Final Report

AMPC
AUSTRALIAN MEAT PROCESSOR CORPORATION

Water Stewardship for Red Meat Processors

– an introduction

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Prepared by
Nicole Price, Penny Prasad, Jane Gaffel, Warren Mortlock and Bernadette McCabe*

*The Ecoefficiency Group and *The University of Southern Queensland*

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Why Water Stewardship

The Australian red meat processing industry is a significant consumer of water, primarily used to ensure food safety and hygiene during processing operations. However, at a broader scale, the availability and quality of water in many communities is under stress due to increasing demand, climatic variability, and the environmental degradation of aquatic ecosystems. Australian red meat processors, along with many other businesses, are increasingly faced with uncertainty and potential disruptions or limitations to their operations due to the lack of assured access to a reliable water supply and the impacts of climate extremes such as floods and droughts. Water Stewardship principles and approaches provide an established framework by which the red meat processing sector can work towards improving resilience and the capacity to adapt to climatic change and variability.

Water stewardship is defined as the use of water that is socially and culturally equitable, environmentally sustainable, and economically beneficial. It is achieved through a stakeholder-inclusive process that covers both site- and catchment-based actions.

Water stewardship goes beyond water efficiency, recycling, and reuse at the site level to companies genuinely understanding and responding to water challenges in their catchment and engaging with stakeholders to harness collective action. Implementation of water stewardship approaches by the Australian red meat processing sector and their communities can also play a critical role in affirming a processor's social license to operate.

This guideline

Water stewardship is a process to help red meat processors progressively expand their water management interest and capacity outside their own site boundaries.

This guideline aims to help red meat processors begin this journey by providing an easy-to-follow stepwise approach.

Water stewardship for red meat processors starts with good management of water used directly at the site level and understanding the risks and challenges faced there. The next step is to better understand and manage water that is used indirectly across the supply chain. Processors must then understand their place within the catchment - its water-related impacts, risks, and opportunities, and, importantly, challenges that are shared within their catchment. This guideline provides a method for how to effectively engage with stakeholders to use collective action to tackle shared water challenges.

There are six steps presented in this guideline:

Step 1: Understand direct water use at the site;

Step 2: Understand indirect water use at the site;

Step 3: Understand water risks and opportunities at the site;

Step 4: Understand water management in the catchment;

Step 5: Plan and undertake stakeholder engagement;

Step 6: Look for leading practices.

These steps put a processor in a position, if it so wishes[1], to:

- look for opportunities to improve water stewardship at their site;
- reach out among adjacent landholders with similar issues for solutions to challenges;
- work with catchment stakeholders on initiatives at larger scales;
- engage in water stewardship more widely across the catchment, and;
- develop a Water Stewardship Plan for their site.

Undertaking these steps

[1] It is the choice of red meat processors to develop a Water Stewardship Plan which may or may not meet the full requirements of the standard and which may or may not be presented as a public document.

While it is not essential to do the steps in the above order, it is recommended.

Completing Steps 1 through 4 first can help red meat processors to broadly understand what lies ahead and prepare for stakeholder engagement in Step 5, which can be a daunting step for some. However, a processor could, if it feels confident, begin Step 5 at any time.

The first three steps also use site-based water-related information that red meat processors may already have at hand. Step 4 relies on collecting information at a catchment level, which it is well-recognised can be a time consuming and resource intensive exercise.

Note that much of the information gathered for the catchment (Step 4) is already compiled, mapped and available. The custodians of much of that data and mapping are among the stakeholders in the catchment, particularly those in local and state government. A red meat processor will greatly reduce the task of understanding its place in the catchment, its risks, impacts, and opportunities if it works with the custodians of that information, leveraging existing knowledge to assemble the information required. The earlier a processor engages with these data custodians, the more time and effort it will save.

Moving on to a Water Stewardship Plan

This guideline provides an introduction for red meat processors to Water Stewardship and is based on the framework set out in the International Water Stewardship Standard (IWS)[2] developed by the Alliance for Water Stewardship (AWS)[3]. It focuses on the first part of the standard - *Step 1 Gather and Understand*.

The information gathered in Steps 1 through 5 may be used as the basis for developing a Water Stewardship Plan if a red meat processor wishes to formalise its approach or communicate its approach to others.

A further step may be to gain recognition that its Water Stewardship approach is compliant with the requirements of the IWS Standard – for which having a Water Stewardship Plan is an essential requirement.

Case Study

Ingham's Murarrie site achieves world-class water stewardship[4]

The Alliance for Water Stewardship (AWS) awarded Platinum certification to Ingham's Murarrie (QLD) Primary Processing Plant in 2021, achieving the highest level in the International Water Stewardship Standard. The plant achieved this by identifying its water impacts, challenges, and sphere of influence in the catchment where they operate. By doing this, the site engages with key stakeholders and understands the water-related risks and opportunities that are available.

In 2021, "the plant has rejuvenated six of the site's ponds that now hold 60 million litres of water and provide a fantastic habitat for the local wildlife, the volume of the on-site wastewater treatment plant's sludge has reduced, and the site's water consumption has reduced by one-third over the last three years. In addition, the site has reduced its trade waste to almost zero and has more projects planned to further reduce its water impact."

Inghams Sustainability Report for 2021 describes the projects and initiatives that have led to water stewardship certification.[5]

[2] Download the International Water Stewardship Standard (IWS) and accompanying guidance material. This guideline does not duplicate guideline material already available from AWS that supports the IWS Standard such as the "AWS-Standard-2.0 Guidance" (53 pages).

[3] AWS is a global membership collaboration comprising businesses, NGOs, and the public sector.

[4] Inghams (2021) Ingham's Murarrie site achieves world-class water stewardship, inghams.com.au/inghams-murarrie-site-achieves-world-class-water-stewardship/#

[5] Inghams Sustainability Report 2021 - inghams.com.au/wp-content/uploads/2022/03/2021_Inghams_Group_Limited_Sustainability_Report.pdf

Example layouts

Example layouts are provided in the guideline to assist red meat processors with recording information collected. These contain an example text referencing "*Emerald Meats"* - a fictious mixed animal processing facility located in the central Queensland township of Emerald. The material is intended to provide possible layouts and is not intended as a template.

Case studies

Case studies are also provided through the document and in the Further Reading section.

Linked data sources

There is an abundance of relevant information, and this guideline can't hope to provide detailed references to even the publicly available information relevant to every catchment or region in Australia. The links provided are to main data pages at websites and may change over time. They were all accessed in 2023.

Further Reading

The Further Reading section provides details on aspects of water stewardship as a primer for further research.

Step 1: Understand direct water use at the site

The intent of this step is to gather information and better understand how water is used **directly** at the processing site covering:

- water-related infrastructure;
- legislated obligations (licences and requirements);
- flows and the water balance;
- water quality;
- contamination and pollution sources;
- important water-related areas, and;
- water-related financial value.

This information will be used in Step 3 to better understand the water-related risks, challenges, and opportunities at the processing site.

Develop a good site map

Start with developing a good site diagram or map (if there isn't one already) extending to the processor's physical (operational) boundary and showing the context of the surrounding area. Include any separate but nearby land parcels owned or leased by the processor and managed as part of the site. Show any significant natural features and man-made infrastructure such as roads and railway.

Identify water-related infrastructure

Identify, map, and briefly describe all the main water-related infrastructure that is owned and managed at the site. This includes infrastructure related to **incoming** water supply (mains, surface and groundwaters) and its treatment and storage, and **outgoing** waters from the site including effluent from wastewater treatment and its storage. Outgoing should also include constructed stormwater management infrastructure such as drains, artificial channels, contour banks, constructed ponds and constructed wetlands. Also include any natural wetlands or features that are part of the water treatment train.

Red meat processors should understand on-site water-related infrastructure owned or managed by the company in terms of asset description, age and condition, monitoring, and maintenance. A broad understanding is needed at this stage, and to highlight and understand any risks associated with this infrastructure.

Table 1 provides an example of how this data may be recorded.

Review legislated obligations

Identify and list the main water-related obligations under legislation that must be met at the processing site.[6] This includes the licence conditions related to water management or any of the infrastructure for water treatment, wastewater treatment, effluent, or supply (including storages). Include reference to any water-related incident response plan(s) required under legislation.

It can also be helpful to list any significant issues experienced recently with meeting these obligations.

Identify how water enters and leaves the site

Identify, map, and briefly describe (including diagrams) all water **sources** at the whole of the processing site level. Sources typically include potable (town) water supply networks, water courses, groundwater aquifers, and rainfall. It may also include treatment trains associated with these sources or on-site or adjacent water storages.

Table 2 provides an example of how this data may be recorded.

Information on which water sources (and catchment) the network water providers extract from can typically be found on the websites of bulk water suppliers and retailers.

[6] There is no obligation to use the document outside the processing site. It may be considered as confidential and for internal use only.

Include all the upstream land area or aquifer bodies that contribute to the site's water sources and any up-stream areas that may impact the quality of that water.

Identify, map, and briefly describe all water **discharges** from the site, including effluent, recycled water, and stormwater.

Table 3 provides an example of how this data may be recorded.

Identify any offsite water treatment (including by any Water Treatment Service providers), the ultimate destination of their discharge and level of treatment.

