Assessment of the hydrological impacts of farm dams in unregulated reaches of the Murray Darling Basin

- Policy and Management
- FINAL - September 2010

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Executive Summary

In unregulated parts of the MDB, one of the biggest factors affecting streamflows is the presence of farm dams. These dams are typically small (<200ML each), but exist in large numbers throughout the basin, intercepting overland flows before they reach waterways. A range of previous work has been undertaken investigating the impacts of farm dams in the MDB. The majority of these have been catchment specific studies to quantify the volume or quantify the hydrological impact of farm dams. The MDBA has commissioned this project, *Assessment of the hydrological impacts of farm dams in unregulated reaches of the Murray Darling Basin*, to quantify the impacts of existing dams on streamflow across the basin.

Changes to streamflow can have a significant impact on the health and ecology of river systems. This component of the project forms a standalone report and looks at the environmental impact of changes in streamflow due to farm dams. Policy and management approaches to address the impacts of farm dams on river health are then canvassed.

Impact of farm dams on water quality and aquatic ecosystems

In areas where many farm dams have been constructed, the impacts on downstream flow, water quality and ecosystem health can be significant. While in most cases the impact of an individual farm dam is relatively small, the cumulative impact of the large number of farm dams that exist in a catchment can be significant. There have been a range of studies that have quantified the impact of farm dams on the downstream flow regime. A recent study of the Murray Darling Basin found that catchments stressed by farm dams impacts are the Campaspe and Loddon valleys in Victoria, while the Mitta Mitta, Upper Murray and Kiewa valleys are the least affected by farm dams. The low flow index (LF) appears the most affected by farm dams across the Murray Darling Basin. A literature review did not reveal any studies that have specifically monitored ecological impacts downstream of farm dams. The majority of studies infer ecological outcomes based on changes to hydrology.

Existing Legislation

All jurisdictions in the Murray Darling Basin have policies and legislation in place to manage farm dams, however the approach and coverage of these policies differs. In summary, the following limitations or difficulties in managing farm dams arise from the current legislation:

- Across the MDB, there are few controls on intercepting run-off in private dams for D&S purposes. Licensing of farm dams for D&S purposes across the MDB is rare, although each state or territory differs in both its definition of a farm dam and the volume of water that can be retained by such a structure. Typically, use of water for D&S purposes is classed as a statutory right. Therefore, in most cases there is no defined limit to the number of stock and domestic storages that may be constructed.

- Although volumetric limitation on the size of stock and domestic storages exists, in most jurisdictions enforcement relies on notification from affected parties and this process may not be effective unless there is a system or regular compliance checks.
- The approach to licensing and registration of farm dams for commercial and irrigation purposes differs. In some instances, the dam is licensed based on dam volume, and in others, where a meter is installed, on metered off-take.
- When metering is required, the geography of the area could make it difficult and expensive to construct a robust metering system with a high level of accuracy.
- Active compliance on whether water is being taken in accordance with the provisions of the licence is limited.
- There is no central source of data on the quantity or impacts of farm dams and the rate of development, although some hotspots are periodically monitored.
- There is limited legislation in place to protect low flow periods downstream of farm dams. Low flow bypasses are used in some areas to address this.

Policy recommendations

Farm dam policy need not necessarily be consistent across the Basin. In general, management of farm dams will be a local issue and can be managed appropriately to match local hydrological conditions and assessing the costs and benefits of changes to jurisdictional policy. It is likely that the most appropriate approach will vary between the north and south of the Basin where hydrology varies substantially. As an example, low flow bypasses are more likely to be appropriate for southern hydrology. The costs of implementing a consistent approach across the Basin will not necessarily yield equivalent benefits in farm dam management.

The following is a list of policy or management actions related to farm dams that will allow greater protection to third parties, including the environment. It should be noted that many of these actions are already in place in some jurisdictions; others will require action such as changes to legislation.

Quantifying farm dams

- Reasonable use guidelines for stock and domestic water use should be developed and community education programs undertaken to support the implementation of these guidelines.
- Metering should be required for use from commercial and irrigation farm dams.
- Stock and domestic farm dams should be monitored through satellite imagery and self assessment methods, except in high risk areas (see below)

- Effort should be put into ensuring that water licensing agencies are involved in planning approvals for new farm dams. A review of how information is managed from this process should be undertaken to ensure data is useful.
- In areas at risk of high development of stock and domestic dams (such as periurban areas where sub divisions are occurring), registration of farm dams should be compulsory to allow the extent of growth to be assessed, and the growth in stock and domestic use should be monitored in these areas over time.
- All commercial and irrigation farm dams should be licensed (or at a bare minimum, registered).
- The MDBA should provide a central point to collate and manage information on farm dams including location, volume and use data.
- Management approaches for farm dams should clearly differentiate between source of inflow (as floodplain or onstream, or as catchment dams).

Managing increased demands

- New commercial or irrigation farm dams should not be permitted unless the water has been sourced through the market according to the basin plan water trade rules (or the system is not yet fully allocated).
- Establishing zones within which trade can occur, based on the knowledge of the resource, may make the trade process more efficient. This should be assessed in the context of the basin plan trading rules, and in particular, and understanding of connectivity.
- In areas at risk of high development of stock and domestic dams (such as periurban areas where sub divisions are occurring), jurisdictions should consider using regulations to limit the growth of farm dams due to sub-divisions and new land holdings.
- It does not appear feasible to require the purchase of a water access right for stock and domestic farm dams unless all stock and domestic rights (including statutory rights) are incorporated into the entitlement regime, or it is proven that no alterative access to water is available. In this instance, the current farm dam trade rule recommendation from the ACCC would need to be modified to ensure access to domestic water needs was met (for example, a zone approach could be adopted).

Managing low flow impacts

- While farm dams will impact on the flow regime, and thus on river ecosystems, it is important that any management action considers the risk posed by farm dams relative to other risks within the catchment.
- The costs and benefits of funding and installing low flow bypass systems should be compared to the purchase of instream water access entitlements as a means of improving environmental

flows in catchments. This is particularly relevant where dry season low flows are the impacted part of the flow regime.

Next steps

In order to progress the recommendations in this study, the following steps are recommended:

- Discussions within the MDBA around the objectives and targets of managing farm dams and whether these vary across the Basin
- Discussions with each of the jurisdiction around the recommendations and the practical issues around implementation (for example legislative changes, on ground costs etc) and the degree to which these recommendations diverge from their current approach
- Development of a business case that assesses each of the recommendations and quantifies their costs and benefits.

Contents

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1. Introduction

In unregulated parts of the MDB, one of the biggest factors affecting streamflows is the presence of farm dams. These dams are typically small (<200ML each), but exist in large numbers throughout the basin, intercepting overland flows before they reach waterways.

A range of previous work has been undertaken investigating the impacts of farm dams in the MDB. The majority of these have been catchment specific studies to quantify the volume or quantify the hydrological impact of farm dams. Two recent key basin-wide studies are as follows:

- Murray-Darling Sustainable Yields Project (MDBSYP) – As part of this project, the potential impact of future farm dams on streamflow within the MDB was assessed.
- Intercepting Activities project – As part of this project, an approximate estimate of impacts of existing and future farm dams on streamflow across Australia was produced. As a broad national study, the results produced in this study do not provide a level of detail suitable for use with the SRA.

Following the completion of these two studies, the key knowledge gap with respect to farm dams in the MDB is an estimate of the impact of **existing** dams on streamflow. The MDBA has commissioned this project, *Assessment of the hydrological impacts of farm dams in unregulated reaches of the Murray Darling Basin*, to quantify the impacts of existing dams on streamflow.

Changes to streamflow can have a significant impact on the health and ecology of river systems. This component of the project forms a standalone report and looks at the environmental impact of changes in streamflow due to farm dams. Policy and management approaches to address the impacts of farm dams on river health are then canvassed.

This report is structured as follows:

- Chapter 2 provides an overview of farm dams and their characteristics
- Chapter 3 discusses the potential ecological impacts of farm dams
- Chapter 4 is a review of current legislation across different jurisdictions
- Chapter 5 presents potential risks and management approaches for farm dams
- Chapter 6 provides a summary of the key recommendations

2. Overview of Farm Dams

2.1. Types of Farm Dams

Farm dams are earth structures designed to capture and store water for irrigation, aquaculture, stock watering, domestic supply or aesthetic purposes (Lewis 2002).

The term 'farm dam' is interpreted in different ways across the MDB. It can be used to encompass both on-stream and off-stream storages. The distinction between an on-stream and off-stream storage depends on the definition of the watercourse itself.

It is difficult to provide a definition of farm dam that will apply consistently across all states as the legislation, terminology and hydrology vary significantly across the MDB (NWC 2005). However, in the context of this report, a farm dam refers to a private dam that:

- intercepts catchment runoff (or overland flow);
- is primarily not filled using extractive water access rights from other water resources; and
- is not located on a registered or defined watercourse.

This discussion is not relevant to dams that are filled through extracting water from other sources and excludes floodplain harvesting.

Below is a description of the most common types of farm dams (SKM 2007).

Gully Dams

The most common type of existing dam in the southern MDB is a gully dam. They are formed by constructing an earthen embankment across a drainage path or ephemeral waterway.

The embankment incorporates a main spillway at one or both ends to pass inflows once the dam is full. The main spillway is usually supplemented with a pipe spillway set at full supply level, also known as trickle pipe, to convey small flows, which helps to protect the main spillway.

Outlet pipes, also called compensation pipes, are commonly provided through the embankment for water supply needs, dam de-watering and to pass environmental flows.

Hillside Dams

Hillside dams are typically constructed with an earthen bank on three sides on a broad inclined slope or hillside. When these dams have small catchments, inflows may be supplemented with diversion banks to increase the catchment area, or with catch drains that divert water from nearby waterways. These dams are sometimes filled by pumping from waterways.

Both hillside and gully dams are sometimes referred to as ‘small catchment dams’.

Turkey Nest Dams

Turkey nest dams are off-stream storages that consist of an above ground storage confined within a continuous embankment. A key characteristic is that they do not capture surface runoff, and are filled by pumping from a waterway or groundwater source. These types of storages will not be considered in this report.

2.2. Characteristics of Farm Dams

Farm dams differ from one another with respect to a number of characteristics. These characteristics determine the benefit that can be derived from having a farm dam (i.e. the volume of water that is generally available for use) and the reduction in the volume of water available for others (either other users or the environment). Conceptually, the characteristics could be placed into the following broad categories:

- The location of the farm dam;
- The size of the farm dam;
- The purpose for which the dam is used;
- The volume of water harvested by the farm dam; and,
- The timing when the farm dams can harvest water.

The nature of these characteristics is discussed throughout this section.

The **location** of a farm dam can be defined in terms of its geographical location and its location with respect to a waterway. The geographical location of the farm dam is important as it will influence the volume of water harvested by the farm dam and this will be discussed further below. The location of the farm dam, in relation to a waterway, is also important. In some cases the location of the farm dam is used to trigger a licensing requirement. For example, in New South Wales a farm dam is required to have a licence if it is located on a larger waterway that receives inflows from several tributaries. The location of the dam in relation to other dams will also affect its ability to harvest water and the extent to which it is connected to other water users downstream.

Farm dams vary substantially in **size** and shape. Lowe et al. (2005) estimated the number and volume of farm dams across Victoria and reported that farm dams range from less than 0.5 ML to over 140 ML. The factors influencing the size of a farm dam include method of construction, the intended use of the farm dam, the magnitude and variability of the catchment runoff at the site of the farm dam and site topography.

The main categories used to define the **purpose** of a farm dam are domestic and stock, irrigation and commercial purposes. Farm dams can also be used for other purposes, such as for aesthetic reasons, erosion control, flood control, water quality control or environmental purposes. A survey undertaken by Lowe et al (2005) indicated that small dams are typically used for domestic and stock purposes and larger dams are used for either irrigation or commercial purposes. Licensing arrangements in all States vary depending on the purpose for which the farm dam is used.

The **volume of water harvested** by the farm dam is one of the most important characteristics of the water access right as it determines the impact of the farm dam on the environment and other water users. The volume of water captured by the farm dam depends on the following factors:

- *Capacity of the farm dam.* The ability of a farm dam to capture runoff when it occurs depends on the capacity of the farm dam. The larger the capacity of the farm dam, the more water it will be able to capture;
- *Inflows.* The volume of water harvested from a farm dam is dependent on the amount of catchment runoff entering the dam. The volume of runoff generated by catchments varies considerably across the Murray-Darling Basin, particularly with climate and topography. The volume of water available for harvesting by farm dams differs between catchments and within catchments. A farm dam located on a waterway with a relatively large upstream catchment will be able to receive more inflows than a farm dam which is not located on a waterway and has a small catchment area. In a given catchment the availability of catchment runoff can be estimated using the catchment area of the farm dam;
- *Extractions from the farm dam.* A farm dam will only capture runoff when it is not full. Therefore, the more water that is extracted from the farm dam, the more water it is able to harvest. Extractions from farm dams are generally not metered. It is commonly assumed that a higher proportion of the capacity of a farm dam is extracted from dams used for irrigation/commercial purposes compared to domestic and stock farm dams (Lowe et al. 2005). However, the extractions from the dam are likely to vary considerably between individual users (Lowe and Nathan 2008). The seasonal pattern of extractions can also affect the ability to harvest water in the dam at any given time of the year; and,
- *Evaporation from the dam.* As with extractions from the dam, evaporation rates will influence how full a farm dam is and consequently the harvested volume. The volume of evaporation from the farm dam will depend on the rate of evaporation in the region (and this varies considerably across the Murray-Darling Basin) and the surface area of the farm dam. For example, there will be more evaporation from a shallow farm dam with a large surface area than from a deeper farm dam with the same volume.

Unlike diversions from a waterway, it is difficult to control the **timing** of when farm dams harvest water. Until it is full, a farm dam will capture all catchment runoff intercepted by the farm dam.

