Sunraysia Drainage Strategy

Volume 2 - Background and Issues Papers
Part 1 of 2

June 2002

Department of Natural Resources and Environment

GOULBURN-MURRAY WATER

SunRISE INC. Sunraysia Regional Initiative for a Sustainable Economy - 21st Century

First Mildura Irrigation Trust

Lower Murray Water

Mildura Rural City Council

EPA Victoria

Murray-Darling Basin Commission

mallee catchment management authority

Sunraysia Rural Water Authority

Sunraysia Drainage Strategy

Issues Paper no.1 - Background Report

June 2002

Department of Natural Resources and Environment

GOULBURN-MURRAY WATER

SUNRAYSIA RURAL WATER AUTHORITY

mallee catchment management authority

SUNRISE INC.

FIRST MILDURA IRRIGATION TRUST

LOWER MURRAY WATER

Mildura Rural City Council

EPA VICTORIA

MURRAY-DARLING BASIN COMMISSION

Contents

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1. Introduction

1.1 Background to Study

As the name suggests, the Sunraysia Drainage Strategy and Urban Stormwater Management Plan Project comprises two separate but inter-linked components.

1.1.1 Sunraysia Drainage Strategy

In response to community concerns, Mildura Rural City Council has identified a need to prepare a Sunraysia Drainage Strategy.

The principal outcome of the Strategy will, as stated in the Project Brief, be "A master plan outlining how urban development to the year 2050 and the existing irrigation development will be serviced with surface and sub-surface drainage." Other outcomes will include:

- "A listing of problems in the existing urban and rural drainage systems and recommend both short and long term solutions to those problems.
- Recommendations to improve the quality of the urban and irrigation drainage water that outfall to receiving waters.
- Incorporate features of the Urban Salinity Management Strategy (if developed in time by the CMA) and the Urban Stormwater Management Plan.
- Preparation of outline designs and costings for proposed works.
- Works program for the short and long term solutions to the current problems and the provision of outfalls and infrastructure to service the new urban development.
- Recommendations on cost sharing and tariff systems to fund the implementation of the drainage strategy."

1.1.2 Urban Stormwater Management Plan

The Urban Stormwater Management Plan Program is a State Government initiative to improve the environmental management of urban stormwater. The Government has committed significant funds over the next three years to the improvement of urban stormwater management, and these will only be allocated to projects that form part of an approved Urban Stormwater Management Plan. The Plan must be prepared in accordance with a process defined by the Environment Protection Authority (EPA).

Both the Mildura Rural City Council and the Mallee Catchment Management Authority have recognised a need to improve urban stormwater management, and this has resulted in the Urban Stormwater Management Plan component of the Project.

The Plan will be shorter term and more operationally based program than the Strategy, and will focus on urban areas.

Elements of Plan preparation include:

- Identification of stormwater threats;
- Identification of environmental values;
- Risk assessment;
- Development of management frameworks and strategies; and
- Development of an implementation framework and plan.

1.2 Issues Paper 1 - Background

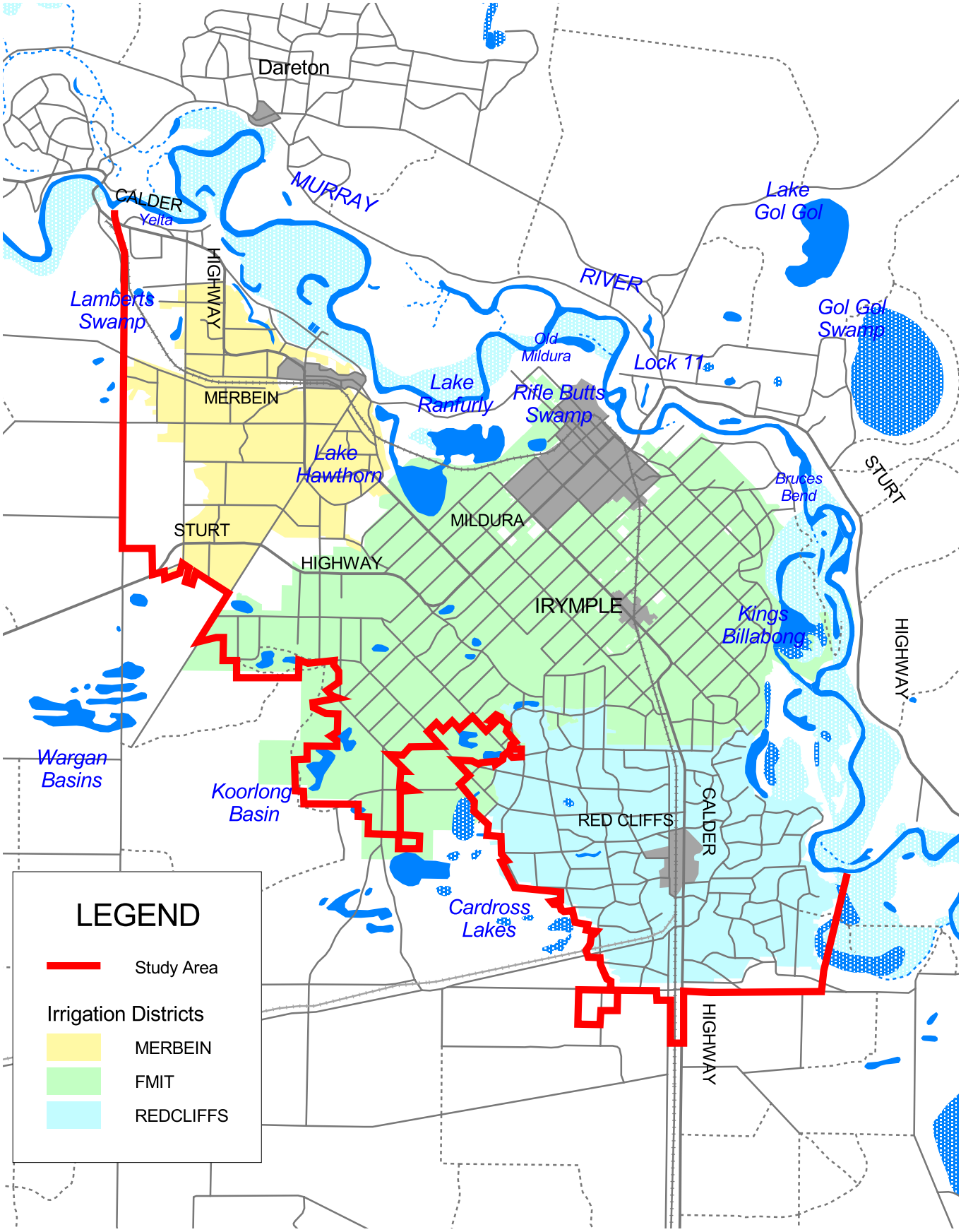
This Issues Paper is the first in a series of Papers that will be produced during the course of the Project. It draws together much of the background information that will provide the basis for development of both the Strategy and the Plan, and is a requirement of the EPA's process.

1.3 Study Area

The Study Area is shown on Figure 1-1. It includes:

- The urban centres of Mildura (current population 25,000), Merbein (3,000), Irymple (2,000) and Red Cliffs (3,000);
- First Mildura Irrigation Trust, Red Cliffs and Merbein Irrigation Districts (total area 15,000 ha);
- Old Mildura, Bruce's Bend and Yelta irrigation areas (700 ha). These are serviced by private diversions from the Murray River; and
- Irrigated areas served by groundwater bores to the south west of Merbein (160 ha), and irrigation development under the Nyah to South Australian Border Salinity Management Plan (170 ha).

FIGURE 1.1 - STUDY AREA



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2. Drainage System

2.1 Introduction

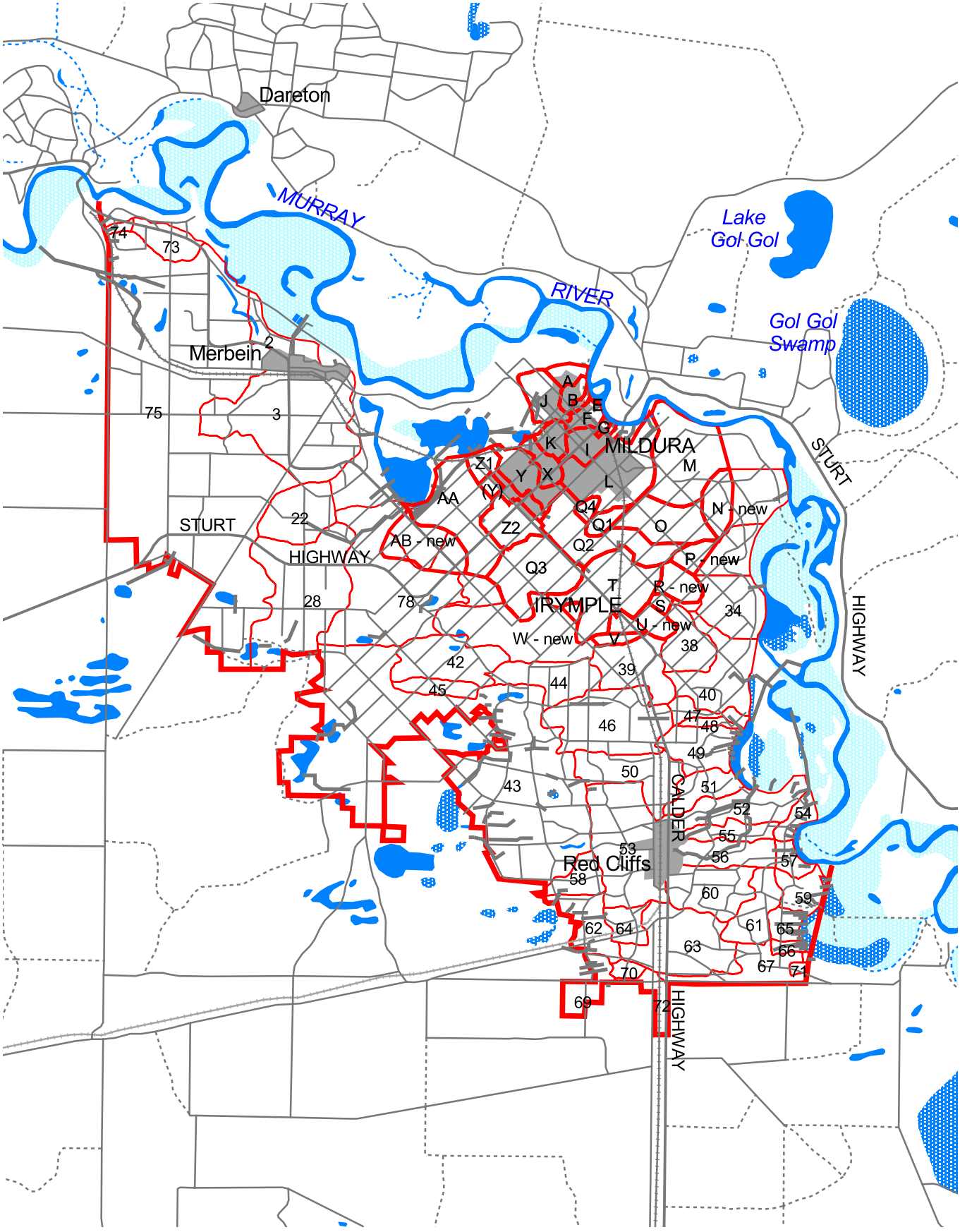
Existing drainage systems serving the Study Area are summarised in the following sections. Further details of catchment areas and disposal locations are provided in Issues Paper No 3 – 2050 Scenario.

All four urban areas being Mildura, Irymple, Red Cliffs and Merbein, are serviced by piped drainage systems. There are relatively few surface stormwater drains in the rural areas. Surface drainage catchments for the urban and rural areas are shown in Figure 2-1.

Much of the irrigation area is serviced by subsurface drains, which discharge to either the Murray River, or inland basins and lakes. Subsurface drainage catchments for the irrigation area are shown on Figure 2-2.

A schematic of the total drainage system is presented as Figure 2-3.