Table 1: Example for Emerald Meats of Water infrastructure and risks

Source	Location	Description/Design	Age (years)	Use	Condition	Risk
Incoming Water						
Groundwater bores	3 bores see diagram	Add bore description	25 yrs	high salinity levels requiring significant treatment prior to 'potable' use	Poor - corrosion Currently no water quality monitoring	Bore failure. Water quality decline requiring more treatment.
Rainwater tank 1 (100 kL)	Western wall	Polyethene tank - water harvested from roof of processing plant. First flush system in use.	9 yrs	Toilet flushing	20 year life. Currently no water quality monitoring	Supply deteriorates during drought. Tank rupture causes water damage to surrounds.
Rainwater tank 2 (100 kL)	Southern wall	Polyethene tank - water harvested from roof of processing plant. First flush system in use.	9 yrs	Washdown non consumables areas	20 year life. Pump condition poor. Currently no water quality monitoring	Supply deteriorates during drought.
other						
Outgoing Water						
1.3 ML settling pond		Clay lined pond (500mm clay compacted to 10^{-9} m/s) with aeration for settlement of biological sludges.	15 years	Treat red and green wastewater streams	Good condition in 2022 survey.	None identified
other						
Stormwater						
Western stormwater system		Rock chutes and drain network to settlement pond on western edge of site.	5 years	Conveys runoff off-site and prevents erosion and sedimentation	Good condition in 2022 survey.	Design capacity is 1 in 10 yr storm which may be exceeded. Failure may lead to licence exceedance.
other						

Table 2: Documenting water entering site - example for Emerald Meats

Service Provider	Main water bodies from which they extract	Reference
Sun Water is the bulk water provider for Central Highlands Regional Council	Nogoa Mackenzie Scheme description here including scheme sources.	Online references or documents
On-site groundwater	Bore field of 3 bores and pumps described here	Report on bore field construction

Others		

Table 3: Documenting water leaving site - example for Emerald Meats

Discharge Point	Location	Description/Level of treatment	References	Risks
Irrigation of holding yards	30 hectares grazed paddocks	Class C treated water from the site's wastewater treatment train		Elevated levels of nutrients (P & N) & potentially pathogens in soil at or downslope of irrigation area. Inability to irrigate for >10% of days in summer season because of high intensity rainfall.
Stormwater overflow to Nogoa Creek	Western boundary	Settling in pond and alum dosing during significant events.	Reports on system design & construction	Breach of licence during storm events. Overtopping of system during events > 1 in 10 year storm. Management and maintenance insufficient to maintain design functions.
WWTP discharge to Nogoa Creek	Northern boundary ML1	Package wastewater treatment plant treats washdown waters and discharges (design specifications here or reference relevant document).	Reports on system design & construction	Breach of licence. Bypass direct to creek during storm events.
Sewer to Black Gully WWTP	Central Highland Regional Council Black Gully WWTP	(Design specifications here or relevant reference) Upgraded 2021 from service population of 4000 to 17,000. Upgraded inlet, new bioreactor, and disinfection. Effluent to Black Gully under licence (EL 12345). Produces recycled water to Class A standard.	www.rdmw.qld.gov.au/__data/assets/pdf_file/0005/1262777/emerald-rwssa.pdf	Rising main to WWTP is insufficient capacity for planned upgrades at Emerald Meats site. Potential for breach of trade waste agreements with CHRC at high processing volumes.
Other				

Quantify water flows and develop a simple model

Quantify the inflows, storage, losses, and outflows at the whole of site level with accurate accounting at (at least) the kilolitre scale. Data is typically collected from on-site flow meter readings, service provider invoices and reports, hours of equipment operation, work logs, rainfall gauges, water storage level readings and other available sources.

Use the above data to develop a **simple** water balance model for the site. The water balance is based on water outflow being *approximately* equal to water inflow plus losses and change in storage volume.

Then do the same to quantify water flows at the level of the main processes at the site (including any recycling and reuse, losses to product, losses to heating or cooling).

Table 4 provides an example of how this data may be recorded.

Some data (such as rainfall) are easily measured, whereas for other data it can be difficult to obtain direct and accurate measurements (such as evapotranspiration or stormwater flows). Focus on the significant flows and use the best available information. Make estimates that are conservative where there is uncertainty. This information is to generally gain a good understanding of what is happening at a red meat processing site. Where information cannot easily be found e.g., stormwater flows, move to the next step. This may end up being an action for the site to invest in determining this information.

Where there is sufficient information available, this model could be replicated on a month-by-month basis and over the course of one year (duration) as a minimum.[7] Use a simple spreadsheet to model the inflows, losses, storage, and outflows See the example in Table 5. This has the benefit of identifying seasonal impacts on water use.

[7] Water stewardship does not require detailed water balance modelling at daily time steps or over decades in duration.

It may be worth looking back over records to prepare a water balance for a drought year and a wet year as well. This may help identify variance in water abstraction, or differences in rainfall patterns or available groundwater depending on seasons.

Table 4: Documenting water flows - example for Emerald Meats site level

Water	Annual used volume (kilolitres)
INFLOWS	4,150,533
Sun Water CHRC Potable Water Supply	3,317,389
On-site groundwater	831,424
Rainwater tank 1 (100 kL)	1,700
Others	-
STORAGE	3,000
1.3 ML settlement pond (Western Stormwater)	3,000
Others	-
LOSSES	1,396,620
Irrigation scheme	1,396,620
Others	-
OUTFLOWS	3,024,300
Sewer to CHRC Black Gully WWTP	2,793,675
Western Stormwater overflows	230,625

Table 5: Water balance model - example for Emerald Meats 2022

Water	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
INFLOWS	(kL)	(kL)	(kL)	(kL)	(kL)	(kL)	(kL)	(kL)	(kL)	(kL)	(kL)	(kL)	(kL)
CHRC Potable Water Supply	263,978	270,000	278,684	290,562	285,791	244,320	290,788	295,000	272,000	265,000	272,316	288,950	3,317,389
On-site groundwater	65,750	63,221	79,089	64,523	72,459	77,489	62,289	65,890	77,490	64,720	62,890	75,614	831,424
Rainwater tank 1	250	230	100	50	80	180	200	220	40	160	100	110	1,720
Others	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
Subtotals	**329,978**	**333,451**	**357,873**	**355,135**	**358,330**	**321,989**	**353,277**	**361,110**	**349,530**	**329,880**	**335,306**	**364,674**	**4,150,533**
STORAGE													
Settlement pond	250	250	250	250	250	250	250	250	250	250	250	250	3,000
Others	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
Subtotals	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**250**	**3,000**
OUTFLOWS													
Irrigation scheme	108,416	112,324	125,678	128,678	124,679	105,678	111,390	113,743	113,821	112,492	112,943	126,778	1,396,620
Others	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
Subtotals	**108,666**	**112,574**	**125,928**	**128,928**	**124,929**	**105,928**	**111,640**	**113,993**	**114,071**	**112,742**	**113,193**	**127,028**	**1,399,620**
OUTFLOWS													
Black Gully WWTP	226,678	235,369	237,571	233,672	240,821	220,679	234,860	242,500	246,653	205,960	227,678	241,234	2,793,675
Western Stormwater	25,000	26,520	15,000	12,546	14,500	23,289	25,169	25,300	11,009	22,789	14,523	14,980	230,625
Others	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
Subtotals	**251,678**	**261,889**	**252,571**	**246,218**	**255,321**	**243,968**	**260,029**	**267,800**	**257,662**	**228,749**	**242,201**	**256,214**	**3,024,300**
Balance	(30,616)	(41,262)	(20,876)	(20,261)	(22,170)	(28,157)	(18,642)	(20,933)	(22,453)	(11,861)	(20,338)	(18,818)	(276,387)

Quantify water quality

Use available data sources to identify the water quality of inflows, storages, and outflows at the whole of site level and for any critical processes at the site. This should cover all incoming water supplies (potable scheme water, groundwater, creek abstraction), waters entering and/or leaving storages on site, outgoing effluent, wastewater discharges and overflows to water bodies.

Identify the water quality parameters of greatest concern with respect to licence conditions, the Australian Water Quality Guidelines[8] (water quality guidelines), or other government water quality requirements.

For each of these parameters, identify measured **concentrations** and the variation with seasonal conditions or within the operational window of infrastructure on site (minimum, maximum and average levels). Identify the cause (if known) of over-limit or exceedance **concentrations** for each parameter of concern.

Most guidelines and legislated requirements relate to the **concentration** of a pollutant in a water (sample), but increasingly there are some that relate to the pollutant **load** carried in a watercourse over time. If these apply in your region, if necessary, annual load may be approximated as average concentration (mg/L) times annual flow volume (kL).

Where this information has already been gathered e.g., as part of an environmental management system – refer to where the information can be found.

Identify sources of water pollution

Use available data sources to identify, map and describe sources of water pollution on-site including actual and potential sources as well as point sources and diffuse sources.

Nutrients, sediments, pathogens, toxicants (heavy metals, pesticides, and other chemicals), acidity, salinity, and gross pollutants (litter) are the most common pollutants and can occur from point and diffuse sources.

Point sources are a single, identifiable source of pollution (such as a pipe or a drain) and might include chemicals used or stored on site, organic waste disposal, livestock pens, or overflow from wastewater treatment. These sources are more obvious and more easily measured.

Diffuse sources occur over a wide area and are not easily attributed to a single source. Diffuse source water pollution is mainly driven by rainfall and runoff, particularly from storms. They are often associated with particular land uses (such as grazing stock) or land use practices (such as fertiliser application). Some diffuse source pollutants (for example, sediment and the nutrients and pathogens that adhere to it) occur naturally and may become a problem during storms when large volumes enter waterways at a faster rate than can be moved through the system. These sources are less obvious and more difficult to measure.

Actual pollution sources are recognised hot spots in the landscape or at the site where pollutants have previously been observed entering waters at above guideline levels.

Where this information has already been gathered e.g., as part of an environmental management system – refer to where the information can be found.