Farm dams intercept the first catchment flows after a dry period thereby extending the period of time over which the waterway could be experiencing those dry conditions. However, it is possible to install bypasses on farm dams and divert runoff through or around the dam.

The characteristics of a farm dam discussed in this section influence the volume of water available to the owner of the farm dam and the reliability associated with the available water. For example, all other things being equal, a farm dam a small upstream catchment that is not on a waterway will be less reliable than a farm dam that intersects a large drainage area. Therefore, if the water access right associated with a farm dam is to be clearly defined each of these characteristics may need to be understood.

3. Impact of farm dams on water quality and aquatic ecosystems

In areas where many farm dams have been constructed, the impacts on downstream flow, water quality and ecosystem health can be significant. While in most cases the impact of an individual farm dam is relatively small, the cumulative impact of the large number of farm dams that exist in a catchment can be significant.

3.1. Impact on the flow regime

In Victoria, farm dams have been calculated to typically reduce annual flow by 5%, however annual flow reductions of up to 30% have been estimated. A South Australian study demonstrated that farm dam development in the Marne River catchment increased at a rate of 47 ML/year over the period 1973 to 1989. This caused a corresponding observed decrease in annual streamflow volumes of 44 ML/year (Nathan et al. 1999). Savadamuthu (2002) conducted a study of the Upper Marne River catchment and modelled the impact of farm dams based on predicted 2009 level of development (assuming an increase in farm dam development equal to that seen from 1992 – 2002). The study showed that farm dams would intercept a total of 1940 ML/yr of runoff, representing a 28% and 39% reduction to the mean and median annual runoff. In very dry years, such as 1982, there would be no flow passing downstream based on this level of farm dam development.

This report forms part of a broader project that aims to estimate the impact of farm dams on streams across the Murray Darling Basin. Approximate results to date from this project indicate that impacts generally range between 0% and 26% of catchment inflows.

Flow variation—both between years and within years—is important for ecological and geomorphological processes. Each flow component provides different benefits to the ecology of the waterway. The key components are:

- Annual and seasonal low flows
- Summer freshes
- Cease to flow events
- Seasonal high flows
- Bank full (minor flood) flows

The magnitude and timing of each of these flow components can be changed as a result of water diversions by farm dams. There is limited literature on detailing the ecological response, and instead flow indicators are used to suggest likely ecological impacts.

Numerous studies have commented on the impact farm dams may have on low flows, and prolonging dry periods. This occurs because the first significant rain after an extended dry period will fill farm dams before reaching streams downstream hence delaying and reducing the magnitude of flows downstream. Bond et al (2008) highlight that the increasing numbers of farm dams in unregulated river catchments has meant:

> *small streams and wetlands have been deprived of what little runoff has occurred during the drought... hydrological modelling suggests that during drought years farm dams can capture most of the annual flow in low-rainfall catchments (McMurray,2006).*

Low flows are important during the drier seasons as they maintain pool and riffle habitats. Native fish often inhabit either slow flowing or still water, but rely on snags, macrophytes (aquatic vegetation), and overhanging banks for cover. Low flows inundate bars between pools and associated snags and macrophytes which maintain habitat availability and diversity. These flows sustain longitudinal connectivity for movement of macroinvertebrates and some fish between pools.

Wet season flows (winter and spring in southern Australia, summer and autumn in North Australia) are important because they inundate large woody debris, low level wetlands and other in-channel habitat for extended periods. Animals may use these habitats during winter, spring, and early summer, and then seek refuge in pools during summer and autumn, but without these flows many animals would not be able to survive in these streams.

Dry season freshes are important for maintaining species diversity in the emergent and marginal aquatic vegetation communities and are the principal driver of zonation up the channel banks. Summer freshes also wet low-lying channel zones such as riffles and benches, thereby helping relieve drought-stress on emergent and marginal vegetation that has become exposed during the low flow period.

Fish and other aquatic fauna will be able to move between pool habitats during summer freshes because of increased depth across riffle areas. The brief increase in flow will also help to improve water quality by flushing and mixing any pools that have begun to stagnate and become stratified. Summer and autumn freshes provide breeding cues for some native fish.

Freshes can also serve to desilt riffle areas thereby improving habitat for macroinvertebrates that use these habitats. Some native fish species lay their eggs on gravel, snag, or macrophyte substrates, but do not tolerate silt and sediment smothering these habitats. Dry season freshes flush silt and sediment from the substrate, and this may increase egg survival. Macroinvertebrates and algae are also more likely to colonise substrates that are not covered in silt, and may benefit from the redistribution of organic matter that occurs during higher flows.

Changes in flow rate due to freshes can have several impacts including changes in current velocity, changes in the underwater light regime because of increased depth and turbidity, and the initiation of wetting and drying processes.

3.1.1. The impacts of climate change

A study that undertook detailed modelling of farm dam interception under climate change showed that while the absolute magnitude of water intercepted may not vary, the relative proportion of inflow captured by farm dams would likely increase under climate change (SKM 2008). The study looked at farm dam interception in the Campaspe Basin under three different scenarios:

- Base case- long-term average, based on the historical flow records from 1890/91- 2006/07
- Scenario 1 - CSIRO medium climate change predictions at year 2055
- Scenario 2 - Continuation of recent low inflows (1997/98-2006/07).

Table 3-1 provides a summary of the results from the study. In absolute terms, the magnitude of the impact does not change considerably across climate scenarios. Upstream of Campaspe Weir, for example, the total volume of water withheld by farm dams per year falls from 18,511 ML to 17,516 ML per year, from the Base Case to Scenario 2. This represents a drop of just 5%. However, the basin experiences a large decrease in flows under the climate change scenarios. Upstream of Campaspe total streamflow drops by 75%, from the Base Case to Scenario 2. So while the basin experiences a large decrease in flows under the climate change scenarios, the amount of water diverted into the dams decreases much less severely. This leads to an increase in impact of farm dams as a proportion of natural streamflow (SKM 2008).

Farm dam impacts were separated into impacts caused by licensed farm dams (generally for irrigation and commercial purposes), and impacts caused by unlicensed (generally for domestic and stock use) farm dams. Upstream of Campaspe Weir, licensed farm dams are typically responsible for withholding a little over 10% of the total volume of water captured by farm dams under each of the climate scenarios, due to the fact that unlicensed farm dams greatly outnumber licensed farm dams.

These results represent only one catchment in the Murray Darling Basin; however it is likely that similar impacts would be observed across the Basin, with the impact of farm dams as proportion of natural stream flow increasing with climate change.

Table 3-1 Results from Campaspe river modelling of farm dams under different climate scenarios (SKM 2008)

Sub-catchment	Climate scenario	Average annual natural flow	Average annual observed (impacted) flow	Average annual impact	Average annual impact as proportion of natural flow	Proportion of impact caused by licensed farm dams	Proportion of impact caused by unlicensed farm dams	Total storage volume	Proportion of storage volume consisting of licensed farm dams	Proportion of storage column consisting of unlicensed farm dams
		ML/yr	ML/yr	ML/yr	%	%	%	ML	%	%
Upstream of Lake Eppalock	Base Case	229.967	211,456	18,511	8	12	88	23,421	13	87
	Scenario 1	158,683	140,035	18,648	12	12	88			
	Scenario 2	69,851	52,335	17,516	25	12	88			
Upstream of Campaspe Weir*	Base Case	298,171	266,881	31,290	10	12	88	39,884	13	87
	Scenario 1	205,746	175,405	30,341	15	11	89			
	Scenario 2	90,102	64,575	25,527	28	11	89			

*Farm dam impacts were not modelled for downstream of Campaspe Weir, so this effectively represents the whole of basin.

3.1.2. Flow Stress Ranking indicators of river health

This report forms part of a broader project that aims to estimate the impact of farm dams on various indices of flow stress in streams across the Murray Darling Basin. The project quantified farm dams across the basin, and modelling was then used to derive the downstream impact for catchments across the MDB. These impacted flow series, along with natural flow series, were used to calculate the FSR scores to provide an indication of river health. Further details of this project can be found in the Sustainable Rivers Audit 2010 hydrology theme report titled *Hydrological assessment of farm dams* (SKM 2010).

The Flow Stress Ranking (FSR) establishes a relative indication of threat to river health based on the level of water extractions. The ranking makes no assumptions about the environmental value of a river, but rather characterises the degree of hydrologic stress of an impacted flow series (in this case due to farm dams) relative to 'unimpacted' flow conditions (that is, if all anthropogenic extractions, water harvesting and impoundments were removed).

The FSR comprises of sub-indices that characterise different elements of the flow regime considered of ecological importance (listed in Table 3-2).

- **Table 3-2: Summary of flow indices derived in this project**

Name	Acronym	Description
Mean annual flow index (annual)	AVac	AVAC is the difference between the percentage of time that the reference and current mean annual flows are exceeded in the reference regime.
Seasonal amplitude index (annual)	SAmc	Difference between the percentage of years that the reference and current seasonal amplitudes are exceeded in the reference regime
Seasonal periodicity index (annual)	SP	A comparison of the reference and current frequency distribution of maximum and minimum monthly flows
Low flow index (annual)	LF(Q90)	Average of $LF_{91.7}$ and $LF_{83.3}$ where LF_x is the difference between the percentage of years that the reference and current x% exceedance flows (for the full period) are exceeded by the annual x percentile flow in the reference regime
High flow index (annual)	HF(Q10)	Average of $HF_{8.3}$ and $HF_{16.7}$ where HF_x is the difference between the percentage of years that the reference and current x% exceedance flows (for the full period) are exceeded by the annual x percentile flow in the reference regime
Proportion zero flows index (annual)	PZD	Difference between the proportion of zero flow occurring under reference and current conditions (ctf threshold is represented by the flow thresholds corresponding to the 99.5 percentile flow for non-

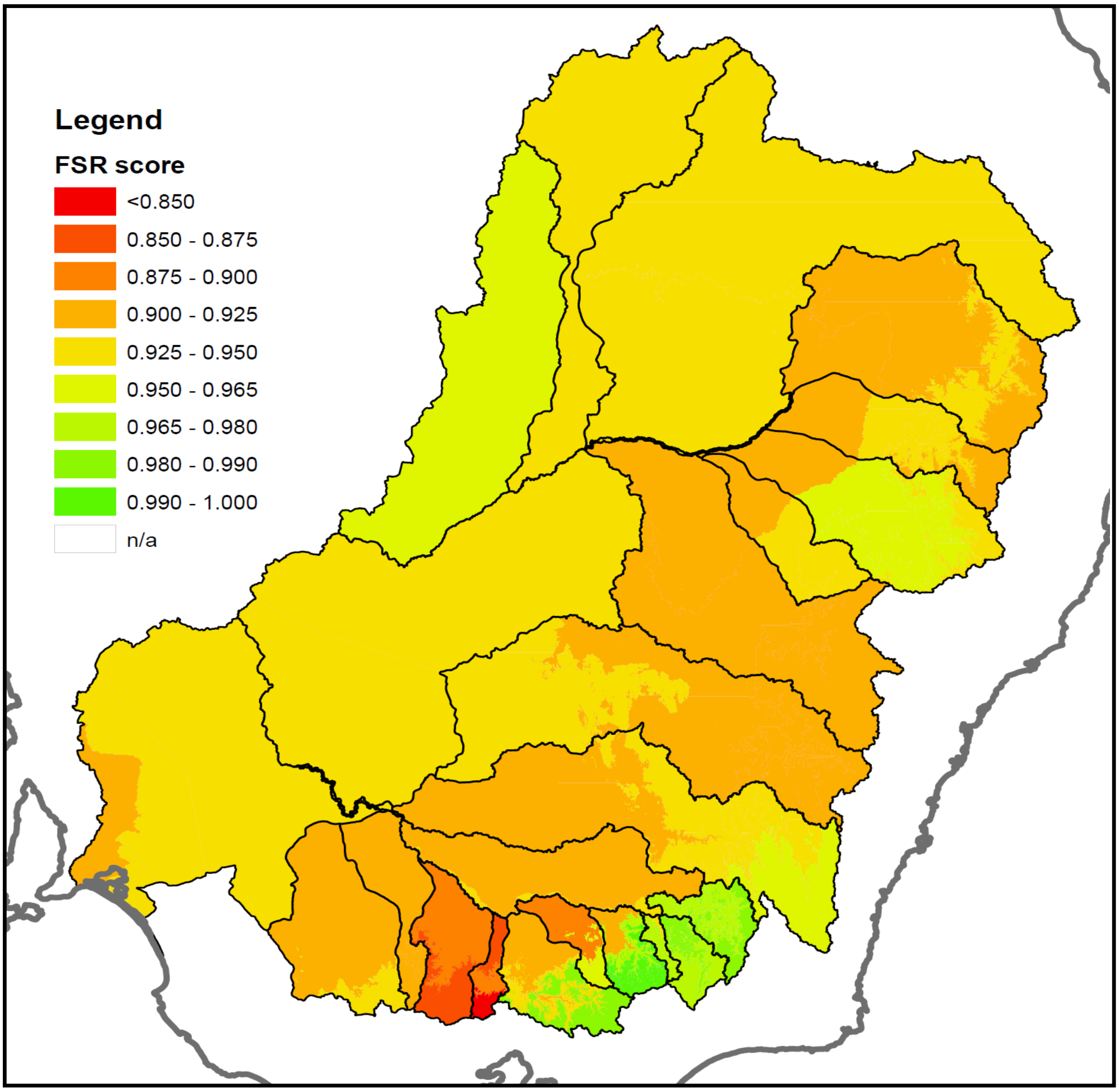
		zero flow days)
Flow duration index (annual)	FDI2	The magnitude of shift in the distribution of flows between reference and current flow regime. Calculated using difference of percentiles rather than ratios of percentiles.
Variation index (annual)	CV	Ratio of coefficient of variation of flow in reference and current regime.