FIGURE 2.1 - SURFACE CATCHMENTS (URBAN AND RURAL)



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LEGEND

- Rural and Urban Surface Catchments
- Drainage Outfalls
- Study Area

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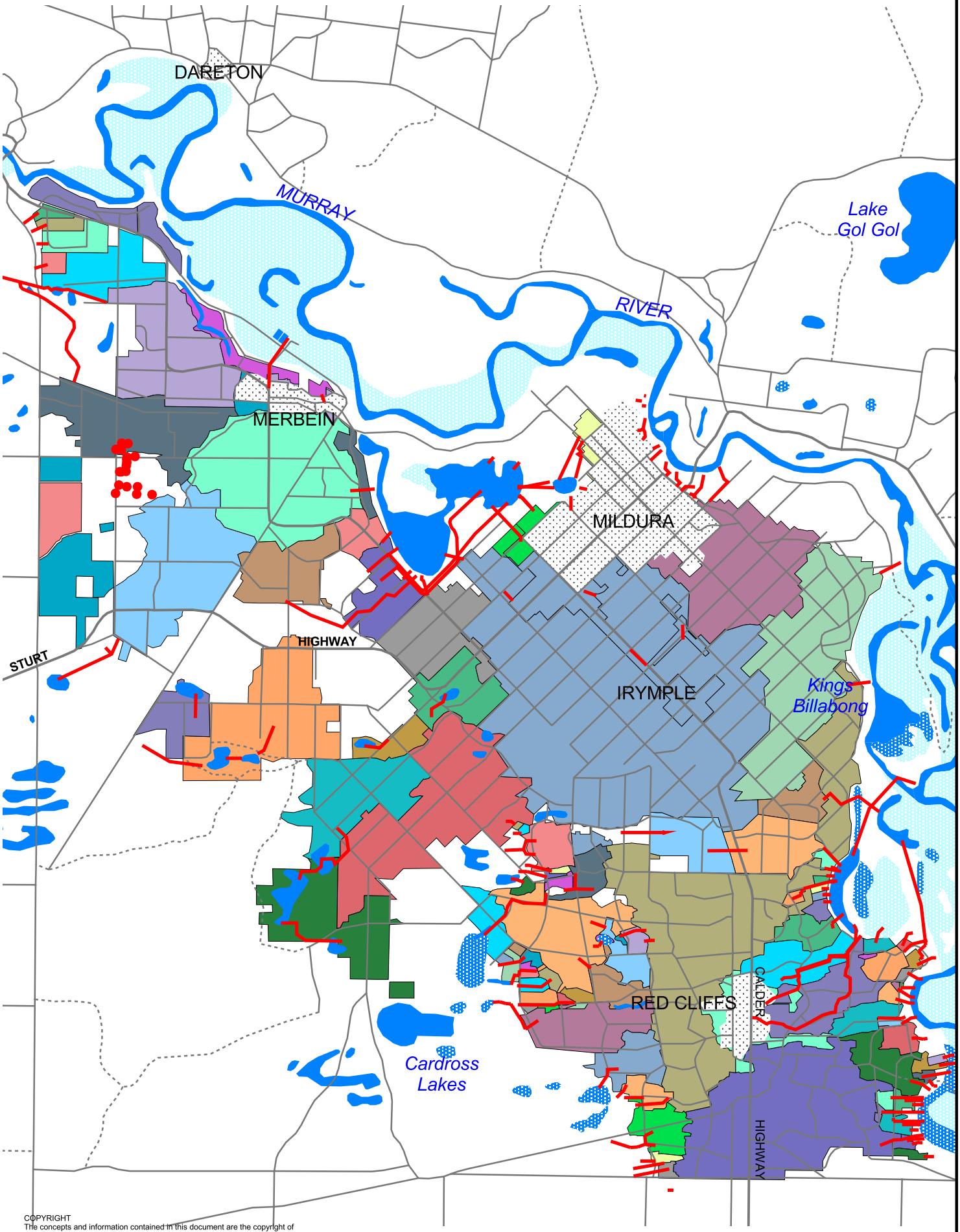
FIGURE 2.2 - SUBSURFACE CATCHMENTS



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Drainage Shafts

Drainage Outfalls

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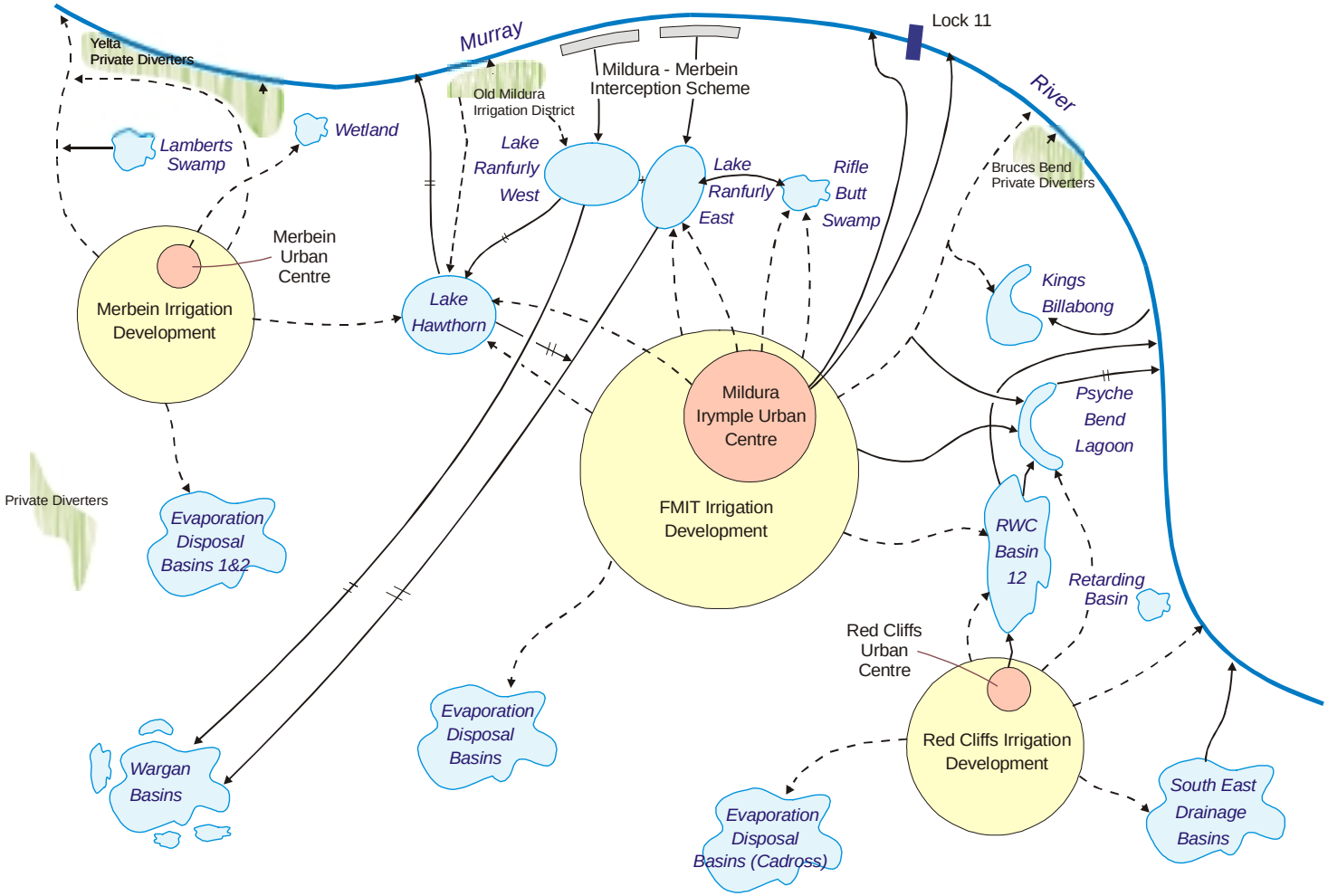
■ **Figure 2-3 Schematic of the Drainage System**



2.2 Urban Stormwater Drainage Systems

2.2.1 Current System

This section provides an overview of the Urban Stormwater Drainage System. It draws on data outlined in the Current Situation Report (2001), and presents the design basis of the existing drainage system. In addition a brief analysis has been undertaken of historic rainfall runoff events and current design standards.

A brief summary of the stormwater system for the four key urban areas is presented below:

Merbein
The stormwater system for Merbein is adequate, except for an area to the west of the town where some works are required. Virtually all stormwater is piped to the floodplain north of the township where it discharges into an open drain, outfalling to a low wetland without any direct connection to the river.

Mildura /Irymple
The most significant urban stormwater outfall drains are the San Mateo and Etiwanda Avenue drains that service 75-80% of the urban areas in the 9 drainage catchments discharging to the River. A further four drainage catchments (Riverside, Tenth Street, Fourteenth Street, Fifteenth Street) discharge into Lake Hawthorn, Lake Ranfurly East or Rifle Butts Swamp. The Fifteenth Street drainage catchments rely largely on retardation basins and pumping stations within subdivisions to pump stormwater into the above water bodies. It has been suggested that works may be required to upgrade the Fifteenth Street drain between San Mateo Ave and Lake Ranfurly due to pipe deterioration.

Council works over the past 15 years have augmented the stormwater drainage system on a case-by-case basis, with design solutions being developed with respect to catchments. The lack of augmentation of the main drainage system within the urban areas over the past 15 years has required the development of retention/retardation basins to store stormwater. Stormwater is discharged by pumping into the above lakes and swamps.

Red Cliffs
All stormwater generated by the urban area is discharged into Basin 12 and Psyche Bend Lagoon; via two separate drains, both of which collect irrigation and stormwater. This water is then discharged into the Murray River. Given that little urban development is occurring in Red Cliffs (12-15 dwellings over the past 3 years), the stormwater system appears to be adequate, apart from some areas where minor works are required.

Council's assessment of the stormwater system is that because of the topography and the design constraints of the existing infrastructure, some works will be required to rectify the current capacity of the stormwater infrastructure.

Table 2-1 presents a summary of the urban drainage systems for Merbein, Mildura/Irymple and Red Cliffs. A detailed breakdown of this information by drainage sub-catchment is presented in Issues Paper No 3 – 2050 Scenario.

■ **Table 2-1 Summary of Urban Systems**

Location	Total Area (Ha)	Current Developed Area (Ha)	Annual Discharge Volume (ML)
Merbein [1]	145	145	80
Mildura / Irymple	5,608	1,609	2,824
Red Cliffs [2]	285		227

Notes 1. Merbein stormwater all drains to floodplains.
2. Red Cliffs stormwater drains to Basin 12 (via floodplains)

2.2.2 Design Basis

Existing urban drainage design standards are discussed in Issues Paper No 3 – 2050 Scenario.

2.2.3 Analysis of Mildura Airport Pluviograph

The data from a number of recent rainfall events recorded at the Mildura Airport pluviograph were compared to the design rainfall depths obtained from Australian Rainfall and Runoff, which is the current Australian standard for design of drainage systems. The pluviographic rainfall data (aggregated to hourly time steps) was analysed over the period 1954 to 1998. The plots, presented in Appendix A, indicate that the design standard might underestimate design flows for infrequent, short duration storm events. By contrast, however, the design standard might overestimate design flows for longer duration storm events, and for frequent storm events of all durations.

Over the period analysed, the largest ten storm events occurred either prior to 1964 or after 1989, viz. none of the largest ten events occurred during the twenty-five years from 1964 to 1989. Local perceptions that rainfall intensities are increasing may therefore have been influenced by the relative scarcity of large storms in the twenty-five years prior to 1989.

2.3 Irrigation Drainage Systems (Rural)

2.3.1 Current System

This section provides an overview of the Irrigation Drainage System. As discussed, the majority of the irrigation area is serviced by subsurface drainage that interconnects into a comprehensive drainage network (refer to Figure 2-3). Most of the irrigation drainage is discharged either directly or indirectly to the River Murray, or to the multitude of inland evaporation basins. However, there are some irrigated areas that still dispose to drainage shafts (or disposal bores).

The majority of the irrigators in the Study Area fall within the Irrigation Districts of Merbein, Mildura and Red Cliffs, which are managed by the Sunraysia Rural Water

Authority (SRWA) and First Mildura Irrigation Trust (FMIT). There are also a number of smaller pockets of private diverters located along the Riverfront and in Red Cliffs (draining to evaporation basins). Table 2-2 presents a summary of the irrigation drainage systems for the Study Area by location and Authority. A detailed breakdown of this information by subsurface drainage catchment is presented in Issues Paper No 3 – 2050 Scenario. In recent years there has been a notable decrease in drainage flows from the irrigation areas. These flows have been analysed in some detail as part of the salt and water balance carried out by Sinclair Knight Merz on drainage into Lake Ranfurly (east and west), Lake Hawthorn and Wargan Basins (refer to Section 4.2 for further details).

■ **Table 2-2 Summary of Irrigation Drainage Systems**

Location/Authority	Total Area	Actual Irrigated Area (ha)	Annual discharge volume (ML/yr)	Annual Salt Load (t/yr)
SRWA (Merbein)	3565	2718	3805	4566
SRWA (Red Cliffs)	5435	3826	5357	6427
Total SRWA	**9000**	**6544**	**9162**	**10993**
FMIT	**11597**	**6281**	**8794**	**10554**
Yelta Irrigators	461	359	502	603
Merbein Irrigators	1062	416	578	693
Mildura / Red Cliffs Irrigators	-	1381	1933	2320
Total Private Irrigators	**-**	**2156**	**3013**	**3616**
Total Draining to Basins			**11167**	**13401**
Total Draining to River			**9801**	**11761**
GRAND TOTAL			**20969**	**25163**

2.3.2 Design Basis

Existing drainage design standards for subsurface drainage systems are discussed in Section 6 of Issues Paper No 3 – 2050 Scenario. Issues Paper No 3 also further documents the current crop types and irrigation methods.

2.4 Rural Surface Catchments

There is currently very limited surface stormwater drainage infrastructure in rural areas within the Sunraysia Region. Water draining from roads and properties tends to pool in localised areas and infiltrate through the soil profile. Due to this lack of infrastructure, flooding has been highlighted as an issue at a number of locations.

Existing design standards for rural surface drainage are discussed in Issues Paper No 3 – 2050 Scenario.

2.5 Regional Groundwater Status

2.5.1 Geological Description of the Study Area

The geological subregion containing the Sunraysia irrigation districts is part of the Murray Groundwater Basin, which consists of unconsolidated sediments of Tertiary

Age or younger, which are also mostly saturated with water. The sediments relevant to the Sunraysia irrigation region, which contain the groundwater systems influenced by irrigation accessions or the River Murray, are:

- Parilla Sands;
- Blanchetown Clay;
- Alluvial Sediments; and
- Aeolian Units

Parilla Sands

The Parilla Sand aquifer system is extensive across the Sunraysia irrigation district and is the principal aquifer system for the region. The unit is variable in thickness, consists of medium-grained sand in most locations and is often bound by a clayey upper section. It was deposited in a marine environment approximately 5 million years ago.

Salinity in the Parilla Sand can vary considerably, ranging from 10,000 to 50,000 EC units depending on geological, River Murray and irrigation influences. The Parilla sand aquifer system is the major source of saline water that enters the River Murray at various locations along its course.

Blanchetown Clay

The Blanchetown Clay is a layer of clay that overlies the Parilla Sand directly, except where it has been removed by river erosion or was not deposited on the structural highs. It is a significant hydrological unit within the regional groundwater system as it provides a semi-confining layer (aquitard) to the Parilla Sand and thus results in the retardation of vertical flow to the Parilla Sand from irrigation accessions. The thickness of the Blanchetown Clay confining layer or aquitard, varies greatly ranging from zero to in excess of 50 metres across the Sunraysia irrigation region.