Identify Important Water-Related Areas

Use available data sources to identify, map and briefly describe any Important Water-Related Areas (IWRA) on or adjacent to the site. The IWS Standard defines an IWRA as an "*area in the catchment that, if impaired or lost, would adversely impact the environmental, social, cultural or economic benefits derived from the catchment in a significant or disproportionate manner*". They are more commonly referred to in Australian planning as areas, sites or matters of significance (international, national, state, or local significance) and identified and described in online mapping resources and databases provided national, state, and local governments. Some websites provide a report function by property description (lot and plan) that lists these sites.[9]

IWRA's of **conservation significance** include:

- national parks and protected areas;
- significant habitat and breeding sites for wildlife;
- wetlands and riparian areas;
- groundwater recharge areas, and;

[8] The Water Quality Guidelines 2018 provide authoritative guidance on the management of water quality. www.waterquality.gov.au/guidelines/anz-fresh-marine

[9] See for example Department of Climate Change, Energy, the Environment and Water website includes the Protected Matters Search Tool www.dcceew.gov.au/environment/epbc/protected-matters-search-tool

- special or unusual landscape areas.

IWRAs that have **cultural or spiritual significance** include**:**

- cemeteries and other sites with cultural, historic or heritage values, and;
- sites with important cultural, ceremonial, or spiritual value to indigenous people.

Identify any impacts (actual or potential) the red meat processing site may have on the IWRA. These impacts could for example include:

- extraction from a water source (bore or water course) that may cause water levels changes in the IWRA;
- wastewater discharges into water bodies linked to the IWRA;
- contaminated stormwater runoff to the IWRA;
- flood water flows from the site to the IWRA, and;
- contamination of groundwater linked to the IWRA.

Step 2: Understand indirect water use at the site

Indirect water use is the water used within the red meat processing supply chain – embodied in primary inputs from suppliers and in services from outsourced providers. That is, the water used in the creation, processing and transportation of goods and services supplied to the processor.

The intent of this step is to better understand the quantity of indirect water use and its impact highlighting:

- how much water is embodied in the processor's inputs (especially stock);
- levels of water stress in the catchments from which stock are sourced and the associated risks;
- which suppliers contribute significant sources of embodied water, and;
- how a processor may influence the water stewardship approach of its suppliers.

The steps to determine a site's indirect water use are:

- identify embodied water in primary inputs from suppliers and in services;
- understand the water intensity of these inputs;
- understand water stress levels in supplier's catchments;
- understand risks associated with vulnerable catchments, and;
- consider opportunities to work with suppliers.

Identify embodied water in primary inputs

In the case of red meat processors, the main indirect water use is embodied water in purchased livestock. Start with a list of all significant stock suppliers and identify:

- stock types and approximate stock numbers supplied;
- the location(s) where their production is concentrated, and;
- the catchment they are located in.

The aim is to establish approximate stock numbers sourced from each catchment. Use a simple spreadsheet to record this data.

Beyond livestock, the IWS Standard suggests input goods and services that account for more than 5% of the total weight of the goods generated or 5% of the costs of the site should also be considered.

One source that may be greater than 5% of the costs of the site is the embodied water in energy used onsite – mainly as electricity. However, AMPC found that electricity fell below the 5% threshold on average for Australian red meat processors.[10]

Understand water intensity of these inputs (livestock)

For each purchased livestock type record an estimate of the total quantity of embodied water annually in kilolitres based on the following Australian average values per kilogram live weight (L/kg LW):

- beef at 9,000 L/kg LW;
- sheep at 6,947 L/kg LW.[11]

Recording this information will highlight which suppliers and which catchments are contributing the greatest and least water use.

This is also referred to as the *water intensity* in red meat processing and is a quantitative measure of water use. These are general figures, and a processor may be able to develop more accurate estimates by working with suppliers, or by reviewing existing studies with similar production and geographic/climatic conditions to their location. There is a summary of relevant Australian studies provided in Further Reading. Be cautious about generalisation on this topic (see Box: Issues with Water Footprint and Life Cycle Assessment Methods). A 35-year analysis found Australian beef

[10] Found to be of 2.6% of total costs excluding livestock costs (3.0% for grain fed stock and 3.2% grass-fed stock). See Heilbron, S. (2018). Cost to operate and processing cost competitiveness. AMPC.

[11] From Hoekstra, A., & Chapagain, A. (2007). Water footprints of nations: Water use by people as a function of their consumption pattern. Water Resources Management, 21, 35-48.

producers have decreased freshwater consumption by 14% in the last 5 years and 68% compared with the period 1980-1985.[12]

Understand catchment water stress

Water stress is an indicator that measures the potential impact of water extraction/use on the water resources available. It is typically the annual water use (by one sector or all users say) expressed as a percentage of total annual water resource available. Where water is plentiful, the stress of use on water resources is typically low, but where water is scarce the stress from use can be much greater.

The water stress from livestock production in one catchment also may be quite different to that of similar production in a nearby catchment, even when the two farms have similar water intensity for livestock production. One catchment can have less water for users, so the water embodied in livestock sourced from that catchment is more significant.

For each catchment that stock are sourced from, record the catchment water stress value. It should be evident which catchments are likely to experience greatest and least water stress due to stock supplies to the processor.

At a general level, water stress levels of a catchment can be sourced from the World Resources Institute's (WRI) Aqueduct Water Risk Atlas (On the left-hand bar click on select 'Water stress' and zoom into the catchment of interest). The atlas accounts for the impact of total environmental water use and sector-based consumptive water use. The baseline water stress indicator measures total annual water use by municipal, industrial, and agricultural sectors expressed as a percent of the total annual available water. It ranges 0.01 (lowest water stress) to 1. The higher the value the more competition among users.

Issues with Water Footprint & Life Cycle Assessment Methods

Some methods of undertaking a water footprint can lead to misconceptions around water use and its impacts on a catchment. There is considerable variation among water footprint results for red meat processors and an ongoing misconception that all beef cattle consume large quantities of water in the production system. Water footprint methods often calculate the total amount of freshwater used to produce the stock or meat product and can overestimate embodied water. For example, through inclusion of total rainfall for growing plants used to feed livestock rather than the actual water extracted by the plants to grow; or inclusion of runoff and groundwater that stays within the natural system to livestock production.

Lifecycle Assessment methods typically estimate extracted or "consumptive water use". They measure the amount of water that is removed from available water supplies to produce stock, and which is not returned to that water system i.e., not returned to water bodies such as rivers or water treatment plant. These methods generally calculate embodied water more accurately than water footprints.

Work with suppliers to reduce indirect water use

Depending on how a red meat processor is integrated with their supply chain, there may be opportunities to work with suppliers to reduce indirect water use and encourage greater adoption of water stewardship. These are arguably 'leading practise' initiatives. However, they may become standard practise during drought or when processors need to demonstrate to customers or the community that they are responsible water users.

Opportunities for working with suppliers could include:

- consultation with suppliers to improve water intensity and catchment stress estimates;
- consultation with suppliers on how to improve water efficiency;
- develop procurement guidelines for suppliers regarding efficient water use;
- encouraging suppliers to carry out self-assessment water audits or third-party water audits;
- educational outreach to suppliers to promote water efficient agricultural practices, and;
- simply communicating a processor's water stewardship effort to suppliers and customers.

[12] Wiedemann, S., Biggs, L., Watson, K., Gould, N., & McGahan, E. (2019). Australian Beef Industry 35-year environmental impact trends analysis. Meat and Livestock Australia.

Case Studies

JBS's Great Southern Farm Assurance certification[13]

JBS Foods established the Great Southern Farm Assurance Program ten years ago covering around 4000 beef and lamb producers in NSW, Victoria, Tasmania, and South Australia. The program captures sustainable on-farm practices and develops ways to promote them directly to customers in Australia and overseas. A Farm Assurance certification logo is used on all products packed under the program.

The program has 7 pillars. The pillars include understanding soils, matching the right mix of pastures to the environment, vegetation to protect soils and maintain healthy waterways, healthy and safe workplaces, stock wellbeing, carbon management and ensuring the use of quality water and managing the water usage. Third-party auditors measure and record producer data to provide a simple sustainability index to explain to customers and producers.

Transparency of value chains and communicating the sustainability story throughout the entire value chain will be critical, and a customer expectation in the future.
Robert Ryan, Head of Domestic and Export Beef Sales

Mars Supplier Code of Conduct[14]

Mars Inc. is a multinational manufacturer of confectionery, pet food, and other food products. As part of 'Mars Sustainable in a Generation Plan', the company has made a commitment to eliminate unsustainable water use in its full value chain, starting with a 50% reduction by 2025.

Work with its supply chain includes:

- mapping total water use across its supply chain;
- using the Mars Supplier Code of Conduct to articulate its expectations to suppliers including requirements related to water;
- conducting sustainability performance and social compliance audits to prioritised suppliers using the EcoVadis online platform (As part of the EcoVadis program suppliers are encouraged to understand their water-related risks and disclose their water impacts to the Carbon Disclosure Project;
- using their Next Generation Supplier Advance collaboration model to support the suppliers of their top 10 raw materials to address the root causes of targeted issues, and;
- using rainwater capture or grey water systems in suppliers' manufacturing plants for toilet flushing, cooling towers and irrigation systems.

