Greater Macquarie Catchment Irrigation Profile

compiled by Meredith Hope, for the Water Use Efficiency Advisory Unit

The Water Use Efficiency Advisory Unit is a NSW Government joint initiative between NSW Agriculture and the Department of Sustainable Natural Resources.

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1. EXECUTIVE SUMMARY

The Greater Macquarie Catchment Irrigation Profile was developed out of a study to obtain regional and industry-based assessments of water use efficiency (WUE) and Irrigation Efficiency (IE)[1]. Readily accessible irrigation data were collected from state and Commonwealth sources, from published research and industry reports and from unpublished reports. These data were assigned a reliability rating using a system developed by the National Land and Water Resources Audit (1999).

The report summarises, where available, by water source and by catchment,

- the number of licences
- the number of enterprises that irrigate
- the entitled volume or area authorised for irrigation
- the area irrigated and water used in total and by crop type
- the method of irrigation
- irrigated crop yields
- the value of irrigation.

This Profile does not attempt to calculate WUE and IE from these data or analyse their reliability and accuracy. This analysis will be carried out in a subsequent report.

Users of this document are advised to proceed with caution. The data presented in this report should be treated carefully and with respect for the various collection, storage and retrieval processes that can impact on information reliability.

1.1 Irrigation in the Greater Macquarie catchment

The Greater Macquarie catchment[2] is located in central NSW, west of the Great Dividing Range. It has an area of 87 201 km^2, or 8% of the Murray-Darling Basin (MDB). The catchment comprises three smaller catchments: from north to south, the Castlereagh, the Macquarie and Bogan catchments (see Figure 1. Note that for water management purposes, the Bogan catchment is usually grouped with the Macquarie catchment, and so the division between them has therefore not been provided in Figure 1.).

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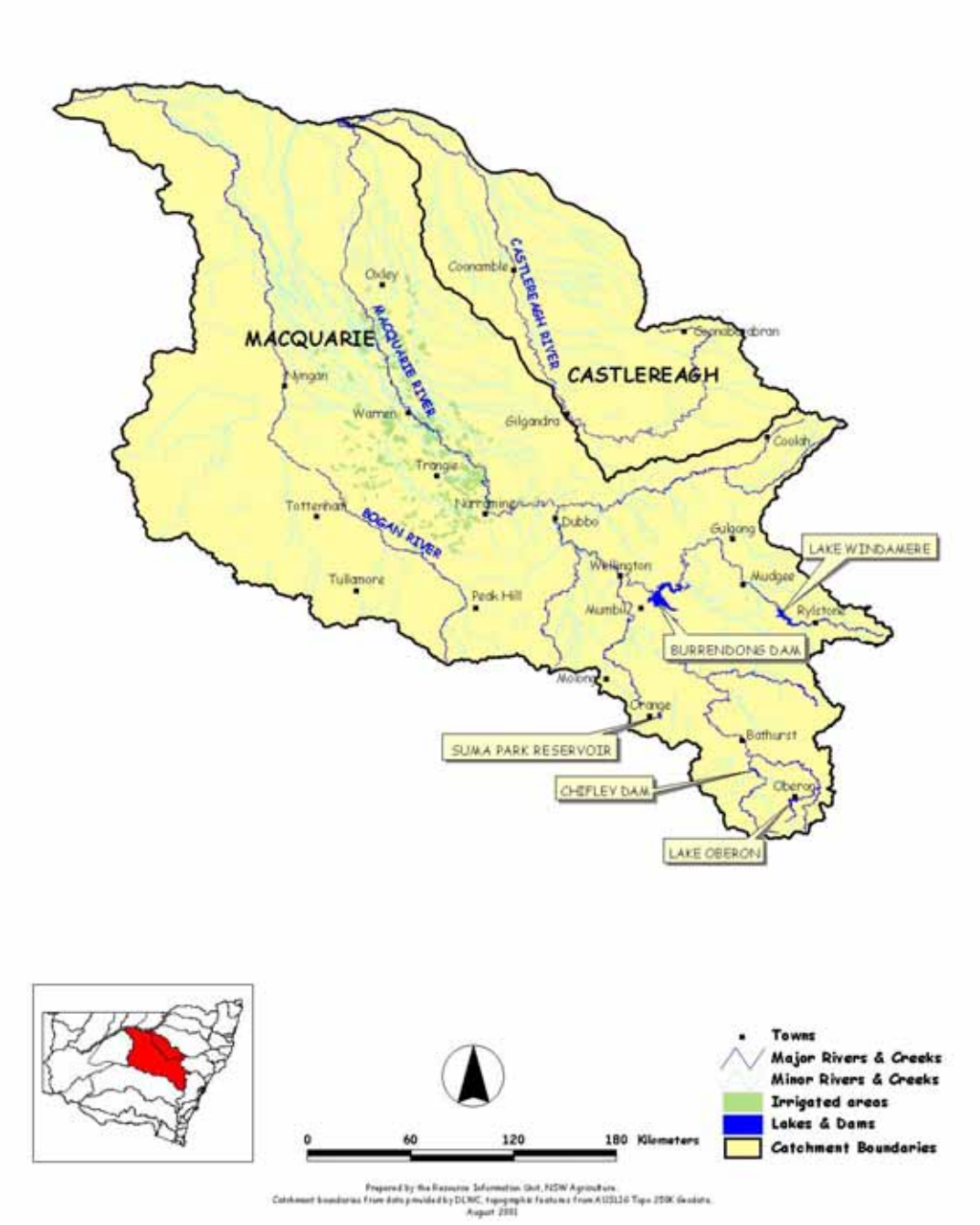
[1] WUE is defined as the volume of crop produced per unit of water delivered to the crop and is usually expressed as tonnes per megalitre (t/ML). IE is a measure, expressed as a percentage, of the volume of water used or delivered by a system relative to the total volume of water entering the system (Alexander and Foley 1998).

[2] Note that for water management purposes, the Greater Macquarie catchment is constituted as the Central West water management area under the *Water Management Act* 2000.

The Greater Macquarie catchment has a semi-arid climate and a summer-dominant rainfall pattern in the north, tending to a winter-dominant rainfall pattern in the south. Annual rainfall decreases from east to west, while evaporation and temperature increase.

Since the construction of Burrendong and Windamere dams, the variability of river flow has been reduced. The irrigation industry in the Macquarie catchment, especially downstream of Narromine, is a major beneficiary of this secure supply. Irrigation occurs adjacent to the Macquarie River or in the seven off-river irrigation schemes of Narromine, Trangie–Nevertire, Tenandra, Buddah Lake, Marthaguy, Nevertire and Greenhide. Irrigation is far less prominent in the Castlereagh and Bogan catchments. These catchments are unregulated (that is, there is no dam to control the catchment's water) and irrigated agriculture relies on supplies that are variable and small.

Figure 1. The Greater Macquarie catchment



Note: The irrigation areas (shaded in light green) present only that irrigation which occurs in the seven off-river irrigation schemes and enterprises along the river. It should be noted that irrigation also occurs above Dubbo around Wellington and Mudgee but that these data have not been presented on this map.

Of the total value of agriculture in the Greater Macquarie catchment in 1996–97 ($1197 million), around 22% can be attributed to irrigation. Total irrigation values have remained reasonably static, ranging from $170 million to $263 million between 1990–91 and 1996–97. Roughly 80% of this total irrigated value can be attributed to irrigated cotton. In 1996–97, cotton was worth $110 million. Fruit and nuts (excluding grapes) and then cereals for grain were the next most valuable irrigated commodities.

In the Macquarie catchment, cotton is mostly grown on the riverine plains west and north-west of Narromine. Summer crops such as oilseeds and cereals and perennial crops such as citrus are also grown in this area.

Vegetables are grown in selected pockets along the Macquarie River (for example, around Wellington). Wine grapes are irrigated in the tablelands around Mudgee and Orange and in the Bell subcatchment around Bathurst. Vegetable growers tend to be opportunistic and production rates vary accordingly. Depending on cotton markets, cotton growers may also turn to growing vegetables.

Stone fruit and lucerne are grown in the Castlereagh catchment while fodder, seed crops and cotton are grown in the Bogan catchment. Some enterprises are located in the Bogan catchment but are fed by water that is channelled overland from the Macquarie River.

Information on irrigated yields is limited, but does show cotton yields have been increasing slowly in the region since the early 1990s. In 1989–90, cotton yielded an average of 1.3 t/ha; in 1993–94, the average was 1.7 t/ha. In 1996–97, an average of 2.3 t/ha was being produced.

Of the 1 150 000 ha of land irrigated in NSW, approximately 5% or 56 000 ha is in the Greater Macquarie catchment (Table 1): most of this is concentrated in the Macquarie catchment. In 1996-97, irrigated cotton comprised more than half of the total irrigated area. Irrigated cotton areas have been increasing as a proportion of the total irrigated areas over the last few years. This trend has been largely driven by improving markets and less favourable returns from alternative agricultural activities.

It is difficult to say accurately how much water irrigated agriculture uses in the Greater Macquarie catchment. The figure could be between 352 600 ML and 372 500 ML, representing around 5% of the total volume that is thought to be extracted by irrigation across NSW from all water sources. A more accurate figure is not available due to the scarcity of data from groundwater and unregulated stream sources. Most water (between 92% and 97%) is supplied from the regulated system to irrigators adjacent to the Macquarie River or to the seven off-river irrigation schemes.

There are many licences for irrigation in the region, although the number that are likely to be active is far less. Of the estimated 24 000 licences in NSW, 8.5%, or 2030 licences, are in the Greater Macquarie catchment. A large number (828) of these are for extraction of water along unregulated streams.

Table 1. Overview of irrigation in the Greater Macquarie catchment, 1996–97

Source of water	Total irrigated area (ha)	Total water used by irrigated agriculture (ML)	Number irrigation licences	Number enterprises irrigating	Yield of major irrigated crop (t/ha)	Value of irrigation ($m)
NSW total	*1 150 000*	*7 700 000*	*24 000*	*7 846*	*cotton 1.8*	*2 496*
All sources	55 556 (over 50% is cotton)	nd *est. 352 600 to 372 500*	2030	560	cotton 2.3	263 (cotton 110)
Regulated	Nd *76 050 (1993–94) (around 50% is cotton)*	341 000	584	nd *361 (1993–94)*	cotton 2.3	nd
Unregulated	12 000 (around 30% is cotton)	nd *8 600 to 28 500 (1989–92)*	828	nd *424 (1993–94)*	nd	nd
Groundwater	nd *4 156 (1993–94)*	nd *3 000 (1980)*	700	nd *133 (1993–94)*	nd	nd
Farm dams	nd *5 286 (1993–94)*	nd	na	nd *153 (1993–94)*	nd	nd
Reticulated	nd *49 (1993–94)*	nd	na	nd *7 (1993–94)*	nd	nd

nd = no data, na = not applicable. The 1996–97 season was used as it was the most current year with greatest amount of data across the chosen categories.

The total number of enterprises irrigating in the Greater Macquarie catchment was 7% of the total number of enterprises irrigating in NSW. Both regulated and unregulated rivers provide the water for most of these enterprises. Fewer enterprises irrigate crops using groundwater, town water supplies (that is, reticulated water), and farm dam water.

Irrigation data issues raised in the Greater Macquarie catchment relate to the general scarcity of irrigation data, the scales at which data have been reported, and the reliability of available irrigation data.

1.2 General scarcity of irrigation data

In the past, data have been collected for different purposes to those currently needed. For example, Water Management Advisory Committees (WMCs) are developing water sharing plans for catchments across the state and need information on how and where water is being used. Information on crop areas, crop water use, yields, irrigation methods and the value of irrigation is needed to help develop water sharing plans and target assistance to irrigators who may need to adjust to new water sharing rules. This Profile has shown that these data were sometimes scant or never collected. Information is particularly needed on extraction from unregulated streams.

Estimation of the volume of water applied to a crop area (for example, megalitres per hectare) is a surprisingly difficult figure to obtain. In some cases, such as irrigation along unregulated streams in the tablelands, crop water use data have never been collected and so it is impossible to estimate the volume applied to a crop on a per hectare basis. In the Lower Macquarie, some enterprises supply water to crops from both groundwater and regulated supplies. The rate at which water has been supplied to crops on these enterprises is difficult to determine due to a lack of information about the groundwater component. In summary, great care is needed when calculating irrigation application rates.

1.3 Scarcity of irrigation data at useful scales

Point-scale data collected by the ABS and ABARE are confidential and have been reported at Statistical Local Area, catchment, groups of catchments or Agro-Ecological Region scales. These scales limit how useful this data are to natural resource managers, who often work at much finer levels, such as river reach.

1.4 Reliability of irrigation data

The reliability of data varied with water source. For example, data from regulated supplies were more reliable than data from unregulated and groundwater supplies.

The reliability of irrigation data is not consistently reported by state agencies. This situation makes it easier for users of these data to manipulate or analyse information inappropriately and draw incorrect conclusions.

1.5 Conclusion

A more comprehensive and consistent approach to the collection of irrigation statistics is needed. This would help to ensure that data are comparable across different water sources and industries.

The following improvements are needed:

- Greater emphasis needs to be given to collecting reliable crop area and water use information. These data underpin many debates on WUE and IE and on how water should be shared and managed in NSW.
- Data are needed at scales that are large enough to protect point-scale confidentiality but small enough to allow users to aggregate information to useful scales.
- Protocols for providing data to users are needed. For example, information providers need to attach reliability ratings to data. This would help users make better decisions on manipulating data.
- Two-way flow of information between agencies and irrigators needs to be fostered. Typically, data have been obtained from irrigators by agencies. These data need to flow back to irrigators in forms that might help them make better water management decisions.
- Two-way flow of information between agencies needs to be fostered. The value of the data collected by the DLWC to other agencies such as NSW Agriculture is great. These data are useful, for example, in devising extension programs to improve WUE and IE.

In summary, a more comprehensive and consistent approach to the collection of irrigation statistics is needed. Such an approach would help to ensure that data are comparable across different water sources and industries. Protocols for the collection, management and distribution of irrigation data are required to ensure that data are accurate and reliable. This comprehensive approach can only be developed with the full involvement of the many agencies and irrigator groups that require these data.

2. INTRODUCTION

During 1998, a desktop study started developing a comprehensive database of irrigation in NSW to obtain regional and industry-based assessments of on-farm WUE and IE. From this study, Irrigation Profiles, or situation statements of irrigation, were developed for each of the major regions in NSW.

This is one such Profile. It focuses on the Greater Macquarie catchment and attempts to detail what is known about the number of irrigators, the area irrigated and water used in total and by crop, irrigated production, irrigation methods and the value of irrigated agriculture. The Greater Macquarie catchment includes the Macquarie, Bogan and Castlereagh catchments (see Figure 1).

This Profile does not attempt to calculate WUE or IE from these data or analyse their reliability and accuracy. This analysis will be carried out in another report.

2.1 Background

Irrigation statistics have been collected in NSW over the last 50 years.

1950s–current The NSW Department of Land and Water Conservation (DLWC) and related agencies collected information over the last 50 years on the area irrigated and water used by sections of the irrigation industry across NSW.

1980 An assessment of irrigation was undertaken by the Water Resources Commission (1980) in NSW. The study provided information on the volume extracted from each water source by the industrial, irrigation and urban sectors.

1980–89 A report on crop areas irrigated, yields of irrigated crops and the values of individual irrigated commodities between 1980 and 1989 was developed for NSW (Deborah Wilson Consulting 1990).

1986 The WRC (1986) undertook a study to assess WUE and IE in NSW. Data on WUE were reported catchment by catchment. The study highlighted a lack of data on crop areas irrigated, water used, yields of irrigated crops and financial returns.

1986–current The Australian Bureau of Statistics (ABS) has been collecting information on irrigation for various years since 1986 (ABS 1998).

1988–92 Sloane (1993) provided an overview of the number of farms and area irrigated for four broad agricultural regions in NSW between 1988 and 1992.

1996–97 The Australian Bureau of Agricultural Resource Economics (ABARE 2000) completed a survey of broadarea[3] and dairy farms in each of the major catchments in NSW in 1996–97. ABARE also completes much smaller surveys each year for specific industries.

[3] Broadarea refers to all crops excluding horticultural and vegetable crops.

Despite the apparently ample collection of statistics in NSW, a basic description of the irrigation industry remains elusive. A review commissioned by the Murray-Darling Basin Commission (MDBC) (Crabb 1997a, 1997b) highlighted a lack of data describing:

1. number of irrigators

2. area of land irrigated

3. location of irrigated land

4. volume of water used.

Four additional points could be added to the list: the crop type, the irrigated yields that are being obtained, the irrigation methods that are being used to irrigate crops, and the value of irrigated agriculture.

Accurate and reliable irrigation data are needed for planning and for assessing the impacts of new water sharing rules on the irrigation industry and other users, such as industry and the environment.

- Under the *Water Management Act* 2000, water management committees constituted by representatives of various community interests and government have been developing water sharing plans. Accurate and reliable irrigation data are needed to develop and implement these plans. (Water sharing plans are operational for 10 years with a review in the fifth year.)

- Catchment Management Boards (CMB) are developing Catchment Blueprints in each major catchment or region in NSW. These plans are designed to improve the management of natural resources and are operational for 10 years. Irrigation data are needed now and in the future to assess their impact.

- As part of the NSW Government's Structural Adjustment Program, an Irrigated Agriculture Water Use Efficiency Incentive Scheme operates to assist irrigators adjust to the NSW Water Reforms. The scheme is jointly managed by the Rural Assistance Authority and NSW Agriculture (2002). To measure change as a result of this scheme, historical and current irrigation data are needed to describe the situation now and after the reforms are implemented.

In summary, accurate and reliable irrigation data are needed to improve WUE and IE, help NSW communities make decisions about sharing water, and help agencies and communities measure change from water reform[4].

[4] In 1994, the Council of Australian Governments (COAG: all states, territories and the Commonwealth) agreed there should be a process for sharing water between users and the environment, trading water, defining water rights, and recovering storage and supply costs.

3. METHODS

3.1 Summary of data collection

During 1998, a desktop study was undertaken to review readily accessible data about irrigation from state sources including the DLWC, and from Commonwealth sources including the ABARE and the ABS.

There were four major sources of electronic data.

1. **the ABS Irrigation Statistics Catalogue, AgStats** (ABS 1998). The ABS have collected information by Statistical Local Area (SLA) and in most instances, these units can be aggregated into the Greater Macquarie catchment. For a definition of an SLA, see Appendix 14.1. For the grouping of SLAs used in the Greater Macquarie catchment, see Figure 2. Only the most current years (1993–94, 1995–96 and 1996–97) with the same Estimated Value of Agricultural Operations (EVAO)[5] and the same collection method have been compared (Table 2). Between 1997–98 and 1999–2000, the ABS collected information by Agro-Ecological Regions (AER). AERs refer to climatic zones, which often span across catchments and cannot be used to build catchment snapshots of irrigation. (Data for the 2000–01 year have been collected but are not yet publicly available).

   Catchment totals may be over-estimated when SLAs cross into other catchments. In this Profile, the Walgett and Brewarrina SLAs spanned important areas of large-scale irrigation in the Namoi and Greater Macquarie catchments. Inclusion of the data from the whole SLA in the Profile may lead to gross over-estimation of area irrigated and number of enterprises irrigating.

   A licence-based concordance was used to apportion the data in SLAs in the Greater Macquarie catchment (Table 3). For example, Walgett SLA had 12.9% of the surface irrigation licences inside the Greater Macquarie catchment. The remainder were in the Namoi and Barwon-Darling catchments (Table 3). Consequently, only 12.9% of the data from this SLA was included in this Profile. The same methodology was applied to Brewarrina SLA.

   For other SLAs such as Cabonne, Coonabarabran, Evans, Greater Lithgow, Mudgee, Oberon, Orange, Parkes and Rylstone, 100% of the data was included. Because the amount of irrigation in these SLAs is relatively small, the data for these SLAs were not apportioned using the licence-based concordance.

[5] The population to be surveyed is determined from the Estimated Value of Agricultural Operations (EVAO). The value of the area of crops sown and the numbers of livestock on holdings at a point in time as well as the crops produced and the livestock turned off during the year is assessed. The aggregation of these commodity values is the EVAO.

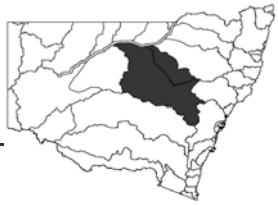


Figure 2. Relationship between the Greater Macquarie catchment and the ABS SLAs

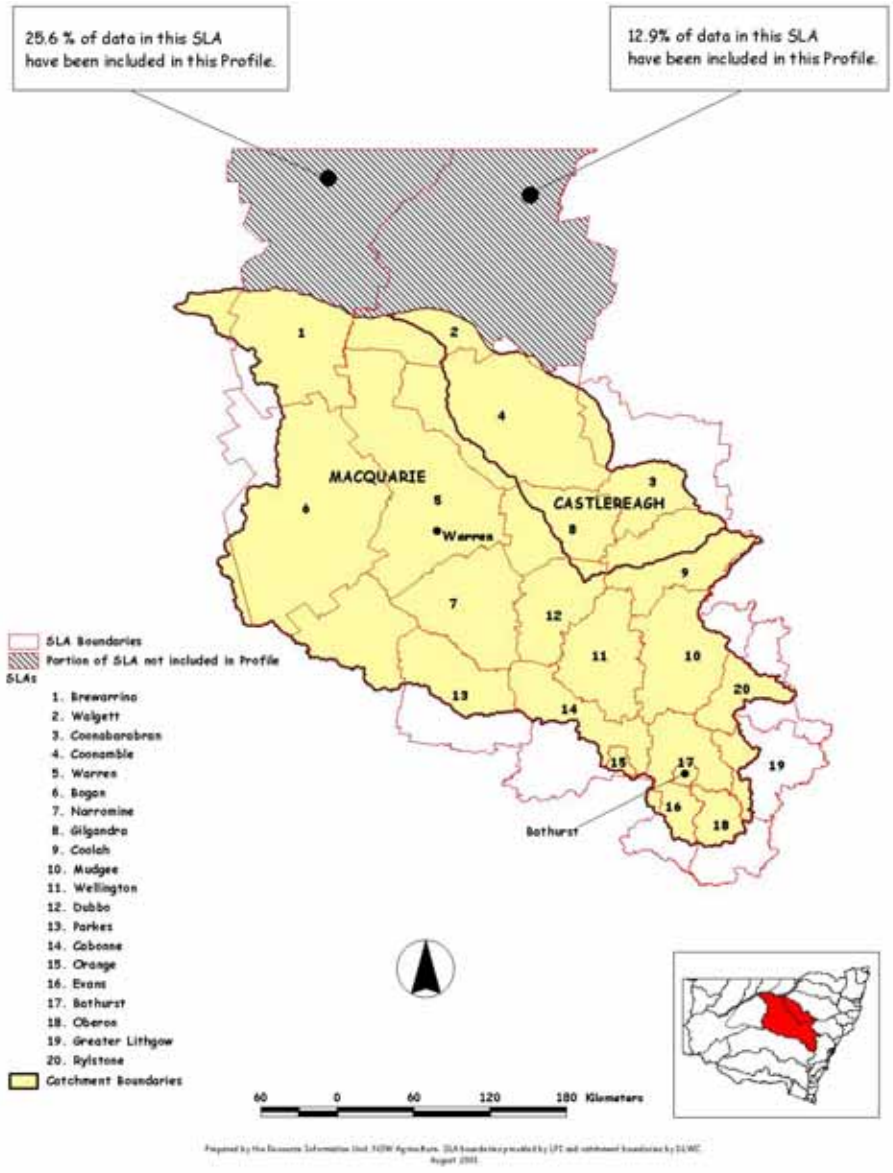


Table 2. EVAOs used by the ABS to collect data about irrigation in NSW

Year	EVAO ($)	Collection Unit
1986–87	20 000	SLA[a]
1989–90	20 000	SLA
1990–91	20 000	SLA
1991–92	22 500	SLA
1992–93	22 500	SLA
1993–94	5 000	SLA
1994–95	5 000	SLA
1995–96	5 000	SLA
1996–97	5 000	SLA
1997–98	22 500	AER[b]
1998–99	22 500	AER
1999–2000	22 500	AER
2000–01	5 000	SLA

[a]SLA = Statistical Local Area. [b]AER – Agro-Ecological Region

Table 3. Surface licences within the SLAs of the Greater Macquarie and surrounding catchments

SLA	Greater Macquarie	Lachlan	Namoi	Barwon Darling	Hunter	Hawk'y Nepean	100% SLA data used
Bathurst (C)[a]	100						✓
Bogan (S)	100						✓
Brewarrina (S)	25.7			74.3			✖
Cabonne (S) - Pt A	74.2	25.8					✓
Cabonne (S) - Pt B	100						✓
Cabonne (S) - Pt C	20.9	79.1					✓
Coolah (S)	100						✓
Coonamble (S)	100						✓

SLA	Greater Macquarie	Lachlan	Namoi	Barwon Darling	Hunter	Hawk'y Nepean	100% SLA data used
Coonabarabran	81.4		18.6				✓
Dubbo (C)	100						✓
Evans (S) - Pt A	100						✓
Evans (S) - Pt B	93.8	6.2					✓
Gilgandra (S)	100						✓
Greater Lithgow (C)	21.0					79.1	✓
Mudgee (S)	94.8						✓
Narromine (S)	100						✓
Oberon (S)	94.5	2.4					✓
Orange (C)	98.4	1.6					✓
Parkes (S)	26.4	73.6					✓
Rylstone (S)	80.6				7.5	11.9	✓
Walgett (S)	12.9		29.5	57.6			✖
Warren (S)	100						✓
Wellington (S)	100						✓

[a] See Appendix 14.2 for SLA naming conventions.