Alluvial Sediments (Channel Sands)

As the River Murray has changed its course overtime it has incised a trench into the surrounding landscape. This has resulted in the deposition of alluvial sediments (sands) within this trench. The geological unit formed within this trench consists of a medium to coarse sand approximately seven to ten metres thick which is overlain by floodplain clays and silts three to four metres thick. This sand unit is generally referred to as the Alluvial Aquifer or the Channel Sand Aquifer and is in direct connection with the Murray River. The flood plain areas in the Sunraysia region are also located within the incised trench.

Salinity within the Channel Sand aquifer is variable from 10,000 to 50,000 EC but is usually fresher than the Parilla Sand due to River Murray flood flows which often recharge the alluvial system providing a relatively fresh zone in the aquifers immediately adjacent to the river.

Within the Sunraysia irrigation area the extent of alluvial sediments is not large, however, they area still significant to the analysis of groundwater levels and salinities due to their connection with the River Murray.

Aeolian Units

Wind blown Aeolian units, the Woorinen Formation and the Lowan Sands, cover much of the Sunraysia irrigation area. Both these units are reasonably free draining and are suited to horticulture enterprises. However, in some areas the units are clay rich and drainage is required to prevent waterlogging in these areas from occurring.

These aeolian units are not a prominent part of the regional groundwater system in the Sunraysia irrigation area but they are important for localised salinity impacts associated with perched watertables. Many of the localised salt issues are related to the perched systems.

2.5.2 Groundwater Status prior to European Settlement

Within the dryland areas of Mildura, the regional watertables were generally 15 to 20 metres below the ground surface, and the groundwater levels below the Mildura irrigation area would have probably been the same prior to irrigation (SSMP, 1991). On the basis of these assumptions the groundwater levels would have been approximately 35 metres above sea level. Groundwater salinity, away from the influence of the River Murray, would have been at similar levels to what exists now. However, groundwater salinity levels close to the river would have fluctuated depending on river levels (ie. high river levels would have recharged the adjacent groundwater systems with fresh water), while in low flow conditions groundwater systems would have discharged to the River Murray, inturn increasing its salinity.

2.5.3 Recent Groundwater Status

Irrigation within the Mildura area has resulted in the formation of a regional groundwater mound beneath the irrigated and urban areas. Irrigation has also caused the development of perched water tables, which subsequently recharge the regional groundwater mound. In 1987, the mound in the regional groundwater system was 10 to 15 metres higher than the pre-determined levels prior to European settlement. The development of this mound has caused salinity problems by forcing highly saline groundwater into the River Murray and to the adjacent dryland areas resulting in groundwater discharge and land salinisation.

To offset the impact of this growing regional mound on the River Murray, the Mildura-Merbein Groundwater Interception Scheme was constructed in 1981. The scheme was upgraded in 1991. The scheme operates along a 15km reach on the Victorian side of the river between the townships of Mildura and Merbein. Groundwater intercepted by the scheme is pumped to the evaporation basins Lake Ranfurly East and West before being transferred further inland to the Wargan Basins. The combined savings of the Mildura-Merbein and Buronga (which operates on the adjacent New South Wales side of the river) is up around 35 EC/yr. Both Schemes are the main focus of a MDBC investigation currently being managed by the Department of Land and Water Conservation. A brief discussion of this investigation is presented in Section 4.2.

Salinities in some sections of the groundwater mound are less than historical levels due to the relatively low salinities of drainage water accessions compared with the regional groundwater system levels. A water and salt load balance between irrigation and groundwater discharge substantiates this status. The salt and water balance

approach used in the development of the Sunraysia SMP revealed that more water is entering the area than leaving, while more salt is generally leaving than entering via irrigation water. This would suggest that the regional groundwater system is contributing substantially to the total salt load discharge (SSMP, 1991).

Studies of groundwater levels and salinity in the southern parts of the Mildura urban area from mid 1993 onwards have identified that water levels in Parilla Sand Aquifer (or regional groundwater mound) have remained fairly constant. However, at one of the groundwater investigation sites (Walnut Park), the perched shallow watertable is within two metres of the surface, potentially causing localised salinisation impacts.

3. Water Quality and Quantity Data

3.1 Existing Data

This section provides a broad overview of the existing monitoring data available for the drainage and groundwater systems in the Sunraysia region. Through the Salinity Management Planning framework the region has been able to develop and maintain a relatively comprehensive irrigation drainage monitoring network. In common with most other urban areas in Australia, unfortunately the same cannot be said for the stormwater monitoring network. Prior to 2000 there was no monitoring of stormwater events. The situation has improved slightly with spot monitoring being carried out as part of the Waterwatch Program, and the installation of a continuous (gamet sampler) water quality and quantity monitoring site to capture stormwater events.

3.1.1 Urban Water Quality Data (Waterwatch, Mallee CMA)

Table 3-1 presents the available water quality data measurements recorded from the urban drainage system as part of the Waterwatch Program.

■ **Table 3-1 Available Water Quality Data (Urban Drainage Systems)**

Site	Parameters	Frequency	Commenced recording data	End Date
Etiwanda Stormwater Drain	EC, Ophos, pH, Turb	Spot data	07/12/00	Current
Stormwater Drain near Mildura Boat ramp	EC, Ophos, pH, Turb	Spot data	07/12/00	Current
Stormwater Drain near Ornamental Lake	EC, Ophos, pH, Turb	Spot data	07/12/00	Current
Stormwater Drain at the Rowers	EC, Ophos, pH, Turb	Spot data	07/12/00	Current
Stormwater Outfall near Old Mildura Homestead	EC, Ophos, pH, Turb	Spot data	07/12/00	Current

The Mallee CMA has also recently purchased an auto sampler. The CMA is also coordinating the use of the sampler by local agencies. The sampler is situated on the Etiwanda drain. It has 24 one-litre bottles that can be used in a given sampling sequence. These samples must be couriered to Melbourne within 24 hours to AWT for analysis. There has been only one set of data collected by the sampler to date.

3.1.2 Rural Drainage Monitoring

Table 3-2 presents the available water quality and quantity data recorded from key irrigation drainage outfalls in the study area.

■ **Table 3-2 Available Water Quality and Quantity Data (Irrigation Drainage)**

Site ID	Site Name	Site Location	Parameter	Frequency	Commenced recording data	End Date
-	North West drain (upstream)	Merbein	salinity	Weekly	10/8/83	current
-	North West drain (u/s levee)	Merbein	salinity	Weekly	9/9/83	current
414706	North West drain (downstream)	Merbein	flow	Continuous	2/11/83	current
			salinity	Continuous	3/8/83	current
			flow	Weekly	2/11/83	current
			salinity	Weekly	3/8/83	current
			Nutrients [1]	Fortnightly	29/3/95	current

Site ID	Site Name	Site Location	Parameter	Frequency	Commenced recording data	End Date
414701	West drain (upstream)	Merbein	Flow	Continuous	18/6/83	current
			Flow	Weekly	18/6/83	current
			Salinity	Weekly	20/7/83	current
414708	West drain (downstream)	Merbein	Flow	Weekly	20/7/83	6/30/99
			Salinity	Weekly	20/7/83	current
-	Lamberts Swamp	Merbein	Level	Weekly	20/7/86	current
			Salinity	Weekly	3/8/83	current
414707	Lamberts Swamp Outfall	Merbein	Flow	Continuous	10/2/84	current
			Salinity	Continuous	9/9/83	current
			Flow	Weekly	10/2/84	current
			Salinity	Weekly	9/9/83	current
414709	North drain (upstream of staff)	FMIT	Flow	Weekly	20/7/83	6/20/99
			Salinity	Weekly	30/7/92	current
414702	North East drain (at First Street)	FMIT	Flow	Continuous	17/6/83	current
			Flow	Weekly	17/6/83	current
			Salinity	Weekly	20/7/83	current
			Nutrients	Fortnightly	29/3/95	current
414710	North East drain (at Bruce's Bend)	FMIT	Flow	Weekly	20/7/83	current
			Salinity	Weekly	20/7/83	current
414711	Mid Area North drain	FMIT	Flow	Weekly	20/7/83	current
			Salinity	Weekly	20/7/83	current
414703	Drain No. 1	Red Cliffs	Flow	Continuous	18/6/83	current
			Flow	Weekly	18/6/83	current
			Salinity	Weekly	20/7/83	current
			Nutrients	Fortnightly	15/7/97	current
414712	Drain No. ¾	Red Cliffs	Flow	Weekly	20/7/83	current
			Salinity	Weekly	20/7/83	current
414704	Drain No. 5	Red Cliffs	Flow	Weekly	20/7/83	current
			Salinity	Weekly	6/8/92	current
414713	Drain No. 7	Red Cliffs	Flow	Weekly	20/7/83	current
			Salinity	Weekly	20/7/83	current
414714 [3]	Drain No. 8	Red Cliffs	Flow	Weekly	20/7/83	current
			Salinity	Weekly	20/7/83	current
414705	Drain No. 10	Red Cliffs	Flow	Weekly	20/7/83	current
			Salinity	Weekly	20/7/83	current
414715	Basin 12 to Psyche Bend Lagoon	Red Cliffs	Flow	Continuous	20/7/83	current
			Salinity	Continuous	20/7/83	current
			Flow	Weekly	20/7/83	current
			Salinity	Weekly	20/7/83	current
-	Psyche Bend Lagoon at River	Red Cliffs	Level	Weekly	20/7/83	current
			Salinity	Weekly	20/7/83	current

1 - Water quality parameters are sampled for on a fortnightly basis are: SS, NOx, TKN, RP, TP (see below for description)
2 - Australian Water Technologies (AWT) undertakes laboratory analysis of water samples collected by either Kinim Contracting or RDWS
3 - continuous flow and salinity monitoring has been undertaken at this site by DNRE, however the data is not used for this project due to poor site maintenance and unreliable data

SKM also undertook some water quality analysis for Rifle Butts Swamp, Lake Ranfurly and Lake Hawthorn in 1997/1998 as part of the Land Capabilities and Infrastructure assessment for SunRISE 21.

3.1.3 Groundwater Monitoring

There are 261 groundwater-monitoring sites still operational in the study area. Kinim Contracting undertakes recording at these monitoring sites, with records taken of monthly WLTC (Water Level Top of Casing). There are also 246 abandoned groundwater bores. The locations of the groundwater monitoring sites (along with other monitoring sites) are shown on Figure 3-1. There are also 181 groundwater bores on the MMGIS, which are monitored monthly and three monthly.

3.1.4 Water Quality References

The following references also discuss water quality issues in the region.

Egis (1999). Mallee region surface water quality inception report. Report prepared by Egis Consulting for the Mallee Catchment Management Authority (July)

Mallee Catchment and Land Protection Board, June 1997, *Mallee Regional Catchment Strategy*

Mallee CMA, June 2000, *Mallee Waterway and Flood plain Management Strategies*

Read Sturgess and Associates, March 2001, *Cost Benefit Analysis of Nutrient Management Strategy Proposed for Mallee CMA Region*

Salinity Action Group, Nov 1991, *Sunraysia – draft salinity management plan*

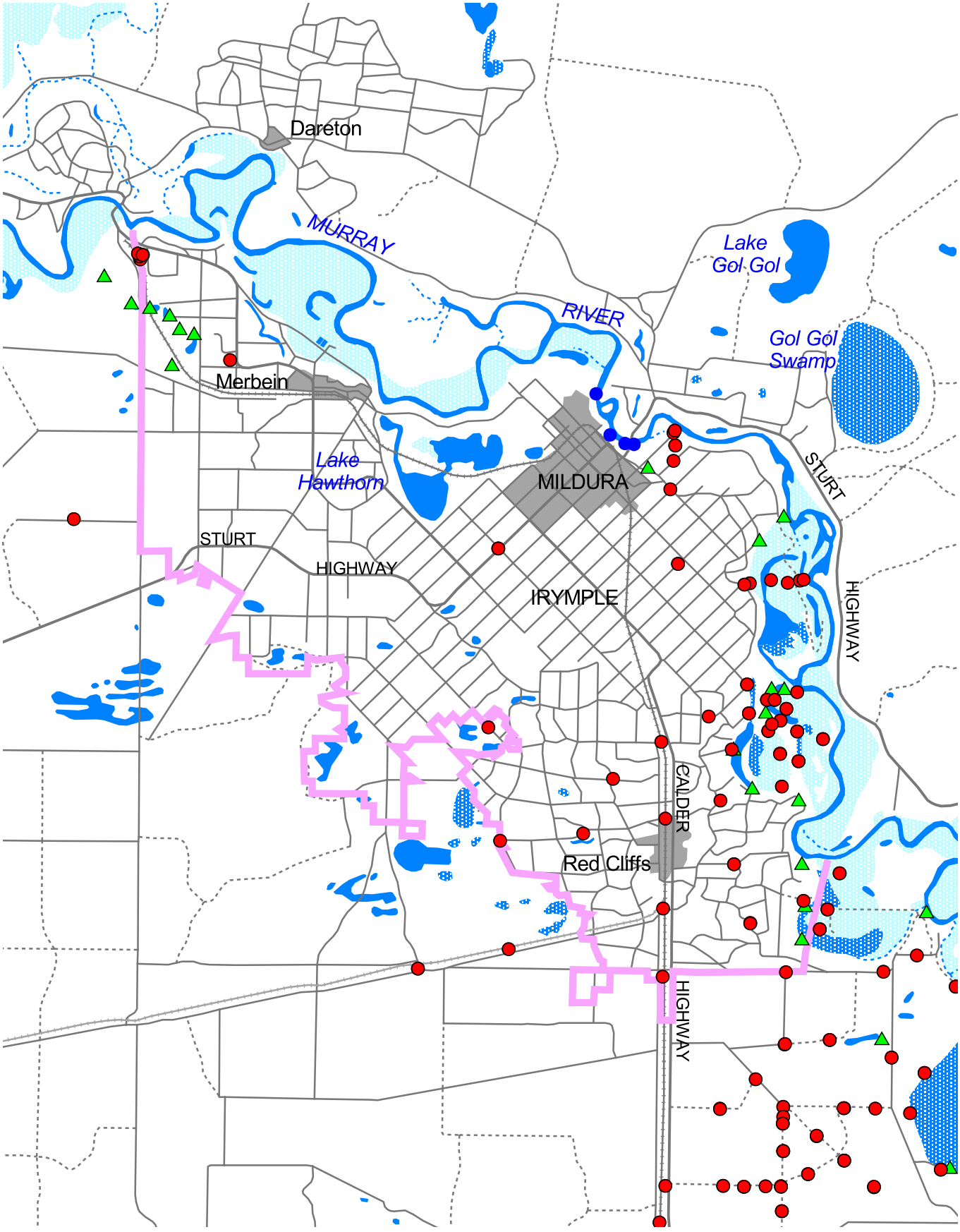
Shirley, M, Souter, N, and Lloyd, L, 1997, *Draft Management Plan for the Cardross Lakes System and the Associated Fish Assemblage. WATER ECOscience Report for the Cardross Lakes Task Group.*

SKM (In progress) on behalf of Mallee CMA. (draft WC01634), *Mallee wetlands Operational Plans*

SMEC (2000). Water quality management plan; investigation report. Report prepared by Snow Mountains Engineering Corporation in association with Lloyd Environmental Consultants for the Mallee Catchment Management Authority

SMEC (in association with Lloyd Environmental Consultants) August 2000, *Water Quality Management Plan – Investigation Report*

FIGURE 3.1 - MONITORING SITES



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LEGEND

- Waterwatch Sites
- Groundwater Sites
- Surface Water Sites
- Study Area

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3.2 Review of Water Quality Issues

Urban stormwater and irrigation drainage water is discharged to several key waterways and wetlands in the study area. These waterways and wetlands have significant environmental value in the region, providing a range of habitat types for flora and fauna. The following section provides a brief description of the water quality and environmental status of receiving waterways in the study area.