Tyson Foods Water Stewardship Strategy[15]

Tyson Foods prioritised water efficiency in processing facilities, with a target of 12-percent reduction of water use intensity by the end of 2020, against a baseline of fiscal year 2015. To expand its water stewardship efforts, Tyson Foods worked with the World Resources Institute (WRI) to assess water risk and develop a water stewardship strategy. Tyson undertook water risk assessment to determine which of its processing facilities were in water-stressed catchments. It also looked at the state of catchments where animals and some feeds (corn and distillers dried grain) were sourced, assessing if they were also water stressed or suffering nutrient loss. Based on the findings, Tyson set two types of targets:

- Supply chain stewardship targets, recognising the bulk of their water consumption is in their supply. These targets will be integrated into existing land stewardships goals and focus on managing water quality impacts from nutrient loading and water consumption in locations with high water stress.
- Contextual water targets at their facilities, recognising that they have significant influence on local watersheds at their processing facilities. They will develop site water stewardship plans that will inform contextual water targets based upon each facility's water withdrawal, exposure to high water stress, and proximity to their entire supply chain.

[13] JBS, 2021, Great Southern Announces Formal Sustainability Commitments jbsfoodsgroup.com/articles/great-southern-announces-formal-sustainability-commitments

[14] Mars, Water Stewardship Position Statement www.mars.com/about/policies-and-practices/water-stewardship

[15] Tyson, 2021, Water Position Statement and Prioritization Scheme, www.tysonsustainability.com/downloads/Water_Position_Statement.pdf and www.tysonfoods.com.au/pages/about-us

Step 3: Understand risks and opportunities at the site

Water stewardship requires that red meat processors understand the risks and opportunities around water on their site to:

- prioritise and better manage these risks at their site;
- reach out to other landholders looking for better ways of tackling issues and problems;
- understand where the water issues and challenges in their wider catchment are most relevant to them, and;
- more confidently and successfully engage with other catchment stakeholders.

The aim of this step is to use standard risk management approaches to identify the risks and opportunities associated with water quantity and quality based on the information developed in previous steps.

Risks can be assessed using a processor's corporate risk assessment process, or by using a basic risk assessment such as that shown in Table 7. Use a brainstorming session with knowledgeable staff members to list and discuss risks under each category. Such sessions really need an experienced facilitator to make risk assessment work efficiently. The facilitator needs to understand the basics of risk assessment, how the method will operate and must be aware of how the descriptions in each of the tables are defined. The group should also include a good cross-section of people who know the operations well and can make good decisions about the most appropriate consequence and likelihood combinations described below.

Develop a water-related risk register

Firstly, develop a risk register. This is basically a list of the water-related risks identified above. Consider each of the four main areas of potential water-related risks for a red meat processor:

- **Physical risks** are related to water quantity and quality as an operational input and have the potential to reduce production capacity. Physical risks include:
  - water scarcity or reduced access to water;
  - poor water quality due to pollution, sedimentation, erosion, salinity, turbidity, hardness, blue green algae, or invasive aquatic species;
  - poor condition of onsite water-related infrastructure;
  - poor condition of onsite Important Water-Related Areas;
  - poor condition of public water supply infrastructure;
  - exposure to extreme weather events (floods, droughts, storms, bushfires).
- **Market risks** are related to inconsistent or reduced product supply, price volatility of raw materials, and loss of contracts or market access. Market risks can include:
  - insufficient and poor-quality stock during or after drought or floods;
  - use of recycled water restricting access to markets.
- **Regulatory risks** are those arising from meeting regulatory requirements and may include:
  - failure to meet licence or legislated limits and conditions;
  - failure to secure new or amended licenses or permits;
  - having to meet higher compliance or remediation costs.
- **Reputational risks** are related to the perceived or actual (negative) impacts of the processor's water use on other water users and the processor's "social license to operate". Reputational risks may include:
  - reactively needing to demonstrate responsible use of water during times of crisis;
  - customer concern around the water footprint of meat products;
  - poor customer acceptance of the use of recycled water in meat product processing;
  - not meeting investor expectations for managing water-related risks;
  - adverse public perception of regulatory breaches, and;
  - adverse public perception of the processor's social licence to operate.

Undertake risk assessment

Develop a company specific matrix of descriptors for each level of consequence for each type of risk, similar to the example provided in Table 6.

For the occurrence of each risk, **assign a consequence rating** (Insignificant, Minor, Moderate, Major, Catastrophic – which score as 1 to 5 respectively)

Table 6: Example for Emerald Meats - Water-related risk consequence scale

Rating	Description
Insignificant (1)	Impact can be easily absorbed without management effort. Cost insignificant or below $50,000 Immediate management or clean up leaves no observed environmental impacts Minor short-term injuries only treated at site
Minor (2)	Impact can be readily absorbed but requires management effort Costs to 1% of budget or up to $0.5 million Observable environmental damage that is confined, requires low cost and/or weeks to rectify Multiple minor casualties requiring medical attention and no long-term effects
Moderate (3)	Impact cannot be managed under normal operating conditions. Requires moderate level of resource and management input to rectify Costs to 2% of budget or up to $1 million Environmental damage that is widespread, requires moderate cost and/or months to rectify Several casualties requiring hospitalisation
Major (4)	Impact requires high level of resources and management effort and to rectify Costs to 5% of budget or up to $2.5 million Serious environmental damage that is confined, requires high cost and/or years to rectify Serious injury and long-term impairment
Catastrophic (5)	Disaster with potential to lead to business collapse Requires maximum resources and full management attention to rectify. Costs over 5% of budget or more than $2.5 million Serious environmental damage that is widespread and long-term or permanent Loss of life

Then, for the occurrence of each risk, **assign a likelihood rating**. Develop a red meat processor specific matrix of descriptors for each level of likelihood. The following is a typical example:

- *Almost certain* (Often occurs e.g., 50% to 100% probability);
- *Likely* (Could easily happen e.g., 10% to 50% probability);
- *Possible* (Could or known to happen e.g., once a year or 5% to 10% probability);
- *Unlikely* (Hasn't happened yet but could e.g., once every 10 years or 1 to 5% probability);
- *Rare* (Conceivable but only in extreme circumstances e.g., once in 100 years or 1% probability).

The Scoring matrix uses these ratings to give each risk a numerical **overall risk score**. The overall risk score can be used to describe the severity of the risk, but it also helps to associate the score with a label for the risk level (Low, Moderate, High, Very High, and Catastrophic). The association between score and risk level can be adjusted to suit as depicted in the scoring matrix below.

Lastly, identify and record on the risk assessment any existing controls or future control opportunities against each of the risks, as a minimum covering those assigned an overall risk rating of High, Very High, and Catastrophic.

Table 7: Water-related risk matrix and scoring system

Priority	Risk	Area of impact	Consequence Rating	Likelihood Rating	Risk Level
Very High High Medium Low Very Low	Description	Physical Market Regulatory Reputation	Minimal Minor Medium High Very High	Almost Certain Likely Possible Unlikely Rare	Low Moderate High Very High Catastrophic

Scoring matrix

		Consequence				
		Minimal (1)	**Minor (2)**	**Medium (3)**	**High (4)**	**Very High (5)**
Likelihood	**Almost certain (5)**	5	10	15	20	25
	Likely (4)	4	8	12	16	20
	Possible (3)	3	6	9	12	15
	Unlikely (2)	2	4	6	8	10
	Rare (1)	1	2	3	4	5

Overall risk level associated with scores.

Risk Level	Risk Score
Low	1 to 3
Moderate	4 to 9
High	10 to 15
Very High	16 to 20
Catastrophic	21 to 25

Identify water-related opportunities

Work on the previous steps in this guideline will have already highlighted potential water-related opportunities at a red meat processing site – especially those that could lead to improved supply, quality, or reduce the impacts or the risks of water use. The important thing is to simply start documenting these opportunities and add to them over time. Grouping and prioritising the opportunities can also help identify the types of opportunities that are most worth pursuing. Some examples of these opportunities are provided below for the three main categories that a red meat processor would identify: physical, regulatory, and reputational. Table 8 provides more detailed examples of technologies and initiatives that address the physical water-related opportunities listed below.

Physical water-related opportunities include:

- initiatives to increase water efficiency;
- initiatives to use or improve water recycling and reuse;
- exploring alternative water supplies;
- increasing or improving capacity of water harvesting;
- generating revenue or energy from wastewater treatment, and;
- generating revenue from the sale or beneficial use of treated water on site or by other land users in the catchment.

Regulatory opportunities include:

- streamlining, amalgamating, or simplifying licences and licence conditions;
- improvements to metering and monitoring of regulated water management;
- participation in nearby monitoring programs in the river or catchment;
- upgrading treatment process, plant, or equipment to improve compliance, or;

- reaching out to other land users in the catchment with similar regulatory issues to compare approaches and methods.

Reputational opportunities include:

- engaging positively with government agencies, regulators, and water providers about water stewardship;
- positive media exposure about water stewardship initiatives taken;
- raising awareness of water-related challenges facing red meat processors;
- providing direct and indirect employment opportunities through water stewardship;
- undertaking restoration, management, or protection of Important Water-Related Areas;
- enhanced relationships through engagement with stakeholders and customers, and;
- strengthening the processor's social licence to operate.