Table 3-3summarises the results for each of the 21 valleys in the Murray Darling Basin (note that the average value over the entire valley is quoted). The index values are colour coded for ease of interpretation. It can be seen that the most stressed catchments are the Campaspe and Loddon valleys in Victoria, while the Mitta Mitta, Upper Murray and Kiewa valleys are the least affected by farm dams. The low flow index (LF) appears the most affected by farm dams across the Murray Darling Basin.

Figure 3-1 shows the FSR index scores across the Murray Darling basin due to farm dams. The FSR score shown represents the average of the six independent indices SAmc, SPm, HF, LF, PZD and CV (note that the results for FDI and AVac indices are highly correlated with CV, suggesting that most of the information contained in the FDI and AVac indices are contained in the CV index.). Red represents a higher level of stress due to farm dams. Consistent with the table results, the Campaspe and Loddon valleys in Victoria are shown as the most impacted.

- **Table 3-3: Average index values for each valley**

Basin	Avac	SAmc	SPm	LF	HF	PZD	FDI2	CV
Avoca	1.00	0.95	0.96	0.82	0.86	0.99	0.96	0.91
Border Rivers	1.00	0.97	0.96	0.78	0.89	0.99	0.97	0.93
Broken	1.00	0.97	0.96	0.78	0.93	0.98	0.97	0.91
Campaspe	0.98	0.93	0.93	0.67	0.89	0.97	0.95	0.86
Castlereagh	1.00	0.97	0.97	0.83	0.91	0.99	0.97	0.94
Central Murray	1.00	0.97	0.97	0.81	0.88	0.99	0.96	0.92
Condamine	1.00	0.97	0.98	0.82	0.87	1.00	0.97	0.94
Darling	1.00	0.98	0.99	0.96	0.82	1.00	0.96	0.95
Goulburn	1.00	0.97	0.97	0.82	0.96	0.99	0.98	0.93
Gwydir	1.00	0.97	0.96	0.79	0.93	0.99	0.97	0.93
Kiewa	1.00	0.99	0.97	0.89	0.99	0.99	0.99	0.97
Lachlan	1.00	0.96	0.96	0.80	0.88	0.99	0.96	0.91
Loddon	0.99	0.94	0.95	0.72	0.84	0.98	0.95	0.88
Lower Murray	1.00	0.97	0.97	0.95	0.82	0.99	0.95	0.92
Macquarie	1.00	0.96	0.96	0.81	0.89	0.99	0.97	0.92
Mitta Mitta	1.00	1.00	0.99	0.93	1.00	1.00	1.00	0.99
Murrumbidgee	1.00	0.97	0.96	0.83	0.93	0.99	0.97	0.93
Namoi	1.00	0.98	0.97	0.87	0.94	1.00	0.98	0.95
Ovens	1.00	0.99	0.98	0.88	0.97	0.99	0.99	0.96
Paroo	1.00	0.98	0.99	0.98	0.84	1.00	0.97	0.96
Upper Murray	1.00	0.99	0.98	0.90	0.99	1.00	0.99	0.98
Warrego	1.00	0.98	0.98	0.87	0.84	1.00	0.97	0.95
Wimmera	1.00	0.96	0.97	0.83	0.89	0.99	0.96	0.92



- **Figure 3-1: FSR index scores due to farm dams, by zone. Each value represents the average of the six independent indices SAmc, SPm, HF, LF, PZD and CV. Valleys are marked in black for reference.**

3.2. Measuring ecological impacts

A literature review did not reveal any studies that have specifically monitored ecological impacts downstream of farm dams. As previously discussed, the majority of studies infer ecological outcomes based on changes to hydrology.

An exception is Susan Lee's PhD research, where she used a series of study farm dams to evaluate the use of low flow bypass structures to provide downstream ecological benefits, using macroinvertebrates as an indicator of ecological condition (Lee 2010). Susan's thesis is under examination and therefore was not available for inclusion in this review.

There are a number of factors that perhaps contribute to making direct monitoring of ecological impacts of farm dams complicated and therefore not readily presented in the literature. These comments refer to the collection of ecological data rather than the assessment of flow regime, and inferred ecological impact. Firstly, any research requires the approval of landowners and thus site selection will be governed by support from individual land owners. It may therefore be difficult to set up study sites located throughout the catchment. It is likely that in the upper catchments, where systems may be more ephemeral, monitoring of species such as macroinvertebrates would yield less data than in the lower catchments where flows are more consistent. Secondly, these studies are resource intensive and the resulting data may be limited. And thirdly, it is difficult to determine the most appropriate indicator of ecological outcome. For example, in some systems, macroinvertebrates may not be an appropriate measure.

3.3. Impact on water quality

A literature review returned no information on studies that have directly investigated the impact of farm dams on water quality. However, as with other aspects of river health, a substantial amount of information can be inferred from the impact of farm dams on the flow regime.

Low flows are particularly important for maintaining instream water quality. In particular, continued low flows or cease to flow events have been shown to be correlated with increases in temperature and salinity (especially in areas of groundwater intrusion), and with decreases in dissolved oxygen (for example, SKM 2006).

Maintaining flows over the riffles and connectivity between pools helps to slow the deterioration of water quality that can occur in pools during times of low flow. Good water quality during the dry season is important as this reduces the impact of sudden temperature, salinity and dissolved oxygen changes that can accompany flushing flows.

However, farm dams may play a role in protecting downstream environment from agricultural runoff. There are a number of studies that have looked at the water quality in farm dams. There have also been a small number of studies that have looked at the possible impacts of removing small dams (for example, Velinsky et al. 2006; Stanley and Doyle 2003), however the ecological and water quality impacts are not well understood and will likely vary based on local conditions (Velinsky et al. 2006).

3.4. Farm dams as habitat

It is important to note however that farm dams themselves provide important habitat and ecosystem services (Casanova et al. 1997).

> *There has been a decline in natural Australian wetland habitats since European habitation (Phillips 1996), so farm ponds have become important features in the Australian rural landscape, not only because they provide water for rural industry but also because they provide water for native plants and animals that might otherwise be absent (Timms 1980).*

There have been a number of studies that have identified a range of aquatic species—some of which are endangered—present in Australian farm dams. As an example, Hazell et al (2001) surveyed 75 dams across the upper Shoalhaven catchment to collect data on frog habitat. Frogs were recorded at a majority of the study sites, with only nine sites showing no evidence of use during the survey. A total of nine frog species was recorded across the study sites. Hazell et al also collected data on potential frog predators and a range of species including freshwater crayfish, eastern long-neck turtles and white-faced heron were recorded. Fish were recorded at seven sites and included yellow-belly perch at one site, mountain galaxias at five sites and the introduced mosquito fish at one site. Other studies have stated the importance of learning more about the ecosystem potential of farm dams as drought refugees (Brainwood and Burgin 2006).

4. Current policies and regulations governing farm dams

The following provides a brief summary of the legislation relating to farm dams in each of the state and territory jurisdictions within the Murray Darling Basin.

4.1.1. Australian Capital Territory

The management of water resources in the ACT occurs under the *Water Resources Act 2007*. Under the Act, all extractions from surface or ground water require a water access entitlement (WAE) (s19) unless it is for domestic and stock purposes. The WAE gives the holder the right to extract the minimum of a percentage of the total volume available for taking and a stated maximum volume. This means that it is possible for the entitlement to change as water resource availability changes due to climate change or other environmental factors. Water use must be metered and reported as a condition of extraction licences. Under s20, the minister can reject a claim for a water access entitlement based on the volume being requested being more than a reasonable amount for its intended purpose or if the water is to be used for urban residential purposes or the licence holder has a poor environmental record.

The WAE gives a person the right to take a particular volume of water, but it does not allow for the water to be taken from any location. A licence to take water is needed to extract water from a particular location. Both of these are available from the Environmental Protection Authority. In addition, a permit to build a dam is required under the *Land (Planning and Environment) Act 1991* unless the storage is less than 2 ML and not on a waterway. The ACT allows dams of less than 2ML to be constructed for D&S purposes (DECCEW 2009).

The planning and land Act in the ACT does not make provisions for rural residential development. This significantly reduces the demand for farm dams on small rural blocks as further residential development and sub-division is limited. The combination of tight restrictions on land use and the limited scale of irrigation assist in limiting the potential growth of farm dams.

4.1.2. New South Wales

Farm dams in New South Wales can be classified as either harvestable rights dams, or as works requiring a licence.

Under the s53 of the *Water Management Act 2000* an owner or occupier of a landholding within a harvestable rights area is entitled to construct a dam for the purpose of capturing, storing and using rainwater run-off in accordance with the harvestable rights order. On the 31 March 2006 two harvestable rights orders were gazetted under s54 of the *Water Management Act.* These cover (1) the Western Division (Department of Natural Resources 2006) and (2) the Eastern and Central Division (Department of Natural Resources 2006) of NSW as set out in s4 *Crown Lands Act 1989* (New South Wales Government 1989) which provides that NSW is divided into these two divisions. This effectively means that all of NSW is covered by a harvestable rights order which governs the right of owner or occupiers to construct new dams.

Under the *Harvestable Rights- Eastern and Central Division Order* (Department of Natural Resources 2006) a landholder in the Eastern and Central Division has the right to build farm dams under two circumstances:

1) A land holder may capture 10% of the average regional rainwater run-off on the land if that land is located on a minor stream. This is known as landholder's harvestable right and is calculated as the maximum harvestable right dam capacity (MHRDC). The MHRDC is calculated by taking into account:
   - Stream order – A minor stream, including 1st and 2nd order streams (minor streams) based on the Strahler stream ordering system applied to the most detailed map available at 1 January 1999, can have unlicensed dams. Any dams on 3rd order streams (or higher) require a licence. The most detailed map is a 1:25,000 scale map for the tablelands and part of the slopes of NSW and further inland it is 1:50,000 or 1:100,000 (a full list of the relevant maps was gazetted on 24 March 2006 under s5(1) of the *Water Act 1912*.
   - Maximum harvestable right dam capacity (MHRDC) – This is determined by applying the MHRDC multiplier previously calculated by the NSW Department of Natural Resources to the property of interest. This multiplier is a spatially variable runoff coefficient that converts a property area into the harvestable right, which is equivalent to 10% of the property's estimated runoff.[1]
2) Where the MHRDC is less than 1 ML and the property was approved for subdivision before 1 January 1999, a farm dam of up to 1 ML can be constructed. This is a transition policy to avoid disaffecting property developers with approved subdivisions prior to the new harvestable rights legislation coming into force in 1999 and is not expected to result in any significant increase in future farm dams from 2007 onwards.

In each case the potential for future dams must be assessed at a property scale. A property is defined as a parcel of land valued as one unit by the Valuer General's Department under the *Valuation of Land Act 1916*. The Department of Natural Resources has the discretion to treat

[1] A MHRDC calculator is available online at http://www.farmdamscalculator.dnr.nsw.gov.au for landholders to calculate their property's MHRDC.

multiple parcels of land as one property for the purposes of calculating the MHRDC, but generally only where landholdings are made up of land in adjoining parcels.

If a property is subdivided or one of the adjoining land parcels in that property is sold after 1 January 1999, then the MHRDC is separated accordingly. If the dams on one of the subdivided properties exceeded the MHRDC, the dams would need to be modified or a new licence would need to be applied for. This means that there is no potential for any new subdivisions after 1 January 1999 to increase total farm dam capacity for the subdivided land.

A number of dams are exempt from harvestable rights calculations. These include dams for erosion control, flood mitigation and drainage water reuse. Farm dams in the Western Division of New South Wales do not require a licence because there is negligible potential to capture runoff in this area (see *Harvestable Rights – Western Division Order (DNR, 2006)*).

As mentioned above, dams in excess of the Harvestable right capacity, or on a 3rd or higher order stream, must be licence. Extractions from licensed dams are not metered. Applications for a new farm dam must be consistent with the requirements of the local Water Sharing Plan. A landholder would have to buy an existing water entitlement and transfer it to the proposed dam.

4.1.3. Queensland

The *Water Act 2000*, in conjunction with the *Integrated Planning Act 1997*, provide the legislative mechanisms to manage farm dams[2]. Since 2000, controls have been in place in Queensland to prohibit the construction of new farm dams other than for stock and domestic purposes. To build a new dam (or works for taking overland flow) the landholder must first have a water entitlement or an authorisation to take water under a water resource plan (DNRW 2007).

In some areas, for example where there is risk in increased take of overland flow, existing farm dams have been licensed. In other cases, any reconfiguration or changes to a farm dam will trigger the dam to be licensed at the time of those works. All resource operation plans require that once a licence is issued, meters must be installed and diversions recorded (DNRW 2007). A moratorium notice, published by the Minister, may provide that (s26 (4)):

- No new works impacting on water (including overland flow) may be physically started; and
- Complete works impacting on water (including overland flow) may not be raised, enlarged, deepened or changed.

Moratorium notices have been established for the Condamine Balonne Basin and Border Rivers Catchment (20 September 2000) and for the Moonie River Catchment and the Warrego/ Paroo/

[2] Note that in Queensland, a farm dam has no legal meaning and has not been formally defined. Instead, legislation refers to the harvesting of overland flow.

Buloo/ Nebine Catchments (9 June 2001). This means that landowners in these catchments are not able to expand the existing network of farm dams in these unless the dam is for stock and domestic purposes (s4).

Exemptions for farm dams for stock and domestic purposes are controlled by development codes which limit the size of storages constructed. Queensland allows farm dams of a size required to meet D&S use of one year (DNRW 2007). Stock and domestic farm dams must adhere to a self assessable code under the *Integrated Planning Act 1997* (DNRW 2007). The Code for Self-assessable Development for Taking Overland Flow Water for Stock and Domestic Purposes outlines the requirements for dam construction, including the maximum capacity of the storage and how it is to be calculated based on stock type, stocking rate and climatic conditions. Provided the works comply with the code, no application is required but the department must be notified on completion of the works.