Water quality in the Murray River is generally considered to be poor with respect to nutrient concentrations but relatively good with respect to parameters such as dissolved oxygen, pH and salinity (Egis 1999). Nutrient concentrations often exceed the ANZECC and EPA nutrient guidelines. At Merbein, the ANZECC guideline for total nitrogen has been exceeded 38% of the time, and for total phosphorus 20% of the time, between 1976 and 1999 (SMEC 2000). Land use practices along the river contribute to increased nutrient concentrations with discharges from irrigation drains and urban stormwater the main sources of nutrient input around the study area.

Excessive nutrients coupled with low flow and warm temperature can contribute to the development of algal blooms. Thirty-one algal blooms have been recorded in the Murray River between 1991 and 1999 (Egis 1999). Blooms have been recorded in the Murray River at Mildura, Merbein, Red Cliffs and in the Mildura Weir Pool.

Several lakes and wetlands also receive stormwater and irrigation drainage water in the study area. There has been little routine monitoring of water quality in these lakes and wetlands, however, ad hoc monitoring suggests that nutrient concentrations and salinity are often elevated. Elevated salinity and nutrients are a consequence of the use of these lakes as drainage and evaporation basins for irrigation drainage water, and algal blooms have been recorded in many of these waterbodies (SMEC 2000).

Saline groundwater is also considered a risk to the Murray River, and groundwater interception schemes have been established to reduce the amount of saline groundwater entering the Murray River.

Although water quality in many of the drainage basins and wetlands in the study area is generally poor, many have high environmental value. The Murray River and other waterbodies in the study area provide important habitat for a range of aquatic fauna and water birds. For example, the Cardross Lakes, an irrigation drainage basin 15km south of Mildura, contains populations of several native fish species listed as threatened under the Victorian *Flora and Fauna Guarantee Act 1988* including a population of the Southern Purple-Spotted Gudgeon *Morgunda adspersa* (Shirley *et al.* 1997). On the other hand, the prime purpose of many of these waterbodies is for "disposal", and the environment that has developed around many basins is not necessarily "natural".

Further issues papers (particularly Issues Paper 2) will identify the values of environments receiving stormwater and irrigation drainage and identify the threats to those values from stormwater and drainage water.

4. Existing Plans, Strategies and Investigations

This section provides a brief overview of relevant existing natural resource planning documents and investigations that are currently being carried out in the region. Figure 4-1 diagrammatically presents the relationship between the Sunraysia Drainage Strategy and Urban Stormwater Management Plan, and other relevant strategies, plans and investigations. The Mildura Planning Scheme is discussed in Section 7.

4.1 Planning/Management Framework

Mallee Regional Catchment Strategy

The Mallee Regional Catchment Strategy was released in June 1997 by the former Mallee Catchment and Land Protection Board (now, 'Mallee Catchment Management Authority'). The Strategy provides a blueprint for integrating the management and protection of natural resources in the Mallee region. It outlines an approach to setting and achieving region targets and identifies opportunities for more efficient natural resource management. The Strategy touches on many aspects that will be considered as part of this study, from reducing water salinity to increasing the value of agricultural exports in an environmentally sustainable manner.

Mallee Waterway and Floodplain Management Strategies

The Mallee Catchment Management Authority has an overarching duty of care for waterway, floodplain, drainage and Crown frontage management in the Mallee region. To assist in the coordination and integration of these management responsibilities the Mallee Waterway and Floodplain Management Strategies document was prepared and released in June 2000. The Strategies identify all of the issues affecting waterway and floodplain health and provide a framework for implementation of waterway and floodplain management programs. The Strategies are based on ten-year planning horizons (MCMA, 2000).

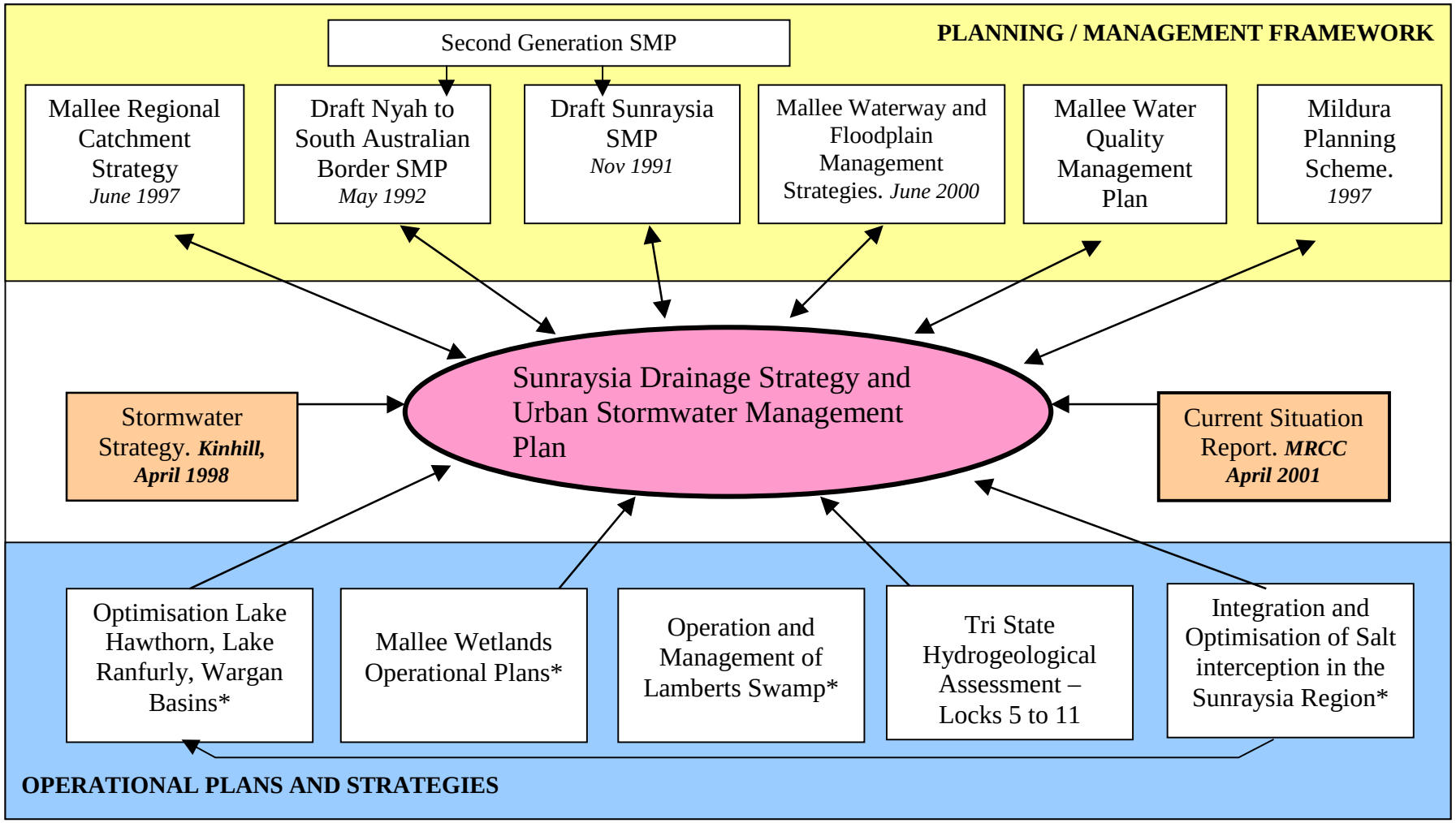
A key objective of the Mallee Waterway Strategy relating to 'Rural Surface Drainage' is:

- To ensure rural surface drainage is managed responsibly, with due regard for the protection of waterway and floodplain health' (MCMA, 2000).

Several objectives outlines in the Mallee Floodplain Strategy are relevant to this study. These include:

- To assess flood risk, and identify cost-effective measures to reduce flood risk, ensuring decisions are made at an appropriate level;
- To establish land use planning measures which minimise future flood risk and damage costs; and
- To ensure that decisions are made that balance the benefits and costs of implementing flood management measures, having regard for and respond to flood events (MCMA, 2000).

■ **Figure 4-1 Relationship between the SDS and USMP, and existing natural resource planning documents**



* Note: Studies currently in progress

Second Generation Salinity Management Plan

The Mallee CMA has recently embarked on the preparation of 'Second Generation Salinity Management Plans' for the dryland and irrigation areas of the Mallee region. The plans will supersede the existing irrigation and dryland salinity management plans. Similar plans are being prepared across the State.

The Plan will provide the overarching framework for Salinity Management across the Mallee Region. Its importance is heightened by the fact that it will be presented for accreditation under the Federal National Action Plan for Salinity Water Quality. If accepted, the Plan will provide the avenue through which future State and Federal funding will be directed. The Plans will feature sequential targets of five-year intervals until the year 2030. Cost benefit analysis will be conducted on a 30-year basis to reflect the changes since the original Salinity Management Plans. A key chapter being prepared under the Second Generation Salinity Management Plan for the Irrigation Area will specifically deal with the issue of 'Drainage'. It is essential that this study links into the strategic planning framework being developed by the Second Generation Plan.

Draft Nyah to the South Australian Border Salinity Management Plan

The Draft Nyah to the South Australian Border Salinity Management Plan (NSABSMP) was released for public comment in May 1992, and was subsequently endorsed by Government in August 1993. The Draft NSABSMP was prepared to specifically deal with the salinity problems associated with all private irrigation diverters along the River Murray between Nyah and the South Australian Border, with the exception of private diverters at Nangiloc-Colignan. The Plan itself has been relatively adaptive, taking into account changes in our understanding of salinity management over time. A handbook has been developed that provides a compilation of policy decisions made and relevant factual information obtained regarding the Salinity Management Plan since its release. Once complete, the Second Generation Salinity Management Plan will supersede the Draft NSABSMP.

Draft Sunraysia Salinity Management Plan

The Draft Sunraysia Salinity Management Plan was released for public comment in November 1991, and was subsequently endorsed by Government in December 1992. The Sunraysia SMP incorporates the irrigation districts of Robinvale, Merbein, Mildura (FMIT) and Red Cliffs. Key management programs initiated under the Plan include:

- River Murray Water;
- Water Supply;
- Irrigation;
- Drainage;
- Environmental Rehabilitation; and,
- Implementation and Monitoring.

Implementation of the Plan is considered to have been a significant driver in irrigation drainage reductions from the Irrigation Districts. Once complete, the Second Generation Salinity Management Plan will supersede the Draft Sunraysia SMP.

4.2 Operational Plans and Strategies

Sustainability of the Mildura Merbein Groundwater Interception and Lake Hawthorn Drainage Diversion Schemes

The objective of the study has been to review the operation of the Mildura-Merbein Groundwater Interception Scheme and the Lake Hawthorn Drainage Diversion Scheme, with a view to rationalisation and possible integration with NSW facilities. This has involved constructing a computer model of the Ranfurly/Hawthorn/Wargan system, with inputs from the groundwater interception scheme, urban and irrigation drainage. The model runs over a 25 years period at a daily time step. A number of system model runs have been undertaken, studying a range of options.

The drainage flows in the area have been analysed by statistical techniques, to determine if improved irrigation management techniques have reduced drainage volumes. It has been shown that after allowing for the effects of recent dry years, there is still a substantial reduction due to better management. The system model can run using these "present day" drainage flows, or flows more representative of the past.

Urban drainage flows for Year 2050 have also been generated using coefficients from the Kinhill Report, and maps of possible future urban development provided by Mr Ron Dudley. The draft report was delivered to Goulburn Murray Water in April 2001.

Integration and Optimisation of Salt Interception in the Sunraysia Region

The NSW Department of Land and Water Conservation, on behalf of the Murray-Daring Basin Commission, is in the process of tendering out an investigation into the integration and optimisation of salt interception in the Sunraysia Region. The project aims to identify a preferred option(s) for future salt interception taking into account the existing infrastructure in place in both NSW and Victoria. The project is to take a regional 'no borders' approach on developing the most efficient and effective means of reducing salt accessions to the River Murray. The investigation is due to commence in August with completion in early 2002. Options considered as part of the investigation may impact on the options to be considered as part of the Sunraysia Drainage Strategy and Urban Stormwater Management Plan.