Table 8: Emerald Meats example - physical water related opportunities

Area	Example Opportunity
Cleaning	• Good workplace design and layout (e.g., smooth, and impervious floors and walls, easy-to-clean, self-draining and correctly sized drains). • Schedule production to reduce cleaning requirements and minimise equipment in use. • Operator training and adequate, readily accessible, dry-cleaning equipment. • Use of low flow / high pressure water after dry-cleaning. • Screen effluent before it enters the wastewater treatment system. • Use of wastewater treated to potable standard (must meet standards) for carcass washing or other meat product process applications. • Use of non-potable water (where there is no risk of contaminating meat products) for cleaning such as around wastewater treatment plant, inedible offal processing, cleaning paved surfaces, watering of landscaped areas, and truck washing. • Use of alternative water sources e.g., bore or dam water (treated to meet potable water standard if used in contact with meat products). • Collect rainwater and stormwater to supplement non-potable water.
Stockyard/stock washing	• Dry cleaning of manure before floor washing. • Suspended mesh flooring of stock to allow for easier cleaning (for hard hooves animals). • Operator training and monitoring. • Screen effluent before it enters the wastewater treatment system. • Use of non-potable water for initial stock wash or washdown. • Use of wastewater treated to potable standard for initial and final stock wash. • Collect rainwater to supplement stock drinking and wash down water.
Carcass washing	• Manual systems - ensure operators are trained as efficacy is directly related to the operator. • Automated systems – monitor/optimise flow rates, dwell times, temperatures, and spray nozzle performance. • Chemical treatment – use of chemical rinses that meet hygiene standards. • Replace wet paunch dumping with dry paunch dumping. • Install flow meters on tripe and bible wash machines. • Reuse final rinse water for pre-rinses cycles.
Stormwater	• Exclude uncontaminated stormwater from waste treatment (areas) inflows.
Wastewater treatment	• Addition of ultrafiltration (UF) or microfiltration (MF) and ultraviolet sterilisation (UV). • Upgraded nitrogen or phosphorous removal.

Step 4: Understand water management in the catchment

The intent of this step is to gain high level understanding of the water-related risks, challenges, and opportunities in the wider catchment outside the red meat processing site. Processors need only have a broad understanding of water-related information for their catchment and how this applies to their processing sites when making a start on water stewardship. They do not need to be experts in how water is managed and the issues with managing water in their catchment. They do need enough understanding to have constructive dialogue with catchment stakeholders and to be able to identify the relevant risks and opportunities for their processing site among those recognised in the broader catchment.

It also isn't necessary to gather information at the same level of detail as undertaken in the steps above for the processing site. The catchment is exponentially larger and there is typically so much available information that this would be a daunting task.

Instead, some basic steps are recommended. These are:

- define the water catchment;
- find data sources;
- understand water governance;
- understand catchment water-balance;
- understand catchment water quality;
- identify Important Water-Related Areas, and;
- identify existing and emerging initiatives.

Most of the information needed is typically already documented for the larger catchments in Australia, in a few primary sources. These will also provide references to where further data and information can be found if a processor needs to further investigate a topic.

Define the water catchment

Develop a good map of the catchment where the red meat processor is located. The physical scope for water stewardship purposes may be defined in terms of the processor's operating site(s) and supply chain. It generally includes the broader catchment on which a site relies for its water supply, and into which flows any runoff and effluent from the site.

The catchment has a geographic boundary that determines where the processor will need to collect data, assess its risks and opportunities, and engage with stakeholders. The catchment boundary needs to be justified. In some cases, it could include multiple catchments. However, try to avoid catchment boundaries that are significantly larger than the site's influence or impacts as this will unnecessarily and greatly expand the scope.

Establish which catchment areas are upstream and which are downstream of the site as clearly as possible.

Upstream areas are generally the inflow (water supply) side and includes the creek or river catchment in which the site is located and any catchments from which water supplied to the site is drawn. It should encompass the area that, if affected by water-related incidents, would impact on the processor's operations (for example, drought, flood, or spills upstream that would affect the site).

Downstream areas are generally the water outflow (effluent) side and may extend much farther than the influence of the red meat processing site. So, it is important to understand any downstream impacts from the site, including any lands affected by the site's water withdrawal or effluent discharge.

In the absence of any more detailed data, this distance can be based on:

- a downstream distance of 50 kilometres (for aquifers and small creeks) or 100 kilometres (for rivers), or;
- the general planning setback distances for development adjacent to waterways included in
- the local council planning scheme, or;
- impact areas determined by any hydrological modelling commissioned by a processor for the site.

Consider which activities at the site have the potential to impact on any areas within this catchment, especially those located downstream and those areas of high conservation value (national parks, reserves, wetlands, etc) or that hold high heritage, cultural or spiritual value.

Find data sources

Look for primary data sources covering the red meat processor catchment boundary. These are generally the Water Management Plans or Water Resource Plans or Water Resource Allocation Plans in your area. For example, there are:

- Water Resource Plans[16] that apply to catchments within the Murray Darling Basin (20 surface water, 22 groundwater water and six combined plan areas);
- Water Resource Plans that apply to catchments outside the Murray Darling Basin - these plans are typically called Water Allocation Plans (e.g., for Great Artesian Basin or Kati Thanda–Lake Eyre Basin);
- Water Resource Allocation Plans prepared under state water legislation in some states – see the links in Table 9.

Table 9: Where to find water plans in your state

State or Territory	Links to Water Resource/Allocation Plans
QLD	www.business.qld.gov.au/industries/mining-energy-water/water/catchments-planning/water-plan-areas
NSW	www.industry.nsw.gov.au/water/plans-programs/water-resource-plans
ACT	www.environment.act.gov.au/water/water-strategies-and-plans/ACT-Water-Resource-Plan
VIC	www.water.vic.gov.au/mdb/mdbp/water-resource-plans
SA	www.environment.sa.gov.au/topics/river-murray/basin-plan/water-resource-planning
TAS	nre.tas.gov.au/water/water-management-plans/adopted-water-management-plans
NT	depws.nt.gov.au/water/water-management/water-allocation-plans
WA	www.water.wa.gov.au/planning-for-the-future/allocation-plans

There are also national websites with high level information, including:

- the Bureau of Meteorology National Water Account which is an up-to-date source of information for the major water basins in Australia (www.bom.gov.au/water/nwa/2021/index.shtml);
- catchment scale land use profiles at Department of Agriculture Fisheries and Forestry website: see catchment scale land use reports (www.agriculture.gov.au/abares/aclump/land-use/catchment-scale-land-use-report
- the Geoscience Australia Digital Earth website, see data and products (www.dea.ga.gov.au/products);
- the Department of Climate Change, Energy, the Environment and Water website includes the Protected Matters Search Tool (www.dcceew.gov.au/environment/epbc/protected-matters-search-tool), and Bioregion Mapping, (www.dcceew.gov.au/environment/land/nrs/science/ibra/australias-bioregions-maps);
- the Department of Sustainability, Environment, Water, Population and Communities website includes the Water for the Future initiative (www.dcceew.gov.au/water).

There are also catchment mapping resources, catchment snapshots and descriptions available online from National, State and even some local government websites. There may be catchment plans developed by local government or groups such as Landcare, catchment management, or natural resource management groups within the processor's catchment.

Water Stewardship Asia Pacific (waterstewardship.org.au/) can also help in providing specific information and mapping a catchment.

Understand water governance in your catchment

Focus on understanding how water in the catchment is governed and identify any initiatives that address opportunities already identified at the site level, or that provide possible opportunities for water stewardship in the wider catchment.

[16] Murray-Darling Basin Authority, Water resource plans, www.mdba.gov.au/basin-plan/water-resource-plans

Water management in Australia is the responsibility of the states and territories and all legislation to manage water and the water governance arrangements are detailed in the primary sources listed above and at the links in Table 9. The National Water Account website also provides links to relevant to water governance - see www.bom.gov.au/water/waterinaustralia.

The National Water Initiative (NWI) www.nwc.gov.au[17] is the principal framework for national water reform and is central to the role of the Australian Government in the management and regulation of water (see www.dcceew.gov.au/water/policy/policy).

Also look for governance programs in the catchment, such as:

- water way assessments and score cards and local government water monitoring programs;
- background reports under drought and climate adaption programs;
- landholder programs that may be able to assist graziers to reduce their water, and;
- water infrastructure programs that could be improving water security in a region.

Understand catchment water-balance

The intent here is to understand enough about the water flows at the whole of catchment or sub catchment level for a red meat processor to understand the significance of its water use allocation at this scale.

Look for information on whole of catchment or sub catchment flows or water balance in the primary sources listed above. What are the recognised supply and demand trends and how does the catchment respond in drought and flood years (El Niño/La Niña cycles)? How does the processor's site water use compare to catchment flows?

The Water In Australia report and Monthly Water Updates at the National Water Accounts show visually and qualify water inflows, outflows, changes in water storage and water liability (water allocation remaining) to calculate the net change in water resource (see link to NWA above). Datasets used to generate this report are available for download through specific information sources available at the Water Information, Bureau of Meteorology (www.bom.gov.au/water/index.shtml).

Understand catchment water quality

Determine how water quality is monitored in the catchment level and what the main findings, trends and issues are. These should be detailed in the primary sources listed above. Water monitoring often involves multi-disciplinary partnerships of government, regional NRM bodies, science providers, industry, community, and other parties. Engage with these data custodians to short-circuit the search for annual summaries and reporting on these trends and issues.

Identify Important Water-Related Areas

Water management can be especially significant around IWRAs in the catchment – so it is a good idea to establish where these are and any located downstream of the processing site or those upstream where major supplies are drawn from. The information sources listed above are a good starting point. Also look for online mapping resources at state government environment department in your state or territory – these IWRAs are usually called sites or areas of national or state significance in online planning maps – see Step 1.

For IWRA nearby in the catchment:

- consider what the status or condition of the site is;
- identify the management in place;
- identify what collective action is or can be taken by catchment stakeholders to protect and manage these sites, and;
- identify any opportunities for the processor to become involved with the management and protection of these sites.

Identify water-related challenges

[17] The Water Act 2007 and the Regulations were also created to provide a legislative framework to implement NWI. The act included establishing the Murry-Darling Basin Authority and Basin Plan 2012 www.mdba.gov.au.