4.1.4. South Australia

In South Australia, farm dams are regulated through the *Natural Resource Management Act 2004*, in combination with the *Development Act 1993* and the *River Murray Act 2003*. Water Allocation Plans will also play a role in managing farm dams.

The Natural Resource Management Act 2004 provides for the regulation of impacts of farm dams in the following ways:

- By requiring a permit for the construction of all new farm dams and modification, enlargement or removal of existing dams in prescribed water resources or the Mount Lofty Ranges Watershed;
- By setting policy in regional Natural Resources Management Plan that require a permit for dams outside prescribed water resources or the Mount Lofty Watershed outlining conditions on the construction, position and operation of dams; or
- By prescribing a water resource, requiring a water licence for diverting surface water into a dam and taking of water from a dam. This may or may not include requiring a licence for the stock and domestic water use, depending on the regulation, but generally stock and domestic use is excluded from requiring a water licence, but the dam construction is still controlled.

In the South Australian component of the Murray-Darling Basin, catchment farm dams only occur to any significant extent in the Eastern Mount Lofty Ranges (EMLR). The Marne Saunders catchments were prescribed in September 2003, and the remainder of the surface water and watercourses in the EMLR was prescribed in September 2005. A legally enforceable water allocation plan is currently being prepared. This will set out the conditions under which new licences in the EMLR can be granted. Licences will only be issued once this water allocation plan has been adopted. In the meantime there is a ban on the issue of new licences in the area. Following the adoption of the water allocation plan new licences will only be issued if the plan identifies that there is water available. The previous policy contained within the River Murray Catchment Water Management Plan prior to the resource being prescribed allowed for farm dam volume development up to 30% of the mean winter flow at both a property scale and a catchment scale, whichever was the most limiting.

4.1.5. Victoria

Rights to water in Victoria are primarily set out in the *Water Act 1989.* Under s8 (1)(c), a person has the right to take water for domestic and stock use because that person occupies land on which the water flows or occurs. Importantly, this right only extends to domestic and stock use and is tied to the occupation of land. Limitations can be placed on the construction of such dams on multi-lot subdivisions through water supply protection area management plans (DSE 2008). The Northern Region Sustainable Water Strategy was released in November 2009 and outlines a range of policy approaches to manage stock and domestic water use, including farm dams.

The Water Act 1989[3] now requires all farm dams for irrigation and commercial purposes to be licensed (s51 (1)(c)). The licence can either be a registration licence, or a tradeable licence with an associated licence fee. In order to licence a new dam a person must apply to the relevant water Authority. Under s55 the water Authority *must* refuse an application if:

- It would conflict with an approved management plan for a water supply protection area;
- It would result in the permissible consumptive volume for the area to be exceeded; or
- It is likely to have an adverse effect on maintaining the environmental water reserve.

An extensive metering program is underway in Victoria that will see all existing take and use licences greater than 10ML metered. Any new irrigation and commercial licences will be metered regardless of the size of the entitlement (DSE 2008).

[3] Note that the *Water Act 1989* was amended with the passage of the *Water (Irrigation Farm Dams) Act 2002*.

5. Potential risks and management approaches

This chapter identifies some of the potential risks and management approaches for farm dams. The management of farm dams should primarily be aimed at ensuring that third party interests are appropriately protected, and that property rights surrounding farm dams are clearly defined and transparent.

Note that some of the identified management approaches would require changes to state or territory legislation. This is particularly the case for policy solutions that change the nature of the water access right itself (for example by requiring licensing).

The following issues are canvassed in this chapter:

- Control, registration and licensing of Farm Dams
- Definitions of farm dams
- Future development of farm dams
- Impact on low flows

5.1. Control, registration and licensing of Farm Dams

There is a lack of accurate information about the volume and scale of farm dams. Quantifying the number, volume and extent of farm dams is an important first step in being able to understand the impacts of farm dams on downstream flow, and the extent of their contribution to the Sustainable Diversion Limit (SDL). Part of the importance in quantifying farm dams and their impact is that any changes to policy will require sound evidence in order to gain community support. The ability to monitor changes over time will also provide spatial information about the localised nature of changes where increases have occurred over relatively short time periods, which highlights areas as management priorities (MDBC 2008).

Options to account for farm dams range from recording use, through to a comprehensive licensing regime. Deciding on the most appropriate option to record and manage farm dams needs to consider protection of existing users, ease of administration, degree to which sustainable water use is encouraged and the overall costs and benefits of implementation.

Table 5-1 is adapted from DSE (2009) and presents broad options to manage farm dams.

It is likely that the option (or combination of options) most appropriate will vary depending on:

- The type of farm dam – stock and domestic or irrigation and commercial

- The extent of overuse or overallocation in the catchment
- The predicted development of resources (and in particular farm dams) in the catchment

As a general rule, stock and domestic licences are usually addressed using softer approaches (such as those listed at the start of Table 5-1), while irrigation and commercial licences are governed by stricter guidelines or licensing requirements (such as those approaches towards the end of Table 5-1). Similarly, the more stressed a catchment is, or the higher the predicted development, the more intensive the management of farm dams.

- **Table 5-1: Broad options for managing domestic and stock water use**

Option	Comment
Collaborative Management	Reasonable use guidelines
Recording Use	Records and tracks use over time a) regulations to report use; b) photographic imagery; or c) self assessment procedures. Improves datasets and tracks changes in use but would be expensive on a large scale.
Requiring referrals under planning provisions - Referral for advice on resource availability - Referral for approval	Requires property owners to obtain a planning permit before constructing a new domestic and stock dam. The application for a permit would be referred to the relevant water corporation for advice or approval. Duplication of the permit approval stage should be avoided, but a complimentary approach between planning provisions and water management plans may be appropriate at an earlier stage in the planning cycle (i.e. new developments and subdivisions).
Registering use - Registration of new use - Registration of new and existing use	Registers new domestic and stock use from all /some sources (including dams). Improves datasets and provides an opportunity to promote sustainable use of water resources in accordance with guidelines for reasonable domestic and stock use because registration would be required before constructing a dam. While it would be possible to register existing use, this would be an expensive process.
Licensing use - Licensing new use - Licensing new and existing use	Convert statutory rights to a right subject to obtaining a licence. Represents the most substantial change from existing rights and would be costly and resource intensive. However, this option is best for resource protection as it provides the greatest capacity to redistribute water to the highest value use.
Low flow bypasses	Not considered for stock and domestic dams due to their small catchment area.

5.1.1. Collaborative Management

For stock and domestic water use, where use from a farm dam is not licensed, reasonable use guidelines provide an indication of the volume of water considered appropriate to meet stock and domestic water needs. These guidelines may or may not be enforceable, however still provide an education and collaborative management tool to help reduce unreasonable extractions.

In NSW, the Water Management Act 2000 gives the Department the power to enforce reasonable use guidelines (section 52 (2)(a)). The Department of Water and Energy have drafted a set of "Reasonable Use Guidelines" which they will be able to enforce under the legislation in the Water Management Act 2000. It is anticipated that these guidelines will be publically released in the near future.

The Department of Sustainability and Environment (DSE), Victoria established guidelines for calculating domestic and stock water requirements in 2002 (DSE 2009). Where stock and domestic water was to be stored in a dam, the guidelines suggested it was reasonable for landholders to build dams to a size suitable to ensure water availability during a drought. Therefore, the guidelines established rule-of-thumb allowances for reasonable security factors based on average annual rainfall.

As part of the development of the Northern River Sustainable Water Strategy, DSE revisited these reasonable use guidelines. A study in the Campaspe River Catchment (SKM 2008) recommended that the reasonable use guidelines be modified so that:

- The kitchen garden allowance varies with different climatic (rainfall) zones
- The stock allowance is based on underlying carrying capacity of the land as measured in dry sheep equivalents
- The security factor for dam dams is based on the mean rainfall since 1997 rather than long-term averages (DSE 2009).

The Campaspe case study identified that many dams in the catchment were significantly larger than would be deemed reasonable under both the original and modified guidelines. The ratio of actual dam volumes to reasonable volumes was up to 20 times higher. This emphasises the importance of assessing the reasonable use guidelines during prior to the construction of the dam as this would promote more sustainable stock and domestic use in the future.

While reasonable use guidelines may be in place and enforceable under the legislation, there is still a logistical and practicality issue about how this enforcement occurs on the ground. Education will therefore remain a major component of adopting this approach. Most compliance activities regarding the construction of farm dams are reactive and are in response to information provided by the general public or departmental officers undertaking other activities. There is a high level of awareness among the community regarding the rules for new storages and they are active in informing water authorities or government agencies about any suspected unauthorised activities.

Recommendation: *Reasonable use guidelines for stock and domestic water use should be developed and community education programs undertaken to support the implementation of these guidelines.*

5.1.2. Recording use

The recording and tracking of farm dam use over time can be done using a number of different approaches.

1. Legislated reporting of use (requiring metering)

Metering use has the obvious advantage of transparently tracking the use of the resource and allowing accurate accounting of farm dam use. South Australia is currently the only state that requires compulsory metering of extractions from farm dams for commercial and irrigation purposes. In this instance, the metering is associated with the licence conditions for the farm dam. Victoria is in the process of rolling out metering in some specific catchments, such as parts of the Goulburn system, however this will be a long process and may take years to implement (James 2010).

There has been little discussion in literature of requiring stock and domestic use from farm dams to be metered. However, the Water Act 2007 (Part 2, Division 1, Section 22 (5)) states:

> The requirements specified under item 11 of the table in subsection (1) may include a requirement for a water resource plan to provide for the metering of stock and domestic water use only to the extent that such metering is necessary for the effective management of the Basin water resources.

Installing meters across all stock and domestic dams would have large associated costs. In Victoria alone, there are estimated to be 310,000 domestic and stock dams. Metering is estimated to cost $3,000 per meter, demonstrating that the cost of metering all existing users would be very expensive (DSE 2009). There are ongoing costs associated with meter reading and data collection, making even the requirement for meters on new dams difficult to justify.

An alternative may be to estimate water use by surveying users. However there would be ongoing survey costs associated with this approach, and the accuracy of the data will vary across users and in many cases could be questionable.

Water authorities and government agencies do not generate revenue from statutory right holders. Therefore, unless it was a community service obligation, paid for by the government, water authorities would have no incentive to administer a recording system (DSE 2009).

2. Satellite or photographic imagery to record use and track growth

The use of satellite or photographic imagery is a feasible and efficient way to track the development of farm dams. The cost of this approach is relatively low on a sub catchment level, but may be prohibitively high on a wider scale (DSE 2009). While this approach would provide information for more accurate accounting, it could only be used to provide retrospective analysis, rather than a tool for promoting efficient use of the resource at a current time. In addition, the quality of satellite imagery has a direct affect on the quality of the farm dam information collected.

It is an expensive process to collect data over such an expansive area and therefore to date, it has not been possible to obtain satellite imagery over the entire Murray Darling Basin for the exact same time period. Thus estimates of farm dam volumes are based on the most recent imagery, which may vary over a period of up to four years depending on satellite imagery available through specific funded projects. This needs to be considered in relation to the speed of development within a catchment. This is the most commonly used technique to quantify farm dams, and in particular stock and domestic farm dams, on a large scale. Time stamped data will allow comparisons with a previous time period, which will be a useful tool to track growth and assess compliance.

There may be applications for the Surface Energy Balance Algorithm for Land (SEBAL) in both assessing compliance and developing a better understanding of historical demand patterns from farm dams. SEBAL maps parameters such as evapotranspiration, water deficit and soil moisture. While providing promise, the possible applications for SEBAL are yet to be fully tested.

3. Low cost self-assessments, backed by random or targeted audits

The effectiveness of this approach would depend on the incentives or sanctions that could be applied to encourage self-assessment. As demonstrated in some jurisdictions where self-assessment methods are in place, for example New South Wales, compliance is difficult to monitor and enforcement can be costly.

***Recommendation**: Metering should be required from commercial and irrigation farm dams.*

***Recommendation**: The presence of stock and domestic farm dams should be monitored through satellite imagery and self assessment methods, except in high risk areas (refer to following sections)*

5.1.3. Requiring referrals under planning provisions

Where a permit is required under planning legislation, it may be possible to implement a process whereby this information is reported to the relevant water licensing agency. This occurs in Queensland, where landholders are required to notify DNRW (now DERM) of the completion of a new farm dam, and the application is reviewed and the information provided assessed against the provisions of the code (DNRW 2007). Ideally this would occur at the application rather than completion stage.

The referral to the water authority, in particular in stressed regions, would ensure that work approval is only granted if it is deemed there would be no adverse impact on water yields. Care would need to be taken to avoid duplication between the agencies. It may be more appropriate to have a complementary approach between planning provisions and water resource management at earlier stages in the planning cycle (e.g. new developments and subdivisions) (DSE 2009). However, for stock and domestic licences, it is unlikely that the planning act could override the statutory rights to water.

There is some concern that where such processes are already in place, it has not yielded useful data (DSE 2009). Very clear directions would need to be given to ensure the approach is applied consistently across all regions to ensure data is accurate and comparable.

***Recommendation**: Effort should be put into ensuring that water licensing agencies are involved in planning approvals for new farm dams. A review of how information is managed from this process should be undertaken to ensure data is useful.*

5.1.4. Registering use

Registering of farms dams would improve water accounting and an understanding of the available resource.

In Victoria a process for registering all existing commercial and irrigation farm dams was initiated after its legislation was amended in 2004, and this later moved to licensing. In Queensland, all landholders with non stock and domestic use dams were required to notify the department of their existence (for dams present as of September 2000). Overall compliance for registration was high, with high penalties applied if landowners were found pumping from an unregistered dam for irrigation or commercial purposes (Weller 2010). Experience in Victoria relating to registration of commercial and irrigation dams suggests that voluntary registration of existing rights in unlikely to be widely adopted without penalties in place (DSE 2009). It may therefore be that registration of existing dams is mandated in stressed catchments. Registration of both existing and new dams would significantly improve water accounting.