Lambert's Swamp Water Balance

A water balance assessment was commissioned for Lambert's Swamp by the Sunraysia Rural Water Authority to determine whether the historical pumped disposal operation is no longer required. The assessment identified that the current "no pumping" operating regime for Lambert's Swamp is not sustainable. Water levels are rising and are reducing the flood attenuation capacity of the swamp. This will result in increasing the potential for more flooding of the adjacent road and associated salinisation impacts to occur. In addition, maintaining a higher operating level will cause adjacent groundwater levels to rise. This will potentially result in groundwater discharge in other areas. Higher groundwater levels may also reduce crop productivity on adjacent properties. Benefit/cost ratios for proposed alternative pumping and/or water diversion options were determined. This appraisal identified that the options could result in achieving a positive benefit/cost ratio and annual salinity benefits.

Follow up work for this project, in progress, includes final validation of the some key water balance flow component data and detailing the effects noted and possible solutions.

Mallee Operational Management Plans

The Mallee CMA is currently developing wetland operational plans for ten key wetlands within the CMA area. The emphasis of the operational plans will be on hydrological regimes and water management within wetlands to maintain and enhance their environmental values. This will include development of operational rules and identification of structures to appropriately manage water within the wetlands. The operational plans will maximise the ecological and biodiversity values of wetlands within the Mallee CMA area by:

- identifying recommended hydrological cycles for targeted wetlands
- making recommendations to enable the hydrological cycles to the implemented (eg inlet or outlet requirements)
- making recommendations to improve/enhance flora and fauna values of the wetland through fencing, revegetation and stock management,
- making recommendations to enhance the water quality of the wetland by managing salinity and nutrient levels,
- provide operational guidelines to ensure the appropriate management of the wetlands.

Sinclair Knight Merz has been contracted to develop operational management plans for Kings Billabong, Bullock Swamp, Karadoc Swamp and Heywoods Lake. These waterbodies are used for a variety of purposes including nature conservation, irrigation supply and irrigation drainage. The project involves the development of an operating regime for the wetlands to maintain or enhance their ecological values, while not compromising any other uses. Key stakeholders will be consulted about threats, values and issues for each of the sites. This project involves a combination of ecology, hydrology, hydrogeology and community consultation, as well as experience in the implementation of multi-criteria analysis.

The Mallee CMA will also be developing wetland operational plans for Lake Ranfurly and Lake Hawthorn towards the end of 2001. As both projects are investigating similar issues, the Sunraysia Drainage Strategy and Urban Stormwater Management Plan Project must consider the role of these wetland operational plans.

5. Ownership and Management Details

This section is broadly divided into two parts. Part 1 considers the roles and responsibilities of key stakeholders organisations and agencies in the region in relation to drainage management. Part 2 specifically focuses on the inland drainage basins and identifies the responsible authority for each basin.

5.1 Roles and Responsibilities

Table 5-1 presents a summary of the roles and responsibilities of key agencies and organisations.

5.2 Management of Inland Water Bodies

Table 5-2 provides a summary tabulation of ownership and management responsibilities, and key basin inflow source(s) for each major inland basin. Further details of all basins are provided in Appendix B.

5.2.1 Basins on Private Land

A number of basins are on private land and are owned and managed by a single authority. Rifle Butts Swamp, for example, is owned and managed by FMIT.

5.2.2 Basins on Crown Land

Many of the basins are located on Crown Land. Management of many of these was the subject of the Land Conservation Council's Final Recommendations for the Mallee Area (1977) and the review of these recommendations undertaken in 1989.

The 1977 report recommended that specific areas of Crown Land "*be used for the disposal of saline drainage water and, as far as possible, for nature conservation and recreation, and that they be reserved under section 14 of the Land Act 1958 and managed by the State Rivers and Water Supply Commission.*"

The 1989 report recommends as follows:

- That for a number areas of Crown Land used for drainage purposes, including Lamberts Swamp, Lake Hawthorn floodway, and the extreme western portion of Lake Ranfurly West:

  "*these drainage areas … continue to be used for those purposes approved by the government following publication of the final recommendations for the Mallee area in May 1977*".

■ Table 5-1 Roles and responsibilities of key stakeholder groups

Organisation/Agency	Roles and Responsibilities
Murray Darling Fresh Water Laboratories	The Lower Basin Laboratory is part of the Murray Darling Freshwater Research Centre and the CRC for Freshwater Ecology. It conducts research on aquatic ecosystems throughout the lower part of the basin, provides expert ecological advice on matters related to aquatic environments and participates as members on relevant committees in the region. It has no responsibility for assets or management of any systems.
Mallee Catchment Management Authority	The prime responsibility of the Mallee CMA is to ensure the health of the Mallee Catchment Region and the promotion of sound and productive land use practices. Responsible for management and protection of natural resources in the Mallee region of Victoria. Its role includes provision of services relating to waterway management, management of water quality and management of a regional drainage scheme. It also has the responsibility of advising State Government on the condition of the catchment and its natural resource related catchment Issues.
Department of Natural Resources and Environment	NRE is the lead state government department in natural resource management. NRE carries out research into farming and Land Use practices as they relate to land protection needs, promoting community education and implementing government policy.
Environmental Protection Authority	The EPA sets standards and broad policy objectives for environmental improvement and promotes and encourages actions to meet them. The Victorian Stormwater Action Program has been established by the EPA to encourage both effective funding and implementation of Stormwater Management Plans. The EPA process must be followed in order to gain accreditation of the Plan.
Department of Infrastructure	Oversees the statutory planning requirements of the State.
Mildura Rural City Council	Mildura Rural City Council is responsible for planning and development within their jurisdiction. It provides urban drainage facilities for urban Mildura, Irymple, Red Cliffs and Merbein.
Sunraysia Rural Water Authority	SRWA issues licences and delivers irrigation water to the districts of Merbein and Red Cliffs. It is also responsible for developing, managing and maintaining the physical infrastructure of the water delivery and drainage systems.
First Mildura Irrigation Trust	FMIT provides irrigation water and drainage facilities to the Mildura area.
Lower Murray Region Water Authority	LMWA services eight towns in the Northern part of the Mallee Region, providing urban water and sewerage services.
Goulburn-Murray Water	G-MW supplies bulk water to Sunraysia Rural Water Authority and hence to Lower Murray Water. First Mildura Irrigation Trust is also supplied and billed directly by G-MW. The Authority also has a role of agent to the Murray Darling Basin Commission in constructing, operating and maintaining MDBC assets in Victoria, including Lock 11 and Mildura Weir. G-MW also owns and operates the Mildura Merbein Groundwater Interception Scheme and the Lake Hawthorn Drainage Diversion Scheme.
Land Care and other community groups	Land Care groups work together to tackle a wide range of environmental issues, encouraging the community to work together.
Parks Victoria	A large portion of public land in the Mallee Region is incorporated in National Parks. Parks Victoria's interest is in maintaining these undisturbed areas.
Murray-Darling Basin Commission	Plan and implement various programs and on-ground works to improve natural resource condition and management at the Basin scale. The Murray-Darling Basin Ministerial Council is responsible for administering the cap on water diversions and other basin-wide policies. They also administer the salinity registers (as defined in the Basin Salinity Management Strategy).

- For a number of "*Drainage Basins within larger blocks of public land*", including Wargan Basins, Cardross Basins, RWC Basins 7, 8, 9 and 18, and RWC South East Drainage Basin:

  *"That portions of these areas actually used as evaporation basins and other allotments considered necessary for water management continue to be used for those purposes approved by the government following publication of the final recommendations for the Mallee area in 1977, and that those areas not considered necessary as evaporation basins or for water management become part of the adjacent public land and be managed by the Department of Conservation, Forests and Lands, except that for those areas of public land surrounding O195, O196 and O204 (*Wargan Basins*) and not required for salinity management purposes and not carrying native vegetation, consideration be given to their alienation (see Note 2 below).*

  Note 1: In 1977, these areas were set aside as relatively large parcels of land of which the drainage basins comprise only a small part. Council considers that the areas not required as drainage basins are integral parts of the surrounding public land and should be managed as such.

  *Note 2: These areas of largely cleared agricultural, land surrounding O195, O196 and O204 (*Wargan Basins*)…… may be required for , or affected by, water drainage works in the future, the extent of which has not been fully determined. The small parcels of native vegetation here should be protected."*

It should be noted that SRWA is a successor organisation of the State Rivers and Water Supply Commission, and NRE is a successor organisation of the Department of Conservation, Forests and Lands. Management arrangements for Wargan Basins are discussed further in Section 5.2.3. Section 14 of the Land Act 1958 has been repealed, and appears to have been replaced by a number of provisions of the Crown Land (Reserves) Act 1978, including:

> ***"4. Power to reserve Crown land for public purposes***
>
> (1) The Governor in Council may by Order published in the Government Gazette reserve by a general or particular description either temporarily or permanently any Crown lands which in his opinion are required for any public purposes and without affecting the generality of the foregoing for any or any combination of the following--
>
> (f) drainage and sewerage works;
>
> ***18. Management and control of reserved land***
>
> (1) The Governor in Council on the recommendation of the Minister given with the concurrence of the responsible Minister may by Order published in the Government Gazette place any land temporarily or permanently reserved under section 4 under the control and management of the Secretary, the Rural Water

> Commission, a person holding a licence issued under Division 1 of Part 2 of the **Water Industry Act 1994**, Melbourne Water Corporation, or Melbourne Parks and Waterways."

At the present time, it is generally understood by informal agreement that the discharging irrigation authority manages the waterbody below the waterline, and NRE undertakes management of the riparian zone and other surrounding Crown Land. It is not always clear what is meant by management in this sense, and for what purpose the water body is managed. It is unclear whether areas indicated in the 1989 LCC report as "*areas actually used as evaporation basins and other allotments considered necessary for water management"* have been clearly defined.

The Land Conservation Council's Recommendations also refer to wetlands on the wildlife reserve in the vicinity of Kings Billabong. The Recommendations state that *Kings Billabong* (and *Basin 12* and *Psyche Bend Lagoon*) be used:

"(a) primarily to conserve native animals, and for public education and recreation where this does not conflict with the primary aim and that:
(b) the use of waterways and pump installations to supply irrigation water to Mildura continue
(c) in the southern part of the area, the disposal of saline drainage water continue to be permitted for the time being,

and that it be permanently reserved under Section 14 of the Land Act 1958 and managed by the Fisheries and Wildlife Division."

There is a lack of detail in agreements between NRE and FMIT/SRWA regarding management of these water bodies for water supply and drainage purposes.

5.2.3 Mildura Merbein Groundwater Interception Scheme and Lake Hawthorn Drainage Diversion Scheme

The former Rural Water Corporation transferred responsibility of its assets to the various Rural Water Authorities in 1994. "The salinity mitigation and disposal works, including the land on which the works are situated, that are associated with the protection of water quality in the major waterways of the State and the River Murray, and comprising...Mildura-Merbein Seepage Interception works, including Lake Hawthorn Disposal Basins" were transferred to G-MW.

The *Wargan Basins* were set up as part of the Lake Hawthorn Scheme in the late 1960's (and as MMGIS in the 1970's) using State and/or Federal funds. The MDBC has funded some upgrades to the MMGIS since 1990, but does not control or own this scheme. While portions of the land at Wargan Basins are Crown Land reserved for Water Supply Purposes, G-MW manages much of this land. To the extent that its statutory powers allow, G-MW owns and operates, the Mildura Merbein Groundwater Interception Scheme (interception pumps, pipelines, valves, fittings, Ranfurly East and West Pump Stations and embankment etc), the Lake Hawthorn Drainage Diversion Scheme (Pump Station, pipelines, valves, fittings) and the Wargan Basins (Basins 1, 2, 3, 4, pt 5, pump stations etc).

Lake Ranfurly land is owned by MRCC. Council also manages the land surrounding the Lake. When the Mildura-Merbein Groundwater Interception Scheme was originally constructed, the former Shire of Mildura and SR&WSC entered into an agreement regarding Lake Ranfurly, by exchange of letters dated January 1984. This agreement included as follows:

> *"2. The Commission shall have full control over:*
>
> *(a) the water in Lake Ranfurly up to and including the level EL 35.00 metres; and*
> (b) *existing and future discharges into and flows from the Lake.*
>
> *3. The Commission shall remove from the Lake the quantity of water which is pumped into it by the Commission and shall also remove any surplus flows generated by Commission works."*

The ownership and management details of *Lake Hawthorn* are complicated. FMIT is the registered proprietor for a large section of the water body, while SR&WSC (now G-MW) holds freehold title over a small portion. G-MW currently manages the water level and is clearly stated as having the right to remove water from the Lake. G-MW however has no statutory role in the "management" of the Lake. The right of FMIT to store and remove water is not clear. There is also a section of college lease land, however the rights of this landowner with regards to the water body are not known.

Funding for the Schemes is provided 75% by the Victorian irrigators along the Murray, and 25% by the partners to the Murray Darling Basin agreement.