2. ABARE Irrigated Farm Survey results 1996–97 obtained from the ABARE Survey of Primary Industry, Resources and Energy (ASPIRE) database (ABARE 2000). The combined area of the Greater Macquarie catchment and the Lachlan catchment is the reporting unit for the 1996–97 survey of irrigators by ABARE (ABARE 2000). These ABARE (2000) data cannot be disaggregated into smaller units such as SLAs or catchments.

3. a DLWC database of crop area and water use, designed for use by NSW Agriculture (DLWC 1998a). The DLWC has collected information on water use and area by crop type and by licence and these data can be aggregated to any small scale (stream reach or subcatchment) or any large scale (catchment scales).

4. various spreadsheets provided by the Water Analysis and Audit Branch, Sustainable Water Management, DLWC, Parramatta (see for example DLWC 1998b).

Data were also obtained from relevant research and industry reports. An Irrigation Profile or situation statement of irrigated industries operating within the Greater Macquarie catchment was developed from this information. The Profile was further developed in collaboration with NSW Agriculture staff in regional offices. As these

staff uncovered regional data (for example, unpublished reports), this information was incorporated into the Profiles.

This Profile was prepared in the time leading up to the full implementation of the *Water Management Act 2000*.

3.2 Rating data reliability

The reliability of these irrigation data has been described using a rating system developed by the National Land and Water Resource Audit (1999). The four classes are:

1. **Class A** – data based on reliable recorded and surveyed information. Little or no extrapolation or interpolation required.
2. **Class B** – data based on approximate analysis and limited surveys. Some measured data and some interpolation/extrapolation required to derive the data-set.
3. **Class C** – little measured data. Data based on reconnaissance survey.
4. **Class D** – data derived without investigation. Figures estimated from other data in nearby catchments or extrapolated/interpolated from any available data.

In this Profile, the reliability rating class has been indicated with the symbols:

- Class A: ①
- Class B: ②
- Class C: ③
- Class D: ④

So, for example, 'the number of irrigated enterprises in the Greater Macquarie catchment was 560 (ABS 1998) ②'.

3.3 Structure of Profile

The availability and reliability of data in the Greater Macquarie catchment has been summarised for the following five water sources:

Regulated rivers[6] are those rivers that have been declared by the Minister, by order published in the Gazette, to be a regulated river (NSW *Water Management Act 2000)*.

[6] **Rivers:** A river is defined in the *Water Management Act* 2000 as:

- any water course, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved;

Unregulated rivers[6] are all other rivers that are not regulated rivers (NSW *Water Management Act 2000)*. Many of these rivers may still have dams or weirs built on them by urban water suppliers to control water flows (DLWC 1999c).

Groundwater is water that can be accessed from an aquifer. An aquifer is a geological structure or formation, or an artificial land fill, that is permeated with water or is capable of being permeated with water (*Water Management Act 2000)*.

Farm dam water is water from dams containing water that is permitted to be captured under a Harvestable Right.

Town water supplies are those that have been reticulated for a town's or city's drinking water.

The presentation of information by water source was necessary as data availability and reliability varied markedly depending on the water source to which it was related. This report summarises, where available, by water source, SLA, subcatchment and by catchment:

1. number of licences with the purpose of irrigation;
2. number of irrigated enterprises;
3. entitled volume or area authorised for irrigation;
4. area irrigated and water used in total and by crop type;
5. method of irrigation;
6. yield of irrigated crops; and,
7. value of irrigated production.

- any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows; and,
- anything declared by the regulations to be a river;

but does not include anything declared by the regulations not to be a river.

4. DESCRIPTION OF THE GREATER MACQUARIE CATCHMENT

4.1 Physical description

The Greater Macquarie catchment is located in central western NSW and covers 87 201 km^2 or 8% of the Murray–Darling Basin (MDB). The region extends from Oberon in the south-east to Bourke in the north-west. There are three major zones in the area: the tablelands, riverine slopes and riverine plains.

- Typically, the tablelands zone around Mudgee and Orange is hilly.
- The riverine slopes between Burrendong Dam and Dubbo are hilly, with small fertile alluvial floodplains next to watercourses. Fertile floodplains can be found along the Macquarie River between Wellington and Dubbo.
- The riverine plains zone, west of Dubbo, is characterised by flat landscapes (slope < 1%) with broad fertile alluvial floodplains.

The region (Figure 1) comprises the Macquarie and Bogan catchments (70 768 km^2 combined) and the Castlereagh catchment (16 433 km^2).

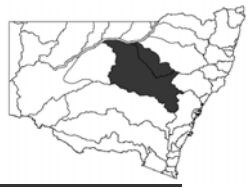
Here is a description of these catchments from north to south.

The Castlereagh catchment lies between the Namoi catchment in the north and the Macquarie catchment to the south. The Castlereagh River (a tributary of the Macquarie River) drains water from the Castlereagh catchment. It has its headwaters in the Warrumbungle and Liverpool Ranges and in the hills between. Most of the run-off comes from these ranges and hills, which represent only 5% of the total area of the catchment. The Castlereagh River joins the Macquarie River downstream of the Macquarie Marshes.

The Castlereagh River is unregulated and its contribution to flows in the Macquarie River is small. High flows are experienced only during floods, and water may spill from the Castlereagh River over the floodplains (EPA 1997). Generally, most of the water in the river evaporates before reaching the Macquarie River or is lost in recharge zones along the river into the Great Artesian Basin (GAB) or to shallow aquifers extending west of Gilgandra.

As is the case in the Macquarie catchment, there are wetlands in the lower parts of the floodplains of the Castlereagh River and Mowlma Creek.

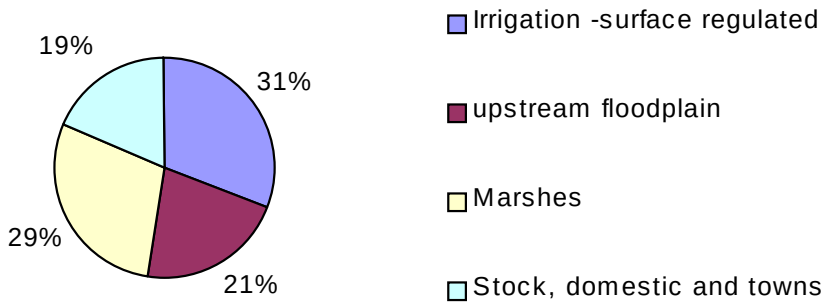
The Macquarie catchment lies between the Castlereagh catchment to the north and the Bogan catchment to the south. The Macquarie River begins in the Great Dividing Range downstream of the joining of the Fish and Campbells rivers and flows north-west to its confluence with the Cudgegong River at Burrendong Dam.



The Macquarie and Cudgegong rivers are the only regulated rivers in the Macquarie catchment and are controlled by Burrendong and Windamere dams. (Fuller descriptions of the regulated system can be found in Section 5.)

Downstream of Burrendong Dam, the Macquarie River flows through Wellington and Dubbo and continues past the seven off-river schemes and then to the Macquarie Marshes, which lie 80 km north of Warren. The Macquarie Marshes are a series of wetlands consisting of a complex system of poorly drained depressions, lagoons and anabranching channels. Extensive flooding at irregular intervals and subsequent slow drainage of inundated areas have created an environment that is conducive to bird life, including waterfowl and ibis (Water Resources Commission 1979, in Crabb et al. 1983). Following flood events, water spills past the marshes and joins the Barwon–Darling River upstream of Brewarrina. The marshes receive around 30% of the water flowing into the Macquarie catchment (DLWC and NPWS nd, 1996) (Figure 3).

Figure 3. Extraction of water from the Macquarie River



Source: DLWC and NPWS nd

The Bogan catchment lies to the south of the Macquarie catchment and to the north of the Lachlan catchment. The Bogan River, which is unregulated, runs parallel to the Macquarie River. The headwaters of the Bogan River are in Goobang National Park, close to Bogan Gate and Peak Hill. This catchment has no regularly flowing tributaries but includes many ephemeral creeks (EPA 1997).

A complex set of effluent streams connect the Macquarie, Bogan and Darling rivers. To cater for a relative lack of water, the Albert Priest Channel was constructed to divert water from the Macquarie River to the Bogan River for Nyngan and Cobar's domestic and industrial water supply needs. Water is raised by Warren Weir downstream of Gunning and is then controlled into Albert Priest Channel. Two weir pools on the Bogan River are used to supply water for domestic and industrial uses. The lower weir pool is used for recreation and small amounts of irrigation.

4.2 Climate

The Greater Macquarie catchment has a semi-arid climate with a mean annual rainfall that decreases in a westerly direction from 674 mm around Mudgee to 355 mm at Bourke (Table 4).

Table 4. Climate in the Greater Macquarie catchment

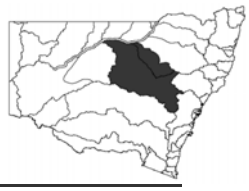
	Orange	Mudgee	Trangie	Nyngan	Coonab'n	Bourke
Elevation (m)	922	454	215	173	180	106
Long-term mean daily max. temp.(°C)	17.7	23	24.3	25.6	26.4	27.6
Highest max. temp.(°C)	36.7	42.2	44.2	46.9	47.8	51.7
Long-term mean daily min. temp.(°C)	7.1	8.3	10.6	11.6	11.4	13
Lowest min. temp.(°C)	-5.6	-8.3	-8	-3.9	-4.4	-2.4
Long-term evaporation (mm)	1472	nd	1976	nd	nd	1869
Long-term reference evapotranspiration [7] (mm)	1197	1414	1401	nd	1499	1871
Long-term mean rainfall (mm)	949	674	500	443	505	355
Long-term evaporative deficit [8] (mm)	249	739	898	nd	994	1516

Source: Bureau of Meteorology 2000 nd = no data

This decrease in rainfall is associated with decreasing elevation and the prevailing directions of incoming weather changes. Most rain throughout the Greater Macquarie catchment falls during summer, with the exception of the tablelands zone (Mudgee and Orange). In Mudgee, rain falls relatively evenly across all months. In Orange, rain falls mostly in winter and early spring (Appendix 14.3).

7 Reference evapotranspiration is the amount of evaporation and transpiration of a grass reference crop (Allen et al. 1998) and was determined using the FAO56 methodology (Allen et al. 1998).

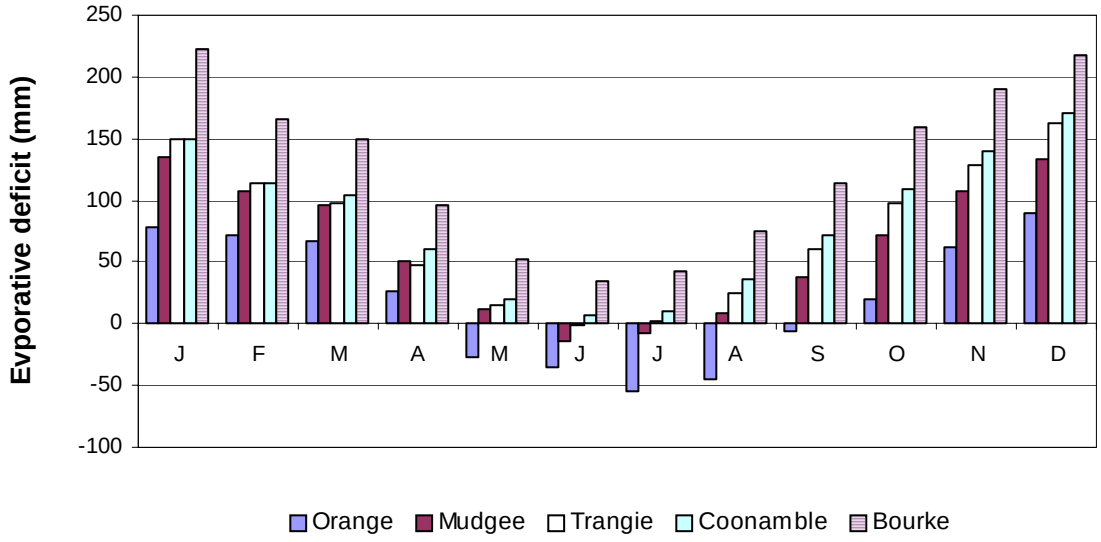
8 Evaporative deficit = long-term monthly reference evapotranspiration minus long-term mean monthly rainfall. Climatic data including rainfall were obtained from the Bureau of Meteorology (2000).



Mean daily maximum temperatures increase in north-westerly and northerly directions, with decreasing elevation (Table 4).

The evaporative deficit gives some indication of when irrigation water is needed by crops. Evaporative deficit is greater in the riverine plains than in the tableland region. Data from Trangie (riverine plains) and Mudgee (tablelands) show that irrigation water is generally needed over the months between August and May (Figure 4). By comparison, irrigation water is needed throughout the year at Bourke. The evaporative deficit is also greater in the north (Coonamble) compared with the south (Orange).

Figure 4.Long-term evaporative deficit for sites in the Greater Macquarie catchment

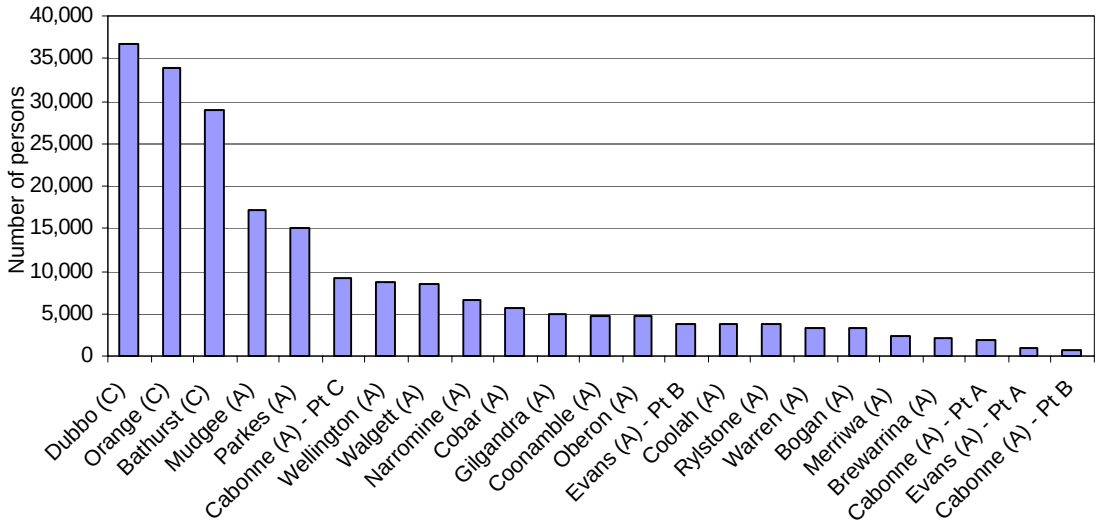


Source: Allen et al. 1998; Bureau of Meteorology 2000

4.3 Main population centres

The largest population centre within the Greater Macquarie catchment in 1996 was Dubbo (36 700 people, Figure 5), situated on the Macquarie River in the riverine slopes (Figure 1). Other major towns (greater than 15 000 people) include Orange, Bathurst and Mudgee.

Figure 5. Population in SLAs of the Greater Macquarie catchment



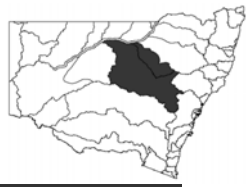
Source: ABS 1997 ①
See Appendix 14.2 for further detail on SLA naming conventions.

4.4 Agriculture

The Greater Macquarie catchment supports a range of agricultural produce including cattle, sheep, wheat, cotton, oilseeds and fruit.

From north to south:

- The Castlereagh catchment depends mainly on dryland activities such as sheep, cattle and cereals, as well as grapes and fruit (EPA 1997).
- The Macquarie catchment supports grazing, cropping, pine plantations and grapes in the tablelands. On the plains, cotton, wheat, oilseeds, vegetables, pasture and grazing (wool and beef) dominate (Russ 1999; EPA 1997).
- Cropping (cotton, wheat, oilseeds, vegetables and pasture) and grazing (wool and beef) dominate the riverine plains of the Bogan catchment (Russ 1999; EPA 1997).



5. IRRIGATION: ALL SOURCES OF WATER

5.1 Irrigation from all water sources

Castlereagh catchment – Irrigation in the Castlereagh catchment is limited because it depends on variable and relatively small volumes of river water. Water is used to irrigate orchards, which are expanding in the catchment (EPA 1997), stone fruit around Coonabarabran and small pockets of pasture and lucerne around Coonabarabran and Gilgandra. There is also an orchard at Coonamble (G. Giddings and B. Swann 1999, pers. comm., NSW Agriculture, Dubbo).

Macquarie catchment – The irrigation industry in the Macquarie catchment is by far the most developed of the three catchments. Historically, irrigation was carried out by pastoralists in this catchment before any dams were built. Water was extracted from the Macquarie river system to irrigate fodder crops for producing reliable sources of feed (Elliott 1995). However, unreliable river flows restricted further development.

In 1967, following the construction of Burrendong Dam, irrigation developed in the mid to lower areas of the Macquarie catchment (Russ 1999; Crabb et al. 1983). People were encouraged to establish new irrigation enterprises and to utilise this water supply (Wolfgang 1998).

Today, irrigation farms can be found either along the fertile riverine plains and slopes close to the Macquarie River or in the seven off-river irrigation schemes of Narromine, Trangie–Nevertire, Tenandra, Buddah Lakes, Marthaguy, Nevertire and Greenhide.

Irrigation plays an important role in the Macquarie catchment, generating considerable amounts of wealth from small areas of land. It has been estimated that 1% of land is used to produce 26% of the Macquarie catchment's agricultural value (Russ 1999).

In 1996–97, the average area irrigated by broadarea and dairy farms in NSW was 189 ha. Broadarea and dairy farms in the Greater Macquarie and Lachlan catchments irrigated 201 ha (ABARE 2000). (These figures do not include horticultural or vegetable farms.)

Cotton enterprises lie west and north-west of Narromine on the riverine plains around Trangie and Warren (EPA 1997). These farms tend to be large-scale enterprises with a massive infrastructure of storage facilities, laser-levelled fields and extensive channel systems. The Macquarie catchment is the third largest cotton-producing area in Australia – approximately 28 000 ha of cotton are regularly planted (Hearn and Cameron Agriculture 1997): the Gwydir and Namoi catchments plant an average of 52 000 and 44 000 ha respectively (Hearn and Cameron Agriculture 1997). Over the last 10 years, as a result of improving markets, irrigated agriculture in the Macquarie catchment has moved away from mixed irrigated cropping systems toward cotton monoculture. Crops such as wheat and legumes are grown in rotation with cotton to

help improve soil structure and fertility (Hulugalle and Cooper 1994; McKenzie and Abbott 1983).

North-west of Dubbo, between Narromine and Gin Gin, citrus is grown. Between Dubbo and Narromine, enterprises grow vegetables, pastures, citrus, lucerne and oilseeds. Upstream of Dubbo, pasture and vegetables are irrigated. Orchards and wine grapes are irrigated on the riverine slopes and in the tablelands around Mudgee and Orange (Wolfgang 1998). There is some concern that extensive pine plantations in the upper parts of the catchment could affect the water supply of these vineyards and horticultural industries (EPA 1997).

Bogan catchment – Irrigation along the unregulated Bogan River system is limited. Extraction of water from Bogan River occurs between the river's confluence with Albert Priest Channel and the Lower Weir Pool. This water is used to grow cotton. Fodder crops are also grown near Tomingley (G. Giddings and B. Swann 1999, NSW Agriculture, Dubbo, pers. comm.).

5.2 Salinity and waterlogging in the Macquarie catchment

Initially, waterlogging and salinity from irrigation were not thought to be an issue in the Macquarie catchment. Irrigated areas are smaller and more sparsely scattered over the landscape than the Irrigation Areas and Districts of northern Victoria and southern NSW (Bird et al. 1996) where considerable problems with salinity and waterlogging exist. However, watertables have been rising in the Lower Macquarie catchment since the late 1980s (Willis and Black 1996; Willis and Hulme 1996; Water Resources Commission 1987). Willis and Black (1996) suggest that irrigation may contribute to this phenomenon. Waterlogging and associated salinisation have been identified in parts of the Macquarie catchment (Lubbers 1993) and potential risk areas have been mapped (Macquarie Valley Landcare Group Inc 1999).

The data presented in this section have been summarised in the matrix in Table 5. Note the areas where there are few data: number of enterprises irrigating, total area irrigated and total water used.

Table 5. Summary of irrigation data from all sources of water

Year	No. enterprises irrigating	Total area irrigated (ha)[b]	Area of cotton irrigated (ha)	Total water used (ML)	Total water used on cotton (ML)[e]	Yield of cotton (t/ha)	Value of irrigation ($ m)[g]	Value of cotton ($ m)[g]
1988–89	-	-	21 853[c] 20 641[e]	-	202 049	1.3[e]	-	-
1989–90	-	-	25 090[c] 25 764[e]	-	231 101	1.3[e]	-	-
1990–91	1686[a]	-	27 000[c] 26 290[e]	-	245 696	1.5[e]	-	-
1991–92	-	-	32 000[c] 29 453[e]	-	280 548	1.4[e]	176	62
1992–93	-	-	31 000[c] 30 194[e]	-	118 439	1.4[e]	170	66
1993–94	706[b]	98 662	28 812[b] 34 000[c] 29 306[e]	-	278 941	1.5[e]	206	90
1994–95	-	-	36 500[c] 37 458[e]	-	-	1.7[e]	260	148
1995–96	449[b]	34 729	14 000[c]	-	-	-	180	54
1996–97	560[b]	55 556	31 527[b] 34 000[c]	-	-	2.3[f]	263	110
1997–98	-	-	45 000[c]	-	-	-	-	-
1998–99	-	-	43 000[d]	-	-	-	-	-
1999–00	-	-	52 000[d]	-	-	-	-	-
2000–01	-	-	-	-	-	-	-	-
Refer to section	5.4	5.5	5.5	5.5	5.5	5.7	5.8	5.8

a Kingsford and Thomas 1995

b ABS 1998 ② (Estimated Value of Agricultural Operations (EVAO) - $5000)[9]

c DLWC 1998b

d D. Barma 2001, Senior Water Analyst, DLWC, Parramatta, pers. comm., March, from Licence Administration System ②

e Hearn and Cameron Agriculture 1997 ③

f ABARE 2000 ③

g Donovan 2000 ③

5.3 Number of licences (all water sources)

In 1999, there were 2030 licences with the purpose of irrigation in the Greater Macquarie catchment. This figure was determined by summing the following data:

- 502 volumetric licences with the purpose of irrigation from regulated surface supplies (DLWC 1999a)① . Note that the Macquarie catchment is the only catchment with a regulated river system.
- 828 area-based licences with the purpose of irrigation from unregulated rivers (DLWC 1999a)① (Greater Macquarie catchment)
- 700 volumetric licences for all purposes for extraction from groundwater aquifers (DLWC 1999b)② (Greater Macquarie catchment). Most of these are assumed to be for irrigation and this figure assumes the lower reliability rating②.