If registration were required for stock and domestic dams, the statutory right to access water would not change, however water users would be required to register before the construction of a new stock and domestic dam.

The benefits of registration include that:

- It would protect existing and new water users by monitoring development of dams and assist in assessing reasonable use
- It would enable information sharing between water corporations and prospective users—before the dam is constructed—including advice on reasonable domestic and stock use
- It would flag where more intensive management is required in the future—and open the option for registered dams to be converted to licensed dams in the future.

The cost of registration could vary considerably depending on the extent to which existing dams are registered. The cost of registering all existing users is likely to be prohibitive and administratively, may take a number of years. In Victoria, there are approximately 310,000 stock and domestic dams, compared to approximately 60,000 entitlements currently recorded in the Victorian water register. If the transaction costs of issuing a licence were say $20 each, this would result in a total cost in the order of $10 million for Victoria alone (DSE, 2009, p13). Storing information on a water register also attracts ongoing annual fees.   Thus it may only be feasible to register irrigation and commercial farm dams, rather than including stock and domestic dams. Alternatively, registration could be required only in intensively used areas.

***Recommendation**: In areas at risk of high development of stock and domestic dams (such as periurban areas where sub divisions are occurring), registration of farm dams should be compulsory to allow the extent of growth to be assessed, and the growth in stock and domestic use should be monitored in these areas over time.*

5.1.5. Licensing use

The process for licensing existing farm dams varies between the basin States. In Victoria a process for licensing all farm dams has been undertaken (a section 51 licence). In Queensland the need to obtain a licence is triggered when an existing farm dam is reconfigured in a way that enables them to capture more water or where the farm dam is also used to store water from another resource and the entitlement associated with the other resource is traded away from the farm dam. Resource Operation Plans allow for an authority to take overland flow water to be replaced by a water licence (for example, the Border Rivers Resource Operation Plan, DNRW 2008, Chapter 8, Part 2, Clause 218). In areas where DERM is concerned about containing the growth of farm dams, there may be a requirement in the resource operation plan (ROP) for farm dams to be licence. This has occurred in the Lower Balonne, where landholders had to supply a certified engineers report to then be issued with a licence (Weller 2010). South Australia has been going through the process of licensing all irrigation and commercial dams in the EMLR. This process has taken a significant amount of time as the licence is based on historical use and must be assessed based on, for example, crop type and planted area where metered data is not available (Franssen 2010).

Not all farm dam characteristics are licensed and those which are included on a licence vary between States (Table 5-2). In all States the location of the farm dam is specified in a licence and the capacity of the farm dam is also commonly included. In NSW compliance with farm dam licences is based on the capacity of the farm dam.

Of the factors that influence the volume of water harvested by a farm dam, only the volume of extractions are included in a licence, and only in a few States. Water extractions from farm dams must be metered within the ACT (Environment Protection and Heritage 2007), and metering may be a future requirement in South Australia and is required for Victorian farm dams which are new or exceed 10 ML in size (DSE 2008). In South Australia and Victoria a low flow bypass may be required on a new farm dam and may restrict the timing of extractions (SKM 2007). There is very limited metering of extractions taken from farm dams in Queensland (DNRW 2007). In Queensland existing farm dams do not need a licence unless changes are made to the infrastructure related to the farm dam. As such, the volume that they can extract is limited by their existing infrastructure.

In some cases not all characteristics are specified in the same licence. For example, in the ACT a Water Access Entitlement is required to extract water from a farm dam and a licence to take water is needed to extract water from a particular location (Environment Protection and Heritage 2007). It is important that the licence provides a realistic representation of actual use to ensure compliance with SDL, protection of third party impacts and appropriate trade conditions.

Table 5-2 Licensed Farm Dam Characteristics (SKM 2009)[4]

Farm Dam Characteristic	ACT	NSW	QLD	SA	VIC
Location	X	X	X	X	X
Capacity		X	X	X	X
Harvested volume					
Inflows					
Extractions	X		X	X	X
Evaporation					
Timing of diversions				X	X

While there has been wide progress in the registration and licences of irrigation and commercial farm dams, there are still a few remaining issues to overcome:

- the characteristics specified in the licence or registration vary across jurisdictions; and
- existing farm dams are not required to be registered or licensed in all jurisdictions.

Licensing of stock and domestic farm dams is more complex. This would involve removing the statutory right to water and converting this into a licensed water right under the relevant state legislation. The volume of water available for use would be quantified with the right to take 'stock and domestic water' converted into a volumetric amount with no specified use. The licensed right would then be subject to ongoing licensing fees, similar to any other licensed water right.

The distinction between registration and licensing is outlined in Table 5-3.

[4] Note that in Queensland, under some resource operation plans, additional licence conditions can be imposed such as the timing of extractions and volume in storage at any given time (for example, Border Rivers ROP, Chapter 8, Part 2, Clause 222)

Table 5-3: The difference between licensing and registering rights (DSE 2009)

Management Approach	Comment
Licensing	▪ Statutory right removed and converted into right under a licence ▪ Amount of water quantified with domestic and stock use concerted into a volumetric amount ▪ Right subject to licence conditions ▪ Ongoing fees and charges ▪ Provides data on the amount being taken
Registration	▪ Statutory right unchanged but conditional upon registration ▪ Otherwise unconditional ▪ May be one-off registration fee but no ongoing fees and charges ▪ Allows data to be collected about location and nature of rights but not amount to be taken ▪ Administratively less onerous than conversion of rights into licences

The major benefits of licensing stock and domestic rights are (DSE 2009):

- Ensuring a high level of protection for existing water users. The licensing arrangements would provide scope to cap usage in fully allocated or stressed water systems.
- Allow water to be reallocated between different users through a cap and trade approach.
- Improve water accounting
- Help recover the costs of managing water resources through licence fees
- Harmonise the administration of all water entitlements ensuring they are easily understood and administratively effective.

However, there is likely to be substantial community resistance and legislative complexities in removing statutory rights to water, even where this right is replaced or converted into a licensed water right. Once licensed, these rights would be subject to the same conditions as other water access rights. This may mean they are subject to rostering or restrictions depending on the local water sharing rules. Policy would need to be implemented around the provision of critical human needs water to farm dam users under low flow conditions.

***Recommendation**: All commercial and irrigation farm dams should be licensed (or at a bare minimum registered).*

5.1.6. Information sharing

There are a range of different studies that have looked at quantifying the number and volume of farm dams, and their hydrological impact. Where data has been collected on the volume and extent of farm dam development, information is not stored in a central location or publically accessible way. This makes it difficult to build on existing data sets or represent trends in farm dam development.

***Recommendation**: The MDBA should provide a central point to collate and manage information on farm dams including location, volume and use data.*

5.2. Definitions of Farm Dams

The term "farm dam" is used to encompass a range of different storage structures. As discussed in Section 2.1, it is difficult to provide a definition of farm dam that will apply consistently across all states as the legislation, terminology and hydrology vary significantly across the MDB. However, in the context of this report, a farm dam refers to a private dam that:

- intercepts catchment runoff (or overland flow);
- is not primarily filled using extractive water access rights from other water resources; and
- is not located on a registered or defined watercourse.

While this definition is clear for the purposes of this study, there remain difficulties in the inconsistency of terms across the jurisdictions. This becomes important where the management approach changes significantly depending on the water use, size of storage or source of inflows.

In general, states have employed different management strategies for stock and domestic storages as compared to commercial or irrigation storages. Part of the need to differentiate stock and domestic use comes from the legal basis of these rights. Stock and domestic water is generally provided through an unlicensed statutory right to water.[5] However, the delineation between stock and domestic and commercial or irrigation varies. In Victoria and South Australia, a dam less than 5ML in volume is considered a stock and domestic storage. In NSW, the capture of rainfall for non-irrigation or commercial purposes is acceptable to a volume of 10% of overland flow (referred

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[5] These rights may be referred to in legislation as **basic landholder rights** (New South Wales), **private rights** (Victoria) or **riparian rights** (Queensland and South Australia).

to as “overland flow harvesting”).[6] One advantage of this approach is that it effectively represents a share in the resource rather than a volumetric right per land holding. This helps limit the possibility of further volumes of dam development, even where sub division occurs. Queensland limits the size of stock and domestic storages within individual resource operation plans.

Another distinction that is made in the majority of jurisdictions is the main source of inflows to the dam. Victoria clearly distinguishes between on-stream and off-stream storages. South Australia also makes this distinction, however due to the ephemeral nature of many of the streams in South Australia, the distinction between on-stream and off-stream storage is less apparent.

New South Wales and Queensland, due to the local landscape and hydrology, have a larger number of floodplain harvesting dams. In New South Wales, the formal definition of floodplain harvesting states (Office of Water 2010):

> *Floodplain harvesting is the collection, extraction or impoundment of water flowing across floodplains. The floodplain flows can originate from local runoff that has not yet entered the main channel of a river, or from water that has overflowed from the main channel of a stream during a flood. For the purposes of this policy the floodplain is defined as extending to the 1 in 100 year flood line*.

NSW distinguishes between “flood plain harvesting” and “rainfall runoff harvesting” (referred to as farm dams in this report) with different policy approaches. The NSW Office of Water is in the process of developing a Floodplain Harvesting Policy to be applied state wide to bring floodplain harvesting activities into a statutory licensing and approvals framework under the *Water Management Act 2000* (Office of Water 2010) .

Queensland’s Water Act does not distinguish between floodplain harvesting and catchment farm dams. The broad term “overland flow water” is used to describe all land surface diversions (*Water Act 2000*, Schedule 4). Overland flow is defined as (DERM 2010):

> *Overland flow is water that runs across the land after rainfall, either before it enters a watercourse, after it leaves a watercourse as floodwater, or after it rises to the surface naturally from underground.*

A dam located on the flood plain will have very different characteristics to a dam located in a gully. For example, the timing and reliability of inflows will be substantially different. These two very different types of dams, while there may be some similarities, require fundamentally different management approaches.

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[6] As mentioned in section 5.1.1, a number of states are developing reasonable use guidelines to guide the use of water for stock and domestic purposes.

***Recommendation**: Management approaches for farm dams should clearly differentiate between source of inflow (as floodplain or onstream, or as catchment dams).*

5.3. Future development of Farm Dams

The ongoing expansion of farm dams could undermine the reliability of supply for all users, including the environment. This is because (DSE 2009):

- the cumulative impact of historically uncontrolled use could pose a serious threat to water availability at the catchment scale;
- the potential increase in utilisation of these rights may cause additional pressure on water resources and undermine existing entitlements; and,
- the lack of verified data may mean we underestimate the impact of farm dams on overall water resource availability.

5.3.1. Commercial and Irrigation dams

The growth potential for irrigation and commercial dams is limited in most jurisdictions by licensing regimes. Each basin State or Territory has mechanisms available to limit further development of farm dams that require a licence and a brief description of these is provided in the table below:

- **Table 5-4: Farm dam development policy in each jurisdiction for commercial and irrigation dams (SKM 2007)**

Jurisdiction	Farm dam development policy
South Australia	No further farm dams will be permitted in areas of South Australia where the resource is prescribed (as is the case for catchments of the Murray Darling Basin) and if there is deemed to be no available water (Department of Water 2007).
New South Wales	New farm dams can only be approved if there is compliance with conditions set out in the water supply plan. Further development in the Murray-Darling Basin was restricted in 2000 (Department of Water and Energy 2008).
Victoria	No new licences are being granted in Victorian catchments within the Murray-Darling Basin. Water use from existing farm dams can be restricted by Streamflow Management Plans and rights can be qualified by the Minister when there are water shortages (Department of Sustainability and Environment 2008).
Queensland	Farm dam development in Queensland can be restricted by a moratorium or a water resource plan. Moratoriums are introduced in catchments which are considered to be reaching their development limit and they can prevent the construction of new dams or alterations to existing farm dams (Department of Natural Resources and Water 2007). Moratoriums have been established in a number of Queensland catchments. Water resource plans completed for catchments in the Murray-Darling Basin do not allow any further increase in the average annual volume of extractions.
ACT	Development can be restricted by the Minister under certain circumstances (Territory and Municipal Services 2008).

The National Water Initiative requires that by no later than 2011, ‘significant’ interception activities must be recorded, and use above a certain threshold must purchase water entitlements. In the Murray Darling Basin, new dams for commercial and irrigation purposes can only be constructed if water is acquired through licence transfers. While this is conceptually a sound approach, there are many difficulties and policy decisions required around how this is implemented.

Firstly, there is a question as to what volume of water needs to be purchased. This would depend on the licensing policy in the relevant jurisdiction. However, it is important that the purchased volume represents the impact the dam will have on downstream users. If the volume required to be purchased is underestimated, there will be negative third party impacts from the dam construction. It is likely that only a system that considered location, storage capacity, extraction and timing of diversions will adequately protect third party interests. However, there is obviously a range of approaches and the requirement to purchase any volume to construct a new dam will be an improvement on no requirement for a licence transfer.

Secondly, there is a question as to where the licence transfer should be purchased from. This relates to how farm dam trade, and trade between surface water and farm dams should be managed. There are many complexities when considering the trade of farm dam water access rights. In its recent draft advice to the MDBA on trading rules, the ACCC suggested a range of factors to consider when approving trade between farm dams. It recommended that where a water resource plan permits trade of farm dam water access rights, applications should be assessed on an individual basis and the following conditions be met before such a trade is approved (ACCC 2009):

- the farm dam water access right is licensed
- the new location is in the same catchment as the original farm dam (to ensure similar characteristics)
- the size of the (current or proposed) dams is comparable
- the catchment areas (or inflow volume) of the two dam locations are similar in size
- third party interests are appropriately protected at the new location, and potentially impacted parties are consulted.