■ **Table 5-2 Summary of ownership and management arrangements of key inland water bodies**

Water Body	Land Tenure	Water Body Management	Key Inflow Source(s)	Receives Groundwater Inflows or Discharges to Groundwater	Notes/Comments
Rifle Butts Swamp	FMIT/MRCC	FMIT/MRCC	• Irrigation drainage • Urban stormwater	Receives groundwater	
Lake Ranfurly West	MRCC	MRCC/G-MW	• Mildura Merbein Groundwater Interception Scheme	Receives groundwater	G-MW has agreement with MRCC to manage water levels, as part of management of Mildura Merbein Groundwater Interception Scheme
Lake Ranfurly East	MRCC	MRCC/G-MW	• Mildura Merbein Groundwater Interception Scheme • Urban stormwater	Receives groundwater	G-MW has agreement with MRCC to manage water levels, as part of management of Mildura Merbein Groundwater Interception Scheme
Lake Hawthorn	FMIT/College lease	FMIT/G-MW	• Irrigation drainage • Urban stormwater	Receives groundwater	G-MW has right to pump water out of Lake Hawthorn, but no clear agreement with FMIT to manage water levels
Wargan Basins	GM-W/Crown Land Reserved for Drainage Purposes	G-MW	• Lake Hawthorn • Lake Ranfurly East and West	Discharge to groundwater (minimal)	
Lamberts Swamp	Crown Land Reserved for Drainage Purposes	SRWA	• Irrigation drainage • Rural stormwater	Receives groundwater	
Koorlong Basins	FMIT	FMIT	• Irrigation drainage	Receives groundwater	
Cardross Lakes	Crown Land Reserved for Drainage Purposes	SRWA	• Irrigation drainage	Discharges to groundwater	
South East Drainage Basin	Crown Land Reserved for Drainage Purposes	SRWA	• Irrigation drainage	Receives groundwater	
Kings Billabong	Crown Land Wildlife Reserve	FMIT	• Irrigation supply from Murray River • Irrigation drainage	Discharge to groundwater	
Basin 12	Crown Land Wildlife Reserve	SRWA	• Irrigation drainage • Urban stormwater (Red Cliffs)	Discharges to groundwater	
Psyche Bend Lagoon	Crown Land Wildlife Reserve	SRWA/FMIT	• Irrigation drainage • Basin 12 overflows • River Murray flood flows	Receives groundwater	

6. Cost Recovery Framework

6.1 Sunraysia Rural Water Authority

SRWA obtains funds for replacement and maintenance of assets through the rates and charges levied on its customers. Whilst a specific drainage rate is charged, this has historically underestimated the true costs of operating and maintaining the drainage system. This was of little real consequence to the total business however, as the total irrigation supply and drainage rate was a true reflection of the business' total operating costs. Therefore in effect the irrigation supply charge has subsidised operation of the drainage system. Rates for the current financial year (2001/02) have been adjusted to provide a more accurate cost of providing both irrigation supply and drainage services. A "full" drainage rate is payable by irrigators with access to the formal drainage system. A "part" rate is payable by irrigators without access to the formal system, on the basis that most drainage water will eventually end up in the drainage system anyway. Rates are currently as follows:

Merbein, full	$16.31/ML
Merbein, part	$12.00/ML
Red Cliffs, full	$19.66/ML
Red Cliffs, part	$12.80/ML

The amount spent each year on operations, maintenance and administration associated with the drainage network is currently as follows:

- Merbein $358,000
- Red Cliffs $543,000

The amount set aside each year for future renewals is currently as follows:

- Merbein $102,000
- Red Cliffs $235,000

The authority also sets aside $20,000 each year in each of the two districts for minor drainage replacement works.

There has been very little expenditure to date on drainage renewals, as most drainage pipes are currently well within their 80 year estimated design life. Renewals to date have generally been limited to piping short sections of high maintenance open drains. Major expenditure on drainage renewals is not expected for some 30 years.

Amounts set aside for renewals have generally been based on replacement of existing gravity systems, many of which are up to 10 metres deep. In reality, these would more than likely be replaced by much shallower pumped systems, so the amount allowed for renewals should be more than adequate. Renewal amounts for each asset are calculated based on estimated remaining design life, adjusted to account for historic maintenance.

6.2 First Mildura Irrigation Trust

FMIT charges a drainage levy based on irrigators actual water entitlement. These funds are used to support all drainage activities. The annual expenditure on operation, maintenance and administration of drainage activities was $91,000 for 2000/01 and $133,000 for 1999/2000.

To date there have been no renewal works carried out on the drains. There is a capital works program in place, however the board is in the process of developing a rationale to determine the amount that should be set aside for future renewals.

6.3 Mildura Rural City Council

Mildura Rural City Council's expenditure on drainage works over the past five years has been approximately as follows:

- Operations and maintenance $1.13 million ($226,000 per year)
- New capital works $0.75 million ($150,000 per year)
- Renewals $0.30 million ($60,000 per year).

Up until early 2001, Council was charging developer's contributions at the following rates:

- Urban $16,200 per ha where pumping not required
  $29,500 per ha where pumped disposal required
- Rural residential $11,300 per ha.

These charges were intended to cover the capital cost of all off-site drainage works. Developers are responsible for constructing all on-site works (viz drains, on-site basins, etc) at their own cost.

In recent months Council has moved to charging developers for drainage works under Section 173 of the Planning Act. These contributions are voluntary, and subject to agreement with the developer prior to issue of a planning permit. The contribution rates are determined on the basis of drainage concept designs and associated cost estimates prepared by Council engineering staff.

7. Council Management Framework

7.1 What does the MSS say about stormwater management, rural drainage and flooding?

Specific reference to stormwater management has not been identified as planning or development issue within the strategic directions identified within the Mildura Municipal Strategic Statement. However Section 21.04-3 Environment deals with the issue of flooding and drainage. It states as one of the major problems being: -

> *The high salinity and nutrient levels within the Murray River are exacerbated by saline water discharges, drainage from irrigated and urban areas and the diversion of less saline water upstream for agricultural usage. Accordingly, the key solution in arresting rising salinity and nutrient levels in the river is to control the water table and the drainage of saline and nutrient rich water from the irrigation and urban areas.*

This Environment section addresses the issue of flooding and drainage by nominating strategies and future work to be completed. Relevant strategies identified within objectives 1 to 5 of this clause include:

- Except where recommended under the relevant Salinity Management Plan, discourage the discharge of irrigation run-off directly into the Murray River and its tributaries.
- Discourage the development of drainage evaporation ponds in wetlands and floodplain areas.
- Discourage development on salinity discharge areas.
- Maintain and improve the condition of waterways and wetlands to achieve acceptable water quality standards and protection of flora and fauna habitats.
- Encourage location of services to private cleared land in both dryland and irrigated areas, rather than on roadsides.
- Avoid any further development, particularly residential development within areas on the floodplain.
- Restrict further development in flood fringe areas.
- Facilitate the development and adoption of common river management controls along the Murray River.
- Encourage drainage works and schemes that redirect rainfall run-off, minimise irrigation drainage and assist in the reduction of salinisation of land.
- Limit nutrient level increases in ground water and water systems.

To assist in this drainage and flooding issue Council identified the need to prepare a waterways, rural drainage and floodplain management strategy to address issues including mitigation, monitoring and statutory planning responses. The Sunraysia Drainage Strategy and Urban Stormwater Management Plan will progress Councils strategies in this area.

7.2 Urban Strategy

The Mildura Planning Scheme has established a strategy for the future residential development of all urban areas, based on development rates that applied when the planning scheme was formulated in 1997.

An urban hierarchy has been developed, which nominated Mildura as being the key service centre for the region, with Irymple, Merbein and Red Cliffs accommodating local development.

The strategy is that Mildura will accommodate a large proportion of the future population growth for the region, which will require approximately 20 hectares of serviced residential land to be developed each year (1997 estimate).

The *Current Situation Report – December 2000* identified that Mildura has experienced an average development rate of 40 hectares per annum since 1986. Whether this trend continues is unknown.

The State Planning Policy Framework (Clause 14.01 Planning for Urban Settlement) states that:

> *Planning authorities should plan to accommodate projected population growth over at least a 10 year period, taking into account of opportunities for redevelopment and intensification of existing urban areas as well as the limits of land capability and natural hazards, environmental quality and the costs of providing infrastructure.*
>
> *In planning for urban growth, planning authorities should encourage consolidation of existing urban areas and especially higher density and mixed-use development near public transport routes.*

The residential *land bank* (630 hectares) has been provided for in three distinct areas, based on a sequence of stages and are identified in the Strategic framework plan for Mildura. These extensive residential areas of Mildura are to be developed in a co-ordinated manner with relevant infrastructure authorities and development is also to be designed to protect the integrity of surrounding rural activities and areas. Appendix 1 contains framework plans for Mildura, Irymple, Merbein and Red Cliffs.

Clause 21.04-2 Settlement identifies the urban strategies and stages of development for Mildura. These stages are:

- Stage 1 - approximately 80 hectares of vacant land zoned Residential 1 that has immediate access to all services.
- Stage 2 - approximately 400 hectares of vacant land zoned Residential 1 that has some but not all services.
- Stage 3 - approximately 150 hectares of land zoned Rural that has been nominated for future residential development.

The development of each successive stage can only occur once 50% of the existing stage has been fully developed. The residential strategy also seeks to:

- Retain the framing of the Rural City's towns by agricultural activity. The adoption of urban growth boundaries to clearly define the limits of urban growth is considered important to achieve this outcome.
- Ensure all forms of residential, commercial and industrial development are located and managed to minimise the impacts of potentially conflicting land uses.
- Ensure that new development does not compromise the integrity, function or appearance of historical sites and key natural and built features that provide the Rural City with a sense of identity and unique character.

Other relevant strategies that have been nominated with respect to urban development include:

- Adopt and implement urban growth boundaries to clearly define the limits of urban growth in the municipality's major townships, utilising soil capability, roads, natural features and the efficient provision of infrastructure to define such areas.
- Promote infill residential development in appropriate areas.
- Encourage the framing of the Rural City's towns by productive agricultural and horticultural activities.
- Maintain the separation of Mildura from Irymple and Merbein.
- Limit the location of sensitive land uses in the vicinity of industries or other activities with significant off site effects including noise, traffic and residual air emissions so as to minimise the potential for future land use conflicts.
- Limit the establishment of housing in locations where amenity may be negatively impacted on by farming and related activities, or where the location of housing may inhibit rural activities.

Investigations into the green belt that separates Mildura form Irymple have been completed in 2000, with the Irymple Greenbelt Review. This report recommended that there is no strategic basis for the amendment of the Rural Zone to either a residential or business zones between these urban areas.

Clause 21.04-7 Infrastructure also lists further strategies that are relevant to urban development and infrastructure issues.

- To ensure that those developing land for residential, business, industrial or rural purposes fund capital works to provide appropriate access and to facilitate water supply, sewerage and drainage and other service, utility and community infrastructure as required by new use or development needed to serve the area. To assist this Council is to formulate and apply Development Contributions Plans incorporating a development levy calculation to make provision for some or all of the following items: Roads.
  - Traffic management works.
  - Sewerage, stormwater, drainage and urban water works.
  - Open space in excess of the minimum requirements set down in the Subdivision of Land Act 1988.
  - Development of open space.
  - Pre-schools.
  - Maternal and child health centres.
  - Child care centres.
  - Neighbourhood houses.

  - Fencing of reserves.
  - Libraries.
  - Aged persons centres.
  - Community buses.
  - Indoor sports centres.
  - Irrigation/drainage works.
- Ensure that land use and development adjacent to and in the flight path of the Mildura Airport is compatible with the functioning and operation of the Airport.
- Identify and protect water and drainage infrastructure servicing farming communities from urban encroachment.
- Encourage development in those areas that are or can be readily serviced with infrastructure services.

7.3 Strategic summary

The strategy for the identification of future urban areas will be dependent on the following:

- The current land supply and demand for urban development.
- Strategic framework plans for the 4 major towns.
- The location and cost of infrastructure.
- Protecting agricultural land from land use conflicts with urban development.
- Maintain the greenbelts and separation between Mildura, Irymple and Merbein.
- Prevent development adjacent to the flight paths of the Mildura Airport.

7.4 Local planning policy framework

No local planning policies have been inserted into the Mildura Planning Scheme with respect to stormwater or drainage issues.

The Schedule to the Rural Zone provides for planning permits to be obtained for drainage works in the following circumstances (identified below in the schedule to the Rural Zone).

Permit requirement for earthworks	Land
A permit is required to construct or carry out earthworks that change the rate of flow or the discharge point of water across a property boundary.	All land
A permit is required to construct or carry out earthworks which increase the discharge of saline groundwater.	All land

7.5 Zones

The VPPs include a number of standard zones and overlays. One zone and two overlays refer to flooding and land subject to inundation. These areas controls are:

- Urban Floodway Zone.
- Land Subject to Inundation.
- Special Building Overlay.

The purposes of these provisions are listed below with the bold text identifying the major differences between these controls.

The purposes of these zones and overlays are: -

- Urban Floodway Zone are to specifically identify those areas subject to inundation from major flood paths involving areas of high hazard: -
- Land Subject to Inundation Overlay - to identify areas on the fringe of Urban Floodway areas which store floodwaters: -
- Special Building Overlay - to specifically identify those areas subject to inundation from natural overland flow from urban drainage system.

The Mildura Planning Scheme has applied the Urban Floodway Zone and the Land Subject to Inundation Overlay to areas subject to inundation along the Murray River floodplain.

The Special Building Overlay is yet to be applied to urban areas affected by stormwater inundation. Stormwater modelling of the drainage infrastructure needs to be completed to accurately identify those areas that will be subject to inundation. Stormwater modelling involves:

- determining the capacity of the drains and outfalls.
- applying Bureau of Meteorology rainfall intensity data to the catchment.
- surveying the sites to determine AHD levels.
- flood modelling, ie take away pipe outflows and prepare flood levels.

This modelling results in inundation maps being prepared which then enables planning authorities to apply the Special Building Overlay in their planning scheme.

7.6 Development assessment

Assessment of drainage and stormwater issues is undertaken by Council and Referral Authorities through the planning process. The Mildura Planning Scheme provides development control through the application of zones and overlays throughout the municipality. Applications to use and develop land require planning permits to be approved by Council. The development approvals process is controlled by the legislative requirements of the Planning and Environment Act 1987 and Subdivision Act 1988. Council's Planning Department is responsible for the consideration, assessment and approval/refusal of planning applications.

The most common planning application that involves drainage, stormwater and infrastructure issues is a planning application that seeks to subdivide land. Planning applications involving change or intensification of the use and development applications can also require assessment on stormwater and drainage issues.

Under Clause 66 of the Mildura Planning Scheme certain planning applications have to be referred to nominated referral authorities. The referral of applications is required under Section 55 of the Planning and Environment Act, which requires Council to refer planning applications within 7 days and for referral authorities to respond within 28 days of receipt of a planning application.