5.4 Number of enterprises that irrigate (all water sources)

There were 560 enterprises irrigating in the Greater Macquarie catchment in 1996–97; in 1993–94, there were 706. Other statistics suggest that the number of irrigators could be much larger. According to Kingsford and Thomas (1995) there were 1686 irrigators in 1990–91 (reliability unknown). When compared to ABS figures in 1993–94, this represents a more than twofold difference. Reasons for this difference are not known.

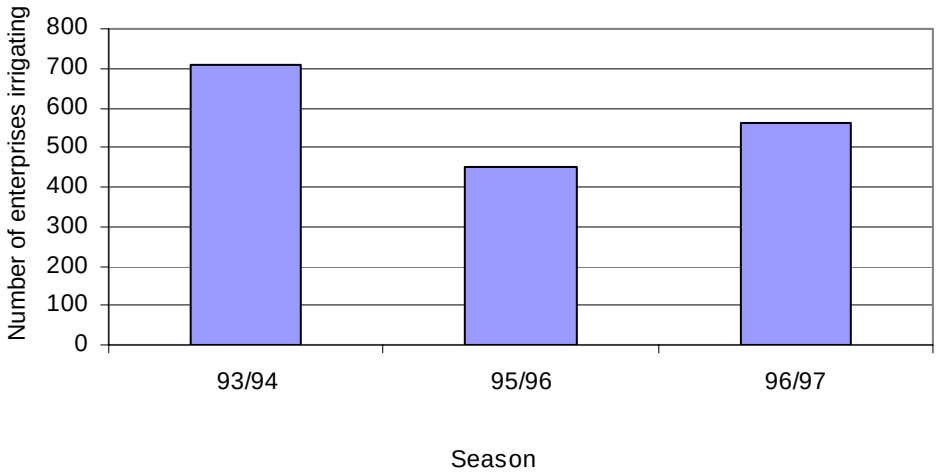
Using the ABS numbers, 28% of enterprises irrigating were in the cotton-growing SLAs of Narromine and Warren (Appendix 14.4) ②. A further 10% were in the SLA of

[9] Only years where the ABS used an EVAO of $5000 have been compared. The smallest unit collected by ABS is the SLA and the population to be surveyed is determined from the EVAO. The EVAO is estimated from a procedure that takes into account the value of the area of crops sown and the numbers of livestock on holdings at a point in time as well as the crops produced and the livestock turnoff during the year. The resultant aggregation of these commodity values is termed the EVAO.

Mudgee and 8% in Orange Both Orange and Mudgee SLAs span important grapegrowing and pome-fruit regions.

According to ABS figures, the total number of enterprises irrigating decreased between 1993–94 and 1996–97 (Figure 6; Appendix 14.4)②. This trend can be seen in most SLAs across the state, regardless of climatic conditions or access to water, and should therefore be treated with caution. The allocation announcements (Appendix 14.5) in the Greater Macquarie catchment do show a lower availability of water in 1995–96 and 1996–97, providing some basis for this trend (ABS 1998)② . When less water is available in the system, the level of irrigation is likely to be depressed.

Figure 6. Number of enterprises irrigating in the Greater Macquarie catchment from all sources of water

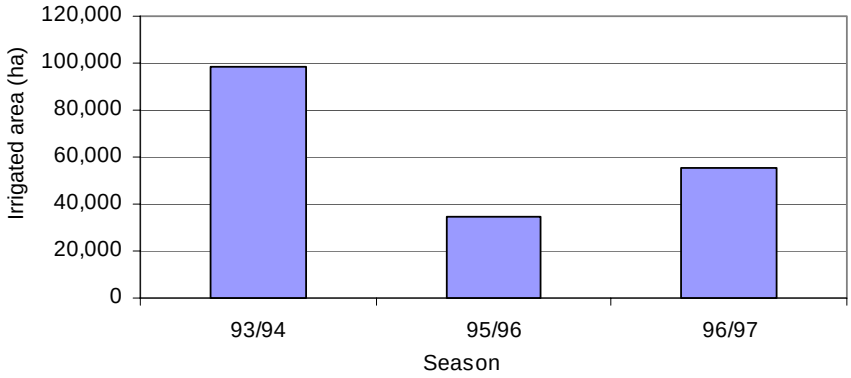


Source: ABS 1998, ②

5.5 Area irrigated and water used (all water sources)

Area irrigated. The area irrigated in the Greater Macquarie catchment from all sources of water decreased over the period between 1993–94 and 1996–97 from 99 000 ha to 55 000 ha (ABS 1998)② (Table 5 and Figure 7). Once again, this decrease in area irrigated can be seen in many SLAs across the state and, for the reasons presented in Section 5.4, should be treated with caution. In the Greater Macquarie catchment, an indication of water availability can be obtained by viewing allocation announcements (Appendix 14.5). These allocations show less water was available in 1995–96 and 1996–97, and this could partly explain the trend toward a smaller irrigated area for these particular years.

Figure 7. Area irrigated (ha) from all sources of water in the Greater Macquarie catchment

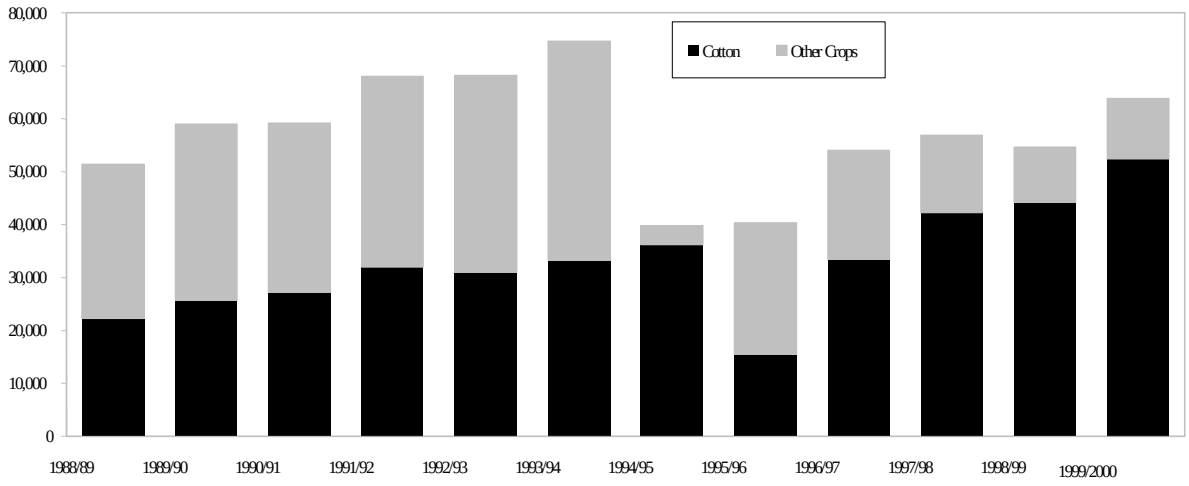


Source: ABS 1998, ②

Cotton is the dominant irrigated crop in the Greater Macquarie catchment and is almost exclusively grown along the Macquarie River downstream of Narromine. Very small amounts of cotton are also grown in the Bogan catchment. The total area of cotton irrigated in the Greater Macquarie catchment has increased from 28,812 ha to 31,527 ha (1993–94 to 1996–97). Other references suggest there has been no change over this time period (see Table 5).

Cotton is mostly concentrated in the SLAs of Narromine and Warren (Appendix 14.6) and areas have increased only slightly in these SLAs between 1993–94 and 1996–97 by around 600 to 700 ha each. A trend toward cotton monoculture has been occurring since 1988–89 (Figure 8) and has been driven largely by less favourable returns from alternative agricultural activities and increasing cotton prices, especially between 1993–94 and 1995–96 and in 1998–99 (IBIS 2000).

Figure 8. Cotton areas in the Greater Macquarie catchment, 1998 to 2000 (in ha, all sources of water)



Source: D. Barma 2001, Senior Water Analyst, DLWC, Parramatta, pers. comm., March, from the licence administration system ②

The ABS category 'other crops' includes a number of miscellaneous crops, one of which is cotton. Given cotton's dominance in the catchment, it was assumed that this category 'other crops' represented mostly cotton (Figure 9).

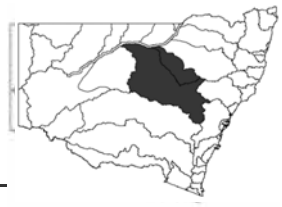
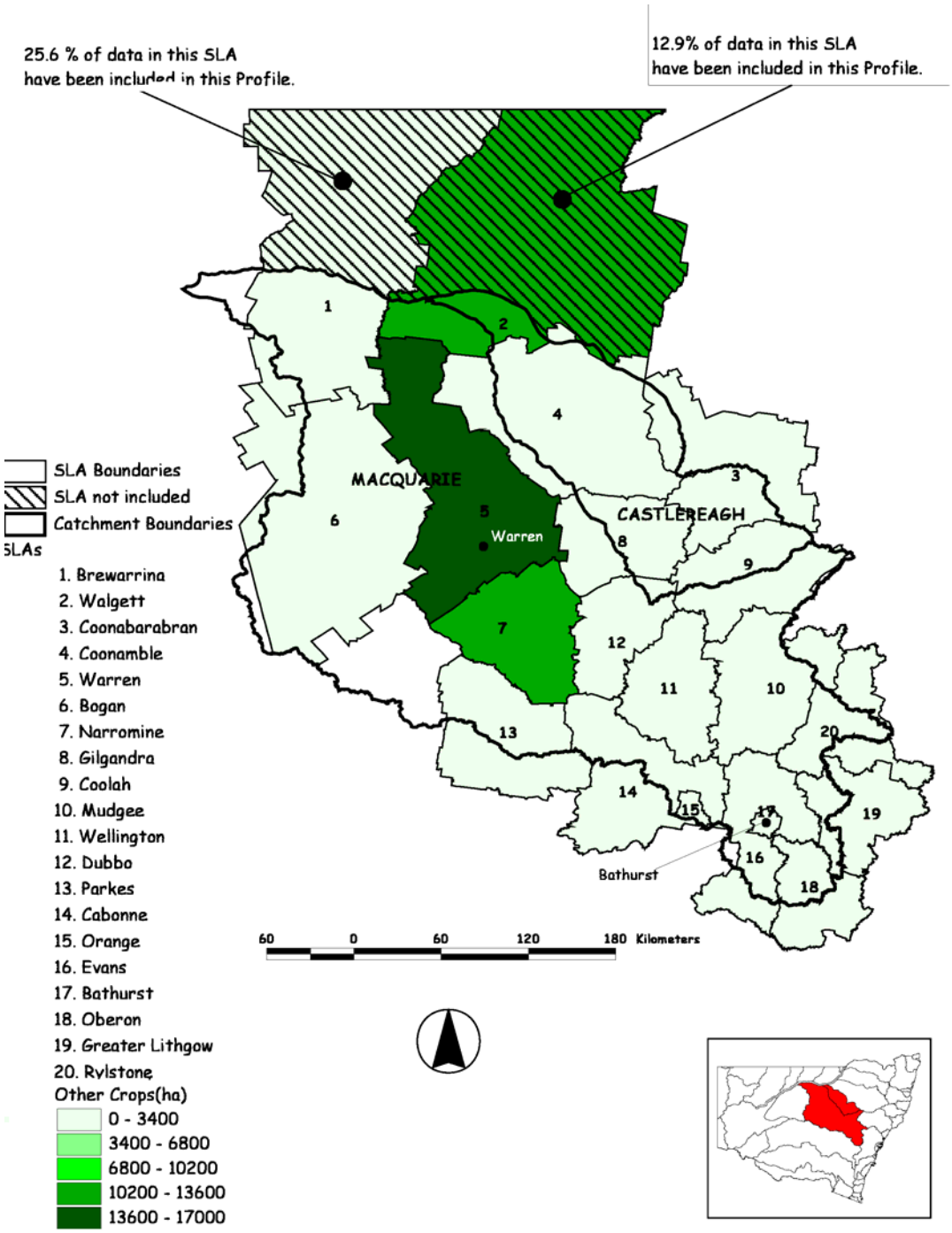


Figure 9. Area of 'other crops' (mostly cotton) irrigated in the Greater Macquarie catchment in 1996–97

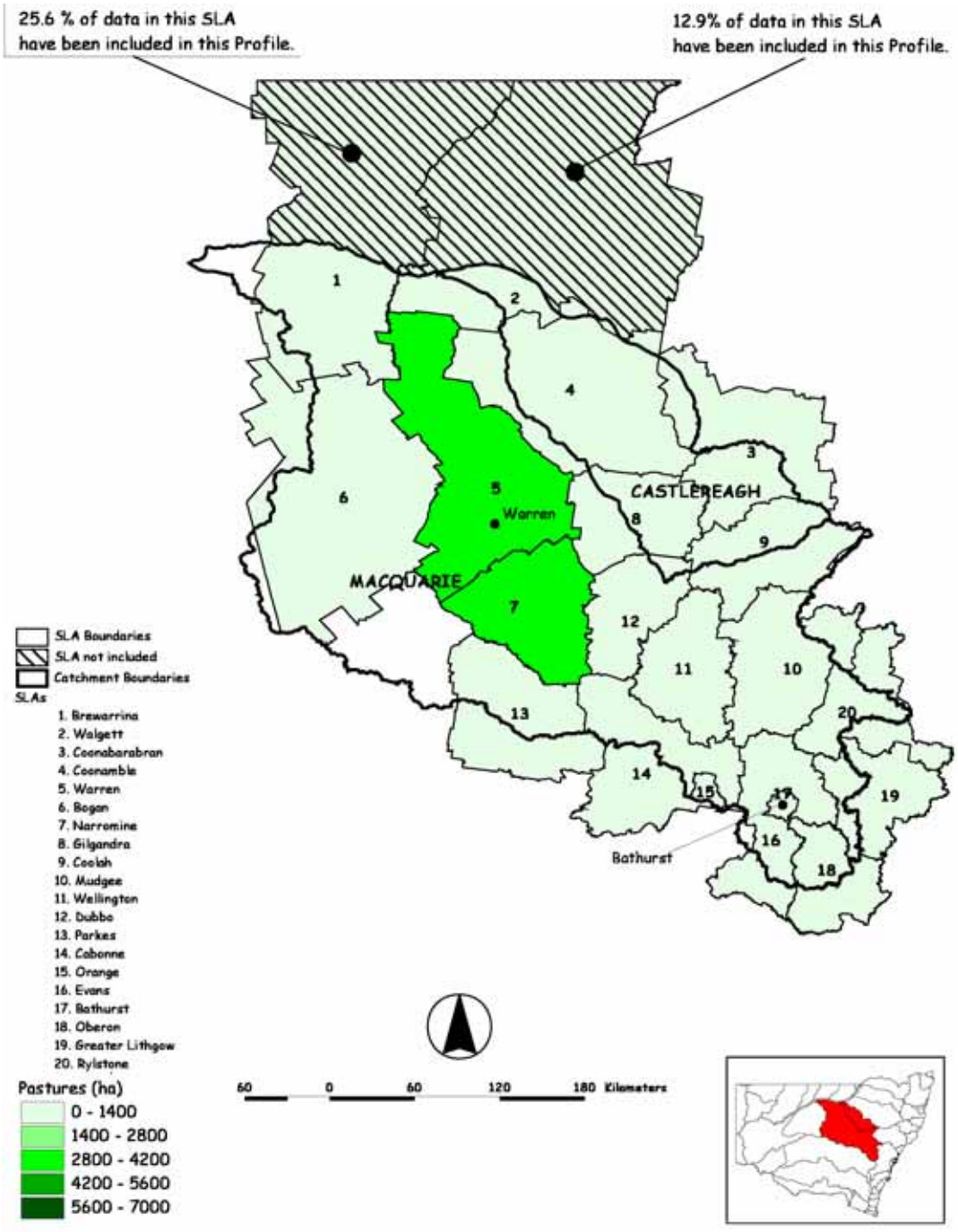


Source: ABS 1998, ② 'Other crops' is mostly cotton.

Irrigated pasture (Figure 10) and then cereals were the next largest irrigated crop groups. Unlike cotton, pasture and cereal areas irrigated declined between 1993–94

and 1996–97. For example, pasture areas dropped markedly from 39 000 to 13 000 ha, and cereal areas dropped from 26 000 to 7000 ha.

Figure 10. Areas of irrigated pasture in the Greater Macquarie catchment in 1996–97



Source: ABS 1998, ②

Most of the irrigated pasture areas were in the Narromine and Warren SLAs (1996–97, Appendix 14.6). It is worth noting that, in 1993–94, Gilgandra SLA had more than 10 000 ha, but by 1996–97, this figure had dropped to 54 ha. Large drops in irrigated pasture areas were also seen for many SLAs in the Greater Macquarie catchment (Appendix 14.6) (ABS 1998) ②.

The main areas for irrigated cereals were in the Narromine and Warren SLAs. Like pasture, cereal areas also dropped in many SLAs across the Greater Macquarie catchment. See, for example, the SLAs of Coonamble, Mudgee, Gilgandra and Wellington (Appendix 14.6).

After pasture and cereals, fruit and nuts (excluding grapes) and then grapes had the next largest areas irrigated and both these categories experienced an increase in area irrigated. In the case of fruit and nuts (excluding grapes), see Orange SLA, and in the case of grapes, see Mudgee SLA.

Water used. It was not possible to determine accurately the total volume of water used by irrigated agriculture in the Greater Macquarie catchment in any year. The volume used by irrigators in 1996–97 is estimated to be between 352 600 ML and 372 500 ML (Table 1). This estimate was constructed by summing:

- 341 000 ML (the amount of water diverted from regulated systems by irrigated agriculture in 1996–97)
- 8600 to 28 500 ML (the range in the volume of water used from unregulated systems by irrigators between 1989 and 1992)
- 3000 ML (the amount of water used by irrigators in 1980).

Use by irrigation from farm dams and reticulated supplies has never been collected but volumes are likely to be very small.

Hearn and Cameron Agriculture (1997) estimate the average total amount of water used on cotton from all sources of water between 1988–89 and 1993–94 to be 226 129 ML. Water was applied to cotton at rates of between 3.9 to 9.8 ML/ha③.

For other crops, the ability to calculate application rates (megalitres of irrigation water per hectare) is limited by factors such as:

- lack of information regarding the volume of water used on crops from groundwater and unregulated supplies;
- lack of integration of information where enterprises may use more than one source of water (for example, groundwater and regulated sources); and,
- lack of data for various periods of time.

In the absence of application rates for other crops, theoretical estimates of crop irrigation requirements[10] (Appendix 14.7) or unpublished estimates (Appendix 14.8)④ must suffice.

5.6 Irrigation methods (all water sources)

The most recent ABARE (1998) survey shows that roughly 91% of irrigated crops in NSW are watered using surface methods (border check and furrow). This proportion is only slightly greater in the Greater Macquarie and Lachlan catchment (Appendix 14.9) ③.

Availability and quality of information on the usage of different irrigation systems across the state is limited. Data presented in this report are based on unpublished information from NSW Agriculture staff from the Greater Macquarie catchment. (Some of the information presented below can also be found in Appendix 14.8.)

- Overhead sprays and micro-sprinklers are generally used to irrigate orchards around the Orange area. Around the Mudgee area, vines are irrigated with surface drip and sprinklers. Few growers in this area use subsurface drip systems (David Coleman, Water Use Efficiency Officer, NSW Agriculture, Orange, pers. comm.).
- Centre pivots are found just downstream of Burrendong Dam (G. Giddings, Irrigation Officer, and B. Swann, Irrigation Advisory Officer, 1999, NSW Agriculture, Dubbo, pers. comm., ④).
- Between Coonabarabran and Gilgandra there are small pockets of spay irrigation (Giddings and Swann 1999, pers. comm., ④).
- Below Gilgandra, there are about six centre pivots (Giddings and Swann 1999, pers. comm., ④).
- Pressurised systems are used to water crops upstream of Dubbo (Giddings and Swann 1999, pers. comm., ④).
- Pressurised and surface systems are used to water crops between Dubbo and Narromine (Giddings and Swann 1999, pers. comm., ④).
- Downstream of Narromine, systems are predominantly surface. Most cotton is typically irrigated using furrow[11], although some is irrigated using subsurface drip or centre pivot (Giddings and Swann 1999, pers. comm., ④).

10 Irrigation requirements refer to the amount of water required by a crop after effective rainfall has been taken into account.

11 Furrows are depressions on the surface of the soil down which water flows. Crops are usually planted on rows or beds that run parallel to these furrows.

5.7 Irrigation yields (all water sources)

Information on irrigated yields based on water from all sources is scant, and most data were obtained through personal communication with staff from NSW Agriculture (Appendix 14.8) ④ or from published material.

The various sources of information on irrigated cotton yields in the Greater Macquarie catchment are generally quite close, with the exception of the ABARE figures:

- 1.4 t/ha (1.3–1.7 t/ha) (1988–89 to 1994–95) (Hearn and Cameron Agriculture 1997) ③
- 2.3 t/ha, Greater Macquarie catchment and Lachlan catchment, 1996–97 (ABARE 2000) ③[12]
- average yields of 1.6 t/ha of cotton with a minimum of 1.1 t/ha and a maximum of 2 t/ha in the Macquarie catchment (G. Giddings, Irrigation Officer, and B. Swann, Irrigation Advisory Officer, 1999, NSW Agriculture, Dubbo, pers. comm., ④) [13].

Yields for other crops are summarised in Table 6. Lucerne yields reported by ABARE are very low when compared with other estimates: this may be due to the different years used.

Table 6. Irrigated yields in the Greater Macquarie catchment

Crop	Avg (t/ha)	Min (t/ha)	Max (t/ha)	References and reliability rating
Cereals				
Barley	2.3	–	–	ABARE 2000, [a] ③
Grain sorghum	4	–	–	ABARE 2000, [a] ③
	4	2.5	7.5	Phil Gardner 1999, Seeds Agronomist, NSW Agriculture, Dubbo, pers. comm., ④
	6	4	8	Paul Lukins 1999, District Agronomist, NSW Agriculture, Condobolin, pers. comm., ④
Oats	0.9	–	–	ABARE 2000, [a] ③

12 The Relative Standard Error (RSE) of the data used to calculate cotton production was: tonnes – 17% and hectares - 16% The RSE is the standard error divided by the actual data value. The result is dimensionless. The RSE shows how big the standard error is as a proportion of the actual data value

13 Numbers converted from bales to tonnes based on conversion rate of 1 bale of cotton being 225 kg.

Crop	Avg (t/ha)	Min (t/ha)	Max (t/ha)	References and reliability rating
	3	2	4.5	Paul Lukins 1999, pers. comm., ④
Wheat	3	–	–	ABARE 2000, [a] ③
	3.6	2.4	5.5	Paul Lukins 1999, pers. comm., ④
Maize	8	6	15	Paul Lukins 1999, pers. comm., ④
Millet	2.5	1	5	Phil Gardner 1999, pers. comm., ④
	1.5	1	2.5	Paul Lukins 1999, pers. comm., ④
Oilseeds				
	1.8	–	–	ABARE 2000, [a] ③
Canola	1.6	1.3	2.7	Paul Lukins 1999, pers. comm., ④
Soybeans	1.9	1.2	2.9	Paul Lukins 1999, pers. comm., ④
Sunflowers	1.8	1.4	2.8	Paul Lukins 1999, pers. comm., ④
Pulses				
Grain legume	1.7	–	–	ABARE 2000, [a] ③
Panicum	2.5	1	5	Phil Gardner 1999, pers. comm., ④
Pasture				
Pasture – annual	3	2	4	Paul Lukins 1999, pers. comm., ④
Lucerne	3.8	–	–	ABARE 2000, [a] ③
	7	4	12	Paul Lukins 1999, pers. comm., ④
Hay and silage production	7.8	–	–	ABARE 2000, [a] ③
Seed lucerne	–	0.4	0.7	Barry Swann 1999, Irrigation Advisory Officer, NSW Agriculture, Dubbo, pers. comm., ④
	0.25[14]	0.2[15]	>1.1[16]	Morthorpe et al. 1987, ②

14 Average commercial yield is 0.25 t/ha.

15 Break-even yield was estimated to be 0.2 t/ha.

Crop	Avg (t/ha)	Min (t/ha)	Max (t/ha)	References and reliability rating
Vegetables				
Beans and peas	5	3	7	C. Beckingham 1999, District Horticulturalist, NSW Agriculture, Bathurst, pers. comm., ④
Sweet corn	19	17	23	C. Beckingham 1999, pers. comm., ④
	3.6	2.4	5.5	Paul Lukins 1999, pers. comm., ④

[a] Yield was calculated by dividing tonnes produce (t) by area (ha) and the RSEs (%) for these values were: barley 24, 26; grain sorghum 53, 53; oats 20, 20; wheat 12, 11; oilseeds 29,30; grain legumes 62, 59; lucerne 21, 22; hay and silage 18, 33.