Briefly list any water-related challenges identified at the catchment level in the material gathered above.

Step 5: Plan and undertake stakeholder engagement

The intent of stakeholder engagement is to understand relevant stakeholders, their water-related challenges, and the red meat processor's ability to influence and improve the catchment water management by collective action with these stakeholders at its own site and potentially beyond in the catchment.

The main pre-requisite is to undertake an assessment of stakeholders and plan engagement with them. Having a plan from the very beginning and capturing and responding to stakeholder feedback is essential.

We suggest a red meat processor take the following steps:

- identify the stakeholders;
- identify stakeholders' interests and challenges;
- assess stakeholders' level of influence and interest;
- assess the stakeholders' level of engagement and commitment;
- identify shared challenges, and;
- develop a stakeholder engagement plan.

Develop a register of water-related stakeholders

Identify and list the stakeholders briefly describing their areas of concern on a Stakeholder Engagement Register (spreadsheet). Don't include everyone. Just focus on stakeholders that have a direct interest in the processor's water management and might reasonably influence decisions made by the processor during times when the issues, problems and opportunities identified above arise.

Look for stakeholders:

- locally among primary producers, businesses, local council, or local university, and local landcare groups, non-government agencies, and not-for-profit groups;
- regionally or at the catchment level including any existing catchment management initiatives and programs in place, and;
- at the state level among politicians, state government departments, industry representative bodies, and development programs.

Ways to identify stakeholders include:

- research on the web and social media;
- among the partners, supporters, and contributors to past catchment management initiatives;
- draw on in-house knowledge;
- community directories, and;
- consulting with local politicians, leaders, and community groups.

Identify stakeholders' interests and challenges

Once stakeholders are identified, an assessment is undertaken to identify their interests and the catchment challenges that are their focus. Use the web and social media to identify stakeholders' interests and the challenges that they focus on addressing. Add these interests and challenges for each stakeholder on the Stakeholder Engagement Register.

Assess stakeholders' level of influence and interest

Next, assess the likely level of influence and interest in engagement with the processor that stakeholders may have.

Assess the stakeholder's **level of Influence**. How much influence does the stakeholder have and "who" do they influence?

- high - support of this stakeholder is required for achieving the goals;
- medium - goals may be achieved without this stakeholder's support, but not easily, and;
- low - achieving goals is not reliant on the support of this stakeholder.

Assess the likely **willingness or interest** of the stakeholder to engage with the processor and level of confidence in that assessment (as Good, Difficult, or Indifferent).

Assess **quality of current relationship** between the red meat processor and the stakeholder and level of confidence in that assessment (as Good, Difficult, or Indifferent).

Add all these assessments to the Stakeholder Engagement Register.

Assess the stakeholders' level of engagement and commitment.

Use the matrix (Figure 1) below to help systematically determine the level of **engagement** and **commitment** by each stakeholder based on their level of interest and influence.

Assess the likely level of engagement that each stakeholder might have with the processor (as Inform, Consult, Involve, or Partner).

Assess the likely level of commitment that each stakeholder might have with the processor (as Listen, Contribute, Participate, Partner).

Add these assessments to the Stakeholder Engagement Register.

Figure 1: Stakeholder matrix – interest vs influence [18]

	Interest of stakeholder	
Influence of stakeholder	**Low interest/ High influence** **Stakeholder's level of engagement:** Involved **Stakeholder's commitment:** Participate	**High interest/ High influence** **Stakeholder's level of engagement:** Partner **Stakeholder's commitment:** Partner
	Low interest/ Low influence **Stakeholder's level of engagement:** Informed **Stakeholder's commitment:** Listen	**High interest/ Low influence** **Stakeholder's level of engagement:** Consulted **Stakeholder's commitment:** Contribute

Identify shared challenges

There are water-related challenges for the whole catchment identified in Step 4, and for the red meat processing site identified in Step 3. The **shared** challenges are those that are shared across the catchment or with one or more stakeholders e.g. impact of drought.

The intent of this step is to identify these shared challenges (or opportunities) and prioritise them, before commencing engagement with catchment stakeholders in earnest. This includes identifying which catchment stakeholders have the greatest potential for developing actions to address these shared challenges.

When prioritising shared challenges consider:

- extent that the challenge directly impacts the processor's water management;
- potential benefit to the processor's operations and to others beyond the boundaries of the processing site;
- special or unique perspectives or abilities that the processor brings to addressing a challenge;
- the scale and cause of the challenge;
- whether the challenge and/or solutions are consistent with science on the subject;
- extent to which a challenge is already addressed by existing public or private initiatives;
- the likelihood of tangible outcomes and success over a timeframe that the processor is comfortable with, and;

[18] Shire of Cocos Keeling Islands, 2019, Community and Stakeholder Engagement Framework, shire.cc/images/files/Community-Engagement-Framework-April-2019.pdf

- whether future issues and uncertainties might adversely impact the work. e.g., population growth, developments, impacts of climate change, aging infrastructure, flood, drought, and bushfire impacts.

Develop a stakeholder engagement plan

An engagement plan outlines the stakeholders involved, their level of engagement and commitment, and the shared challenges addressed. It outlines the purpose of engagement, the red meat processor's commitment to engagement, appropriate methods to use, and perhaps an allocation of time and resources.

Use Table 10 to establish the likely levels of commitment sought through the engagement plan.

Table 10: Likely commitment levels on shared challenges

Assessment of Stakeholder	Stakeholders' commitment	Processor's commitment
Low interest Low influence	Listen	We will keep you **informed**
High interest Low influence	Contribute	We will **consult** with you – to keep you informed and respond to questions or concerns.
Low interest High influence	Participate	We will **participate** with you to meet your needs and aim to raise level of interest.
High interest High influence	Partner	We will **partner** with you to pursue a shared challenge.

Use Table 11 to match the level of engagement with the purpose and methods of engagement for each stakeholder. Add further possible initiatives and amend the purposes to suit the processor's needs.

A processor will need to decide how much engagement it undertakes, who participates in that engagement and the resources it is prepared to commit to methods and initiatives. These should be included in the plan but are likely to change over time and as engagement progresses.

Case Study

Positive engagement with regulators

The Renmark Irrigation Trust is Australia's oldest irrigation trust and the first irrigation scheme in the world to achieve Gold Level certification with AWS. The Trust delivers water through 140 kms of pipelines to over 600 irrigators at 98% efficiency, which is well above the Australian average.

Initial engagement through the water stewardship process involved working with Nature Foundation SA and local government to deliver environmental water to Johnson's Waterhole. The water hole has now been transformed into a thriving wetland supporting a huge range of biodiversity. Based on the success of the Johnson's Waterhole project, a partnership agreement was drawn up between an irrigation scheme and the Commonwealth Environmental Water Holder (CEWH) in relation to planning and managing the transfer, delivery and monitoring of Commonwealth environmental water to wetland and floodplain sites in the Renmark region.[19]

Tourism operators have reported that environmental watering has underpinned development by providing confidence to invest in tourism businesses. Now local businesses and Renmark-Paringa Council are also implementing water stewardship with the Council being the first local government in the world to be recognised for its leadership in sustainable water management through International Water Stewardship Standard certification– see Renmark Paringa Council Water Stewardship Plan.[20]

Undertake stakeholder engagement

[19] Australian Government, Department of Climate Change, Energy, the Environment and Water, Partnership arrangements on the use of Commonwealth environmental water, www.dcceew.gov.au/water/cewo/publications/agreements-use-commonwealth-environmental-water

[20] Renmark Paringa Council, Water Stewardship Plan, www.renmarkparinga.sa.gov.au/__data/assets/pdf_file/0033/1078773/RPC-Water-Stewardship-Plan.pdf

The engagement plan prepares a red meat processor for engagement activities but should be amended and updated as engagement progresses. Again, the intent of stakeholder engagement is to understand relevant stakeholders, their water-related challenges, and the processor's ability to influence the catchment water management by actions at its own site and by actions beyond its site boundaries.

At first, just get to know the stakeholders and refine the plan. Be seen to be interested and as a participant.

Look for and carefully select one or two headline projects or initiatives to become involved in and limit exposure and commitment to levels that the processor is comfortable with. Identify where the processor can contribute unique or special skills, and where is a processor's return on investment of time and resources likely to be greatest?

Case Study
Support for community groups[21]

Radfords, in West Gippsland, Victoria is the only large-scale abattoir in the region. They pride themselves on the 'billions of dollars of economic activity within the region and the creation of many thousands of jobs generated through their business and the flow-on effects to the wider community.'

They support numerous organisations across their community – schools, colleges, sporting and social clubs, community groups and service organizations – generating, in their words, 'reciprocal goodwill'.

