW/SW)	completed	100	Plan accredited			
Condamine Balonne (GW/SW)	Assisted phase	40	Progress in developing draft material, providing to the MDBA for review, and updating draft material	Late assist phase	Aug-18	Jun-19
Moonie (GW/SW)	Assisted phase	40	Progress in developing draft material, providing to the MDBA for review, and updating draft material	Late assist phase	Aug-18	Jun-19
Qld Border Rivers (GW/SW)	Assisted phase	40	Progress in developing draft material, providing to the MDBA for review, and updating draft material	Late assist phase	Aug-18	Jun-19
VIC						
Wimmera-Mallee (GW)	Late assist phase	60	Progress in developing draft material, providing to the MDBA for review, and updating draft material	Assess phase	May-18	Sep-18
Wimmera-Mallee (SW)	Late assist phase	60	Progress in developing draft material, providing to the MDBA for review, and updating draft material	Assess phase	May-18	Sep-18
Goulburn-Murray (GW)	Late assist phase	30	Some early draft material available to the MDBA for review	Assess phase	Oct-18	Feb-19
Northern Victoria (SW)	Late assist phase	30	Some early draft material available to the MDBA for review	Assess phase	Oct-18	Feb-19
Victorian Murray (SW)	Late assist phase	30	Some early draft material available to the MDBA for review	Assess phase	Oct-18	Feb-19
SA						
SA Murray Region (GW/SW)	Assess phase	80	Final plan submitted to the MDBA for assessment	Accreditation phase	May-18	Jul-18
Eastern Mount Lofty Ranges (GW/SW)	Late assist phase	60	Progress in developing draft material, providing to the MDBA for review, and updating draft material	Assess phase	Jul-18	Nov-18
River Murray (SW)	Assisted phase	30	Some early draft material available to the MDBA for review	Late assist phase	Jul-18	Jun-19

Source: Murray Darling Basin Authority, NSW Water, BGA Work Product

9.7 Glossary

This glossary is based on generic terminology used by the ACCC in relation to the National water industry and assists in allowing a coherent discussion of the issues without reverting to individual State specific terminology.

gigalitre one thousand megalitres

groundwater (a) water occurring naturally below ground level (whether in an aquifer or otherwise), or

(b) water occurring at a place below ground that has been pumped, diverted or released to that place for the purpose of being stored there, but does not include water held in underground tanks, pipes or other works.

irrigation right a right that a person has against an irrigation infrastructure operator to receive water that is not a water access right or a water delivery right.

irrigation infrastructure operator an infrastructure operator that operates water service infrastructure for the purposes of delivering water for the primary purpose of being used for irrigation.

infrastructure operator a person who owns or operates infrastructure for the storage; delivery; or drainage of water (water service infrastructure) for the purpose of providing a service to someone who does not own or operate the infrastructure.

kilolitre one thousand litres

megalitre one million litres

National Water Initiative the inter-governmental agreement on a national water initiative between the Australian Government and the governments of New South Wales, Victoria, Queensland, Western Australia, Tasmania, the Australian Capital Territory and the Northern Territory.

regulated system means a surface water system in which water in a watercourse can be stored or flow levels can be controlled, through the use of structures such as large dams or large weirs. **surface water** includes water in a watercourse, lake or wetland, and any water flowing over or lying on land after having precipitated naturally or having risen to the surface naturally from underground.

transmission loss water lost to evaporation, seepage, over bank flow etc. along the length of natural water courses. Losses vary with in-stream flow volumes and individual water course characteristics.

unregulated system means a surface water system that is not a regulated system.

water access entitlement a perpetual or ongoing entitlement, by or under a law of a state, to exclusive access to a share of the water resources of a water resource plan area.

water access right any right conferred by or under the law of a state or territory to hold water from a water resource and/or take water from a water resource.

water allocation the specific volume of water allocated to water access entitlements in a given water accounting period.

water delivery right a right to have water delivered by an infrastructure operator.