5.8 Value of irrigated production (all water sources)

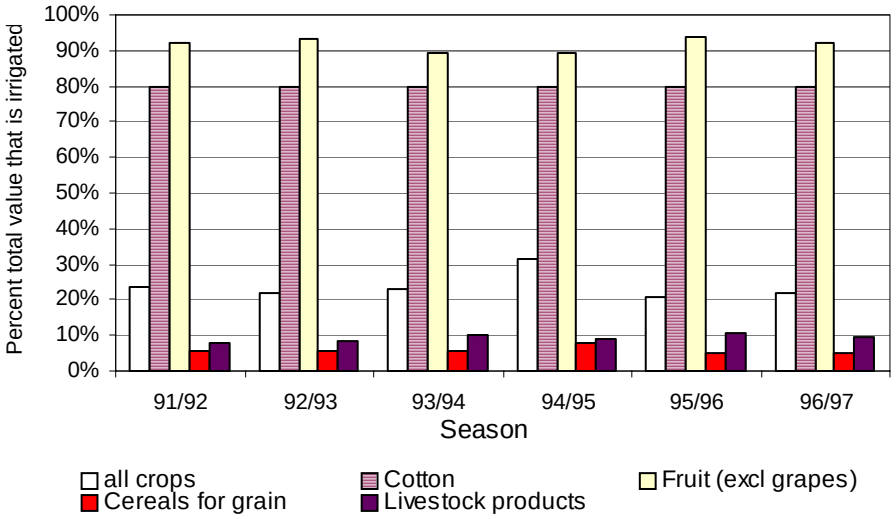
Irrigated agriculture produces nearly a quarter of the total value of production in the Greater Macquarie catchment. Of the $1197 million② produced from all agriculture, whether dryland or irrigation, $263 million could be attributed to irrigation alone (Donovan 2000)③. Irrigation values have ranged from 21% to 31% of the total value over the last decade (Figure 11).

These irrigation value data should be treated with some caution as Donovan (2000, ③) derived them synthetically. The individual irrigated commodity values for Australia were determined by estimating the percentage of the total commodity value that could be attributed to irrigation. The irrigated percentage was determined from numerous agency reports, and wide consultation with industry bodies (Deborah Wilson Consulting 1990). These individual commodity percentages were then applied to the total NSW commodity value data from the ABS for each SLA over the period between 1991 and 1997 (Donovan 2000, ②[17]). These estimated irrigated commodity values were then summed to provide synthetically generated estimates of the total value of irrigated agriculture for each catchment.

16 Highest measured yield (seed was machine harvested) exceeded 1.1 t/ha from a 3-year-old crop.

17 These data have not been manipulated by Donovan and receive a reliability rating of ②.

Figure 11. Percentage of total value of agriculture in the Greater Macquarie catchment that can be attributed to irrigation



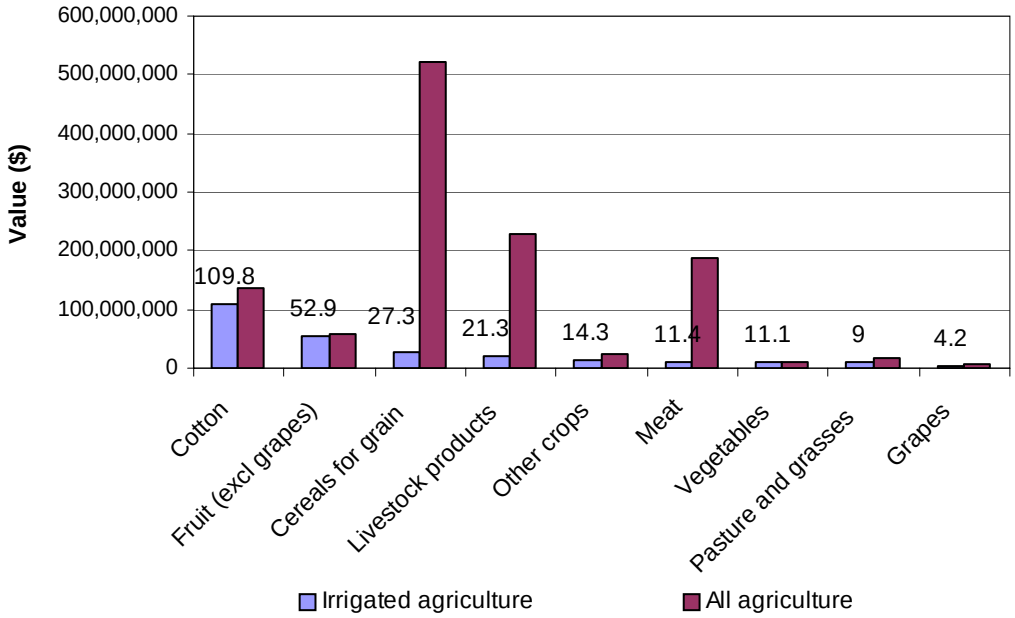
Source: Donovan 2000 ③

The reliability of the estimated percentage value for individual commodities may vary from crop to crop. For example, grape values are more likely to be reliable than wheat values. This is because grapes are usually irrigated with high security water, which helps to ensure yields and areas remain reasonably static. Cereal areas and yields can, by comparison, vary markedly with climate and water availability. The overall reliability rating for these data is ③[18].

Cotton is highly dependent on irrigation (see Figure 11) and is the most valuable irrigated crop in the region (Figure 12). Of the total value of irrigated agriculture ($263 million), just under half ($110 million) was generated from cotton in 1996–97 ③. Values have been fluctuating each season and have ranged from $62 million to $148 million between 1991–92 and 1996–97 (Appendix 14.10) (Donovan 2000)③.

18 These data have been manipulated by Donovan and so receive a lower reliability rating (③)

Figure 12. Value of agricultural commodities produced using dryland and irrigation practices compared with those produced using irrigated agriculture alone



Source: Donovan 2000 ③ Note: value of livestock products produced from irrigation is mostly from milk production. Labelled values are in millions.

Fruit and nuts (excluding grapes) were the next most valuable irrigated product in the Greater Macquarie catchment, totalling $53 million (Figure 12). This category was also highly dependent on irrigation water (Figure 11), and has been slowly increasing in value since 1991–92 (Appendix 14.10) ③.

Irrigated cereals for grain were the next most valuable category ($27 million) and, like fruit and nuts (excluding grapes), have increased in value (Appendix 14.10) ③. Most cereals in the region are produced on dryland properties and only 5% of the total value ($522 million) could be attributed to irrigation (Figure 11). Irrigated cereals are typically planted in rotation with cotton to improve soil structure and fertility rather than to produce income. Cereals may also be planted to utilise excess soil moisture following cotton and are generally not irrigated to full potential.

Livestock products dependent on irrigation remained stable at around $20 million between 1991–92 and 1996–97: values did not deviate widely from this (Appendix 14.10, ③). There was little dependence on irrigation by this industry (Figure 11).

6. IRRIGATION FROM REGULATED RIVERS

6.1 Description of the regulated supply

The figures and description provided below relate only to the Macquarie catchment and specifically to extraction by irrigation from the regulated portions of the Macquarie and Cudgegong rivers. The Castlereagh and Bogan catchments do not have any regulated rivers.

Flows in the Macquarie and Cudgegong rivers are controlled by Burrendong and Windamere dams respectively. These dams have a combined capacity of up to 2 048 000 ML of water.

- Of the total storage capacity in Burrendong Dam (1 680 000 ML), 490 000 ML is retained for flood mitigation. The general security[19] and high security[20] allocations for all purposes from the Macquarie River are 610 346 ML and 34 960 ML respectively.
- Windamere Dam (368 000 ML) is located at the top of the Cudgegong River, and water is mostly used to supplement Burrendong Dam during drought years (EPA 1997). The general security and high security entitlements for all purposes from the Cudgegong River are 22 082 ML and 5489 ML respectively.

Water released from the dams for irrigation is ponded by Dubbo, Narromine, Gin Gin, Warren and Marebone weirs and regulators and by Reddenville Break Block Dam. All weirs except Marebone Weir are fixed in height and do not regulate the river. Rather, these weirs raise the height of the river so that pumping can occur or so that water can be diverted into a channel for off-river irrigation.

Downstream of Dubbo, several large irrigation schemes pump water from the river to supply major channel schemes (Elliott 1995) (Table 7). As with any off-river irrigation scheme, the large earthen supply channels have to be managed to minimise the high transmission losses. Filling empty channels consumes large amounts of water, and these channels are only emptied when absolutely necessary (Water Resources Commission 1985). There are no figures on the amount of water lost in the process of emptying channels.

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19 General security water is dependent on the volume of water stored in the dams. An allocation is announced at the beginning of the season and represents a percentage of the total licensed entitlement. If the announced allocation is 80%, then a licence with an entitlement of 100 ML would receive 80 ML.

20 High security water is guaranteed under most circumstances. If the entitled volume is 20 ML, then that licence will receive 20 ML every year.

Table 7. Irrigation schemes and riparian irrigators in the Macquarie catchment

Scheme	Year commenced	Entitlement (ML)	Number of members	Length of channel (km)	Source of water
Riparian irrigators		394 400	600		Macquarie River
Narromine Irrigation Scheme	1970	60 100	90	350	Narromine Weir pool
Trangie–Nevertire Irrigation Scheme	1970	63 500	66	250	Gin Gin Weir pool
Tenandra Irrigation Scheme	1969–72	34 800	32	150	Gin Gin Weir pool
Buddah Lake Scheme	1969	32 500	19	58	Narromine Weir pool
Marthaguy Irrigation Scheme	1988	16 600	16	60	Marebone Weir
Nevertire Irrigation Scheme	1966	32 000	15	50	Macquarie River
Greenhide Irrigation Scheme	1969	7 800	10	30	Macquarie River
Total		**641 700**	**848**		

Source: Elliott 1995; Russ 1999; Wolfgang 1998

6.2 Number of volumetric licences (regulated supply)

There were 584 licences for all purposes in the Macquarie catchment, and most of these (502) have a purpose of irrigation (DLWC 1999a)①. The remaining licences are for mining, town water supply and stock and domestic purposes. Of the licences with an irrigation purpose, roughly 300 recorded use each year (DLWC 1998a)[21]. The location of these irrigation licences using water from the regulated system can be found in Figure 13.

21 Not all licence details have been entered into the licence administration system database.

Table 8. Summary of irrigation data from regulated water supplies

Year[22]	Number enterprises irrigating	Total area irrigated (ha)	Cotton area irrigated (ha)	Total water use (ML)	Total volume water used on cotton (ML) ②[b]	Yield of cotton (t/ha)	Value of irrigation ($/m)	Value of irrigated cotton ($/m)
1988–89	-					1.3[c]	-	-
1989–90	-	59 553[a]	25 533[a]	413 591[a]	209 802[a]	1.3[c]	-	-
1990–91	-	59 085[a]	27 540[a]	459 314[a] 486 300[b]	224 502[a]	1.5[c]	-	-
1991–92	-	87 822[a]	39 461[a]	526 344[a] 503 600[b]	268 834[a]	1.4[c]	-	-
1992–93		61 450[a]	31 138[a]	222 813[a] 424 300[b]	117 833[a]	1.4[c]	-	-
1993–94	361[e]	76 050[a] 64 928[e]	34 552[a]	535 554[a] 534 300[b]	278 941[a]	1.5[c]	-	-
1994–95	848[f]	-	-	512 600[b]	-	1.7[c]	-	-
1995–96	-			190 400[b]	-	-	-	-
1996-97	-			341 500[b]		2.3[d]	-	-
1997–98	-			394 200[b]	-	-	-	-
1998–99	-			-	-	-	-	-
1999–00	-			-	-	-	-	-
2000–01	-	-	-	-	-	-	-	-
Refer to Section:	6.4	6.5	6.5	6.5	6.5	6.7	6.8	6.8

a DLWC 1998a – area ②, water use ① b DLWC 2001a ①

c Hearn and Cameron Agriculture 1997③. Since most cotton is produced from regulated supplies, the irrigated yield figures calculated for all sources of water have been used.

d ABARE 2000 ③. e ABS 1998 f Elliott (1995)

NOTE: The figures provided in Table 8 summarise data provided in the text. The reader should note:

1. a lack of information on the value of irrigated agriculture dependent on regulated supplies only
2. in several years, differing versions of values for area and water used by irrigation.

22 It should be noted that data for the Macquarie catchment are based on a July to June water year.

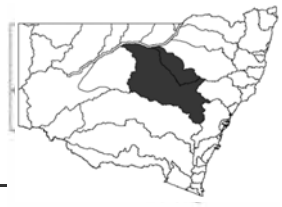
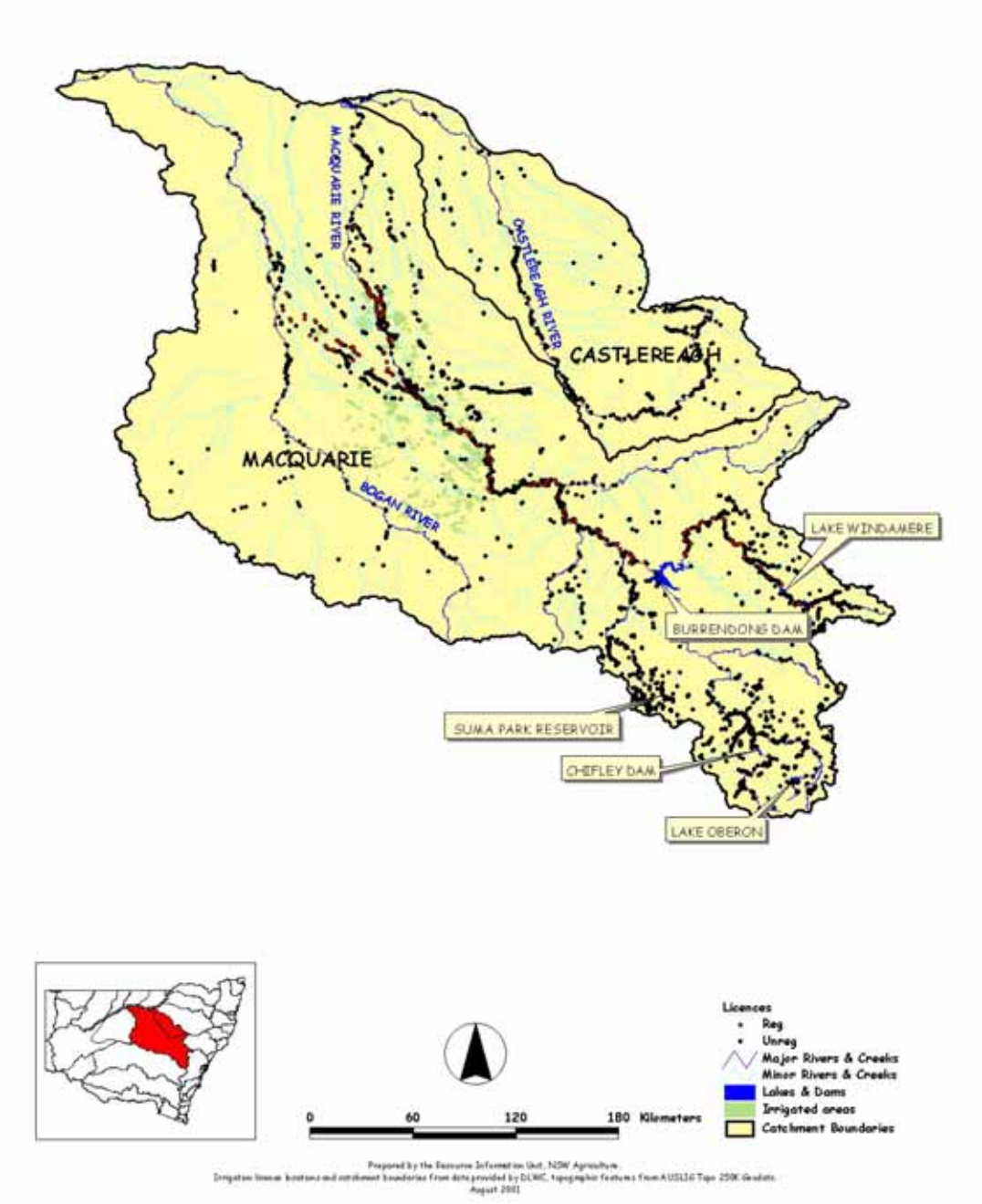


Figure 13. Location of regulated and unregulated surface licences with the purpose of irrigation in the Greater Macquarie catchment



6.3 Volumetric entitlement (regulated supply)

The combined entitlement for all purposes in the Macquarie catchment is 672 877. The entitlement to irrigation from Burrendong & Windamere dams is 641 700 ML/year

(DLWC 1999a), which includes the supply of water to general, high flow and high security irrigation licences. See the yearly allocation announcements in Appendix 14.5. There is some concern that trading water between the unregulated and regulated systems would reduce the security of entitlement in the regulated system (DLWC 1999f).

General security and high flow licences are used to water annual crops such as cotton, corn, lucerne and pasture. High security licences are used to supply water to perennial crops such as citrus.

Around half the water from the dams is allocated to irrigators operating along the river outside the schemes. The remainder of the entitlement is for irrigation within the schemes (Table 7; Elliott 1995).

In 1996, the Macquarie Marshes were granted a high security entitlement of 50 000 ML (available at greater than 10% allocation announcement) and a general security entitlement of 75 000 ML with a carryover provision. There were also supplementary releases to the Macquarie Marshes, and releases to create a continuous flow for stock and domestic purposes down the Macquarie River, Gunningbar and Duck creeks, and around the western side of the Marshes. The North Marsh By-Pass Channel was built to supply water for stock and domestic purposes to the northern areas of the Macquarie Marshes and to users downstream of the Marshes.

Existing irrigation licences allow extraction of up to 58 000 ML/year from unregulated streams in and downstream of the Marshes, but not all of these are fully developed (EPA 1997).

6.4 Number of enterprises that irrigate (regulated supply)

The number of irrigation enterprises in the Macquarie catchment using water from regulated supplies was taken from two sources. The reasons for the difference between both references is not known.

- In 1993–94, the ABS conducted a survey to find how many enterprises were using water from different water sources. These data suggest 361 irrigation enterprises use water from the regulated system. Caution is advised when using these data since the ABS questionnaire did not clearly differentiate irrigation from unregulated and regulated systems (Appendix 14.11). As a result, some respondents have recorded usage from regulated streams in areas where there are no regulating structures. This will mean these figures could be overestimated.
- In the following year, the number of irrigators using water from regulated supplies was estimated by Elliott (1995) to be 848. It should be noted that this figure could include some irrigators that use groundwater in the area as well. Around 70% of these were outside the irrigation schemes, along the river (Table 7).
- The number of enterprises irrigating could also be determined from DLWC licence databases, but this was not attempted in this profile.

6.5 Area irrigated and water used (regulated supply)

Area irrigated. An average of 70 000 ha of land is irrigated annually in the Macquarie catchment from regulated supplies. The total annual area irrigated between 1989–90 and 1993–94 ranged from 60 000 ha to 87 800 ha (Table 8 and Appendix 14.12) ②[23] . Most of the area irrigated from regulated rivers occurs below Narromine (Appendix 14.13).

Where comparisons between data sources could be made, these were not particularly close: see, for example, 1993–94 data in Table 8. Reasons for the difference are not known.

Just under half of the total area irrigated is on land serviced by private schemes (Appendix 14.14), the rest being outside the schemes along the river (Table 9).

Table 9. Area irrigated from regulated water supplies in 1993–94

	Area irrigated (ha)	Reference	Location in Profile
All Macquarie catchment	76 050	(DLWC 1998a) ②	Appendix 14.12
Below Narromine only	67 831	(DLWC 2001b)②	Appendix 14.13
Within Schemes only	36 040	(Elliott 1995)[a]	Appendix 14.14

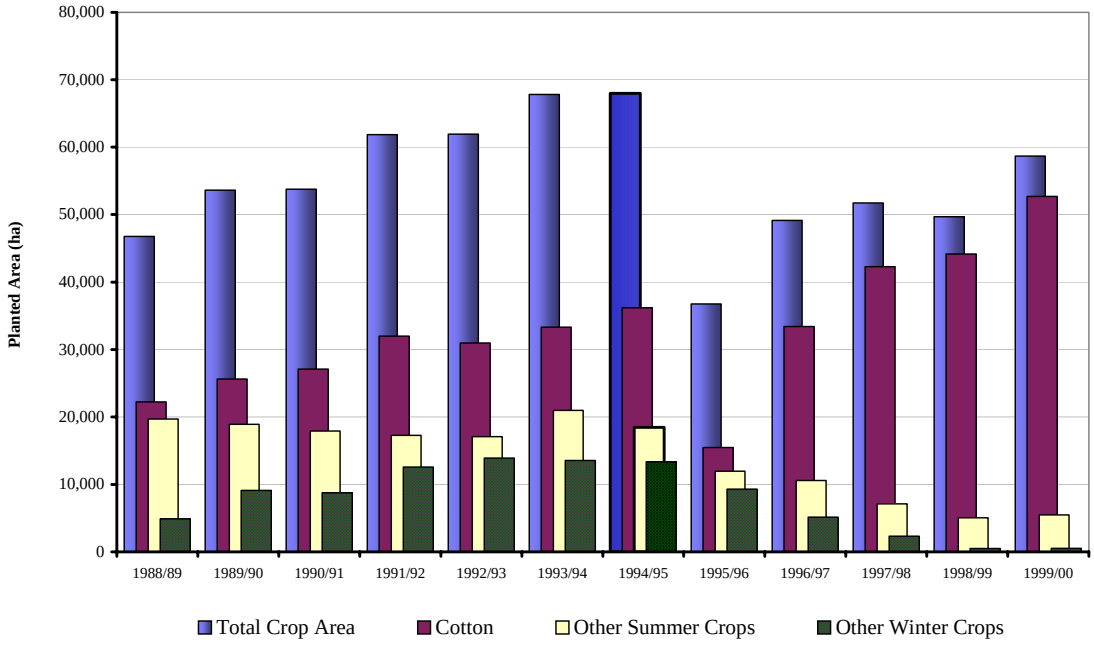
[a]Reliability unknown

Cotton is the major crop irrigated from regulated supplies. This crop represents just under half the total area irrigated from regulated supplies (Table 8) and around 45% of the total cotton area irrigated is grown within the schemes (data taken from Table 8 and Appendix 14.14). By 1998–99, cotton was increasing in irrigated area (Figure 14).

In 1993–94, wheat and lucerne had the next largest irrigated areas, with the remainder being pasture, other cereals and oilseeds (Appendix 14.12). This cropping mix was also evident in data collected from the schemes (Appendix 14.14).

23 Information on area irrigated was estimated by meter inspectors for every licence, and attracts a reliability rating of ③.

Figure 14. Macquarie catchment crop areas downstream of Narromine



Source: DLWC 2001b

Water used. An average of 1 400 000 ML of water enters the Macquarie River system each year (DLWC and NPWS 1996). Of this, approximately 430 000 ML is used by irrigation on regulated streams (DLWC 2001a)① (see Table 8). This represents two-thirds of the total volumetric allocation to irrigation (641 700 ML). For some years, there were two estimates of the total water used in the Macquarie catchment (Table 8). These figures were extracted from DLWC databases at different times, and estimates have changed as figures were refined. Where comparisons could be made, some values were reasonably close. In other cases, values were very different *eg*. figures for 1992–93. Reasons for this difference are not known.

Crop water use figures for the whole of the Macquarie catchment are only available from the DLWC between 1988–89 and 1993–94. These data show that around half the total volume used by irrigation was used on cotton. Approximately 20% of the total water used was on lucerne and summer pasture (Appendix 14.12). The volume of water used on cotton is expected to have increased since then.

Records in relation to individual members within each of the seven private irrigation schemes are held by scheme managers rather than centrally, and are not incorporated in this Profile

6.6 Irrigation methods (regulated supply)

There were no data on the irrigation methods used by irrigators drawing water from the regulated system. Again, most irrigation in the Greater Macquarie catchment depends on regulated supplies, the detail provided in Section 5.6 can be used. Generally, most of the water used from the regulated system is delivered to crops by furrows.