Table 11: Purpose and methods of engagement

Level of engagement	Possible initiatives	Purpose
Inform	• Social media • Article in local paper • Web Site • Fact sheet • Webinars • Visual media • Media release • Displays (e.g., libraries) • Information sessions / briefings	One-way communication to provide balanced and objective information to assist understanding about something that is going to happen or has already happened: • Develop and maintain reputation and social licence. • Increasing awareness of challenges faced by processor. • Informing processor's position on a decision or direction. • Providing advice on an issue.
Consult	• Direct contact - personal telephone call, email, or meetings • Online discussion forums, blogs, social networking, ratings, & voting • Paper or phone survey • Online and written feedback / submissions	Two-way communication process aimed at obtaining feedback on ideas, alternatives, and proposals to inform decision-making: • Seek or share knowledge or data • Seek or share advice • Seek or share to learning experiences • Seek or share feedback
Participate	• Meetings with key stakeholders • Focus groups • Workshops • Public hearing • F2F and online discussion forums • Site tours	Participatory process to help identify issues and views to ensure that concerns and aspirations are understood and considered: • Seek to involve in discussions and planning process to achieve mutually desirable outcomes • Encourage participation • Build capacity

[21] Radfords Warragul, About Us, radfords.com.au/about-us.html

Partner	• Meetings with key stakeholders • Focus groups • Workshops • Working group • Shared projects	Working together to develop an understanding of all issues and interests to work out alternatives and identify preferred solutions: • Involve in decision making • Allocate responsibilities to achieve outcomes • Leverage resources • Ongoing involvement

Step 6: Look for leading practices

Leading practices (or best practices) can take the form of guidelines, ethics, or ideas that represent the most efficient or best course of action in a given business situation. Leading practices may be established by regulators, government, non-government organisations, or industry associations. There's always something worth discovering and to learn from in these examples of how people tackled problems in the past. For example, considering if the approach be applied to the red meat processor's situation and also what would be retained from the approach and what would be changed.

Look for examples of water stewardship, particularly leading practice within the catchment for water governance, water balance, water quality, and maintaining important water-related areas. There may be good models to emulate, and it may help processor's to understand past and current initiatives and programs within the catchment. Table 12 provides example case studies on water balance, Table 13 on water quality and Table 14 on Important Water-related Areas.

Leading practices in water balance such as:

- beneficial reuse of water;
- water harvesting;
- water recycling, and;
- capture of energy.

Leading practices in water quality such as:

- offsetting impacts;
- wetland treatment of agriculture runoff;
- utilising traditional land management methods;
- remediation of eroded water ways;
- reef credits for water quality projects;
- innovative wastewater treatment trains, and;
- rehabilitation and protection of riparian areas along waterways.

Leading practices in Important Water-related Areas such as:

- improving groundwater recharge;
- fish re-stocking;
- monitoring programs;
- restoration projects;
- weed and pest management;
- litter removal, and;
- bushfire prevention management.

Case Study
The Australian Beef Sustainability Framework (ANSF) www.sustainableaustralianbeef.com.au

The ABSF was created to meet the changing expectations of customers, consumers, investors, and other stakeholders. The Framework defines sustainable beef production and tracks performance over a series of indicators annually. The Framework currently has progress against all its 23 priorities. The framework has 4 main themes including environmental stewardship with priorities relating to water including:

- Minimising nutrient and sediment loss: Indicator - water quality.
- Balanced tree and grass cover: Indicators - % land set aside for conservation or protection purposes, % land managed by beef producers for conservation outcomes through formal arrangements and % cattle producing land managed for environmental outcomes through active management.
- Manage Climate Change Risk: Indicator - Produce confidence in climate change adaptation and preparedness information, technologies, and resources/tools.
- Efficient use of water: Indicator - Kilolitres of water used per tonne of liveweight for raising cattle.

Table 12: Leading practice case studies in water balance

Case study	Challenges	Stakeholder	Description and reference
Discharge of treated water for beneficial use	Solutions for mine voids with water acidification problems and to initiate employment and commercial enterprise opportunities for the Collie community	Mining site Aquaculture Community Traditional owners	**Ngalang Boodja Mine Lake Aquaculture Project** Pumped acidic water from the mine lake into a limestone treatment system to supply an aquaculture project that supports commercially viable marron farming, research, and education in aquaculture for local Aboriginal enterprises. www.industry.gov.au/publications/leading-practice-handbooks-sustainable-mining/water-stewardship
Rainwater collection, storage, and reuse for irrigation	Needed a long-term sustainable solution to reduce mains water use in parkland	Local council Government Consultant South Bank corporation	**South bank Parklands Rain Bank** The Rain Bank rainwater harvesting system collects and treats stormwater from a highly developed urban catchment in central Brisbane, through a series of underground pipes. Water is stored, treated, and redistributed to the Parklands irrigation system. southbankcorporation.com.au/projects/rain-bank
	Achieve green and resilient turf, open space, sustainable irrigation using harvested stormwater and wicking bed technology	Government Local community University Council Indigenous community	**Gladstone East Shores Precinct.** The integrated park design features an innovative application of “wick bed” technology to store locally collected stormwater runoff for passive irrigation of recreational lawn areas. Storm water transfers from roads and park shelters into a shallow storage zone where wicking beds use the natural process to draw water to the active root zone to improve conditions for healthy turf growth. The community and stakeholders were consulted in stakeholder workshops, resulting in the successful redevelopment of the degraded port site. watersensitivecities.org.au/wp-content/uploads/2018/10/8-Gladstone-East-Shores_FINAL.pdf
Water efficiency to reduce pressure on raw water supplies	Pressure on ground water supplies	Mining site	**OZ Minerals Prominent Hill in South Australia** Water is used to process the ore and to separate copper minerals and gold from waste products. An opportunity was identified to reclaim water before the tailings are sent to the tailing’s storage facility for reuse in the processing facility with any excess reclaimed water used in the flotation circuit which occurs at an earlier stage of the process. Groundwater intake was reduced by 600 ML or 10%. www.industry.gov.au/publications/leading-practice-handbooks-sustainable-mining/water-stewardship
Water storage in water constrained region	Lack of a permanent water supply	Mining company School	**Valkyrie State School drought proofing** Glencore provided financial support for the installation of hydro panels and associated plumbing infrastructure to enable water to be stored within a reservoir to drought proof the school and to address water safety problems. www.glencore.com.au/media-and-insights/news/p-and-c-grant-delivers-queensland-school-drinking-water
Upgrade the heat pump system: Heat transfer from treated effluent to heat source water	Extracts energy from treated wastewater effluent	Government Public aquatic centre Tasmania government Water plant regulator	**Doone Kennedy Hobart Aquatic Centre energy systems** The Aquatic Centre uses a heat pump to recover heat from treated council effluent water. Heated water is then transferred to a thermal storage tank for secondary heating of pools, space heating and domestic hot water systems. www.hobartcity.com.au/Projects/Current-projects/Doone-Kennedy-Hobart-Aquatic-Centre-redevelopment/The-Doone-Kennedy-Hobart-Aquatic-Centre-Energy-Systems

Table 13: Leading practice case studies in water quality

Case study	Challenges	Stakeholder	Description and reference
Investment in catchment management works to offset impacts	Manage natural wetland to offset nutrient loads released from sewage treatment plants.	Water and Sewerage Service Provider	**Maroochy River Wetlands** In 2016, Unitywater purchased two lots of former cane farming land on River Road, Maroochy River as part of a larger program to improve the health of the rivers and creeks in the area. Much of the former cane land is being restored as a wetland. This wetland removes nutrients and sediments from the river, which improves water quality and overall river health. Unitywater can offset the amount of nutrients removed by these wetlands against the nutrients discharged to the Maroochy River following treatment of the local community's sewage. www.unitywater.com/about-us/projects-in-your-area/major-projects/yandina-creek-wetland
Wetland treatment train to improve water quality	Water high in nutrients, herbicides and pesticides was draining from 500 hectares of sugar cane into wetland and eventually the Great Barrier Reef during rainfall events	NRM groups Agriculture (sugar cane) Catchment Solutions, Reef Catchments NRM	**Wetland treatment system Mackay, Central QLD** The wetland treatment system was developed on sugarcane farmland upstream of the Mackay degraded lowland wetlands. It contains three water quality treatment chambers: a sediment basin, deep-water macrophyte zone and detention/irrigation re-use chamber. The first chamber is used to filter sediment, while the second chamber is used to absorb nutrients. The last chamber is used by landowners to irrigate the sugar cane before discharge into existing wetlands. www.catchmentsolutions.com.au/this-train-is-a-treat/
Recovery Program after extreme weather events	Remediation of two eroded sections of the Endeavour River damaged by the 2019 Monsoon Event	Cape York NRM group Neilly Group Engineering and Queensland and Australian Government	**Riparian Recovery Program Endeavour River, Queensland.** This program undertook reconnaissance to identify the environmental impacts of monsoon events in north Queensland in 2019 and the rehabilitation and restoration of flood-affected riverine, wetland and riparian environments. The remediation design includes bank reprofiling, rock armouring, timber pile fields and revegetation with grasses and trees. capeyorknrm.com.au/projects/drfa-riparian-recovery-program
Purchasing of Reef Credit for water quality projects undertaken by landholders	Encourage farmers, graziers, landholders to partner with Reef Credit investors and generate an additional diversified income stream from improving water quality.	Bank Queensland Government Landholders Project Developer (Green Collar)	**Purchase Reef Credits (Great Barrier Reef)** HSBC and the Queensland Government are the first-ever private and public sector buyers of Reef Credits (from Green Collar). Reef Credits are the tradable units used to quantify and assess the work done by landowners to improve water quality flowing into the Great Barrier Reef. The Reef Credits can then be sold, paying landholders for improved water quality resulting from their on-farm actions – all without compromising the productivity of their land. greencollar.com.au/hsbc-and-the-queensland-government-purchase-world-first-reef-credits/
Building traditional owner capacity to maintain water quality	Wetlands damaged by pigs and cattle	Traditional Owners NRM Alwal National Park	**Maintaining water quality on traditional lands** The project improves water quality and builds capacity by teaching traditional owners how to build and maintain fences to prevent cattle/pigs entering the river frontage. They also learn about weed control, wetland monitoring, fish surveys, and cattle management. capeyorknrm.com.au/projects/building-traditional-owner-capacity-maintain-water-quality-traditional-lands