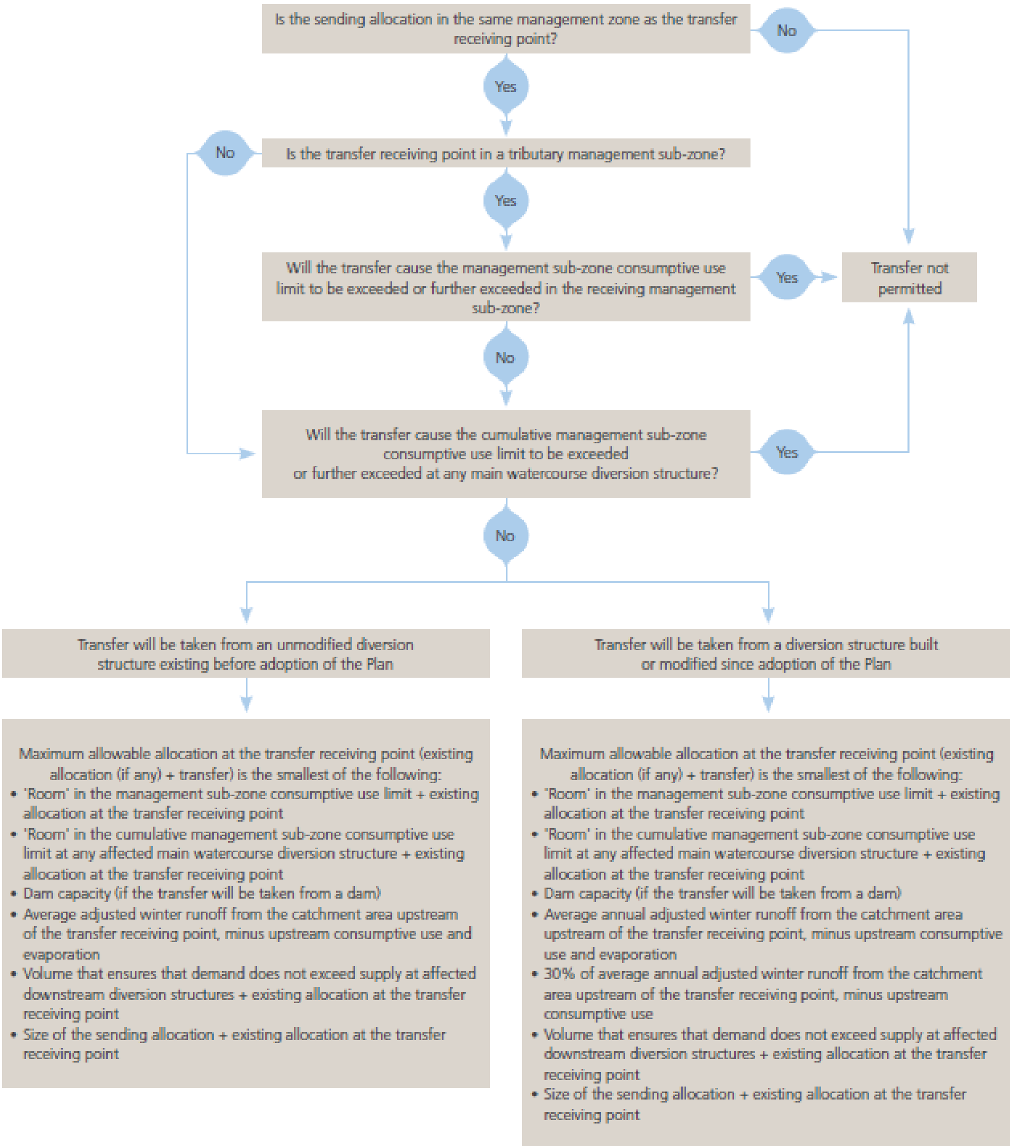
The ACCC's proposed approach would require individual assessments of trading applications. This may be a resource intensive process, but the ACCC suggested this be required due to the location-specific issues associated with farm dam water access rights. This process also allows potentially impacted third parties to respond. In terms of protecting aquatic ecosystems, the downstream environment would need to be considered in any assessment of third party impacts. The ACCC acknowledged that water licensing authorities may pass on the administrative costs of processing such a trade and, depending on the transaction cost, this may limit the number of trade applications. The ACCC also emphasised that these conditions may not currently be met in many areas of the MDB. If this is the case, the draft trade rules state that trade between farm dams should not be permitted.

Similarly, a number of conditions were outlined by the ACCC relating to trade between farm dams and surface water. Again, the ACCC recommend that trade between farm dams and surface water should not be permitted unless certain prerequisites are met. The ACCC does not anticipate that these can be fulfilled in the immediate future (ACCC 2009). According to the ACCC advice, in a catchment where the criteria for trade between farm dams, or trade between surface water and farm dams, are not met, new farm dam developments would not be possible.

In Victoria, the landholder can purchase water providing this occurs within the trade rules, and without impacting the sustainable diversion limit of any catchment (including downstream catchments).

The South Australian Murray-Darling Basin Natural Resource Management Board has released the Marne Saunders Water Allocation Plan (WAP) (SAMDNRMB 2010). It is anticipated that other Water Allocation Plans will include similar guiding principles. The WAP differentiates between *surface water* and *watercourse* water. Watercourse water is in a river, stream or other natural watercourse, whereas surface water flows overland and is commonly captured by intercepting flow, such as using a farm dam (SAMDNRMB 2009). It should be noted that many of the watercourses are ephemeral and thus the distinction between a watercourse and overland flow is not as distinct as in some other regions. The Marne Saunders WAP includes details around managing the transfer of water between *surface water* and *watercourse* water.[7] The resources are managed at a number of different spatial scales, using zones and sub zones to define areas within which water can be transferred between locations. Extraction limits are established for each zone and these extraction limits cannot be exceeded due to a transfer. The management zones are established to allow adequate sharing of water between upper and lower catchments. The sub-zones are based on the major tributaries that feed into watercourses. Rules are set at the sub-zone scale to ensure that each sub-zone contributes its share of flow to support the ecosystem requirements of the main watercourses. A limit on the volume that can be taken at a particular location, structure or dam, is also applied and cannot be exceeded (SAMDNRMB 2009). The following flow chart outlines the process used to assess transfers between surface water (farm dams) and watercourses. This approach provides a transparent process to assess trades and limit the impact on third parties, including the environment.

[7] Note that the term ‘transfer’ is used here as is the language adopted in the Marne Saunders Water Allocation Plan. In the context of this report, this term is used to have the same meaning as ‘trade’ involving a change in location.



- **Figure 2 Flow chart of the process for determining the maximum allowable volume that could be taken as a result of a transfer (SAMDNRMB 2009).**

Recommendation: *New commercial or irrigation farm dams should not be permitted unless the water has been sourced through the market according to the basin plan water trade rules (or the system is not yet fully allocated).*

Recommendation: *Establishing zones within which trade can occur, based on the knowledge of the resource, may make the trade process more efficient. This should be assessed in the context of the basin plan trading rules, and in particular, an understanding of hydrologic connectivity.*

5.3.2. Stock and domestic dams

Growth in small dams for stock and domestic purposes is still occurring, particularly in periurban areas. Significant dry seasons may also be resulting in additional construction of domestic and stock dams to protect against drought. The challenge is to manage the risk of stock and domestic use where required, without imposing significant costs or preventing regional growth.

As discussed in section 5.2, stock and domestic water is generally provided through an unlicensed statutory right to water. This complicates the approach of using the water market to meet new stock and domestic demands.

The ACCC's draft advice on Basin Plan Water Trading Rules discusses the issues surrounding trade of stock and domestic rights in some detail (ACCC 2009, section 3.5). Allowing stock and domestic use to increase may erode the reliability of other water users.

Arguably, new stock and domestic water requirements should be sourced through the water market, similarly to the approach outlined for irrigation and commercial dams. However, allowing the sale of stock and domestic rights where an unlicensed statutory right remains on the property, may lead to an additional uptake of water. Similarly, with an unlicensed statutory right to water, there is no incentive to purchase a water access right. This approach would therefore only be appropriate where legislation is changed to remove ongoing unlicensed access to water. A further complication is that, according to the trade rules adopted for commercial and irrigation use, there may not be an appropriate seller (due to the location) from which to purchase stock and domestic water. Given the critical need for domestic water supply, the trade rules may not be appropriate in this situation.[8] The ACCC draft advice identified a number of other considerations including the cost of licensing these rights and metering and compliance difficulties if they were to become tradable. The legislative changes alone make this a less feasible approach.

However, the continuing growth of these rights, coupled with the tendency for dams to store more water than is reasonable to service those rights, is leading to environmental stress. It is also eroding the rights of other downstream water users (DSE 2009). It is therefore appropriate that stricter registration or monitoring of stock and domestic use is applied to collect information on the extent

[8] It is noted that in South Australia and Victoria some stock and domestic water rights have been converted into tradeable water access rights. However this has occurred in irrigation network areas and has not occurred where farm dams provide the water source.

and speed of growth in stock and domestic use. This will be particularly important in high growth areas, such as periurban areas where extensive sub division is occurring. Should monitoring of stock and domestic farm dams indicate significant growth and potential for third party impacts, options to control this growth should be considered. This could include allocating the existing stock and domestic right as part of the subdivision process, and requiring additional stock and domestic rights be purchased for the additional properties.

Rights for stock and domestic purposes are generally combined into the one water access rights. The ACCC considered that water for stock purposes arguably should not have the same status as water for domestic consumption (ACCC 2009). This links to the discussion on how stock and domestic rights are defined (refer to section 5.2). For example, in NSW, 10% of runoff can be harvested without a licence required. In the majority of cases, this volume would exceed domestic water requirements. There appears little to justify differentiating between large stock water requirements and other commercial uses. It is therefore recommended that reasonable use guidelines be developed, and where possible enforced, such as those currently under preparation in NSW and Victoria.

Recommendation: *In areas at risk of high development of stock and domestic dams (such as periurban areas where sub divisions are occurring), jurisdictions should consider using regulations to manage the growth of farm dams due to sub-divisions and new land holdings.*

Recommendation: *It does not appear feasible to require the purchase of a water access right for stock and domestic farm dams unless all stock and domestic rights (including statutory rights) are incorporated into the entitlement regime, or it is proven that no alterative access to water is available. In this instance, the current farm dam trade rule recommendation from the ACCC would need to be modified to ensure access to domestic water needs was met (for example, a zone approach could be adopted).*

5.4. Impact on low flows

As outlined in section 2, in areas where many farm dams have been constructed, the impacts on downstream flow can be significant. Management of farm dams must consider the ability to maintain passing flows in the downstream waterway to protect river health, and to protect the reliability of supply for existing users.

Flow regimes vary both inter- and intra- annually. This variation is important for ecological and geomorphological processes, but the magnitude and timing of this variation can be changed as a result of water diversions by farm dams. While a new farm dam may be permitted in a region based on the annual take and SDL in that region, the local impacts on particular flow components (such as low summer flows) require specific management that cannot be addressed with annual extraction limits. While a limit on new dams could be implemented, this could unnecessarily limit development if other options exist to manage the impacts during certain times of year.

Where new dams are constructed, one option is to protect downstream summer flows by constructing the dam off-stream or installing bypasses to allow the passing of flows during low flow seasons. Farm dams frequently have a much more pronounced effect during the summer low flow months. Bypasses therefore can be an important management tool as they ensure that low flows and summer freshes are passed downstream.

Existing policy in each jurisdiction regarding bypass mechanisms is summarised in Table 5-5. While bypass systems are used in both Victoria and South Australia, they are not required in Queensland or New South Wales. This in part reflects the distinct differences in hydrology across the regions. In addition, Queensland's definition of farm dams includes flood plain harvesting, and in many regions, extensive numbers of dams are on flood plains. A low flow bypass is not an appropriate mechanism for these types of storages where the majority of water harvested is from flood events.

- **Table 5-5: Bypass mechanisms policy in each jurisdiction (SKM 2007)**

Jurisdiction	Bypass policy
South Australia	All new farm dams are required to have a low flow bypass installed. In some regions, existing dams are required to be retrofitted. This bypass has to pass the minimum flow all year round and so the design of bypass systems is simpler than those that require seasonal adjustments. The capacity of low flow bypasses is based on the runoff rate multiplied by the size of the catchment in which the dam is located. The runoff rate is based on the 10^{th} percentile on a flow duration curve. This percentile was selected as the flow is very seasonal with long dry periods and only a few events per year.
New South Wales	There are currently no requirements for low flow bypasses on farm dams in NSW.
Victoria	All new farm dams are required to have a low flow bypass installed. The bypass volume is calculated based on the minimum flow threshold calculated through the sustainable diversion limits project.
Queensland	There are currently no requirements for low flow bypasses on farm dams.
ACT	There are currently no requirements for low flow bypasses on farm dams.

Given that the installation of bypasses is intended to mitigate against the negative impacts of farm dams on waterway health and downstream users, it is important to determine what flow rate needs to be accommodated. If the bypass is very small, there will be inadequate maintenance of the summer flow regime. However, if the bypass is very large, there will be clear maintenance of river health, but the farm dams will have less potential to harvest flows in winter. As a result, determining the ideal bypass rate becomes a balance between maintaining river health and protection of downstream users' reliability, and reliability of the bypassed farm dam.

Bypassing all seasonal low flows around new dams is difficult to implement in practice. For example, to bypass low flow freshes could require a bypass mechanism with very large capacity, which could be very expensive. If the passing flow requirement between summer months and winter months varies, the ability to change the bypass flow on a farm dam would require a landholder to actively change the bypass mechanism and require more effort in ensuring compliance. A simpler approach would be to require that a certain flow is passed all year round, ensuring minimum passing flows in winter and summer and allowing for a number of smaller freshes in summer.

When determining the appropriate passing flow rate, consideration would need to be given to both the minimum passing flow for the catchment as a whole, and the location and catchment area of the dam itself (SKM 2007).