6.7 Yields from irrigation (regulated supply)

There were no data on the yields of crops irrigated from regulated supplies in the Macquarie catchment. Since most of the cotton grown in the Macquarie catchment depends on water from regulated rivers, the data provided in Section 5.7 can be used.

6.8 Value of irrigated production (regulated supply)

There were no data showing the total value of crops irrigated from regulated supplies only, but, because most of the cotton grown in the Macquarie catchment depends on water from regulated rivers, data from Section 5.8 can be used to approximate the value of cotton irrigated using regulated supplies only.

7. IRRIGATION FROM UNREGULATED RIVERS

7.1 Description of the unregulated water supply

Unregulated rivers can be found in the Castlereagh, Macquarie and Bogan catchments. The figures provided in this section therefore relate to the entire Greater Macquarie catchment.

There are two major unregulated rivers in the Greater Macquarie catchment: the Castlereagh and the Bogan. Water flow in these streams is highly variable, and irrigated agriculture has responded to this variability either by building farm dams or by supplementing river water with groundwater.

There are also numerous unregulated subcatchments in the hills of the upper Greater Macquarie catchment (see Appendix 14.15). These streams and rivers feed into the major watercourses of the Greater Macquarie catchment, that is, the Macquarie and Cudgegong rivers.

The way water is managed in the Greater Macquarie catchment has changed in several ways over the last decade.

- In 1993, an embargo was placed on the issue of any licences for areas greater than 10 ha. This has reduced irrigation development in the catchment generally (DLWC 1999d).
- Since 1998, WMCs have been developing water sharing plans in each catchment across NSW. These plans will provide rules for water access and use.
- Subcatchments were assessed for levels of stress in 1999: these ratings are helping to prioritise planning activities in the Greater Macquarie catchment (see Table 15 in Appendix 14.15).
- Licences on unregulated streams were converted from area-basis to volume-basis in 2000, and it is expected that in the future the volumes of water used by individual irrigators will be metered (DLWC 2000c). Conversion rates are provided in Appendix 14.7 and are given on a crop-by-crop basis, ranging from 2 to 12.5 ML/ha. As a comparison, when licences on the regulated system were being converted from area-basis to volume-basis, annual crops received 8 ML/ha, whereas permanent horticultural crops received 10–12 ML/ha (Department of Water Resources 1991).

The data presented in this section have been summarised in Table 10. Most notably, there is a lack of information regarding the number of enterprises irrigating, crop water use, yields and value of irrigated agriculture.

Table 10. Summary of irrigation data from unregulated water supplies

Year	Number enterprises irrigating	Total irrigated area (ha)	Area of cotton irrigated (ha)	Total water used (ML)[a]	Water used by cotton	Yield of cotton (t/ha)	Value of irrigation ($/m)	Value of irrigated cotton ($/m)
1988–89	-	-	-	-	-	-	-	-
1989–90	-	3 260[a]	972[a]	28 507	-	-	-	-
1990–91	-	3 061 [a]	972[a]	21 848	-	-	-	-
1991–92	-	2 923[a]	324[a]	8 670	-	-	-	-
1992–93	-	2 575[a]	200[a]	14 220	-	-	-	-
1993–94	424[c]	10 733[b] 55 830[c]	2 021[b]		-	-	-	-
1994–95	-	1830[a] 10 070[b]	2 039[b]	3 542	-	-	-	-
1995–96	-	10 623[b]	1 749[b]	-	-	-	-	-
1996–97	-	11 629[b]	2 564[b]	-	-	-	-	-
1997–98	-	13 863[b]	4 183[b]	-	-	-	-	-
1998–99	-	12 971[b]	3 399[b]	-	-	-	-	-
1999–00	-	-	-	-	-	-	-	-
2000–01	-	-	-	-	-	-	-	-
Refer to Section:	7.3	7.5	7.5	7.5	7.5	7.7	7.8	7.8

[a] DLWC 1998a, ④. Data on irrigation from unregulated streams were collected by crop return survey. Not all growers returned the survey to the DLWC, and the figures above should be used as a guide only.

[b] DLWC 2000b, ②

[c] ABS 1998

7.2 Number of licences with the purpose of irrigating (unregulated supply)

The total number of licences with the purpose of irrigation in 1999 in the Greater Macquarie catchment was 828 (DLWC 1999a)①. These were converted from area-basis to volume-basis in 2000 (DLWC 2000c).

7.3 Number of enterprises that irrigate (unregulated supply)

Based on ABS (1998) data, the number of enterprises irrigating from unregulated supplies in the Greater Macquarie catchment was 424 (1993–94). Caution should be applied when using these data for the reasons noted in Section 6.4.

7.4 Volumetric entitlement (unregulated supply)

Conversion of licences from area to volume is being finalised across the state, but the total volumetric allocations for the Greater Macquarie catchment are not yet available.

A total of 25 949 ha was authorised for irrigation in the Greater Macquarie catchment and more than 60% of this land was located in the Macquarie catchment. This total figure was calculated from the following data:

- 4272 ha - Castlereagh catchment (DLWC 1999b)
- 15 934 ha – Macquarie catchment (DLWC 1999a)
- 5743 ha - Bogan catchment (DLWC 1999b)

7.5 Area irrigated and water used (unregulated supply)

Area irrigated. The area irrigated from unregulated water supplies ranged between 10 000 ha and 14 000 ha (Table 11) (DLWC 2000b)②, representing roughly 10% of the total area irrigated in the Greater Macquarie catchment. Where comparisons between databases could be made (see Table 10), ABS figures were five times larger than DLWC figures (2000b). Reasons for this difference are not known.

Cotton areas have been steadily increasing since 1993–94 (Table 11). Cotton is grown just below the Marshes and near the confluence of the Macquarie River and the Barwon River. Cotton is also grown on Duck Creek and along Albert Priest Channel (Barry Swann 1999, Irrigation Advisory Officer, NSW Agriculture, Dubbo, pers. comm.). Areas of perennial pasture, winter cereals, orchards, summer oilseeds and vines have also been increasing (Table 11), while summer cereals, pulses and citrus experienced a decline in area irrigated.

Water use. There were very few data on the volume of water used by the irrigation industry from unregulated streams in the Greater Macquarie catchment. Information on the total water used by area-based licences began to be collected by crop return

cards in 1989–90 across the state, but ceased in 1994–95. The information attracts a low reliability rating, as not all growers submitted survey cards. These data show that extraction of water ranged from a low of 3 500 ML in 1994–95 to a high of 28 500 ML in 1989–90 (DLWC 1998a) ④ (Appendix14.16). (See also the summary in Table 10.)

There were no data collected on the total amount of water used on different crops. Theoretical crop water requirements must suffice until better records can be obtained: see Appendix 14.7 for long-term average irrigation requirements for crops in the Greater Macquarie catchment.

Table 11. Area of crops (ha) irrigated in the Greater Macquarie catchment from unregulated rivers

	1993–94	1994–95	1995–96	1996–97	1997–98	1998–99	Trend 93-94 to 96-97
Cotton	2021	2039	1745	2564	4183	3399	↑
Lucerne	2605	2688	2781	2958	2668	2595	↓
Perennial pasture	1839	1858	2053	2007	2072	2063	↑
Winter cereal	1359	997	1459	1534	2048	1765	↑
Trees – orchards (not including citrus)	678	778	782	762	792	773	↑
Vegetables	740	723	804	702	738	739	↓
Summer oilseeds	21	41	31	21	183	454	↑
Vines - wine grapes	119	119	156	211	242	289	↑
Summer cereal	640	299	293	380	254	267	↓
Other	96	93	101	86	133	112	↑
Fodder	181	173	232	207	223	106	↓
Pulses	200	0	25	22	50	94	↓
Citrus	172	174	65	75	71	92	↓
Winter oilseeds	0	0	0	0	101	91	↑

	1993–94	1994–95	1995–96	1996–97	1997–98	1998–99	Trend 93-94 to 96-97
Turf	32	45	45	45	45	54	↑
Trees - other	16	19	22	25	30	34	↑
Olives	0	0	2	12	12	17	↑
Nurseries	6	16	15	6	6	12	↑
Vines - table grapes	10	10	10	11	10	10	NC
Nuts	1	1	5	5	5	5	↑
Citrus	0	0	0	0	0	1	↑
Total	**10 733**	**10 070**	**10 623**	**11 629**	**13 863**	**12 971**	↑

Source: DLWC 2000b ②

An increase in irrigated area is indicated by ↑. A decrease in area irrigated is indicated by ↓. NC means no change in area irrigated.

7.6 Irrigation methods (unregulated supply)

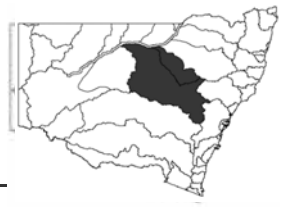
Data were unable to be obtained on methods used to irrigate crops using water from the unregulated rivers of the Greater Macquarie catchment. See Section 5.7 for further details on methods used to irrigate crops from all sources of water.

7.7 Yields from irrigation (unregulated supply)

The yields of irrigated crops in the Greater Macquarie catchment reliant on unregulated streams have not been specifically collected. See Section 5.6 for further details on yields obtained from crops irrigated using water from all sources.

7.8 Value of irrigated production (unregulated supply)

Data were unable to be obtained on the value of irrigation dependent on unregulated systems in the Greater Macquarie catchment.



8. IRRIGATION FROM GROUNDWATER

8.1 Description of the groundwater source

Extraction of groundwater by irrigators is restricted to a few alluvial deposits in the Greater Macquarie catchment. There are large sections of land where groundwater is generally absent or is too saline.

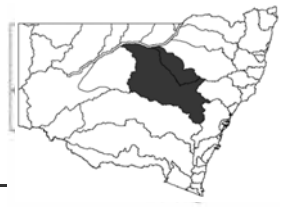
This is the extent of groundwater systems and extraction in each of the three catchments:

Castlereagh catchment. There is limited use of groundwater by irrigation in the Castlereagh catchment. The most important groundwater source is from the sandstone beds of the Great Artesian Basin (GAB). Low salinity and high-yielding bores suitable for irrigation can be found around the GAB intake beds between Coonamble and Coonabarabran. Groundwater becomes increasingly unsuitable for irrigation west of this point due to residual alkali content (Water Resources Commission 1980).

Macquarie catchment. Irrigation extracts groundwater from a number of small areas in the Macquarie catchment, including:

- along the Macquarie River between Wellington and Narromine
- in the Bell River Valley upstream of Wellington
- around Orange and Mudgee (on the Cudgegong River)
- along the upper sections of the Talbragar River near Dunedoo and its tributaries (Water Resources Commission 1980)
- between Geurie and Narromine
- upstream of Dubbo, where groundwater is used to irrigate vegetables, vines, pasture and orchards
- downstream from Dubbo to Narromine, where groundwater is used to irrigate vegetables, pasture, lucerne and oilseeds (Department of Water Resources 1991).

Groundwater development during the 1980s was relatively small. Even so, investigations revealed a rising groundwater problem in the Lower Macquarie catchment Groundwater Management Area (GWMA) 008 (Keshwan and O'Shaughnessy 1999). Government policy was implemented to increase extraction of groundwater to ameliorate this problem. However, this led to excessive drawdown of the watertable and policies subsequently had to be implemented to halt over-extraction. The development of groundwater policy in this catchment has been



lengthy, and a more detailed commentary can be found in Keshwan and O'Shaughnessy (1999).

Currently the NSW Government is developing a Groundwater Structural Adjustment Program for the Lower Macquarie groundwater system. The program aims to assist high level groundwater users to adjust to reduction in groundwater access over the ten years of the water sharing plan through financial assistance and supplementary water.

The regulation of the Macquarie River has affected recharge to alluvial aquifers in the Lower Macquarie catchment. There is a connection between the river levels and groundwater levels in zone 8A and 8C of GWMA008.

Most irrigation bores extracting water from the alluvial deposits of the GWMA008 yield volumes of between 5 L/s to 100 L/s. One irrigation bore in the area yields as much as 300 L/s (Keshwan and O'Shaughnessy 1999). These alluvial aquifers are generally between 30–120 m deep and salt concentrations range from 300 $\mu S/cm^{-1}$ to 6000 $\mu S/cm^{-1}$ (Narromine Irrigation Board of Management 2001).

The Bogan catchment. Limited groundwater is extracted from the Bogan catchment. Known aquifers are usually thin and low-yielding and have poor water quality.

There was a distinct lack of information across all categories, and a summary matrix has consequently not been presented. The only irrigation data covering the whole Greater Macquarie catchment related to ABS figures from 1993–94 and these are presented in the text. Where data were available for specific locations in the catchment, these have also been provided

8.2 Number of licences with the purpose of irrigation (groundwater supply)

There are 700 licensed bores for town water, irrigation and stock and domestic purposes in the Greater Macquarie catchment (DLWC 1999b)①. The number of licences that are being used for irrigation is not known but it has been assumed that most are for irrigation. This value has a lower reliability rating of ③ accordingly.

It is not known how many groundwater licences are actually used each year in the Greater Macquarie catchment. Nor is the number of ghost licences known. (A ghost licence is one that has been purchased but may have no water available for extraction.)

8.3 Number of enterprises that irrigate (groundwater supply)

There were 133 enterprises irrigating with water from groundwater supplies in the Greater Macquarie catchment (ABS 1998)② and most of these enterprises were in the SLAs of Bathurst, Cabonne, Dubbo, Narromine, Mudgee, Orange, Rylstone and Wellington (Appendix 14.17). These SLAs generally correspond to the high-yielding,

low-salinity groundwater zones noted in Water Resources Commission (1980) and in Department of Water Resources (1991).

8.4 Volume entitled to irrigation (groundwater supply)

The entitled volume of groundwater is available from the regional DLWC office for the Greater Macquarie catchment. However, these data were not available at the time this Profile was published.

In the Lower Macquarie catchment in GWMA008, there are four zones with different base allocations (Table 12). Allocation in all zones exceeds the sustainable yield. The alluvial aquifers in 8A and 8C are the most used by irrigation and have predominantly fresh water due to recharge from the Macquarie River.

Table 12. Groundwater allocation, surface water makeup and sustainable yield for zones in GWMA008

GWMA Zone	Groundwater base allocation (ML)	Surface water makeup[24] (ML)	Sustainable yield (ML)
8A	27 909	10 367	1 800
8B	35 153	5 686	18 600
8C	24 012	18 641	700
8D	18 789	6 809	4 600[a]

Source: Keshwan and O'Shaughnessy 1999

[a] Sustainable yield is calculated for the area to the east of the Trangie–Dandaloo Road where the majority of irrigation bores in zone 8D occur.

8.5 Total area irrigated and water used (groundwater supply)

Area irrigated. In 1993–94, the total area irrigated in the Greater Macquarie catchment was 4156 ha (ABS 1998)② [9 and 25]. The area irrigated is mostly located in the

24 Surface water makeup is the volume of additional groundwater that may be pumped when surface water allocations have been reduced. This is determined on a sliding scale depending on the amount of reduction in the surface water allocation. The volumes given in table 4 refer to the worst case scenario: when surface water allocations are at 0%.

25 Data on the area irrigated from groundwater are available for other years (i.e. 1987, 1990, 1991) (ABS 1998), but were collected using different EVAOs. It is therefore not possible to use these data to show trends in the area irrigated over long periods of time.

SLAs of Mudgee, Narromine, Orange, Rylstone, Walgett and Wellington (Appendix 14.17).

Water used. The volume of water currently being extracted from groundwater aquifers for the purpose of irrigation is not known, due to an absence of a consistent monitoring programme. Data from 1980 shows that irrigation uses a small volume of groundwater – roughly 3000 ML (Appendix 14.18). This volume is likely to have increased given the policies that have promoted increased extraction. The volume of water used on different crops is unknown. The high urban use in Appendix 14.18 is probably for parks and domestic watering.

8.6 Irrigation methods (groundwater supply)

Data were unable to be obtained on the methods used to irrigate crops with water from groundwater supplies in the region. See Section 5.6 for more details on the irrigation methods used to irrigate crops from all sources of water.

8.7 Yields from irrigation (groundwater supply)

There were no data showing the irrigated yields from groundwater supplies in the Greater Macquarie catchment. See Section 5.7 for more details on the yields obtained from crops irrigated using all sources of water.

8.8 Total value of irrigation (groundwater supply)

Data on the value of irrigation dependent on groundwater supplies in the Greater Macquarie catchment was not available.

9. IRRIGATION FROM FARM DAMS

9.1 About farm dam water supplies

The level of dependence of irrigation on farm dams in the Greater Macquarie catchment is limited and similar to that for groundwater (ABS 1998). Enterprises are scattered across the upper half of the area, especially in the SLAs of Cabonne, Orange and Evans (Appendix 14.17).

There have been a number of developments in farm dams policy. In the past, a dam of up to 7 ML could be built without needing to be licensed, provided the water was used for non-commercial purposes. No allowance was made for the size of the property or for climatic variation. In addition, the number of dams that could be built on a property was not restricted.

Part 10 of the Water Act 1912, which came into operation on 1 January 1999, created a Harvestable Right. This gives landholders the right to capture and use for any purpose 10% of the average regional yearly rainfall run-off for their property, regardless of the dam's purpose (DLWC 1999f). Harvestable rights are now addressed in Chapter 3, Part 1, Division 2 of the *Water Management Act* 2000.

Once again, a summary matrix has not been provided for this water source due to a lack of information across all categories. The ABS provides the only information on irrigation from farm dams for the Greater Macquarie catchment and these have been presented in the text.

9.2 Number of licences with the purpose of irrigation (farm dams)

These data are not available at present, as farm dams are currently being licensed.

9.3 Number of enterprises that irrigate (farm dams)

There were 153 enterprises using water from farm dams to irrigate crops in the Greater Macquarie catchment (ABS 1998)② in 1993–94. Most of these are in the SLAs of Cabonne, Evans, Orange and Mudgee (Appendix 14.17).

9.4 Area irrigated and water used (farm dams)

Area irrigated. There were 5286 ha of land irrigated using water from farm dams (1993–94) (ABS 1998)② and around a third of this land was located in the SLAs of Cabonne and Greater Lithgow. There were no data on the crop areas.

Water used. There were no data on water used in total and by crop type.

9.5 Irrigation methods (farm dams)

See Section 5.6 for more details on the irrigation methods used to irrigate crops from all sources of water.

9.6 Yields from irrigation (farm dams)

See Section 5.7 for more details on the irrigation yields obtained from crops irrigated using all sources of water.

9.7 Value of irrigated production (farm dams)

There were no data on the value of irrigated production from farm dams.

10. IRRIGATION FROM RETICULATED WATER SUPPLIES

10.1 Description of irrigation from reticulated supplies

Extraction of water from reticulated water supplies for agriculture is limited. Most (82%) of the area irrigated using water from reticulated supplies occurs in the Bathurst SLA.

Due to a lack of information across all categories, a summary matrix has not been provided. The ABS has the only information on irrigation from farm dams for the Greater Macquarie catchment. These data are for the 1993–94 season and have been presented in the text.

10.2 Number of enterprises that irrigate (reticulated supplies)

There were 7 irrigated enterprises using water from town water supplies in the Greater Macquarie catchment, and just half of these were in the SLAs of Bathurst (ABS 1998) ②. There were no data on the number of enterprises by crop type.

10.3 Area irrigated and water used (reticulated supplies)

Area irrigated. There was 49 ha of land irrigated using town water supplies in the Greater Macquarie catchment and 40 ha of this total was in the Bathurst SLA (ABS 1998)②. There were no data on crop areas irrigated.

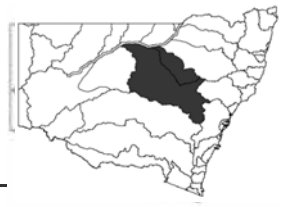
Water used. There were no data on water used in total and by crop type.

10.4 Irrigation methods (reticulated supplies)

There were no data on the methods used to irrigate crops from town water supplies.

10.5 Yields from irrigation (reticulated supplies)

There were no data on irrigation yields used to irrigate crops from town water supplies.



10.6 Value of irrigated production (reticulated supplies)

There were no data on the value of irrigated agriculture dependent on town water supplies.

11. OPPORTUNITIES AND ISSUES

This section identifies opportunities and issues for irrigated agriculture in the Greater Macquarie catchment.

11.1 Opportunities for irrigation data collection

Opportunities for improving both the quantity and quality of irrigation data will arise as new water sharing rules are implemented. The opportunity exists to collect irrigation data at more useful scales and to enable a two-way flow of information between irrigators and data-collecting agencies.

- **Information on irrigation will increase as WMCs measure change as a result of new sharing rules.** As water sharing agreements are finalised and signed-off, accurate and reliable irrigation data will be needed to assess the future impacts of management rules on the environment and on other water users such as the irrigation industry. This will ultimately help to increase the base of knowledge regarding irrigation.
- **Volumetric conversion of area-based licences will lead to better information regarding usage of water from unregulated streams.** Because of the conversion of licences from area-basis to volume-basis, users will no longer be billed on authorised area but on the actual volume used. Water extraction will eventually be metered and recorded by the DLWC. This will improve knowledge regarding crop water use and patterns of extraction on unregulated streams.
- **Data should be reported at scales that are more useful to resource managers.** The opportunity exists to provide agencies and communities with data that can be aggregated to useful scales (that is, river reach or subcatchment) through geographic information systems. The challenge would be to continue to maintain data confidentiality (that is, licence and enterprises information) while maximising the usefulness of the data to resource managers.
- **Better data-sharing partnerships between government and irrigators should be developed.** Often data are collected from irrigators for agency requirements such as billing, operational and reporting purposes, and are seldom returned to irrigators. The opportunity exists to return data to irrigators in useful formats that could help them improve farm water management and productivity. An example of mutually beneficial data collection and storage is the MDBC Irrigation Infrastructure GIS project. This project aims to collect all irrigation and drainage data within the basin and in the Macquarie catchment. This project is being undertaken in cooperation with and support from the Macquarie 2100 Landcare group.

11.2 Other opportunities for irrigated agriculture

Opportunities for irrigated agriculture in the Greater Macquarie catchment will arise as water is liberated through water trading or increased WUE and IE.

- **Expansion of the olive industry.** The opportunity exists to expand the already established olive industry in the Greater Macquarie catchment (Magner 1997). Olives are suited to the well-drained soils (Rural Industries Research and Development Corporation 1998) in the area, and there is local infrastructure to support the industry at Inverell. Olives are suited to a cool winter, hot summer climate, and can achieve gross margins of up to $7000 per hectare (Department of Agriculture – Western Australia 2000). Recent information from the volumetric conversion survey shows that the irrigated olive industry is increasing, albeit slowly (see Section 7.5). This crop responds well to irrigation, but can at the same time survive drought. Olives are therefore well suited to the high variability in water supply associated with unregulated river systems. Further development of the industry will depend on markets, access to water and funding.

- **Trading water will help shift irrigation activity from low value to high value enterprises**. Gross margins for enterprises such as cotton are significantly higher than traditional low capital irrigated agricultural commodities, that is, pasture and wheat (DLWC 1999e) Information on trading in other states (South Australia and Victoria) has already shown that water is moving from low-value to high-value enterprises. Available evidence suggests the same is occurring in NSW catchments (DLWC 1999e)

- **Trading water will help shift irrigation activity away from salinised land.** With salinity becoming an increasing concern in the region, the opportunity exists to develop an agroforestry industry. Deep-rooted perennial trees could be used to reduce localised shallow watertables, minimising salinity and at the same time produce income. Agroforestry has been investigated as a possible alternative industry for the Liverpool Plains area in the Namoi catchment where salinity and waterlogging are an issue (Powell 1995). Similar investigations may prove fruitful in the Greater Macquarie catchment.

11.3 Data issues

- **There is a scarcity of information about irrigation.** Since the implementation of water reforms and the development of water sharing plans, a much greater range of irrigation data are needed than is currently available (for example, irrigation data on crop areas, crop water use, yield, value of production and irrigation methods). In the past, agency and community data needs were fewer and therefore, fewer data were collected. For example, details of the volume of water extracted from regulated rivers were collected by the DLWC for billing, operation or reporting purposes from each licence holder. There were no requirements to record other information such as crop area and crop water use, yield, irrigation method and value. As a result, these data tend to be scarce.