Table 14: Leading practice case studies in Important Water-Related Areas

Case study	Challenges	Stakeholder	Description and reference
Maintaining wetland water levels & restoration	Preservation of water levels in a wetland on the National Wetland Register that adjoins the site	Mine site University of Western Australia Government regulators	**Fortescue Marsh wetland management** Cloudbreak Mine is on the northern fringe of the nationally significant Fortescue Marsh. Saline water that is abstracted from mine dewatering is reinjected into the saline aquifer under the marsh to maintain the pre-mining water level in the surficial aquifer. The project is managed with an extensive network of monitoring points and studied by the University of Western Australia to better understand improved groundwater model simulations. www.industry.gov.au/publications/leading-practice-handbooks-sustainable-mining/water-stewardship
	Rehabilitation of disused and disconnected ponds from a previous piggery operation. Preservation of water levels in a council owned wetland that adjoins the site.	Ingham's Food processing company Local government Traditional Owners	**Ecosystem restoration and wetland polishing of effluent** At Ingham's Murarrie Processing Plant in Queensland, biodiversity restoration project involved redirecting the flush water from the site's own Advanced Water Treatment Plant into ponds. Ponds were connected by an overflow and pipe system that allows water wildlife to move between the ponds. With the support of the Brisbane City Council, the final pond overflow flows off-site into the freshwater swamplands on the adjacent Doboy Wetlands owned by the Council with an average of 3 ML per week being released into the creek system. The project also contributed to traditional owners' culture and values by introducing Yellow Belly Bass into ponds. inghams.com.au/wp-content/uploads/2022/03/2021_Inghams_Group_Limited_Sustainability_Report.pdf
Install barrier to filter litter in the Great Barrier Reef Marine Park	Litter passing into waterways in the Whitsundays	Government Local Government Australian Charity NGO Industry	**Stopping litter at its source** To reduce the amount of rubbish entering the Great Barrier Reef Marine Park, the project has installed barriers (gross pollutant traps) in the Whitsundays waterways to prevent rubbish from passing through. Collected data will be used to design further reduction programmes and support local businesses and communities in implementing waste management strategies. healthyriverstoreef.org.au/wp-content/uploads/2021/11/hr2r-stewardship-report-2020-21-041121.pdf

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Australian Government. (2016). *Water Stewardship: Leading Practice Sustainable Development Program for the Mining Industry.* Retrieved from www.industry.gov.au/sites/default/files/2019-04/lpsdp-water-stewardship-handbook-english.pdf

Beef Central. (2021). *JBS adds sustainability elements to Great Southern brand program*. Retrieved from Beef Central: www.beefcentral.com/news/jbs-adds-sustainability-elements-to-great-southern-brand-program/

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Ridoutt, B., Sanguansri, P., Nolan, M., & Marks, N. (2012). Meat consumption and water scarcity: beware of generalizations. *Journal of Cleaner Production, 28*, 127-133.

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Further Reading

Water management initiatives by Red Meat Processors

Technical and economic feasibility of water recycling and energy recovery for red meat processing operations in abattoirs	Technical and economic feasibility study to identify technologies capable of water recycling while simultaneously recovering energy from red meat processing waste streams - BioWin and WAVE Reverse Osmosis. *www.ampc.com.au/research-development/sustainability/technical-and-economic-feasibility-of-water-recycling-and-energy-recovery-for-red-meat-processing*
Investigating water and wastewater reuse and recycling opportunities: identification and segregation of various waste streams	Project aimed to progress water recycling and reuse in the red meat industry by providing a selection and assessment tool, incorporating cost benefit analysis (CBA), that will enable AMPC and industry members to evaluate specific water treatment options with consideration of raw water quality and desired end use application. *www.ampc.com.au/getmedia/205aabb3-fe4b-4c87-9582-6c37fdf9fde9/AMPC_investigatingWaterAndWastewaterReuseAndRecyclingOppotunities_FinalReport.pdf*
Strategic opportunities for water reuse and recycling at Australian abattoirs	Strategies' included water efficiency, direct reuse of water (with or without prior treatment), recycling at non-potable standard and recycling water at potable standard *www.ampc.com.au/research-development/sustainability/strategic-opportunities-for-water-reuse-and-recycling-at-australian-abattoirs*
Strategic evaluation of RD&E opportunities for water reuse and recycling at Australian abattoirs	Project was to identify the needs and opportunities to achieve water efficiency gains in Australian meat processing facilities through water conservation, reuse and recycling whilst maintaining food safety and highest quality product. www.ampc.com.au/research-development/sustainability/strategic-opportunities-for-water-reuse-and-recycling-at-australian-abattoirs
Stormwater Management Framework and Good Practice Guidelines for Meat Processing Plants	A review current methods of stormwater runoff management undertaken in abattoirs in Australia and identify best practices for the management of water runoff from abattoirs. www.ampc.com.au/getmedia/745b4586-dab8-4600-b0db-a6f6b13b12d6/AMPC_StormwaterManagementFrameWorkAndGoodPracticeGuidelines_FinalReport.pdf
Feasibility of using alternative storm water treatment technologies and new innovative policy, for sustainably managing contaminated storm water run-off	Stormwater management options identified and investigated in this report for their potential to deliver upon regulatory obligations for a red meat processor. www.mla.com.au/research-and-development/reports/2015/feasibility-of-using-alternative-storm-water-treatment-technologies-and-new-innovative-policy-for-sustainably-managing-contaminated-storm-water-run-off/
Oakey Beef Exports Water Resource Sustainability	Project assessed water efficiency, water supply risk, water savings initiatives and irrigation management tools/options for the Oakey Beef Exports in Queensland. www.mla.com.au/research-and-development/reports/2019/oakey-beef-exports-water-resource-sustainability/

Water intensity studies for the beef and sheep in Australia

Stock Type	Reference	Authors/Project funding	Location of studies
Beef cattle and sheep	• Peters, G., Rowley, H., Tucker, R., Wiedemann, S., Short, M., Schulz, M. & Feitz, A. 2009. Southern Red Meat Production – a Life Cycle Assessment. Final Report. University of NSW and FSA Consulting, for Meat and Livestock Australia (MLA). • Peters, G., Rowley, H., Wiedemann, S., Tucker, R., Short, M. & Schulz, M. 2010a. Red meat production in Australia: life cycle assessment and comparison with overseas studies. Environmental science & technology, 44, 1327-1332. • Peters, G., Wiedemann, S., Rowley, H. & Tucker, R. 2010b. Accounting for water use in Australian red meat production. The International Journal of Life Cycle Assessment, 15, 311- 320. • Peters, G. M., Wiedemann, S., Rowley, H. V., Tucker, R., Feitz, A. J. & Schulz, M. 2011. Assessing agricultural soil acidification and nutrient management in life cycle assessment. The International Journal of Life Cycle Assessment, 16, 431-441.	UNSW (Water Research Centre) FSA Consul ting Meat and Livestock Australia	3 Case studies - WA, VIC, NSW
Beef cattle	• Eady, S., Viner, J. & Macdonnell, J. 2011a. On-farm greenhouse gas emissions and water use: case studies in the Queensland beef industry. Animal Production Science, 51, 667-681.	CSIRO (Lives tock Indus tries)	2 Case studies - QLD
Beef cattle	• RIDOUTT, G., SANGUANSRI, P. & HARPER, G. S. 2011. Comparing Carbon and Water Footprints for Beef Cattle Production in Southern Australia. Sustainability, 3, 2443-2455. • RIDOUTT, B. G., SANGUANSRI, P., FREER, M. & HARPER, G. S. 2012b. Water footprint of livestock: comparison of six geographically defined beef production systems. The International Journal of Life Cycle Assessment, 17, 165-175. • RIDOUTT, B., PAGE, G., OPIE, K., HUANG, J. & BELLOTTI, W. 2012a. Assessing carbon, water, and land use footprints for beef cattle production in southern Australia. 8th International Conference on Life Cycle Assessment in the Agri-food Sector. St. Malo, France.	CSIRO (Sustainable Agriculture Flagship)	6 Case studies - NSW
Beef cattle	• Wiedemann, S. G., Murphy, C., Mcgahan, E. J., Renouf, M. A., Prasad, P., Bonner, S. L., Zadow, E. N. & Henry, B. H. 2013. Northern Australian Beef Supply Chain Life Cycle Assessment. FSA Consulting for Meat and Livestock Australia (Project number B.CCH.2028).	FSA Consul ting Meat and Lives tock Australia	2 Case studies - QLD
Beef cattle	• Wiedemann, S. G., Murphy, C., Mcgahan, E. J., Bonner, S. L. & Davis, R. J. 2014. Life cycle assessment of four southern beef supply chains. FSA Consulting for Meat and Livestock Australia.	FSA Consul ting Meat and Lives tock Australia	4 Case studies - NSW & VIC
Beef cattle	• Wiedemann, S. G., Henry, B. H., Mcgahan, E. J., Grant, T., Murphy, C. & Neithe, G. 2013 The Environmental Intensity of Australian Beef Production from 1981 to 2011. FSA Consulting for Meat and Livestock Australia	FSA Consul ting Meat and Lives tock Australia	National
Sheep	• Ridoutt, B. G., Sanguansri, P., Nolan, M. & Marks, N. 2012c. *Meat consumption and waterscarcity: beware of generalizations.* Journal of Cleaner Production, 28, 127-133.	CSIRO (Sustainable Agriculture Flagship) VIC DPI	1 Case study - VIC
Sheep	• Wiedemann, S., McGahan, E., Murphy, C., Yan, M., Henry, B., Thoma, G., & Legard, S. (2015). Environmental impacts and resource use of Australian beef and lamb exported to the USA determined using life cycle assessment. Journal of Cleaner Production, 94 , 67-75.		