Referral Authorities for the Sunraysia Region include all servicing authorities involved in water, sewerage, and power and gas reticulation and Government Departments such as the Department of Natural Resources and Environment and the Mallee Catchment Management Authority.

The Planning Department also refers planning applications internally to Councils infrastructure department with respect to drainage and stormwater issues.

All requirements by Referral Authorities and Council are placed as conditions onto a planning permit, which is issued by Council. Should a referral authority inform Council that it objects to a planning application, and then Council must refuse the planning application (Section 61(2)).

Council considers approximately 1000 planning applications per annum.

Planning Approvals Process

The two most common methods of approval, with respect to planning permits are to:

1) Place conditions on a permit (conditional approval) to ensure that future work is completed to Council/Referral Authority satisfaction OR
2) Place conditions that prescribe (prescriptive approval) actual design and or work in accordance with plans/information that have been submitted to Council/Referral Authority with the planning application.

The first course of action enables the applicant to prepare design work or submit further plans and information after the planning approval is obtained. This is a cheaper and sometimes more convenient option to pursue from an applicant's perspective. However from a Council or Referral

Authority perspective if the amount of information is less than adequate a request for further information can be required or a refusal can be issued. The usual course of action by referral authorities and Council however is to place as many conditions onto a planning permit as possible to cover for all possible outcomes in the development of the land. Conditions will usually specify works to be completed to the satisfaction of an authority or require further plans to be submitted before the planning approval can have any force or effect.

The second course of action requires developers to have prepared designs or submit information that demonstrates to Council/Referral Authorities that the use and development can be undertaken and approved. This course of action is not a common due to the perceived *up front* cost of design or the development of submissions and the fact that such work may be unnecessary should the permit be refused.

A common problem with infrastructure issues such as drainage and flooding is that the approval of planning applications prior to design can result in developments that either cannot be constructed or require substantial modification to enable such developments to proceed. This has caused some angst within the both the development industry and the community with respect to development that has to be modified or changed at a later date.

The modification of planning applications is subject to Section 73 of the Planning and Environment Act 1987, which only allows for minor modification/variations to be completed. Modifications outside of the criteria listed within this section require a new planning application to be submitted.

Hence conditional planning approval, although initially expedient and cheaper to obtain from an applicants perspective, can result in more delay or may ultimately prove that land us unsuitable for development.

8. Key Issues

8.1 Overview

A number of key drainage issues have been identified, and these are summarised in the following sections. Sources of information have included:

- the Current Situation Report (2001);
- review of previous studies;
- discussions with stakeholders and agency personnel;
- a workshop held with the Project Working Group; and
- a review of Council's current management framework as it relates to drainage.

8.2 Issues Identified in the Current Situation Report (2001), and other Reports

Significant issues identified in the Current Situation Report (2001), review of previous studies, and discussions with stakeholders and agency personnel are summarised below:

8.2.1 General

- Relatively little drainage water is currently reused.
- Both urban and irrigation drainage waters may be contributing significantly to algal blooms in the Murray River.
- Inland diversion of drainage waters could potentially provide EC credits.
- Drainage waters are often disposed of to the floodplain, rather than directly to the River. In some locations this may increase pressures on regional groundwater systems, resulting in increased salt loads to the River. Disposal of drainage waters to basins on the floodplain may similarly increase pressures on groundwater systems. Evaporitic concentration in basins may also increase salt loads to the River.
- Reduced drainage flows resulting from improved irrigation practices may have significant implications for the quantity and quality of water in inland basins.
- Rural surface flooding is experienced in many areas, and often results from landlocked catchments, and lack of culverts and other suitable drainage infrastructure.
- Multiple authorities own, discharge to, and have a range of roles in the management of inland drainage basins. Relevant authorities include Council, SRWA, FMIT, G-MW and NRE. Agreements between authorities owning, discharging to, and having different roles in the management of the same waterbody are often ad hoc, informal, lacking in detail, and/or not well understood.

8.2.2 Location Specific

Merbein

- Significant salt loads and poor quality drainage waters discharge to the River from the drainage shafts, Lamberts Swamp and the West and North West Drains.

- There is potential for implementation of the Merbein Integrated Development Scheme (MIDS) to overload Wargan Basins. The MIDS Scheme would result in diversion of flows from the West and North West Drains, Lamberts Swamp and the drainage shafts to Wargan Basins.
- The floodplain is being degraded by drainage from the Yelta Area, and other private drainage systems.
- Discharge of untreated urban stormwater from Merbein to floodplain is also causing degradation.

Mildura Irymple

- The rate of urban development in the Mildura Irymple area has been 40 ha per year over the past 14 years. This is double the rate assumed in preparation of the Mildura Planning Scheme.
- There is virtually no drainage infrastructure in place in any of the undeveloped parts of Mildura Irymple currently zoned for urban development. This may ultimately impede development.
- Developers' contributions collected in the past have been inadequate to fund required offsite urban drainage works.
- Lack of masterplanning and coordination of urban drainage has often resulted in standalone subdivisional drainage systems with inadequate outfall capacity.
- Progressive urbanisation of the FMIT irrigation district has resulted in urban and irrigation drainage systems covering the same areas. There has however been relatively little capacity sharing between the two systems. Issues include:
  - disruption of subsurface drainage systems during subdivisional development, causing localised waterlogging;
  - a need for FMIT to maintain under-utilised irrigation drains traversing urban areas; and
  - management of and liability for redundant irrigation drains.
- There is potential to reduce urban nutrient and other pollutant loads using wetlands, gross pollutant traps, and basins to collect first flush runoff.
- Conversion from irrigation to urban use may have a significant impact on flows to Lake Hawthorn.
- Consideration is required of future disposal options for the Mildura Merbein Groundwater Interception Scheme, and Lake Hawthorn Drainage Disposal Scheme.

Red Cliffs

- The long-term sustainability of Cardross Lakes may be threatened by reduced irrigation drainage flows.
- Basin 12 may be ineffective in removing nutrients from drainage waters.
- There is a possibility that drainage shafts in the area are still being used for drainage disposal.

8.3 Council Management Framework

Issues identified with the development approvals and referral process have been:

- Lack of consistency on advice and requirements received from Referral Authorities and Council.
- Too many staff involved in the assessment process, leading to inconsistent advice.
- Referral Authorities requiring conditions to be inserted onto planning permits, requiring works to be completed which bear no relationship to the planning application sought (nexus).

- Poor standard of planning application and the information that accompanies such applications.

Solutions to these issues have been identified by Council and include:

- Requiring applicants to have pre-application meetings with all referral authorities and Council prior to formulating and lodging a planning application.
- Access to information - Referral Authorities and Council having resources required to identify major design and works issues that will affect the development of land.
- Appointment of dedicated staff to co-ordinate subdivision and design issues (subdivision officer).

Council is attending to some of these issues with the following:

- Pre- application meetings with applicants on large developments.
- Council is trialing the development of a GIS system, which will place all drainage infrastructures for Red Cliffs onto an electronic database. This will enable Council to then develop models and scenarios for flooding and stormwater inundation, which will assist in design work and consideration of planning applications. It is anticipated that the trial will allow other urban areas to be placed onto an identical system.
- Funding has been set aside for the appointment of a subdivision officer to co-ordinate all subdivision, development and planning issues.
- Working with Referral authorities to identify superfluous conditions and requirements.

8.4 Issues Identified in Project Working Group Workshop

A number of issues were also identified at a Project Working Group workshop held during the initial stages of the Study. These issues have been summarised in Figure 8-1. Issues occurring at a particular location have been cross-referenced with; other issues identified are more generic in nature and are applicable across the whole Study Area. There are many common elements in the issues identified here, with those identified in the Current Situation Report, and these are included under both headings for completeness.

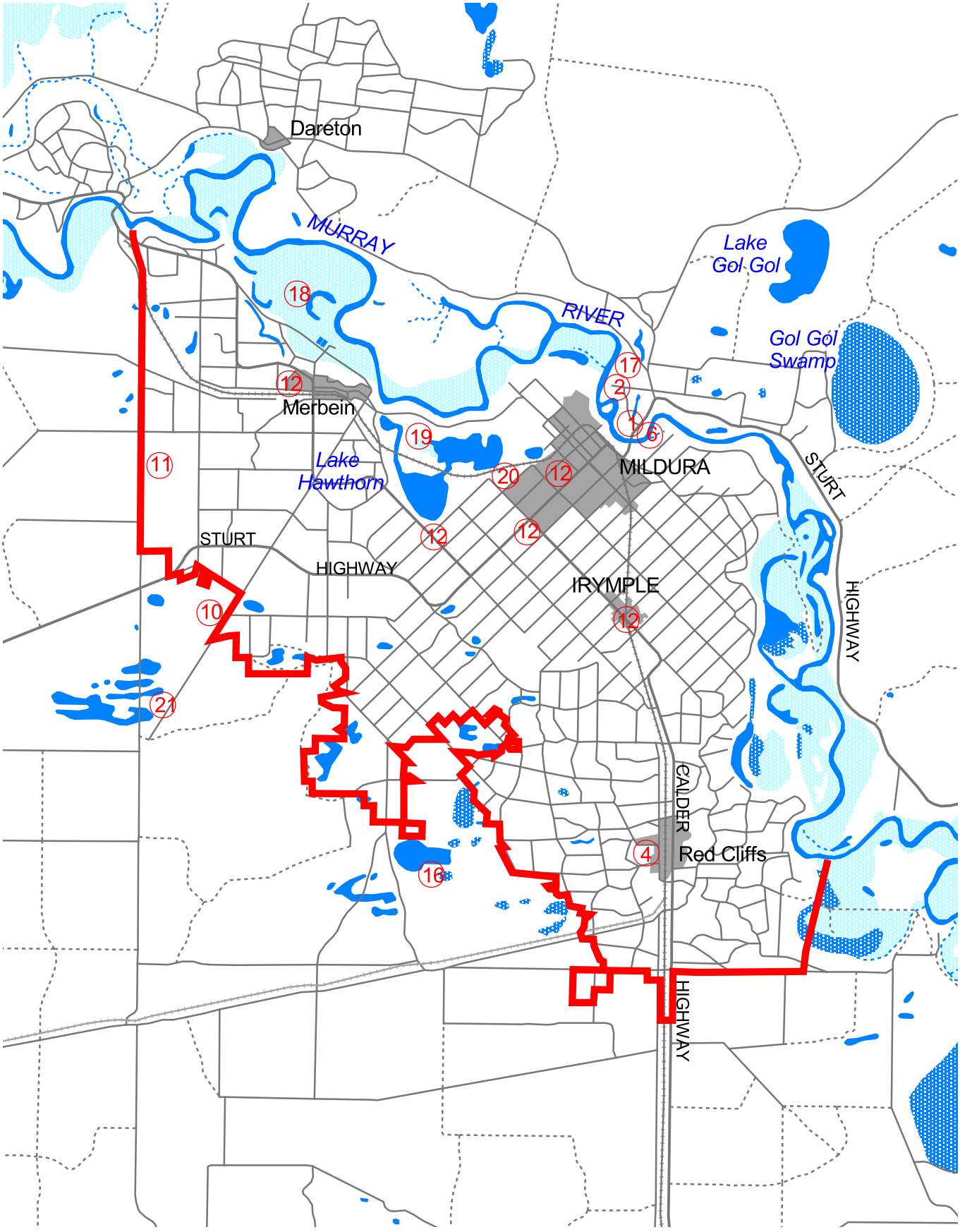
■ Table 8.1 Stormwater and irrigation drainage issues identified at the Project Working Group Workshop

Issue	Sub Issue	Map reference	Comment
Designated Development Areas	Septic Issues		- Some blocks still have tail drains from septic tanks. Therefore nutrients discharge into the groundwater and drains.
	Service	11	- There are many irrigation areas being cut of by new development. The irrigation water supplier must then realign the existing pipelines in order to maintain service to the outer irrigation areas. Expensive process to maintain. - Balance need for large easements against excessive encumbrance of land. - Unserviced development areas
	Irymple		- Due to the topography, effluent must be pumped out. High development costs.

Issue	Sub Issue	Map reference	Comment
Stormwater Discharging to River	Gross Pollutants and Contaminants	1 2	- Especially after large storm events, large amounts of debris enter the River from stormwater outfalls. - The outfall near the Rowing sheds, where large oil slicks appear on the River after storm events (may be caused by auto industry on 7th Street). - The outfall near Mildura homestead is often blocked with leaf litter - The River in this area has important recreational value
	Algal Blooms	17 18	- 36 Algal blooms on the River since 1990. - Weir pool – due to upstream impacts - Merbein Common – contaminants are also killing the fish. - Lake Hawthorn - Kings Billabong
Stormwater Reuse		4, 10, 16	- Previously considered at Red Cliffs Golf Club - Potential reuse sites, including Council properties including ovals, median strips, parks and gardens - Major issues with stormwater reuse include quality control, salt loads, collection, recirculation and treatment. - Need to consider which authority has responsibility for maintaining quality
Drainage System Capacity	Flooding	12	- Consider Retarding Basins as part of new developments - Need to consider strategies for reducing the impact of overland flow. - Flooding "hotspots" marked on map - Consider putting in surface drains or culverts to reduce overload on subsurface drains. - Potential impacts of retarding basins on groundwater accessions. - Impacts of changes in irrigation methods.
Drainage System Capacity	Service		- Drainage system is designed so that neighbours water at alternate times. During large rain events, everyone waters at once causing large volumes of drainage water that the system is not designed to cope with. - Some landowners have pop up drains to which they direct surplus surface runoff, thus passing the problem to a downstream neighbour.
Water Quality	Treatment trains	6	- Integrate water treatment into town planning, creating public amenities (eg. Wetlands). - Have a clearly defined treatment system – include at source treatment, gross pollutant traps etc.
	Gross pollutants	20	- Rubbish dumping
Ownership and Management			- Requires integration between different agencies - Currently different benchmarks (eg. Retarding basins 10 – 120 ARI events) - Need to integrate developers - Conditions of Assets - Better planning at initial stages - Clearer definition of responsibilities
Rising Groundwater			- Impacts on infrastructure and river - Restrict drainage in high impact areas

Basins and Lakes	Lake Hawthorn	15	- Currently outlets to the River, consider increased flow to Wargan, increased disposal to River, or reuse. Increased flow to Wargan not feasible without an upgrade of the outlet channel.
	Lakes Hawthorn and Ranfurly		- Pump operating criteria.
	Lake Ranfurly		- Impact on lake level and pumping after rain storms.
			- Many basins are not natural. Conditions will change over time due to improved drainage management. To maintain current conditions would result in little or no improvement in disposal methods.
		19	- Drainage Basins held at a higher level than is natural – competing issues between drainage and environment.
	Cardross	21	- Consider links between Cardross and Wargan. Cardross might need more water to support fish.