- **There is a scarcity of data on irrigation at useful scales.** Natural resource managers involved in developing water sharing plans require data at planning scales, that is, river-reach or subcatchment. There is a scarcity of data at, or less than these scales, particularly with respect to yield, irrigation method and value of production. These data are typically collected by, or determined from, either ABARE or the ABS. The difficulty with these datasets are as follows:
  - ABARE report data for the amalgamation of the Greater Macquarie and Lachlan catchments. This presentation is much larger than that required by, for example, WMCs. These data contain potentially useful information about yields and methods of irrigation but are of less value at this large scale.
  - The ABS has been collecting data on irrigation by SLAs for a number of years. The difficulty with these data is that they do not align well with catchment and subcatchment boundaries. Consequently, the area irrigated may be underestimated or overestimated depending on the SLA composition and its relationship with catchment boundaries. In the Greater Macquarie catchment, only 12.9% of the Walgett SLA was included when calculating catchment totals. A similar methodology was used for Brewarrina SLA.
  - The ABS ceased collecting data by SLAs in 1996–97 and began collecting information by AER in 1997–98 (Table 2). These AERs often span many catchments and cannot be disaggregated into smaller units (for example, catchments). This reduces the usefulness of data on the number of enterprises irrigating and area irrigated.
- **Data about irrigators and irrigation enterprises are limited.** Due to the difference in ABS definitions and DLWC definitions of regulated and unregulated water supplies, the number of enterprises using water from these water sources could not be determined with any accuracy.
- **Data reliability ratings need to be provided by data collection agencies.** The National Land and Water Resources Audit provides reliability ratings and metadata (data about the data) for public information. No systematic data rating system is currently being used by state information providers. Without a rating system, data may be inappropriately manipulated and analysed.
- **Collection strategies can limit data usefulness.** The ABS has collected irrigation data at three different EVAOs or survey cut-off points over the last 13 years (Table 2). This means that it is more difficult to show trends in the area irrigated or enterprise number. For example, changes in the area irrigated between 1992–93 and 1993–94 may be due to a change in the EVAO rather than actual change in the area irrigated. Only data between 1993–94 and 1996–97 were compared in this Profile.

11.4 Other issues

- **Salinity under irrigated crops is becoming an issue in some areas of the Greater Macquarie catchment.** A salinity hazard map has been developed to locate areas of concern (Macquarie Valley Landcare Group Inc 1999).

- **The development of new industries may be limited by access to water.** Trade on unregulated rivers is very limited at present and is subject to Interim Guidelines introduced in December 1998 (DLWC 1999e) There is also an embargo on the provision of new licences, making it more difficult for new or developing industries to access water. Major demands for water are emerging from new developments such as cool-climate vineyards, cherries and olives (DLWC 1999e). For example, access to water has been noted as a factor that will limit the development of the olive industry nationally (Rural Industries Research and Development Corporation 1998).

  The growth of these enterprises will be dependent on the development of a stable market for water. This stability depends on the development of appropriate river planning arrangements which, among other things, link water trading rules with agreed river flow and water quality objectives (DLWC 1999e).

- **There is concern that trading from regulated to unregulated systems would reduce security of entitlement in the regulated system.** Users on regulated streams are resisting trading upstream to support the development of new irrigation industries. Irrigators fear this would reduce regulated supply water security (DLWC 1999e).

- **There is concern that developments in the upper catchments may affect stream inflows.** Extensive pine plantations in the upper catchment are thought to reduce run-off into river systems. This in turn, reduces the volume of water available to vineyards and horticulture enterprises (EPA 1997).

12. SUMMARY

This study highlighted variable quantities of information on irrigation in the Greater Macquarie catchment. In some cases, data were abundant, such as the volume of water used from regulated streams by licences. In other cases, data were scarce or had never been collected, such as the volume of water used on crops from unregulated rivers. For some water sources, such as farm dams and reticulated supplies, data were virtually non-existent.

Reliability varied with water source. Data on volumes extracted from regulated streams were metered, and these are considered some of the most reliable information available in the state. For other water sources, such as unregulated streams, data were considered to be unreliable and at best a guide.

A more comprehensive and consistent approach to the collection of irrigation statistics is indicated. This would help to ensure that data are comparable across different water sources and industries. The following improvements are needed:

- Crop data are needed, for example, crop water use and irrigated area, yields and value.
- Protocols for providing data to users are needed. Information providers need to attach reliability ratings to data to help users make better choices about the reliability and therefore the usefulness of the data.
- Two-way flow of information between agencies and irrigators needs to be fostered. These data need to flow back to irrigators in forms that could help them make better water management decisions.
- Two-way flow of information between agencies needs to be fostered. Establishing better linkages between organisations that use irrigation data (for example, through data sharing agreements and publications) are required. Irrigation data are needed to enhance the effectiveness of extension programs such as WaterWise on the Farm and to improve natural resource planning processes.
- Data are needed at scales that are large enough to ensure confidentiality of individual enterprises but small enough to allow users to aggregate information to useful scales.

Finally, such a comprehensive approach can only be developed with the full involvement of the many irrigators, agencies and community groups that require these data.

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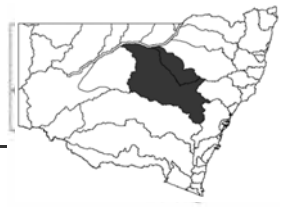

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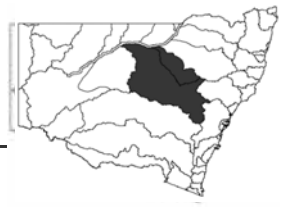

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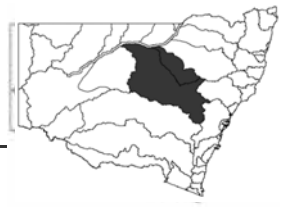


14. APPENDIXES

14.1 Definitions of statistical units used by the ABS

(Extract from ABS 1999)

An SLA is a general purpose spatial unit. It is the base spatial unit used to collect and disseminate statistics other than those collected from the Population Censuses. SLAs are based on the boundaries of incorporated bodies of local government, where these exist. These bodies are the Local Government Councils and the geographical areas which they administer are known as Local Government Areas (LGAs). In the Northern Territory, an incorporated administrative body gazetted under the Northern Territory Local Government Act can take the form of a Community Government Council (CGC). Where there is no incorporated body of local government, SLAs are defined to cover the unincorporated areas

An LGA is an SLA if:

- the LGA fits entirely within an Statistical Subdivision (SSD) and
- the LGA is broadly similar in size, economic significance and user needs for statistics to other LGAs in Australia

An LGA forms two or more SLAs when the two conditions above are not met. This can occur when:

- an LGA is divided by the boundary of one or more SSDs. The LGA is split into two or more SLAs each of which falls within the relevant SSD or
- an LGA is substantially different in size, economic significance and user needs for statistics to other LGAs. The LGA is split into two or more SLAs which generally correspond to one or more suburbs (as occurs in the predominantly urban LGA of the City of Brisbane) or other areas of interest.

For those parts of Australia which are not administered by incorporated local government bodies, an SLA is an unincorporated area. Unincorporated SLAs cover the following areas:

- unincorporated on-shore area(s) and/or off-shore island(s) in an SSD
- that part of an unincorporated area which is considered of sufficient economic significance as to warrant the formation of a separate SLA
- off-Shore Areas & Migratory SLAs, formed for census purposes for all S/Ts [states and territories] except the Australian Capital Territory and Other Territories to encompass off-shore, shipping and migratory CDs (off-shore, shipping and migratory CDs [collection districts] are explained in chapter 2)
- the entire area of the Australian Capital Territory. Each SLA is either a suburb, a locality or the non-urban area of an SSD and

- the unincorporated part of the Northern Territory. In some SSDs (e.g. Daly, Bathurst-Melville) the entire area is covered by one unincorporated SLA. In other SSDs (e.g. East Arnhem), the unincorporated area is split into several SLAs to distinguish an economically significant town (e.g. Nhulunbuy), island (e.g. Groote Eylandt) or administrative region.

14.2 Naming conventions for SLAs

(Extract from ABS 1999)

An SLA which is a whole LGA adopts the name of the LGA including its LGA status as a suffix. Thus, Northam (S) and Northam (T) in Western Australia are separate SLAs. The various LGA types currently in use by States and the Northern Territory are specified in chapter 3. For example:

- Ballina (A) — New South Wales Area
- Queenscliffe (B) — Borough
- Liverpool (C) — City
- Coomalie (CGC) — Community Government Council
- Mid Murray (DC) — District Council
- Roxby Downs (M) — Municipality
- Murray Bridge (RC) — Rural City
- Broome (S) — Shire and,
- Roma (T) — Town.

An SLA which is part of an LGA may adopt a hyphenated name the first part of which is the name of the LGA. For example:

- the LGA of Stirling (C) in Western Australia is split into three SLAs
- Stirling (C) – Central
- Stirling (C) – Coastal and,
- Stirling (C) - South-Eastern.

If the name includes - Pt A, - Pt B, or - Pt C, this indicates the SLAs were formed by splitting an LGA between one or more SSDs (see example below). In this case, - Pt A usually denotes the more urban part of the split LGA.

If the name includes - Pt A, - Pt B, or - Pt C, this indicates the SLAs were formed by splitting an LGA between one or more SSDs (see example below). In this case, - Pt A usually denotes the more urban part of the split LGA. For example:

- the LGA of the Municipality of Latrobe in Tasmania is split into two SLAs
- Latrobe (M) - Pt A and,
- Latrobe (M) - Pt B.

An SLA which is part of an LGA may adopt a locality or suburb name. For example:

- the LGA of the City of Brisbane in Queensland is split into many SLAs, including: Acacia Ridge Albion Yeronga and Zillmere.

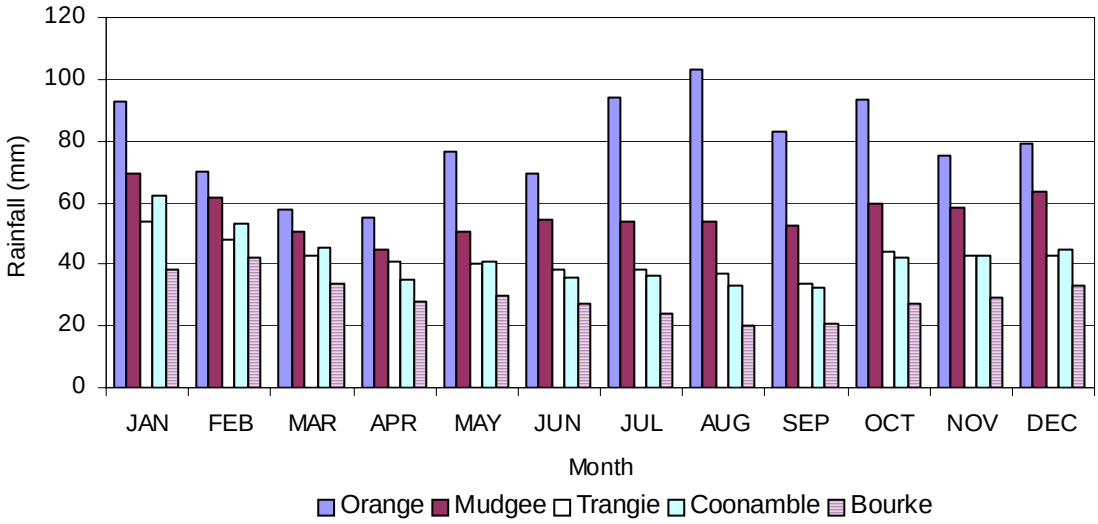
An SLA which covers an unincorporated area does not contain LGA type. In New South Wales, Queensland and South Australia the SLA name may include Unincorp:

- West Arnhem (in Northern Territory)
- Bruce (in Australian Capital Territory) and,
- Unincorp. Far West (in New South Wales).

A small number of SLA names are duplicated across S/Ts and one SLA name is duplicated within an S/T. These names become unique when used in conjunction with SLA codes.

- City (Queensland and Australian Capital Territory)
- City - Inner (Queensland and Northern Territory)
- City - Remainder (Queensland and Northern Territory)
- Kingston (Queensland and Australian Capital Territory)
- Oxley (Queensland and Australian Capital Territory)
- Red Hill (Queensland and Australian Capital Territory) and,
- West End (Townsville (C) and Brisbane (C)).

14.3 Monthly rainfall in the Greater Macquarie catchment



Source: Clewett et al. 1999 ①

14.4 Number of irrigation enterprises and area irrigated between 1993–94 and 1996–97

Region	1993–94		1995–96		1996–97	
	Area irrigated (ha)	Number enterprises irrigating	Area irrigated (ha)	Number enterprises irrigating	Area irrigated (ha)	Number enterprises irrigating
Bathurst	747	34	531	23	448	25
Bogan	729	11	227	7	962	9
Brewarrina	592	1	217	0	715	1
Cabonne Pt A	367	16	156	7	176	9
Cabonne Pt B	1 281	55	643	31	660	31
Cabonne Pt C	3 078	4	1 376	33	1 627	35
Coolah	1 692	15	359	7	484	11
Coonabarabran	1 611	15	145	9	89	12
Coonamble	1 246	5	252	4	663	4
Dubbo	2 026	40	1 903	22	2 315	39
Evans Pt A	634	14	144	8	94	9
Evans Pt B	666	27	315	14	340	22
Greater Lithgow	1 225	14	15	2	39	6
Gilgandra	11 383	14	85	8	64	6
Mudgee	2 734	60	1 259	50	1 655	57
Narromine	24 620	117	13 179	60	17 631	93
Oberon	1 772	18	84	5	89	5
Orange	1 036	48	820	36	1 014	47
Parkes	1 963	16	107	2	242	2
Rylstone	954	38	540	25	924	30
Walgett	2 943	5	891	3	1 965	4
Warren	31 928	85	10 522	61	21 751	65
Wellington	3 433	54	960	32	1 611	38
Total	**98 662**	**706**	**34 729**	**449**	**55 556**	**560**

Source: ABS 1998 ② See Appendix 14.2 for SLA naming conventions.

14.5 Macquarie River allocation announcement history

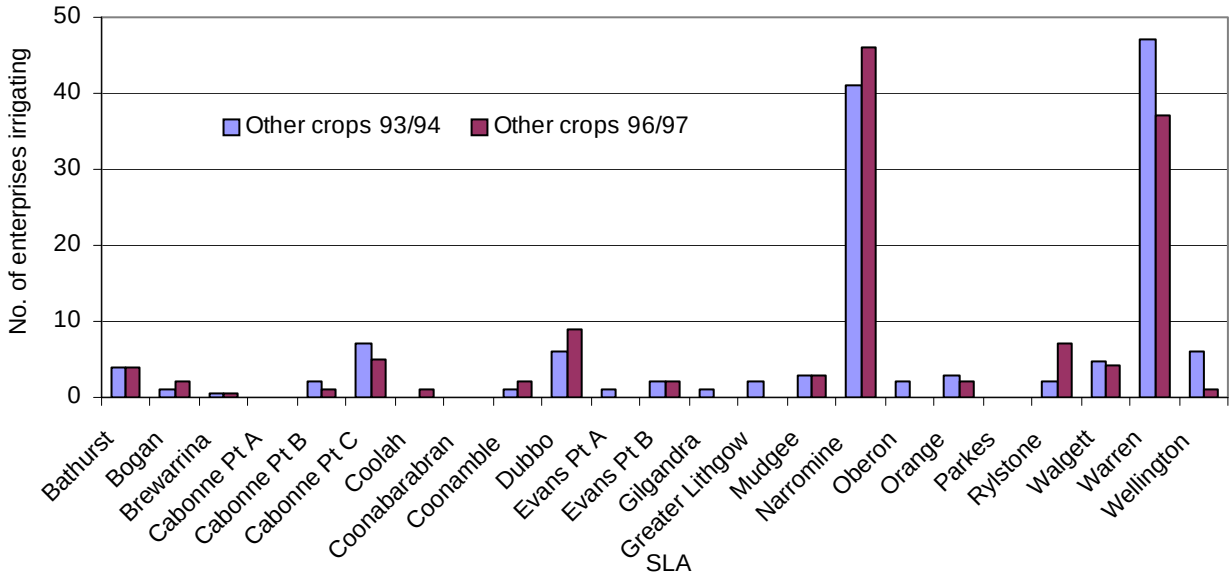
Year	Date announced	Allocation announced	Overdraw next season	Carryover		Comments
				Last season	Used by	
1980–81[a]	4/07/1980	40%	0%			Volumetric Allocation Scheme Commenced.
	9/10/1980	50%	0%			
	29/01/1981	60%	0%			
1981–82[a]	29/05/1981	10%	0%			
	11/08/1981	85%	0%			
	16/12/1981	100%	0%			
1982–83[a]	5/07/1982	60%	0%			
1983–84[a]	22/07/1983	20%	0%			
	4/08/1983	25%	0%			
	30/08/1983	40%	0%			
	9/09/1983	55%	0%			
	21/09/1983	60%	0%			
	24/10/1983	75%	0%			
	1/12/1983	90%	0%			
	8/02/1984	100%	0%			
1984–85[a]	6/07/1984	100%	0%			
1985–86[a]	19/07/1985	85%	0%			
1985–86[a]	20/08/1985	95%	0%			
	23/08/1985	100%	0%			
1986–87[a]	10/07/1986	60%	0%			
	14/08/1986	100%	0%			
1987–88[a]	13/07/1987	100%	0%			
	13/01/1988	100%	20%			
1988–89[a]	18/07/1988	100%	0%			
1989–90[a]	31/07/1989	100%	0%			
1990–91[a]	19/07/1990	100%	0%			
1991–92[a]	23/07/1991	90%	0%			
	8/08/1991	100%	0%			
1992–93[b]	12/08/1992	100%	0%			
1993–94[b]	2/08/1993	100%	0%			540 GL used
1994–95[b]	23/08/1994	80%	0%			506 GL used
1995–96[b]	2/08/1995	10%	0%			
	11/10/1995	15%	0%			
	9/12/1995	20%	0%			175 GL used plus a carryover of 160 GL.
	15/12/1995	24%	0%			
	5/01/1996	40%	0%			
	29/02/1996	50%	0%			
	30/04/1996	55%	0%			

Year	Date announced	Allocation announced	Overdraw next season	Carryover		Comments
				Last season	Used by	
1996–97 [b]	1/07/1996	0%	0%	25%	Unlimited	
	6/08/1996	10%	0%	25%	Unlimited	
	12/08/1996	20%	0%	25%	Unlimited	
	10/09/1996	50%	0%	25%	Unlimited	November inflows not converted to allocation due to 70% plus
	4/10/1996	70%	0%	25%	Unlimited	25% Carryover = 95% total allocation available.
	17/02/1997	85%	0%	25%	Unlimited	Later relaxation to allow 85% allocation.
1997–98 [b]	1/07/1997	10%	0%	60%	Unlimited	50 GL WLA not available due to 10% Allocation.
1998–99 [b]	7/08/1998	100%	0%	10%		Carry-over forfeited due to effective spill of Burrendong on 8/8/1998.

Source: DLWC 2000a ① Announced by [a]Minister,[b] Manager

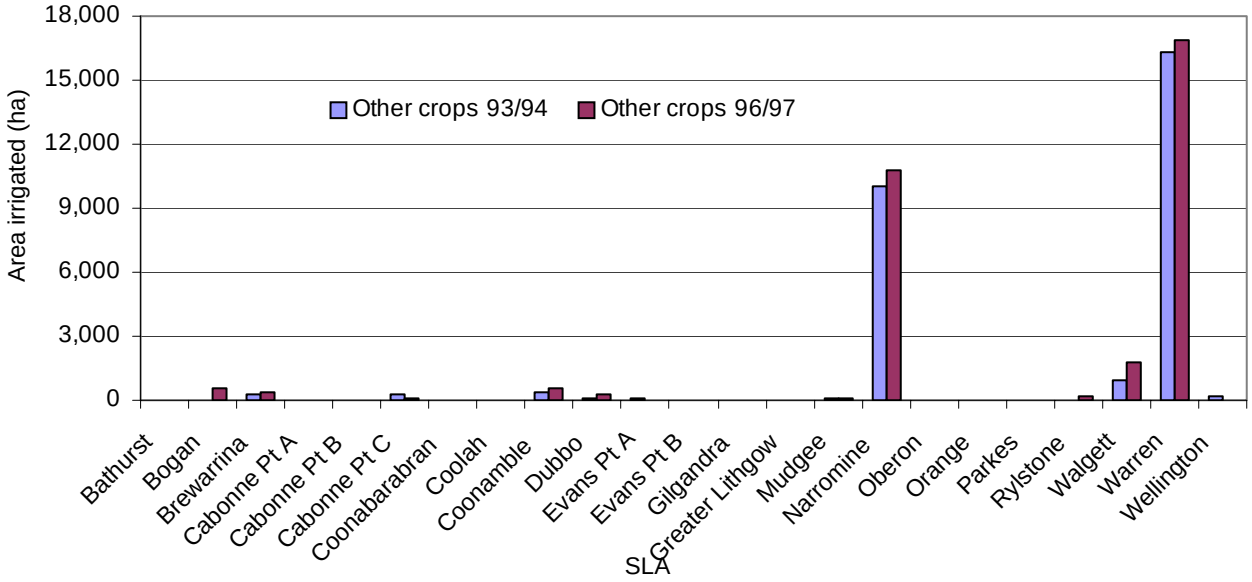
14.6 Crop areas irrigated, and the number of irrigation enterprises, in the Greater Macquarie catchment

14.6.1 Number of enterprises (cotton)



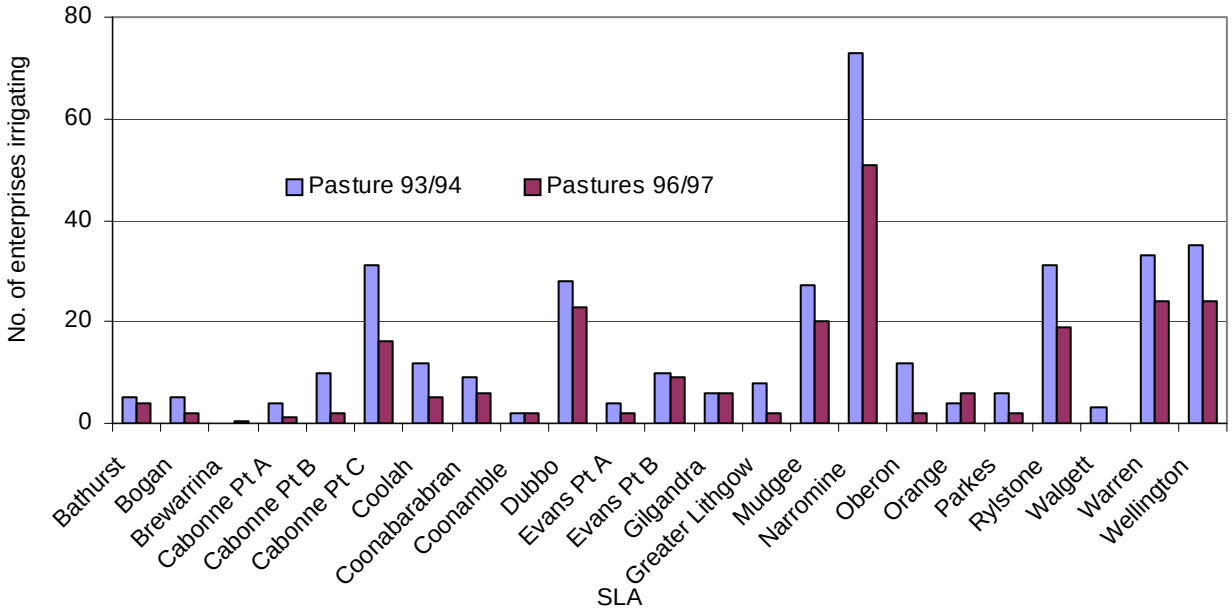
Source: ABS 1998, ② NB: 'Other crops' roughly approximates cotton.