A study of four catchments in Victoria investigated the effect of different farm dam bypass rates (or minimum passing flow) on both downstream flows and farm dam reliability (SKM 2007). The study assessed river health in terms of additional flow at the catchment outlet (Mean Annual Flow (MAF)), spells analysis on low flows and freshes, and impact on early high flow (or winter) events. The impact on farm dam reliability was assessed in terms of storage volumes and shortfall statistics. The study also recommended an approach for determining the appropriate bypass rates.

In terms of downstream flows, it was shown that:

- Even if all existing farm dams in a catchment were fitted with bypasses, the **total additional flow** at the catchment outlet would be small compared to total flow.
- Any low flow bypass will reduce the duration and frequency of **low flow spells**.
- In larger catchments, farm dam bypasses have little effect on the timing of high flow freshes.
- For individual farm dams, bypasses will help to mitigate the impact of dams on flows downstream of the dam in runoff events after prolonged dry spells. Typically, larger bypasses are better early in the wet season, but smaller bypasses provide more opportunity for farm dams to harvest earlier in the wet season thereby reducing the impact on flows in the latter part of the wet season.

In terms of farm dam reliability, the study showed that:

- Installation of low flow bypasses has an appreciable negative effect on the typical storage volumes in farm dams, with the effect varying depending on regional factors and water supply demands.
- Shortfalls in demand are typically common in farm dams, but the impact on the frequency and magnitude of shortfalls appear to be moderate when the bypasses are 30% of MAF or less.

As described in section 3.1.1, the impacts of farm dams are likely to have a more significant impact on streamflow under climate change in terms of proportion of annual flow harvested. It is likely that low flow bypasses would help moderate this impact.

There are a range of different bypass mechanisms. SKM (2007) recommended the dam and bypass combinations listed in Table 5-6. This was based on an assessment of the quantity of water passed downstream, the technical complexity and the likely compliance with licence conditions on bypass flows. More details of bypass types are given in SKM (2007).

- **Table 5-6: Dam and Bypass Combinations (SKM 2007)**

Dam Type	Local situation	Preferred Bypass Type
Turkey nest dam	Turkey nest dam and pumped diversion from a waterway	Off-stream type
Hillside dam	Broad sheet flow, no well defined depression or waterway	Floating pipe offtake
Hillside dam	Broad sheet flow, no well defined depression or waterway, catchment increased with diversion banks	Upstream weir and bypass pipeline in a diversion bank
Gully dam	Typical gully dam, 50 – 200 m long	Upstream weir and bypass pipeline
Gully dam	Very long dams, typically 200 to 1,000 m long	Floating pipe offtake
Gully dam	Multiple tributaries at dam site	Upstream weir and bypass pipeline on a significant tributary

The costs of constructing farm dams varies depending on the capacity, topography, haul distance to suitable soils and type of outlet works. It is estimated that the current cost to construct a dam is in the range of $1,500 to $2,000 per ML. Bypass works typically would cost between $5,000 and

$13,000. Based on, for example, a 50ML dam (dam construction cost of approximately $100,000), installing bypass works would represent an additional 10% cost (SKM 2007).

There are ongoing maintenance requirements for bypass channels and compliance checks would be required to ensure the bypass system is still operational. For bypass pipelines, the main maintenance requirement would be cleaning of the screens. The depth of silt would also need to be monitored and silt periodically removed to ensure the screen does not become blocked. The simplest way to check compliance may be to require the landholder to record rain events and flow observations upstream and downstream of the dam (SKM 2007). Alternatively, instream flows could be monitored and checked against predicted modelled flow rates. If the flow is not as expected, this would trigger a compliance check for the bypass structures (Franssen 2010).

It may be that in some catchments, funding the installation of low flow bypass systems could provide a bigger instream environmental benefit than purchasing water through an instream tender process. This will depend on the characteristics of the particular system. The case study investigated as part of this project and presented in the following text box demonstrates this point. While in the Merri River, reducing the volume of direct diversions provides greater improvements to instream flow, in the Year River catchment it is low flow bypass systems that provide the greater improvement. The relative merits of reducing direct diversions from waterways and installing low flow bypasses will depend on the individual system and the associated cost of each approach. However, both approaches to improving instream flow should be compared and considered.

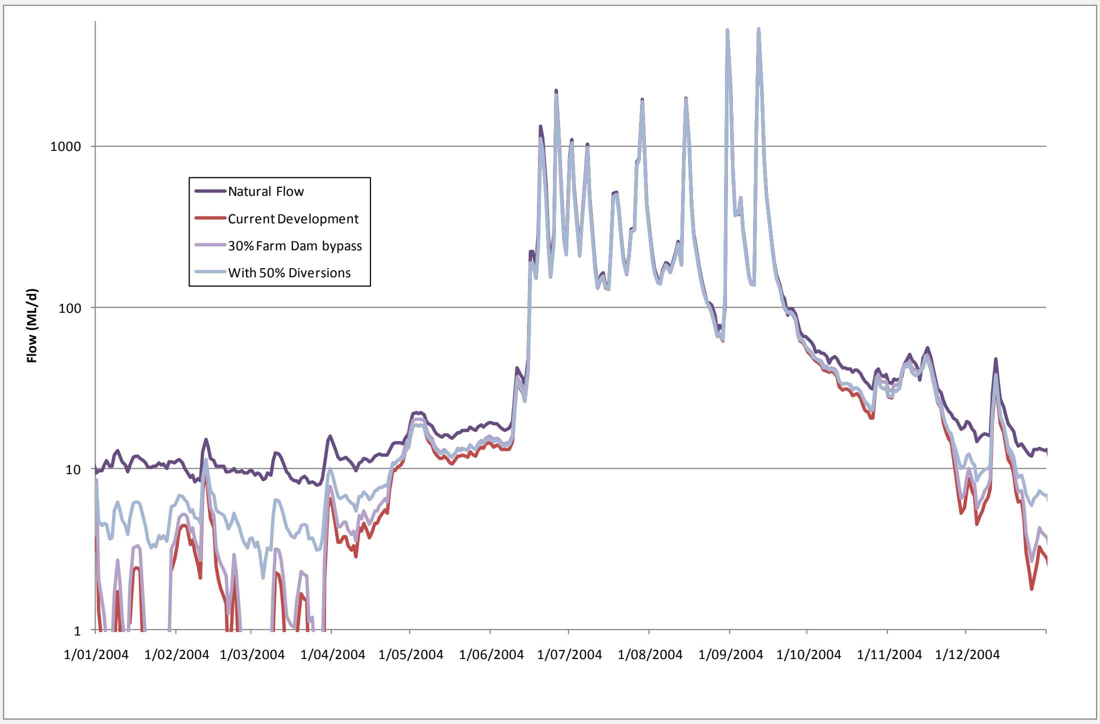
Case study: A comparison of low flow bypass installation and entitlement purchases in providing improved instream flows

This case study compared the relative improvements to streamflow that occur from the installation of farm dam bypasses, as compared to removing direct extraction from the stream (for example through purchasing entitlements).

The analysis was conducted for two catchments, the Merri River in south-west Victoria and the Yea River, which is a tributary of the Goulburn River. Natural streamflow data, farm dam data and the modelled streamflow impacts of various bypass structures were available from a previous study (SKM 2007). A hypothetical irrigation demand pattern (based on PRIDE) modelling, was then used to calculate the impacts of different levels of direct extraction on streamflow. In total, 4 different streamflows are compared:

1) Natural streamflow
2) Current Streamflow impacted by farm dams and private diversions (annual diversion volume equal to the volume of farm dams in the catchment)
3) Current streamflow adjusted by bypasses on farm dams equal to 30% of the Mean Annual Flow
4) Current streamflow adjusted by removing 50% of private diversions

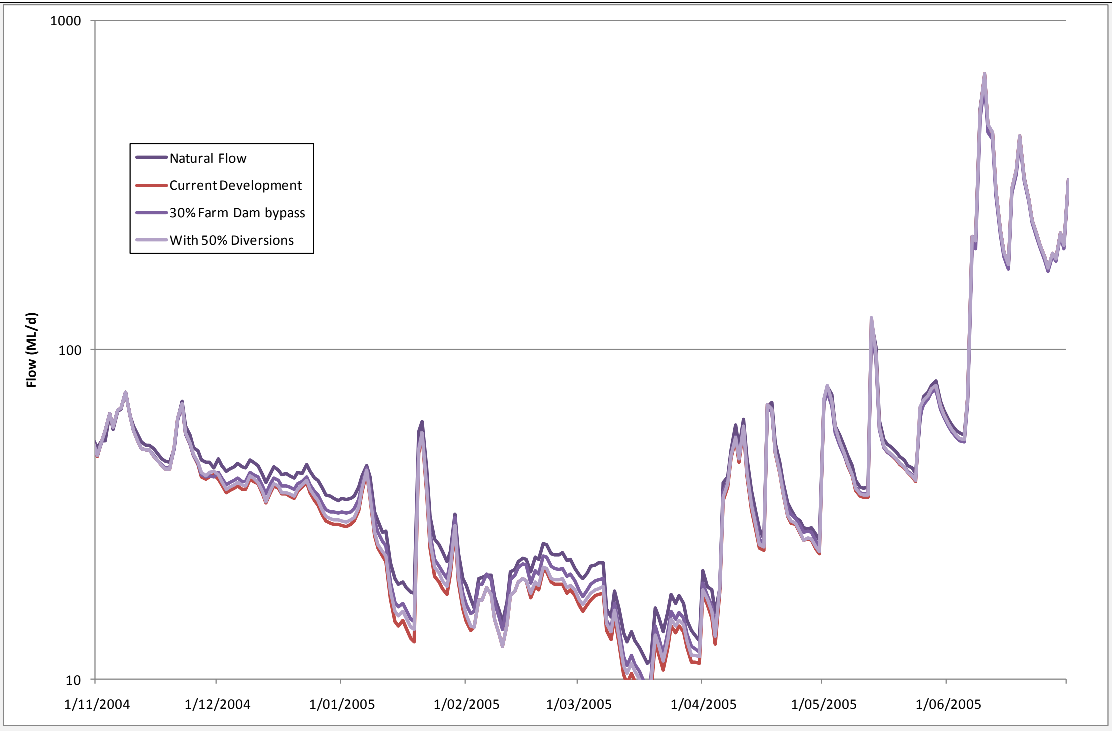
Merri River is located in the Hopkins Basin, and has an area of 631 square kilometres and a mean annual flow of 45700 ML/year. The total farm dam capacity in the catchment is 1928.4 ML. The following figure shows the four flow series for the Merri River catchment. This, along with the FSR scores listed in the table below, demonstrates that purchasing 50% of diversion licences would provide a greater environmental flow benefit than bypassing 30% of MAF on farm dams. For the FSR scores, the higher the score the closer it is to without development conditions.



Flow stress ranking scores

	Variability index	High flow index	Low flow index	Zero flow index	Annual FSR score
Current	0.5756	0	0.5674	0.0875	0.7007
With 30% MAF bypass	0.6373	0	0.6106	0.2125	0.7138
With 50% reduction in diversions	**0.7227**	**0.0072**	**0.6797**	**0.5875**	**0.7638**

However, the results from the Yea River catchment are significantly different. Yea River is located in the Goulburn Basin, and has an area of 361 square kilometres, and a mean annual flow of 108400 ML/year (SKM, 2007). The total farm dam capacity in the catchment is 460.7 ML. In this instance, bypassing 30% of MAF from farm dams provides more improvement than the reduction in diversion licences.



Flow stress ranking scores

	Variability index	High flow index	Low flow index	Zero flow index	Annual FSR score
Current	0.9162	0.4433	0.8552	0.98	0.9316
With 30% MAF bypass	**0.9651**	**0.6149**	**0.8724**	**0.99**	**0.9616**
With 50% reduction in diversions	0.9284	0.5407	0.8656	0.98	0.9454

South Australia is the process of developing a monitoring program that will provide information to verify the predicted flows with low flow bypass systems in place, and to test how well these flows meet ecological objectives. The program—Verification of water allocation science (VWASP)—will extend existing monitoring sites (where baseline ecological data will be available) and implement new sites (Bruce 2010).

Recommendation: *While farm dams will impact on the flow regime, and thus on river ecosystems, it is important that any management action considers the risk posed by farm dams relative to other risks within the catchment.*

Recommendation: *The costs and benefits of funding and installing low flow bypass systems should be compared to the purchase on instream water access entitlements as a means of improving environmental flows in catchments. This is particularly relevant where dry season low flows are the impacted part of the flow regime.*

6. Accounting for farm dams

The provisions of the Water Act (2008) recognise that Sustainable Diversion Limits (SDLs) defined in the Basin Plan are to include water that is taken by interception activities (Section 21(b)), which includes water harvested by farm dams.

Under the existing cap arrangements in the MDB, the focus of policy in terms of cap compliance has been preventing unaccounted growth in farm dams. In the overall cap calculations, farm dams are a relatively small component and efforts to improve the accuracy of other larger elements (such as large irrigation offtakes) has been a higher priority (James 2010).

In contrast to the existing cap arrangements, the SDL will cut existing volumes available for consumptive use. The approach to including farm dams within the SDL therefore requires more detailed consideration than simply adopting the current cap compliance approach. The approach to defining the SDL and assessing compliance is not currently known by the authors. Therefore, the following points are raised for consideration, but may have already been addressed through existing work by the MDBA.