14.6.2 Crop areas irrigated (cotton)



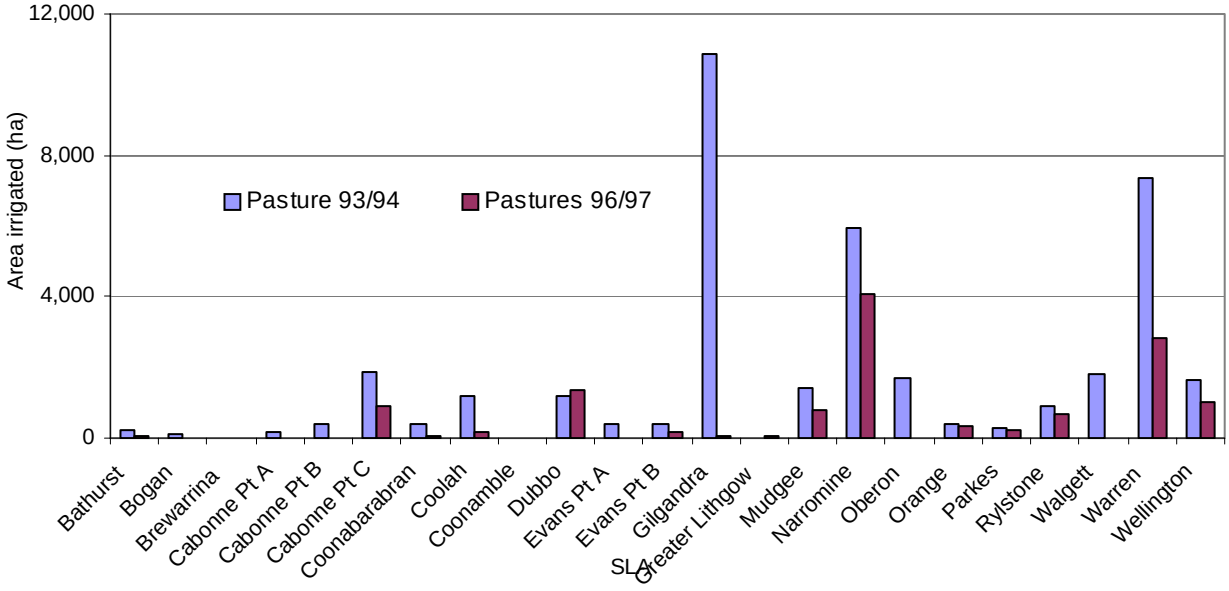
Source: ABS 1998, ② NB: 'Other crops' roughly approximates cotton.

14.6.3 Number of enterprises (pasture)



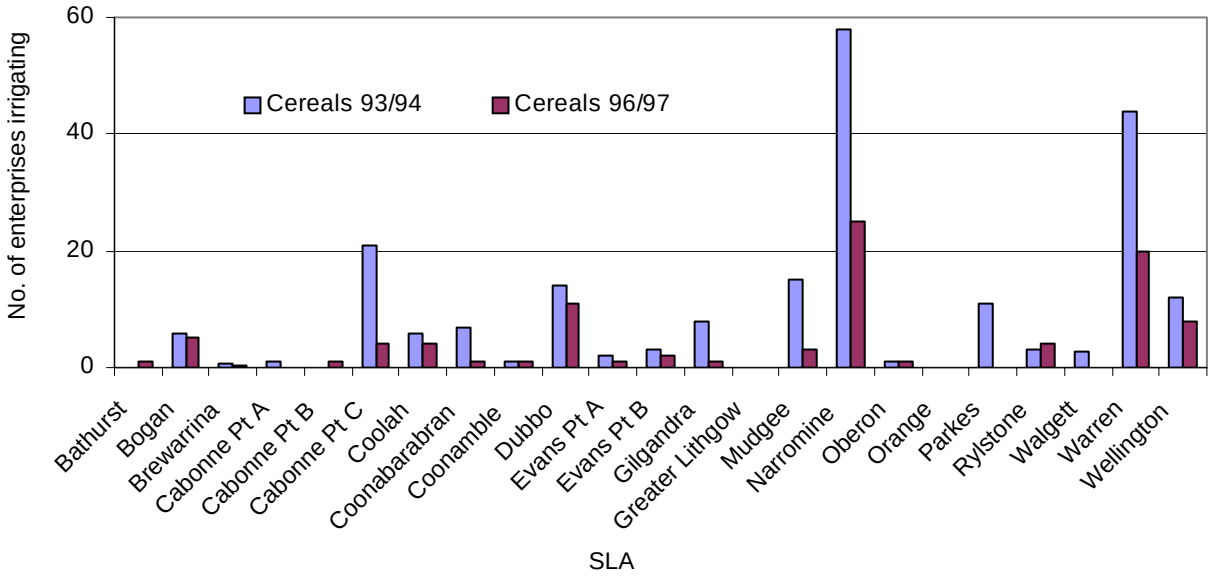
Source: ABS 1998, ②

14.6.4 Crop areas irrigated (pasture)



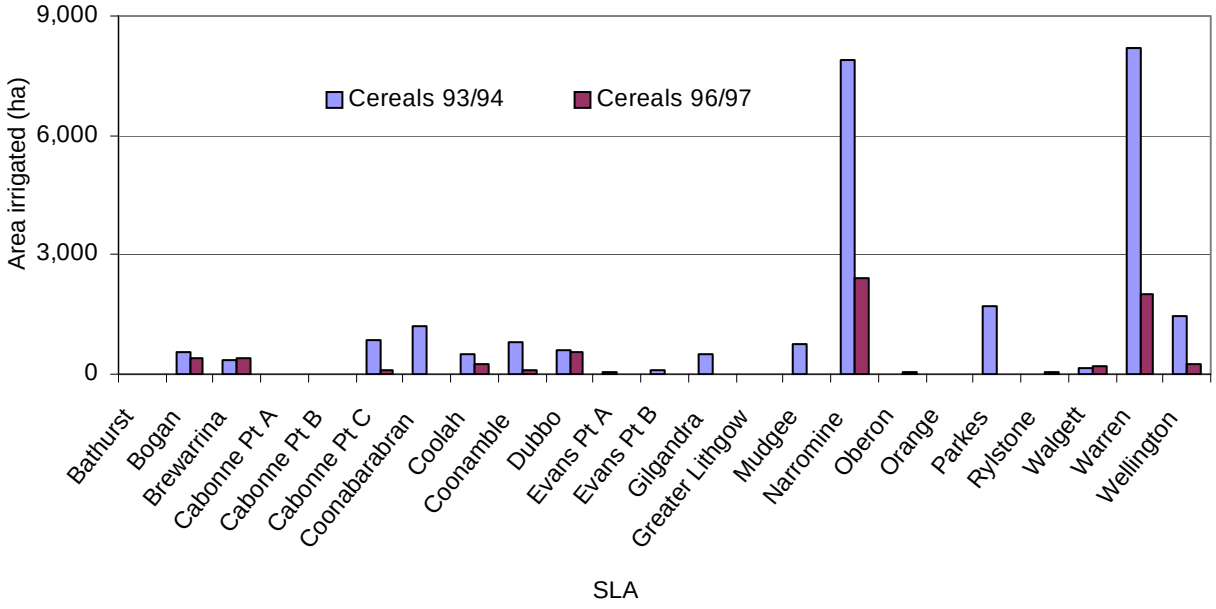
Source: ABS 1998, ②

14.6.5 Number of enterprises (cereals)



Source: ABS 1998, ②

14.6.6 Crop areas irrigated (cereals)



Source: ABS 1998, ②

14.7 Theoretical estimates of irrigation requirements in the Greater Macquarie catchment

The theoretical amount of irrigation water required by crops is provided in Table 13 and is taken from DLWC (2000c). Estimates are for well-watered, disease-free, pest-free crops and assume an irrigation efficiency of 70%.

Table 13. Irrigation requirement [26] of crops in the Greater Macquarie catchment (ML/ha)

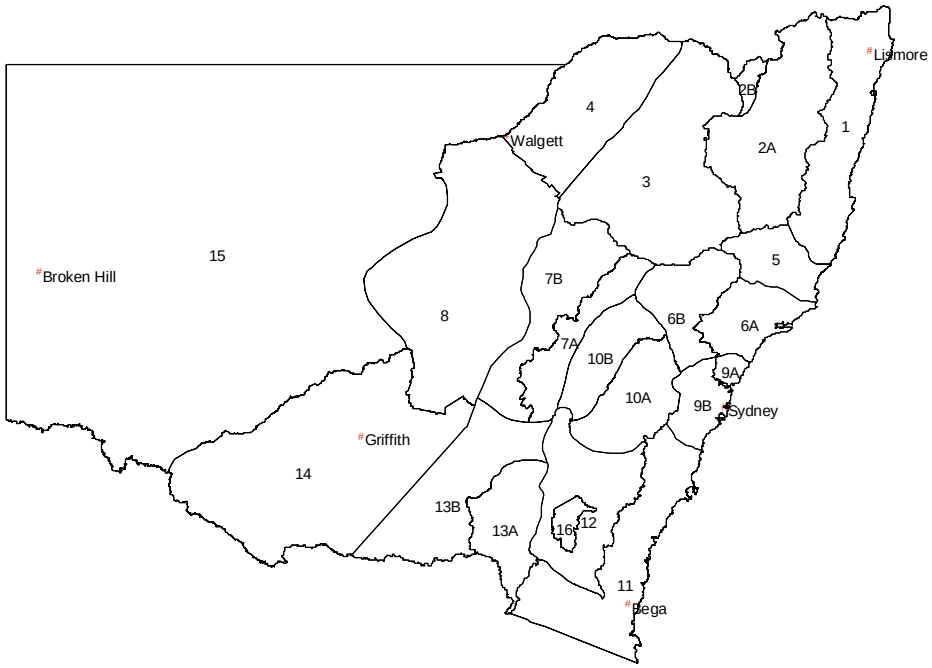
Crop class[a]	Tablelands (Zone 10A)a	Tablelands (Zone 10B)a	Slopes (Zone 7A)a	Slopes (Zone 7B)a	Plains (Zone 8)a
Annual pasture	1.5	2.0	3.0	3.5	4.5
Cotton				9.0	10.0
Cut flowers			5.0	5.5	
Inactive area	1.5	2.0	3.0	3.5	4.5
Lucerne	5.0	6.0	6.0	6.5	7.0
Nuts		6.0			
Olives		4.0		7.5	
Orchards	5.0	6.0	8.5	9.5	12.5
Perennial pasture, extensive grazing	5.0	5.0	5.5	6.0	6.0
Perennial pasture, dairy	7.0	7.0	7.0	7.5	8.0
Pulses		3.0		5.0	7.0
Summer cereal	3.5	4.0	6.0	6.5	8.5
Summer oilseeds			6.0		9.0
Turf	8.5	11.0	11.0	11.5	12.5
Vegetables	3.5	4.5	6.5	7.5	10.0

26 The irrigation requirement is the depth of water required to satisfy crop water requirement, leaching requirement and system inefficiencies (conveyance, distribution, and application). Essentially it is the depth of water that must be delivered to the farm to ultimately satisfy actual crop water use (ML/ha or mm).

Crop class[a]	Tablelands (Zone 10A)a	Tablelands (Zone 10B)a	Slopes (Zone 7A)a	Slopes (Zone 7B)a	Plains (Zone 8)a
Vines		6.0	9.0	10.0	15.0
Winter cereal	1.5	2.0	3.0	3.5	4.5
Winter oilseeds		2.0		3.5	4.5

Source: DLWC 2000c ③. [a] Crop class refers to the grouping of like crops (wheat and maize, for example) within a generic crop class (such as cereals). [a] see Figure 15 for location of zones.

Figure 15. Climatic zones used for volumetric conversion in NSW



14.8 Irrigated crop information for the Greater Macquarie catchment

Crop class[a]	Location	Crop	IR[b] avg. (ML/ ha)	IR min (ML/ha)	IR max (ML/ha)	Y[c] avg. (t/ha)	Y min (t/ha)	Y max (t/ha)	Root depth (m)	Sowing date [d]	Time of growth total[e]	System[f]	Name, position
Cereals	Dubbo	Grain sorghum	–	–	–	4.0	2.5	7.5	1.8	14Dec	112	flood	P. Gardner, Seeds Agron
	Macquarie Valley (Narromine Shire and below)	Grain sorghum	9.0	4.0	10.0	–	–	–	–	15-Oct	138	furrow or border check	G. Giddings, IO, and B. Swann, Irrigation AO
	Condobolin	Grain sorghum	11.0	10.0	12.0	6.0	4.0	8.0	1.5	15-Oct	160	rows (flood)	P. Lukins, DA
		Maize	12.0	10.0	14.0	8.0	6.0	15.0	1.5	15-Sep	140	rows (flood)	P. Lukins, DA
	Dubbo	Millet	–	–	–	2.5	1.0	5.0	1.8	1-Oct	90	flood, spray	P. Gardner, Seeds Agron
	Condobolin	Millet	8.0	6.0	11.0	1.5	1.0	2.5	1.3	15-Aug	130	rows (flood)	P. Lukins, DA
		Oats	3.5	1.5	5.0	3.0	2.0	4.5	1.5	15-Mar	193	border check	P. Lukins, DA
	Dubbo	Panicum	–	–	–	2.5	1.0	5.0	1.8	1-Oct	90	–	P. Gardner, Seeds Agron
	Condobolin	Wheat	3.0	2.5	4.0	3.6	2.4	5.5	1.2	15-May	177	border check	P. Lukins, DA

Crop class[a]	Location	Crop	IR[b] avg. (ML/ ha)	IR min (ML/ha)	IR max (ML/ha)	Y[c] avg. (t/ha)	Y min (t/ha)	Y max (t/ha)	Root depth (m)	Sowing date [d]	Time of growth total[e]	System[f]	Name, position
Fibres	Macquarie Valley (Narromine Shire and below)	Cotton	8.0	3.0	9.0	7.0	5.0	9.0	0.7	1-Oct	185	furrow	G. Giddings, IO, and B. Swann, Irrigation AO
	Condobolin	Cotton	14.0	12.0	16.0	–	–	–	1.2	15-Sep	180	rows	P. Lukins, DA
Oilseeds		Canola	3.0	2.5	4.0	1.6	1.3	2.7	1.2	15-May	180	rows and check	P. Lukins, DA
	Macquarie Valley (Narromine Shire and below)	Soybeans	7.5	3.0	8.0	–	–	–	–	1-Dec	147	furrow	G. Giddings, IO, and B. Swann, Irrigation AO
	Condobolin	Soybeans	13.0	12.0	14.0	1.9	1.2	2.9	0.9	15-Nov	148	rows and check	P. Lukins, DA
	Condobolin	Sun flowers	9.0	8.0	11.0	1.8	1.4	2.8	0.8	15-Sep	135	rows and check	P. Lukins, DA
Pasture	Condobolin	Annual	3.0	1.0	4.0	3.0	2.0	4.0	0.6	15-Mar	275	border check	P. Lukins, DA
	Condobolin	Lucerne	7.0	3.0	12.0	7.0	4.0	12.0	3.0	15-Apr	365	border check	P. Lukins, DA
	Dubbo	Lucerne seed	–	–	–	0.5	0.0	1113.0	1.8	–	90	flood, spray	P. Gardner, Seeds Agron.

Crop class[a]	Location	Crop	IR[b] avg. (ML/ ha)	IR min (ML/ha)	IR max (ML/ha)	Y[c] avg. (t/ha)	Y min (t/ha)	Y max (t/ha)	Root depth (m)	Sowing date [d]	Time of growth total[e]	System[f]	Name, position
	Mid Lachlan	Perennial (seed lucerne)	–	–	–	–	0.4	0.7		1-Dec	100	–	G. Giddings, IO, and B. Swann, Irrigation AO
Pulses	Macquarie Valley (Narromine Shire and below)	Beans (mung)											G. Giddings, IO, and B. Swann, Irrigation AO
Stone fruit	–	Orchards (high chill)								1-Sep	240		J. Slack, DH
Vegies	Macquarie Valley (Dubbo City Shire)	Beans, peas	2.5	1.5	4.0	7.0	5.0	10.0		15-Oct	70	centre pivot	C. Beckingham, DH
		Peas green	1.5	1.0	2.0	5.0	3.0	7.0		15-Jul	110	centre pivot	C. Beckingham, DH
		Potatoes	3.5							10-Aug	144	centre pivot	S.Wade, DH
		Potatoes	7.5							15-Feb	181	centre pivot	S.Wade, DH
		Sweet corn	7.0	5.0	8.0	19.0	17.0	23.0			90	centre pivot	C. Beckingham, DH

Crop class[a]	Location	Crop	IR[b] avg. (ML/ ha)	IR min (ML/ha)	IR max (ML/ha)	Y[c] avg. (t/ha)	Y min (t/ha)	Y max (t/ha)	Root depth (m)	Sowing date [d]	Time of growth total[e]	System[f]	Name, position
	Macquarie (downstream of Narromine and upstream of Dubbo)	Sweet corn (Early sowing date)								20-Sep	104	pivot	B.Swann, Irrigation AO
		Sweet corn (Late season)								5-Jan	82	centre pivot	B.Swann, Irrigation AO
		Sweet corn (mid season sowing) Jubilee								5-Oct	86	centre pivot	B.Swann, Irrigation AO

Source: Hope 1999

a Crop class refers to a category under which similar crops can be grouped.

b The depth of water required to satisfy crop water requirement, leaching requirement and system inefficiencies (conveyance, distribution, and application). Essentially it is the depth of water that must be delivered *to the farm* to ultimately satisfy actual crop water use. Average, minimum, and maximum figures correspond to irrigation requirements in normal, wet and dry seasons respectively.

c Y Avg., Min and Max – Average, Minimum and Maximum Yield or the total seasonal production derived from the irrigated crop. The unit being considered should be specified (for example, dry matter, grain, fibre).

d Date on which annual crops are typically sown.

e For field and vegetable crops, the total number of days between sowing and harvesting. For perennial crops this is usually taken as 365 days.

f System refers to irrigation system used.

DA (District Agronomist), DH (District Horticulturalist), AO (Advisory Officer), IO (Irrigation Officer)

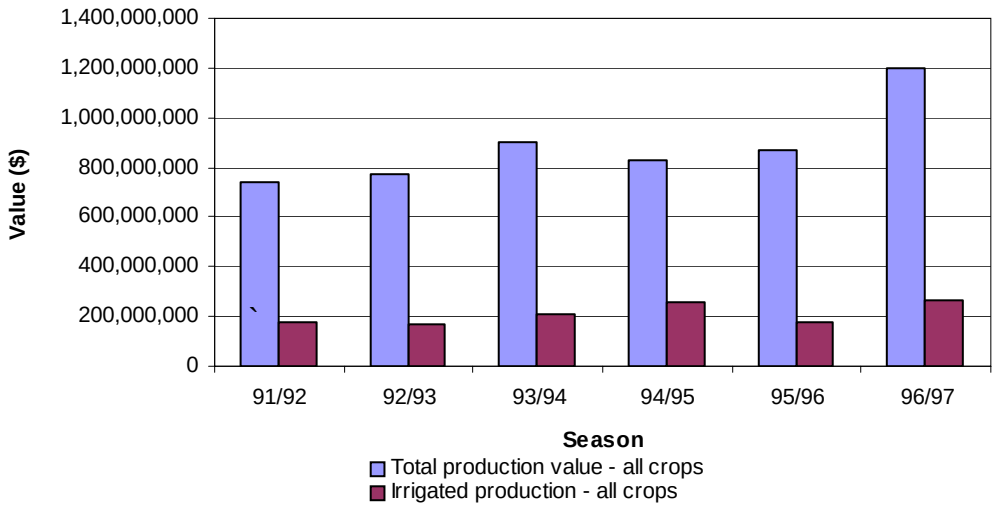
14.9 Irrigation methods in the Greater Macquarie and Lachlan catchments– broadarea and dairy enterprises only

Irrigation method	State %	Greater Macquarie and Lachlan catchments (%)
Surface	91.3	91.2
Moveable spray	3.5	2.3
Travelling irrigator	4.4	5.6
Trickle/drip/subsurface	0.2	0.7
Fixed low throw sprinkler	0.02	0.0
Fixed micro sprays	0.3	0.0
Fixed overhead sprinkler	0.2	0.2
Other	0.1	0.0

Source: ABARE 2000 ③

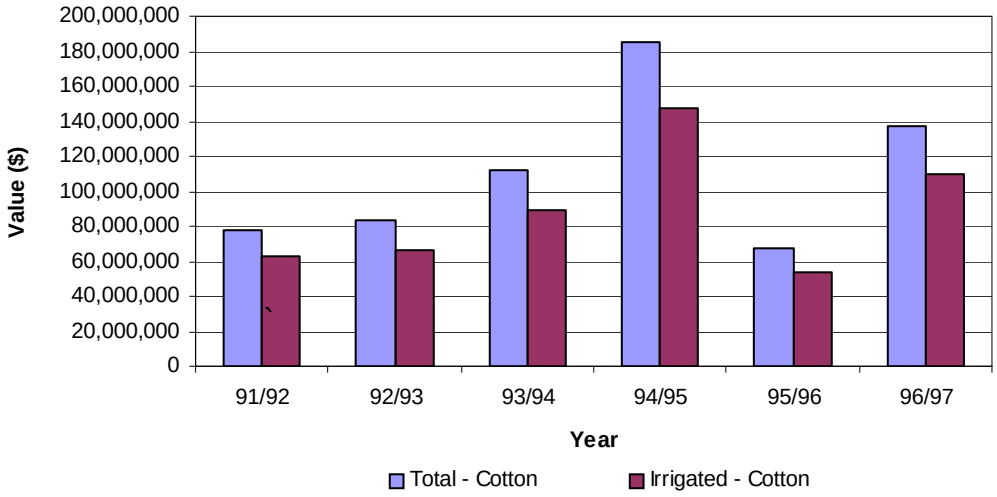
14.10 Value of irrigated agriculture production for major crops in the Greater Macquarie catchment

14.10.1 Value, all crops



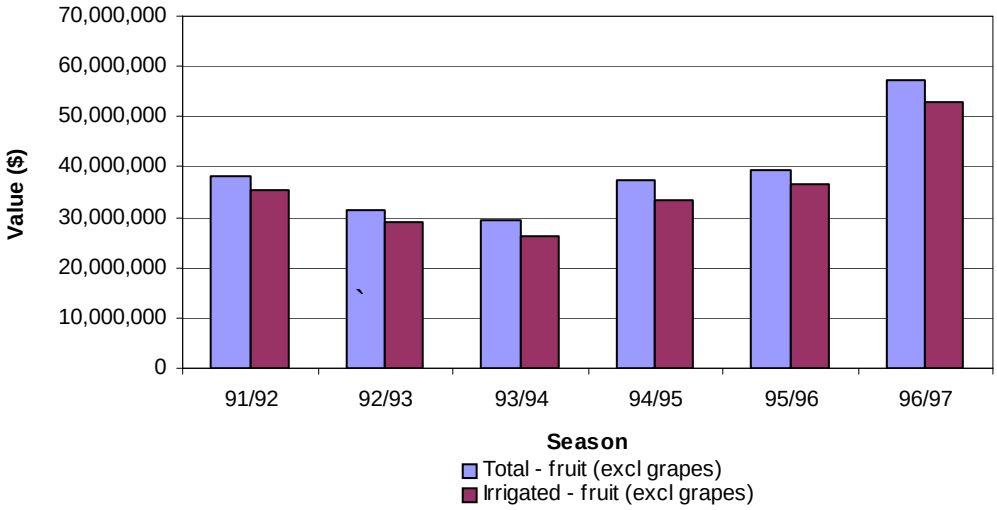
Source: Donovan 2000, ③

14.10.2 Value, cotton



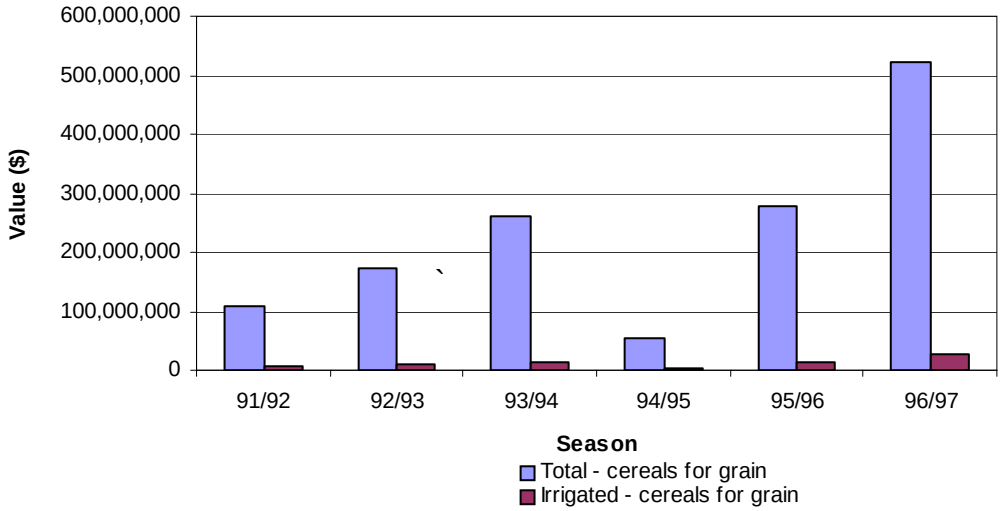
Source: Donovan 2000, ③

14.10.3 Value, fruit



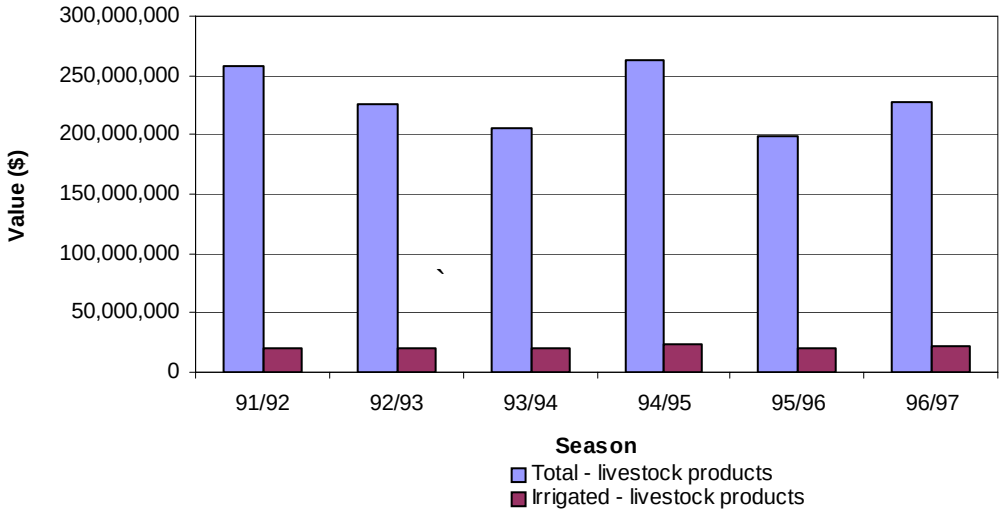
Source: Donovan 2000, ③

14.10.4 Value, cereals



Source: Donovan 2000, ③

14.10.5 Value, livestock



Source: Donovan 2000, ③

14.11 ABS question profile

Part 8. Do you irrigate or use any artificial fertilisers or soil conditioners

No □ Go to part 9

Yes □ *show details below*

a. Pastures and Crops Irrigated – Season 1993-94

Where any area of pasture or crop was irrigated more than once during the season, show this area once only

	Hectares
• Pasture (native or sown)	.....
• Cereals	.....
• Vegetables for human consumption	.....
• Fruit (including nuts)	.....
• Grapevines	.....
• All other crops	.....

b. Source of water – season 1993-94

Where more than one source of water is used on a particular area of pasture or crop, show the area only once according to the main source.

Area irrigated using:	Hectares
• Channel or pipe supply in an irrigation area or district	.....
• Other surface water (*Include* • private group schemes)	.....
• A river or stream controlled by water board or a water resources commission dam or weir	.....
- An uncontrolled river or scheme	.....
- A farm dam with its own catchment and not filled by pumping from a river or stream	.....
• Underground water supply (e.g. bore, spear, well)	
- Within State schemes	.....
- Other	.....

Source: (ABS 1994)

14.12 Area irrigated and water used by irrigation in the whole Macquarie catchment

14.12.1 Area irrigated (ha)

Crops	1989–90	1990–91	1991–92	1992–93	1993–94
Cotton	25 533	27 540	39 461	31 138	34 552
Wheat	5 782	4 208	10 543	6 356	8 620
Lucerne	5 141	4 817	6 964	5 687	7 764
Summer pasture	5 416	6 471	6 238	4 584	6 389
Soya beans	3 381	3 727	3 836	1 804	4 771
Oats	3 731	4 545	6 732	3 674	4 579
Maize	415	560	969	435	2 326
Sorghum	4 294	1 830	3 719	3 445	1 822
Summer cereal	959	726	1 484	929	1 291
Barley	342	436	1 284	445	1 011
Sunflower	1 093	873	1 306	121	925
Winter pasture	254	219	310	306	261
Pre-irrigation	205				250
Legumes	201	238	1 022	926	226
Fodder	235	565	1 096	481	215
Vegetables	885	314	249	227	190
Sudax	77	175	465	412	186
Millet	412	234	238	92	140
Citrus	209	306	210	210	131
Chickpeas	190	730	730		96
Canola			426	45	80
Mung beans	80		40	40	56
Vines	6	4	1		50
Orchard	2	38	44	39	44
Turf		10	34	35	33
Nursery		30	20	20	20

Crops	1989–90	1990–91	1991–92	1992–93	1993–94
Triticale	215	118	112		15
Rape	299	228	228		8
Lupins		84			
Winter cereal	197	61	61		
Total	**59 553**	**59 085**	**87 822**	**61 450**	**76 050**

Source: DLWC 1998a

14.12.2 Water used (ML)

Crops	1989–90	1990–91	1991–92	1992–93	1993–94
Cotton	209 802	224 502	268 834	117 833	278 941
Lucerne	41 768	46 716	49 972	26 284	63 185
Summer pasture	36 536	49 153	49 975	15 606	49 978
Soya beans	28 845	31 899	18 815	7 364	41 382
Wheat	20 838	22 253	32 297	14 648	31 734
Maize	2 824	5 189	5 647	1 434	16 101
Sorghum	27 287	12 506	21 635	14 991	12 180
Oats	8 138	16 358	16 853	7 172	12 161
Summer cereal	7 397	4 293	8 696	2 936	7 565
Sunflower	7 802	6 772	4 925	1 151	7 229
Barley	1 649	2 568	7 359	1 630	4 752
Fodder	1 981	4 968	7 597	1 304	1 604
Sudax	454	1 426	3 800	1 563	1 353
Citrus	2 302	2 170	2 667	824	1 329
Legumes	1 535	1 960	5 486	4 655	1 250
Millet	3 378	2 009	2 162	376	790
Winter pasture	704	394	1 040	747	781
Vegetables	5 422	1 974	1 169	837	764
Storage			4	73	545
Pre-irrigation	485	13 764	9 188		542

Crops	1989–90	1990–91	1991–92	1992–93	1993–94
Canola			2 256	128	399
Orchard	5	227	263	266	267
Turf		25	103	94	166
Mung beans	440		832	832	125
Chickpeas	832	5 598	2 598		116
Nursery		68	91	64	109
Vines	14	7	10		100
Rape	1 995	1 331	1 415		71
Triticale	473	405	185		38
Lupins		309			
Winter cereal	685	470	470		
Total use	**413 591**	**459 314**	**526 344**	**222 813**	**535 554**

Source: DLWC 1998a

14.13 Area irrigated and water used by irrigation below Narromine only

	1988–89		1989–90		1990–91		1991–92		1992–93		1993–94		1994–95		1995–96		1996–97		1997–98		1998–99	
	ha	ML	ha	ML	ha	ML	ha	ML	ha	ML	ha	ML	ha	ML	ha	ML	ha	ML	ha	ML	ha	ML
Cotton	22 229	183 534	25 624	223 487	27 118	250 940	31 992	278 284	30 971	223 227	33 317	272 159	36 197		15 474		33 412		42 284		44 167	
Soya bean	6 708	51 849	3 111	26 455	3 578	31 726	2 083	18 140	2 370	18 913	4 633	40 753			358		953		471		784	
Lucerne	3 563	30 325	3 536	34 755	3 146	37 047	3 655	44 205	4 487	42 567	5 037	52 638			5 597		3 720		2 257		1 773	
Summer pasture	3 301	20 261	4 752	33 523	5 631	43 693	4 000	32 867	3 522	26 323	5 597	45 819			3 048		2 608		2 234		1 165	
Sorghum	2 553	15 130	3 872	25 431	1 694	12 247	3 106	25 394	2 285	16 031	1 373	10 075			1 371		672		453		391	
Oats	2 254	6 526	3 239	7 019	4 171	10 328	3 901	9 792	3 276	6 969	4 324	11 678			3 412		1 998		871		233	
Wheat	2 024	9 722	4 943	18 839	3 787	20 817	7 349	24 844	9 939	38 334	8 157	30 804			5 158		2 624		1 195		223	
Sunflower	1 008	6 790	1 093	7 802	833	6 737	554	4 108	751	4 953	925	7 229			630		239		200		272	
Vegetables	863	5 081	242	1 328	19	120	90	763	29	192	46	189			100		53		24		20	
Millet	520	3 804	341	2 860	170	1 366	92	676	149	853	20	125			0		75		28			
Summer cereal	481	2 720	415	2 824							0				0		0		0			
Winter pasture	273	797	237	655	138	394	197	626			211	630			0		0		0			
Citrus	208	1 971	208	2 275	207	2 238	207	2 452	207	1 659	131	1 327			133		127		127		126	
Sudax	147	799			175	1 426	461	4 023	321	2 099	206	1 517			0		0		0			
Mung bean	143	725					40	414	0	0	0	0			0		0		0		111	
Canola	125	789	291	1 943	341	1 974	408	2 055	81	332	80	399			556		113		0			
Triticale	121	121									0				0		0		0			
Pulses (peas & lupins)	103	300									0				0		0		12		101	
Barley	71	363	182	1 353	251	1 438	727	3 915	601	2 472	778	3 794			161		406		260		20	
Clover	65	653							0	0	0	0			0		0		0			
Golf Course	11	53	11	61	11	86	11	124	11	65	0	0			0		0		0			
Race Course	10	94	10	143	10	139			10	93	0				0		0		0			
Roses	8	53	8	52	8	72	8	84	8	65	8	71			20		8		8		20	
Canary Seed					22	140			81	321	0				0		52		0			

	1988–89		1989–90		1990–91		1991–92		1992–93		1993–94		1994–95		1995–96		1996–97		1997–98		1998–99	
	ha	ML	ha	ML	ha	ML	ha	ML	ha	ML	ha	ML	ha	ML	ha	ML	ha	ML	ha	ML	ha	ML
Coriander																			30		81	
Faba bean									0	0	0	0			25		0		0			
Forage crops			312	2 435	645	5 657	711	5 396	502	3 138	195	1 440			124		127		674		53	
Legume			201	1 535	968	7 558	966	6 589	659	3 354	226	1 250			212		715		150			
Maize					560	4 960	580	4 435	410	1 551	2 164	14 911			305		898		320		50	
Mining									0	102	0	0			0		0		0			
Parks & gardens								9		6	0				0		0		0			
Pre Irrigation (oats)			205	485		15 462					0				0		0		0			
Rye					61	470					0				0		0		0			
Safflower							71	351	269	662	0				0		0		0			
Saltbush											0				18		0		0			
Sesame											0				0		55		0			
Stock & domestic		73		47		318		58		376	0				0		0		0			
Sweet corn			793	5 135	250	1 868	647	5 043	1 021	6 303	403	2 849			48		286		127		83	
Town supply		5 384		7 425		4 387		4 881		4 183	0				0		0		0			
Vines																					18	
Total	46 789	347 917	53 626	407 867	53 794	463 608	61 856	479 528	61 960	405 143	67 831	499 657			36 750		49 141		51 725		49 691	

Source: (DLWC 2001b)②

14.14 Area irrigated (ha) (1993–94), irrigation schemes only

	Narromine	Buddah Lake Scheme	Tenandra Irrigation Scheme	Trangie–Nevertire Scheme	Greenhide	Marthaguy	Nevertire	Total
Cotton	1 180	1 215	2 835	4 495	170	1 855	3 500	15 250
Wheat	995	570	565	775		475	400	3 780
Pasture	1 040	760	585	1 085	185		50	3 705
Lucerne	1 395	145	660	1 155	175		100	3 630
Soybeans	1 425	240	210	510	55	75		2 515
Oats	1 000	150	530	755	10	30		2 475
Corn	730	270			90		100	1 190
Grain sorghum	550	80						630
Sunflowers	405	10		510				925
Barley	55	180		265	120	30		650
Fallow		525						525
Forage sorghum	165	55						220
Sorghum			150	75	30	30		285
Legumes				150				150
Citrus								0
Canola				80				80
Millet	20							20
Nursery	10							10
Total area	8 970	4 200	5 535	9 855	835	2 495	4 150	36 040

Source: Elliott 1995

14.15 Stressed stream classification in the Greater Macquarie catchment

An environmental stress rating of each of the freshwater subcatchments within the Greater Macquarie catchment was determined using the following environmental indicators:

- extent of riparian vegetation
- geomorphologic health
- presence of major dams
- barriers to fish passage
- gully erosion
- dryland salinity
- presence of acid sulfate soils and,
- water quality (indicative purposes only – not used in decision tree).

Following the analysis of these indicators, an overall environmental stress rating for each subcatchment was made. The environmental stress was determined using a decision tree method. This method was used for both the estuarine and freshwater indicators. Where two-thirds of the environmental indicators returned a high classification for a particular subcatchment, the overall environmental stress was assessed to be high. Where two thirds of environmental indicators returned a low classification for a particular subcatchment, the overall environmental stress was determined to be low. The remaining subcatchments were classified as being of medium environmental stress.

The hydrological stress of a subcatchment was calculated as the estimated proportion of daily flow that has been made available for extraction under existing licences. This required estimation of streamflow and water use.

Streamflow estimation was made using information available through DLWC's flow gauging network and a range of hydrologic predictive techniques to extend estimates into rivers without local gauging sites. Estimates of the peak monthly water extractions have been made using the surface water returns lodged by licence holders. However, not all survey cards are returned to DLWC and the volumes were adjusted for the proportion of licence holders who have chosen not to lodge a return. A hydrologic index (indicating hydrologic stress) was derived for each subcatchment for current use and full water use development by proportioning estimated water extraction to the estimated streamflow. Each subcatchment was then classified as being of low (0 to 30% extraction of flow), medium (40 to 60% extraction) or high (70 to 100% extraction) hydrologic stress.

The data that were used to generate hydrological and environment stress ratings and therefore management options were not always reliable. For example, the hydrological stress rating was determined using crop return card information and is a source that is known to be unreliable. Despite underlying difficulties and concerns with the data, the

assessment provides the most comprehensive overview of the land and water resources of subcatchments in the Greater Macquarie catchment. The matrix showing stress categories and the ratings given to individual subcatchments in the Greater Macquarie catchment are provided in Table 14 and Table 15 respectively.

Table 14. Stress matrix

	Low environmental stress	**Medium environmental stress**	**High environmental stress**
High proportion of water extracted	CATEGORY U1. Despite high levels of water extraction, the river seems reasonably healthy. However, evaluation that is more detailed should be undertaken to confirm. It is also likely that conflict between users may be occurring during critical periods.	CATEGORY S3. Water extraction is likely to be contributing to environmental stress.	CATEGORY S1. Water extraction is likely to be contributing to environmental stress.
Medium proportion of water extracted	CATEGORY U2. There is no indication of a problem and, therefore, such rivers would be a low priority for management action.	CATEGORY S4. Water extraction may be contributing to environmental stress.	CATEGORY S2. Water extraction may be contributing to environmental stress.
Low proportion of water extracted	CATEGORY U4. There is no indication of a problem and, therefore, such rivers would be a low priority for management action.	CATEGORY U3. Environmental stress is likely to be due to factors other than water extraction and, as stress is not high, these rivers would be a low priority for management action.	CATEGORY S5. While environmental stress is likely to be due to factors other than water extraction, the high level of environmental stress means it is important to ensure extraction is not exacerbating the problem.

Source: DLWC 1999d

Table 15. Stress ratings for subcatchments in the Macquarie catchment

Name	Environmental stress	Hydrologic stress	Management class	Future risk
Castlereagh above Binnaway	high	high	S1	none
Castlereagh Binnaway Gilgandra	medium	high	S3	none
Tooraweenah Gulargambone tributaries	medium	low	U3	none
Teridgerie Creek System	medium	low	U3	none
Castlereagh River Gilgandra	medium	high	S3	none
Castlereagh River - below Coonamble	high	high	S1	none
Nedgera Creek System	high	low	S5	none
Campbells River	medium	high	S3	none
Fish River	medium	high	S3	none
Queen Charlottes Vale Creek/Evans Plains Creek	high	high	S1	none
Macquarie above Burrendong	medium	high	S3	none
Winburndale Rivulet	medium	high	S3	none
Turon/Crudine River	low	low	U4	none
Summerhill Creek	high	high	S1	none
Upper Cudgegong River above Windamere	medium	medium	S4	none
Lawsons Creek	high	high	S1	none
Burrendong Dam Storage Tributaries	medium	low	U3	none
Piambong Creek	high	low	S5	none
Pipeclay Creek	medium	medium	S4	none
Cooyal Wialdra Creek System	medium	medium	S4	none
Goolma Creek	medium	low	U3	none

Name	Environmental stress	Hydrologic stress	Management class	Future risk
Bell River	high	high	S1	none
Molong Creek and tributaries	high	high	S1	none
Little River	medium	medium	S4	none
Maryvale-Geurie	medium	low	U3	none
Upper Talbragar River/Coolaburragundy River	high	medium	S2	none
Lower Talbragar	high	low	S5	none
Marthaguy Creek System	medium	high	S3	none
Coolbaggie Creek System	medium	low	U3	none
Wambangalong - Whylandra system	high	low	S5	none
Backwater - Boggy Cowal System	high	low	S5	none
Upper Bogan River catchment	high	medium	S2	none
Bulbodney - Grahway Creek System	high	low	S5	none
Ewenmar Creek System	high	low	S5	none
Marra Creek System	medium	low	U3	none
Unregulated Lower Macquarie System	high	high	S1	none
Lower Bogan River System	high	medium	S2	none

Source: DLWC 2000b Unres = unresolved

14.16 Area (ha) and water used (ML) on crops irrigated in the Macquarie–Castlereagh catchment from unregulated rivers

(based on raw and incomplete data)

Area (ha)	Crops	1989–90	1990–91	1991–92	1992–93
	Summer cereal	8	15	127	78
	Winter cereal	65	216	171	128
	Summer oil			10	
	Winter oil				
	Cotton	972	972	324	200
	Citrus	< 1	27	15	< 1
	Lucerne	698	722	899	753
	Summer pasture	311	254	299	190
	Winter pasture	123	74	144	109
	Vegetables	575	510	554	495
	Vines	30	47	54	61
	Wheat	193		144	141
	Other	302	224	184	418
Total area (ha)		3 260	3 061	2 923	2 575
Water usage (ML)		*28 507*	*21 848*	*8 670*	*14 220*

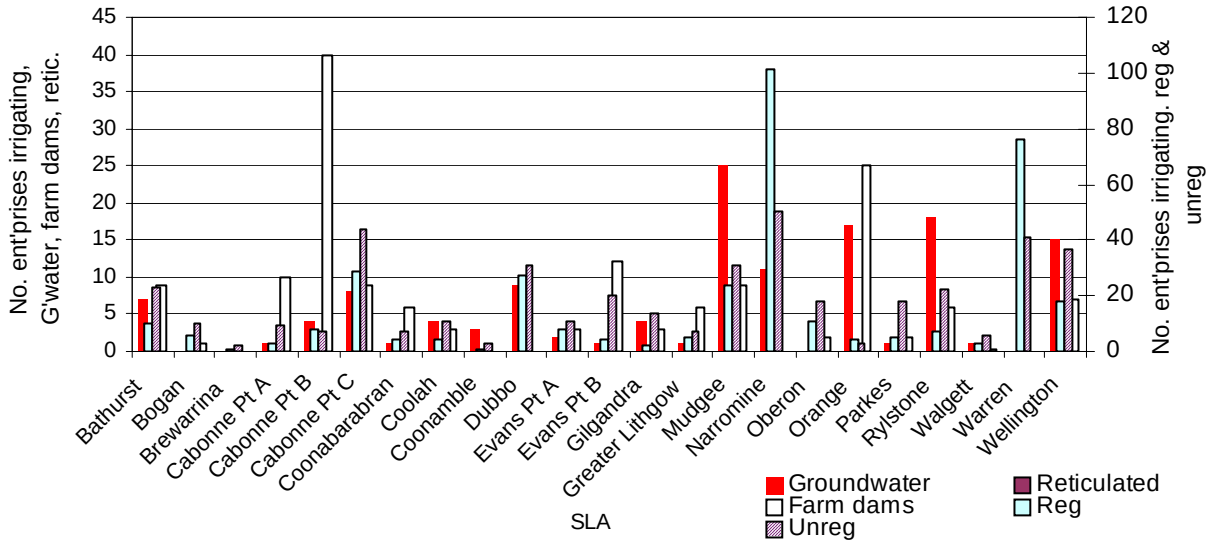
Area (ha)	Crops	1993–94	1994–95
	Adzuki beans		
	Barley		
	Carrots		
	Citrus		
	Cotton		
	Garlic		
	Grapes	5	
	Hybrid seed		0
	Lucerne	20	558
	Maize		
	Millet		
	Oats		13
	Orchard	40	41
	Other crops		3
	Other vegetables		418
	Peas		55
	Potatoes		2
	Pumpkins		0.5
	Rice		
	Safflower		
	Sorghum		

Area (ha)	*Crops*	*1993–94*	*1994–95*
	Soybeans		*188*
	Summer cereal		
	Summer grains		
	Summer pasture		*174*
	Sunflower		*127*
	Sweet corn		
	Tomatoes		*85*
	Triticale		*0.2*
	Turf		
	Vegetables		
	Vines		*35*
	Wheat		
	Winter cereal		*30*
	Winter grains		*26*
	Winter pasture		*76*
Total area irrigated (ha)		*65*	*1830*
Water usage (ML)		*49*	*3542*

Source: DLWC 1998a

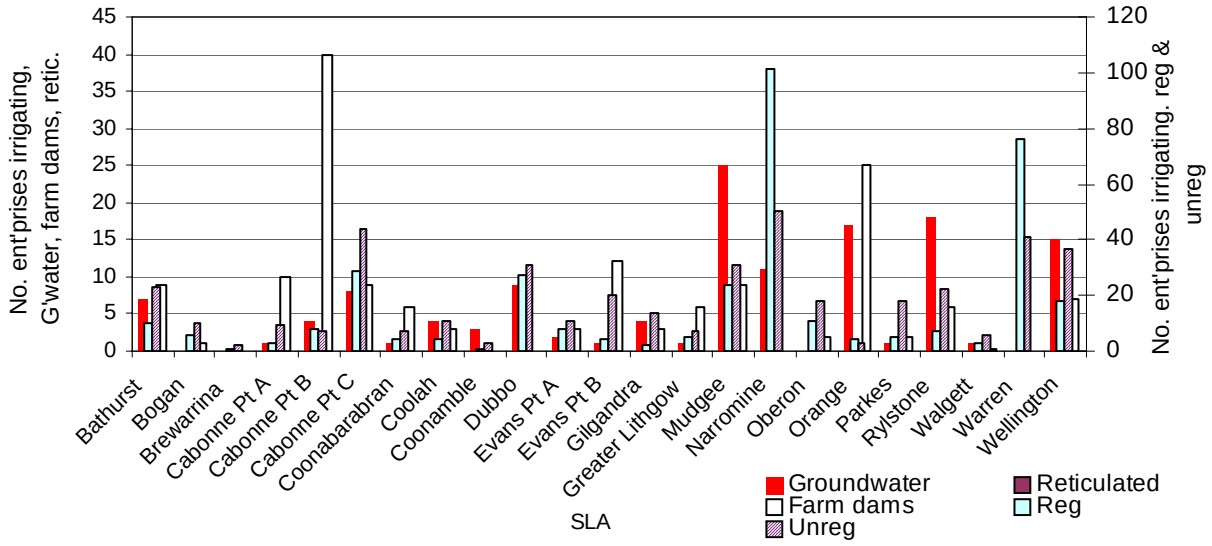
14.17 Number of enterprises and area irrigated from different water sources

14.17.1 Number of enterprises, different sources



Source: ABS 1998 ②

14.17.2 Area irrigated, different sources



Source: ABS 1998 ②

14.18 Annual usage in 1980 in the Greater Macquarie catchment (ML)

Extraction by salinity category	Urban	Irrigation	Other[a]	**Total**
0–1000 mg/L	11 300	3 000	31 700	**46 000**
1000–3000 mg/L	-	-	16 700	**16 700**
3000–7000 mg/L	-	-	5 100	**5 100**
Total	**11 300**	**3 000**	**53 500**	**67 800**

Source: Water Resources Commission 1980, ③

[a]Other refers to industrial and mining uses.