- There needs to be consideration of the potential for inequity in terms of the relative impact of the SDL on licensed commercial or irrigation farm dams as compared to users that extract directly from a waterway. This is particularly the case if trade is permitted between the farm dams and surface water systems, and may be exaggerated with climate change and farm dams capturing a greater proportion of streamflow. However, there is a technical difficulty in how this reduction would be implemented for farm dams.
- The level of consistency in the way storages are accounted for under the SDL needs to be considered. Conceptually, private storages and public storages have a similar impact on instream flow. This is relevant to the decision as to whether the volume extracted from a farm dam for consumptive purposes, or the 'impact' of farm dams should be used to account for farm dams. The extent to which the volume harvested and evaporation from farm dams is included in the SDL—as opposed to just the volume extracted—should be the same approach adopted to account for major public storages in the system as the impact on instream flow will be very similar. However, consideration would also need to be given to the ability to actively manage the impact on streamflow.
- The way farm dams are accounted for under the SDL should reflect the method by which farm dams have been included in the model to determine the volume of the SDL. If the method has varied across the MDB, the method to account for farm dams may need to vary to reflect this and minimise third party impacts.

The policy around farm dams and how they are monitored will ultimately depend on the approach taken to account for farm dams under the SDL. This will in turn need to consider the relative costs of the required level of monitoring and the likely gains in certainty and understanding of the overall water balance when compared to other aspects of take.

7. Conclusions

In areas where many farm dams have been constructed, the impacts on downstream flow, water quality and ecosystem health can be significant. While in most cases the impact of an individual farm dam is relatively small, the cumulative impact of the large number of farm dams that exist in a catchment can be significant.

The first step in managing the impacts of farm dam on river health is assessing the scale of the impact. This requires improved knowledge about the number, size and impact of farm dams in a catchment. Once this is understood, policies can start to address growth in farm dams and impacts on specific components of the flow regime.

The following sections provide a summary of the difficulties and limitations of current legislation, and proposed management approaches to address these issues.

It should be noted that farm dam policy need not necessarily be consistent across the Basin. In general, management of farm dams will be a local issue and can be managed appropriately to match local hydrological conditions and assessing the costs and benefits of changes to jurisdictional policy. It is likely that the most appropriate approach will vary between the north and south of the Basin where hydrology varies substantially. As an example, low flow bypasses are more likely to be appropriate for southern hydrology. The costs of implementing a consistent approach across the Basin will not necessarily yield equivalent benefits in farm dam management.

7.1. Difficulties and limitation of current legislation

In summary, the following limitations or difficulties in managing farm dams arise from the current legislation:

- Across the MDB, there are few controls on intercepting run-off in private dams for D&S purposes. Licensing of farm dams for D&S purposes across the MDB is rare, although each state or territory differs in both its definition of a farm dam and the volume of water that can be retained by such a structure. Typically, use of water for D&S purposes is classed as a statutory right. Therefore, in most cases there is no defined limit to the number of stock and domestic storages that may be constructed.
- Although volumetric limitation on the size of stock and domestic storages exists, in most jurisdictions enforcement relies on notification from affected parties and there is may not be complied with unless there are active compliance activities.
- The approach to licensing and registration of farm dams for commercial and irrigation purposes differs. In some instances, the dam is licensed based on dam volume, and in others, where a meter is installed, on metered off-take.

- When metering is required, the geography of the area could make it difficult and expensive to construct a robust metering system with a high level of accuracy.
- Active compliance on whether water is being taken in accordance with the provisions of the licence is limited.
- There is no central source of data on the quantity or impacts of farm dams and the rate of development, although some hotspots are periodically monitored.
- There is limited legislation in place to protect low flow periods downstream of farm dams. Low flow bypasses are used in some areas to address this.

7.2. Policy recommendations

The following is a list of policy or management actions related to farm dams that will allow greater protection to third parties, including the environment. It should be noted that many of these actions are already in place in some jurisdictions; others will require action such as changes to legislation.

Quantifying farm dams

- Reasonable use guidelines for stock and domestic water use should be developed and community education programs undertaken to support the implementation of these guidelines.
- Metering should be required for use from commercial and irrigation farm dams.
- Stock and domestic farm dams should be monitored through satellite imagery and self assessment methods, except in high risk areas (see below)
- Effort should be put into ensuring that water licensing agencies are involved in planning approvals for new farm dams. A review of how information is managed from this process should be undertaken to ensure data is useful.
- In areas at risk of high development of stock and domestic dams (such as periurban areas where sub divisions are occurring), registration of farm dams should be compulsorily to allow the extent of growth to be assessed, and the growth in stock and domestic use should be monitored in these areas over time.
- All commercial and irrigation farm dams should be licensed (at a bare minimum, registered).
- The MDBA should provide a central point to collate and manage information on farm dams including location, volume and use data.
- Management approaches for farm dams should clearly differentiate between source of inflow (as floodplain or onstream, or as catchment dams).

Managing increased demands

- New commercial or irrigation farm dams should not be permitted unless the water has been sourced through the market according to the basin plan water trade rules (or the system is not yet fully allocated).
- Establishing zones within which trade can occur, based on the knowledge of the resource, may make the trade process more efficient. This should be assessed in the context of the basin plan trading rules, and in particular, and understanding of connectivity.
- In areas at risk of high development of stock and domestic dams (such as periurban areas where sub divisions are occurring), jurisdictions should consider using regulations to limit the growth of farm dams due to sub-divisions and new land holdings.
- It does not appear feasible to require the purchase of a water access right for stock and domestic farm dams unless all stock and domestic rights (including statutory rights) are incorporated into the entitlement regime, or it is proven that no alterative access to water is available. In this instance, the current farm dam trade rule recommendation from the ACCC would need to be modified to ensure access to domestic water needs was met (for example, a zone approach could be adopted).

Managing low flow impacts

- While farm dams will impact on the flow regime, and thus on river ecosystems, it is important that any management action considers the risk posed by farm dams relative to other risks within the catchment.
- The costs and benefits of funding and installing low flow bypass systems should be compared to the purchase on instream water access entitlements as a means of improving environmental flows in catchments. This is particularly relevant where dry season low flows are the impacted part of the flow regime.

7.3. Possible next steps

There are a range of approaches to managing farm dams across the various jurisdictions in the Murray Darling Basin. This project has provided a summary of some the difficulties and limitations of current legislation, and proposed management approaches to address these issues. However, it should be noted that farm dam policy need not necessarily be consistent across the Basin. In general, management of farm dams will be a local issue and can be managed appropriately to match local hydrological conditions and assessing the costs and benefits of changes to jurisdictional policy. It is likely that the most appropriate approach will vary between the north and south of the Basin where hydrology varies substantially. As an example, low flow bypasses are more likely to be appropriate for southern hydrology. The costs of implementing a consistent approach across the Basin will not necessarily yield equivalent benefits in farm dam management.

In order to progress the recommendations in this study, the following steps are recommended:

- Discussions within the MDBA around the objectives and targets of managing farm dams and whether these vary across the Basin
- Discussions with each of the jurisdiction around the recommendations and the practical issues around implementation (for example legislative changes, on ground costs etc) and the degree to which these recommendations diverge from their current approach
- Analysis and quantification of the costs and benefits of each of the recommendations.

8. References

ACCC (2009). Water trading rules - draft advice. Canberra, Australian Competiton and Consumer Commission.

Bond, N., P. Lake, et al. (2008). "The impacts of drought on freshwater ecosystems: an Australian perspective " Hydrobiologia **600**(1): 3-16.

Brainwood and Burgin (2006). "An exploration of hte relationship between Macroinvertebrate community composition and physical and chemical habitat characteristics in farm dams." Environmental monitoring and Assessment **199**: 459 - 480.

Bruce, B. (2010). Personal Communication. A. Horne, 30 July 2010.

Casanova, Douglas-Hill, et al. (1997). " Farm ponds in New South Wales, Australia: relationship between macrophyte and phytoplankton abundances." Marine Freshwater Research **48**(4): 353-360.

DECCEW (2009). Fact Sheet - Information about dams, *Water Resources Act 2007*.

Water Management Act 2000, Order under Section 54, Harvestable Rights – Eastern and Central Division Order (2006). Government of New South Wales.

Water Management Act 2000, Order under Section 54, Harvestable Rights – Western Division Order (2006). G. o. N. S. Wales.

Department of Natural Resources and Water (2007). Risks to the Shared water resources of the Murray-Darling Basin - Regulatory approaches to manage farm dams, groundwater and afforestation, State of Queensland.

Department of Sustainability and Environment (2008). Victorian regulatory framework relating to farm dams, groundwater and afforestation - Prepared as part of the MDBC Risks to Shared Water Resources Program, State Government of Victoria.

Department of Water and Energy (2008). Risks to the Shared Water Resources of the Murray Darling Basin - Implementation of regulatory approaches to manage farm dams, groundwater and afforestation, NSW Government.

Department of Water, L. a. B. C. (2007). Risks to the shared water resources of the Murray-Darling Basin - Implementation of regulatory approaches to manage farm dams, groundwater and afforestation in South Australia, Government of South Australia.

DERM. (2010). "Website - Overland flow." Retrieved 25 May, 2010, from http://www.derm.qld.gov.au/water/management/overland_flow/index.html.

DNRW (2007). Risks to the Shared water resources of the Murray-Darling Basin - Regulatory approaches to manage farm dams, groundwater and afforestation, State of Queensland.

DNRW (2008). Border Rivers resource operations plan. Brisbane, The State of Queensland.

DSE (2008). Victorian regulatory framwork relating to farm dams, groundwater and afforestation, Prepared as part of the MDBA Risks to Shared Water Resource Program.

DSE (2009). Northern Region Sustainable Water Strategy.

DSE (2009). Protecting water users and the environment from uncontrolled growth in domestic and stock water use. Northern Sustainable water strategy, Background report 13.

Environment Protection and Heritage (2007). "Water Information Sheet - Information about Dams."

Franssen , I. (2010). Personal Communication. A. Horne, 10 May 2010.

Hazell, Cunningham, et al. (2001). "Use of farm dams as frog habitat in an Australian agricultural landscape: factors affecting species richness and distribution." Biological Conservation **102**(2): 155 - 169.

James, B. (2010). Personal Communication. A. Horne, 14 July

Lee, S. (2010). Personal Communication. A. Horne, 18 June 2010.

Lewis, B. (2002). Farm Dams, Planning, Construction and Maintenance, CSIRO Publishing.
Lowe, L. and R. Nathan (2008). Consideration of Uncertainty in the Estimation of Farm Dam Impacts. Water Down Under, 2008. Adelaide, Engineers Australia and The International Centre of Excellence in Water Resource Management.
Lowe, L., R. Nathan, et al. (2005). "Assessing the impact of farm dams on streamflows, Part II: Regional characterisation." Australian Journal of Water Resources **9**(1).
MDBC (2008). Mapping the growth, location, surface area and age of man made water bodies, inlcuding farm dams, in the Murray Darling Basin.
Nathan, R., B. Neal, et al. (1999). The impact of farm dams on streamflow in the Marne River Catchment, Sinclair Knight Merz.
New South Wales Government (1989). Crown Lands Act 1989
NWC. (2005). "Website - Australian Water Resources 2005 - Interception Activities." Retrieved 18 June, 2010, from http://www.water.gov.au/WaterAvailability/Whatisourtotalwaterresource/Interceptingactivities/index.aspx?Menu=Level1_3_1_8.
Office of Water. (2010). "Advice to the Water Management Committees - No.3 Floodplain Harvesting." Retrieved 18 June, 2010, from http://www.water.nsw.gov.au/Water-Management/Water-sharing/Advisory-notes/Advisory-notes/default.aspx.
Office of Water. (2010). "Website - Floodplain Harvesting - Frequently asked questions." Retrieved 25 May, 2010, from http://www.water.nsw.gov.au/Water-management/Law-and-policy/Key-policies/Floodplain-harvesting/faq/default.aspx.
SAMDNRMB (2009). Guide to the draft Marne Saunders Water Allocation Plan - A guide for consulation, South Australian Murray Darling Basin Natural Resource Managment Board.
SAMDNRMB (2010). The Water Allocation Plan for the Marne Saunders Prescribed Water Resource Area, South Australian Murray Darling Basin Natural Resource Managment Board.
Savadamuthu, K. (2002). Impact of Farm Dams on Streamflow in the Upper Marne Catchment, Resource Assessment Division , Dept for Water Resources.
SKM (2006). Campaspe River Environmental Flow Assessment, Prepared for the North Central CMA.
SKM (2007). Guidelines for meeting the Passing Flow requirements for licensable Farm Dams in Victoria, Prepared for the Wimmera Catchment Management Authority.
SKM (2008). Farm dam interception in the Campaspe Basin under climate change. Northern Sustainable water strategy, Background report 1., Prepared for the Department of Environment and Sustainability.
SKM (2009). Water Trade Between Water Sources, Prepared for the ACCC.
SKM (2010). Sustainable Rivers Audit 2010 Hydrology Theme - Hydrological assessment of farm Dams (draft), Prepared for the Murray Darling Basin Authority.
Stanley, E. H. and M. W. Doyle (2003). "Trading off: the ecological effects of dam removal." Frontiers in Ecology and the Environment **1:**: 15-22.
Velinsky, D. J., K. L. Bushaw-Newton, et al. (2006). "Effects of small dam removal on stream chemistry in southeastern Pennsylvania." Journal of the North American Benthological Society **25**(3): 569-582.
Weller, J. (2010). Personal Communication. A. Horne, 30 April 2010.

Appendix A – Project Brief

The objective of this is to provide a review and recommendations to MDBA on policy, guidelines and regulations in relation to farm dams (regulated and unregulated) in the MDB, to improve and/or protect water quality and quantity for aquatic ecosystems. This review of policies should be undertaken on a catchment, jurisdictional and basin wide scale. Consideration should be given to the cumulative impacts of seasonality and climate variability.

The review will include:

- Compliance levels with current regulations;
- Adaptability of current policies for climate variability (wet, dry and mid scenarios) and seasonality;
- Applicability and adaptability of current policies in ephemeral ecosystems.

Following review of the policies in the context of the points above, recommendations should be made for management options and policy development for farm dams, to protect and/or improve water quality and quantity for aquatic ecosystems in the MDB.