FIGURE 8.1 - ISSUES SITES



SINCLAIR KNIGHT MERZ

21 KEY ISSUES SITE

N

2 0 2 4 Kilometres

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9. Reuse of Water

There is currently little or no reuse of irrigation water or stormwater in the Mildura region. An opportunity exists to make use of this water resource, allowing more efficient use of water, less environmental impacts and more effective infrastructure management.

9.1 Potential Reuse Opportunities

A number of potential reuse sites have been identified:

- An application for funding has been made to the Water for Growth Initiative for funding of a reuse scheme in Merbein (reuse of irrigation water). The project would consist of an initial feasibility study (building on the Hallows report) and then design and implementation. The program will allow a greater understanding of the environmental gains of such a reuse scheme, development of a drainage system that is economically self-sustaining, and will act as a pilot study to encourage growers in the region to adopt such schemes.[1]

  Should similar irrigation reuse schemes be adopted, consideration must be given to the storage required, the irrigation area and the secondary evaporation basin. The storage must be adequate to balance irrigation drainage inflows and rainfall against reuse crop requirements. A suitable area with suitable crop types must be located, and drainage and disposal from that site considered.

- Due to the topography of the region, drainage and wastewater must be pumped out from Irymple and Red Cliffs. Reuse of water in these areas could possibly reduce the reliance on traditional water supply infrastructure, along with reducing the load on the drainage system (where there are currently areas that have regular flooding). A number of reuse options exist, including domestic scale reuse or reuse for irrigation. The Red Cliffs golf course has been identified as a possible site for both storage and use of water. It should however be noted that this site already uses some treated effluent for irrigation.

- Urban reuse schemes are becoming more common. Investigation into suitable storage and water balance on rainfall and demand would be required. However, they may be the possibility of incorporating domestic scale reuse schemes into new developments, thus reducing the reliance on traditional infrastructure.

9.2 Factors affecting reuse opportunities

The factors affecting reuse opportunities include:

- **Community attitude**: If a reuse scheme is to be successful, it is important that the community embrace the project in order to ensure both efficient use of water and water quality. As part of the Feasibility Study for the Merbein Integrated Development Scheme, P.J. Hallows and Associates conducted a survey of local farmers. This survey indicated that farmers are reluctant to develop their properties for irrigation with drainage water due to the high risks involved. The perceived constraints included the high costs involved and the risks associated. It is also anticipated that reuse scheme will be more rapidly adopted by newer farmers to the region.
- **Economics, management and ownership**: Any reuse scheme would require co-ordination and co-operation between authorities and the community, including cost sharing. Establishing the

[1] The project submission was made by Miriam Hopkins (NRE) and Darren Raeck (SRWA).

infrastructure for a reuse scheme will have associated costs, however there will be long-term economic benefits should the scheme be effective.

An agreement must be made between the relative authorities as to the rights and responsibilities for maintenance of the system and the water in the system itself.

- **Technical feasibility**: Water currently discharges to multiple points. In order to have a reuse scheme, the drainage water must be collected at a single outlet point for treatment and storage. There are also technical issues to be considered including the suitability of soil in the region for such a scheme.
- **Water quality**: Must establish how an adequate water quality will be achieved and how it will be monitored and maintained.

10. Cultural and Heritage Values

10.1 Indigenous Cultural Heritage

There are 84 registered indigenous sites within the study area. Site types comprise shell middens, scarred trees, burials, hearths, surface scatters of stone artefacts and post-contact sites. Shell middens dominate the archaeological record and comprise over 50% of all recorded sites. Shell middens are deposits of freshwater mussel shell, which are generally found in a linear distribution along the margins of existing and relic drainage features.

The vast majority of registered sites occur on, or directly adjacent to the riverine floodplain (Riverine Plain land system). Sites are particularly prevalent along the river to the south-east of the township where systematic archaeological surveys have been undertaken of public land (Edmonds 1992; 1994). There are few recorded sites away from the river in the Mallee Dunefield. This is mainly due to the lack of systematic archaeological survey within this land system. Previous research has shown that sites are likely to occur within 500 metres of a fresh or saline water source in the Mallee Dunefield.

Currently, the archaeological record for the Sunraysia region indicates continuous Aboriginal occupation of the riverine corridor spanning the last 21,500 years (Edmonds 1997).

Key Issues

- Lack of previous systematic archaeological survey within the study area landscape;
- Poor identification of impacts to indigenous sites both within public land and on private property in the study area;
- Low level of consultation with key Aboriginal organisations and individuals regarding site significance and site management and preservation within the study area.

10.2 Non-indigenous Cultural Heritage

There are approximately 22 heritage sites/places listed on various registers and/or planning schemes within the study area. These mainly comprise built structures associated with the centre of townships, with the advent of late settlement and/or irrigation. Very few heritage studies have been conducted within the study area but the following main historical themes relating to the study area have been defined (Edmonds 1999);

- Exploration
- Pastoral settlement and forest grazing
- Aboriginal communities
- Surveying
- Land communications
- The development of inland shipping and trade
- Timber getting
- The development of rural industry and settlement
- Irrigation
- Leisure and tourism

Key Issues

- Lack of previous systematic heritage surveys within the study area landscape;

10.3 Ecological Issues

Management of water quality and volumes of water entering the various waterbodies is of key concern. A detailed assessment of the ecological and biodiversity values of the wetlands and waterbodies will form the major component of Issues Paper # 2 – Threats and Values.

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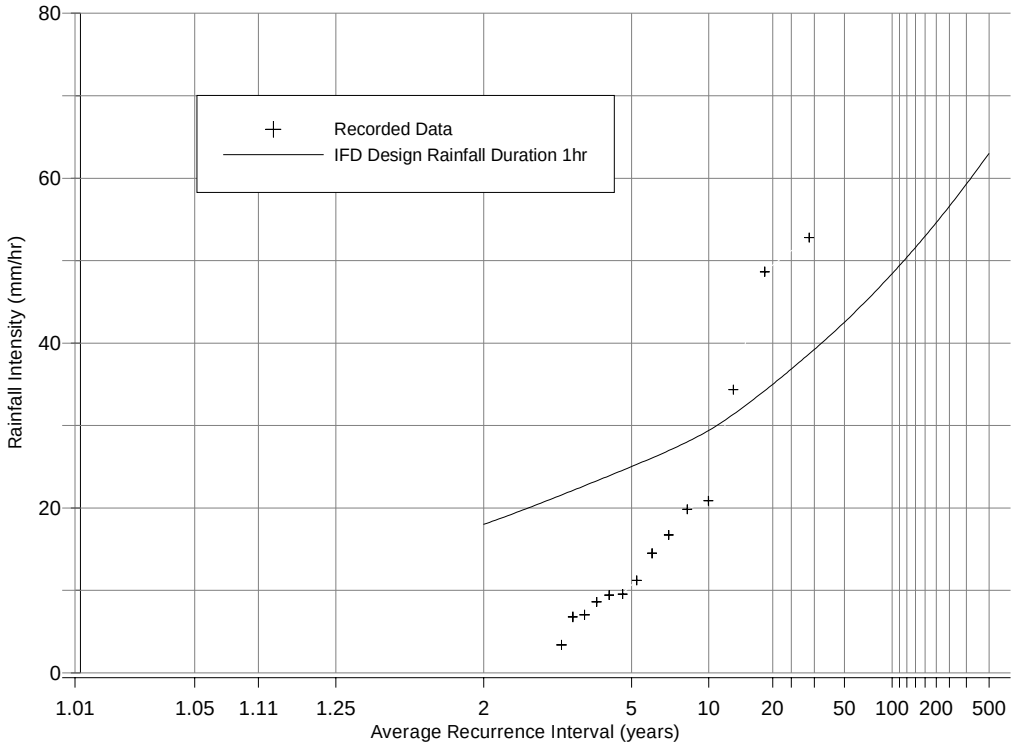
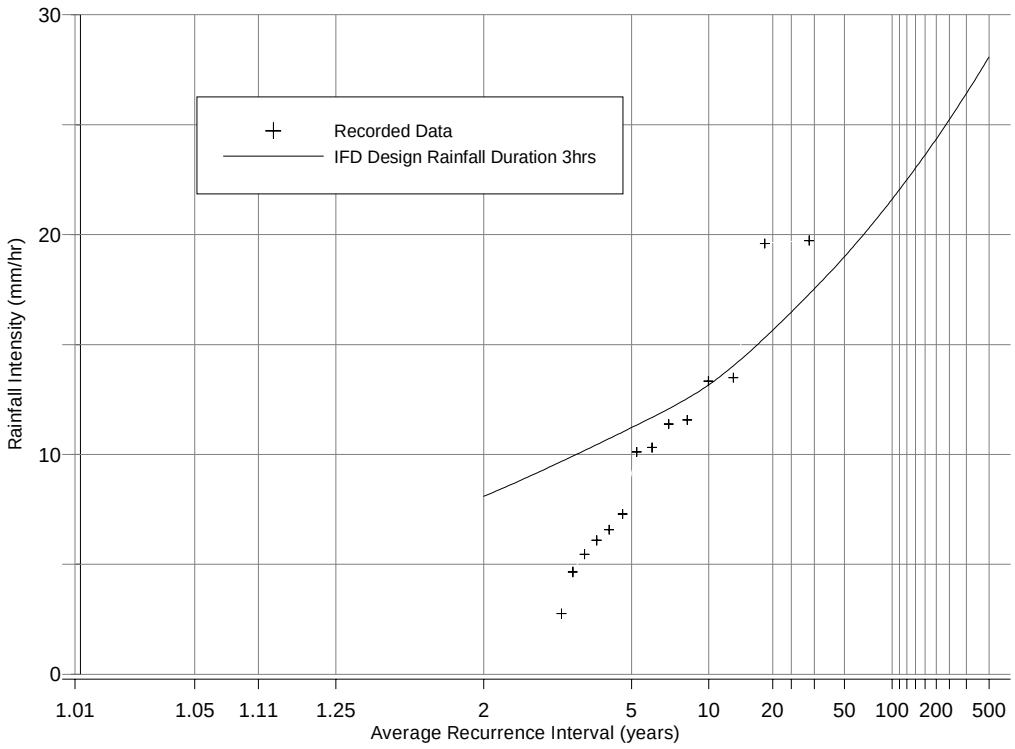
Appendix A Rainfall Intensities for Varying Storm Durations

This presents a comparison of:

- design rainfall information from Australian Rainfall and Runoff; and
- analysis of Mildura Airport pluviograph data for the period of 1954 to 1998.

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IFD Design Rainfall Duration 3hrs
Rainfall Intensity (mm/hr)
0
10
20
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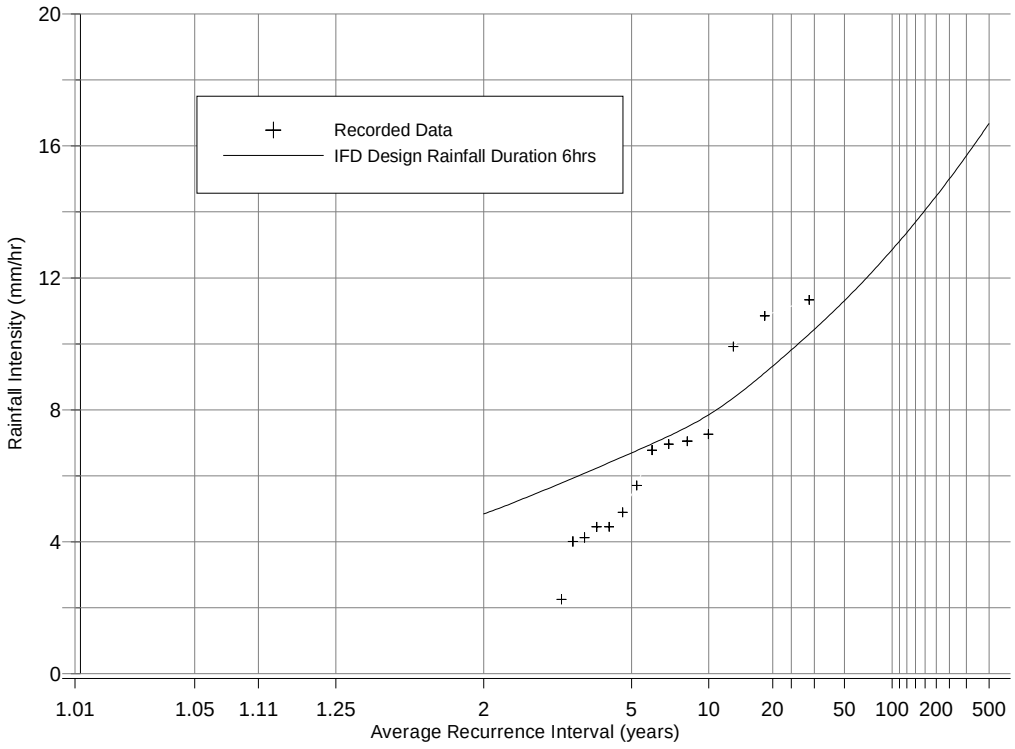
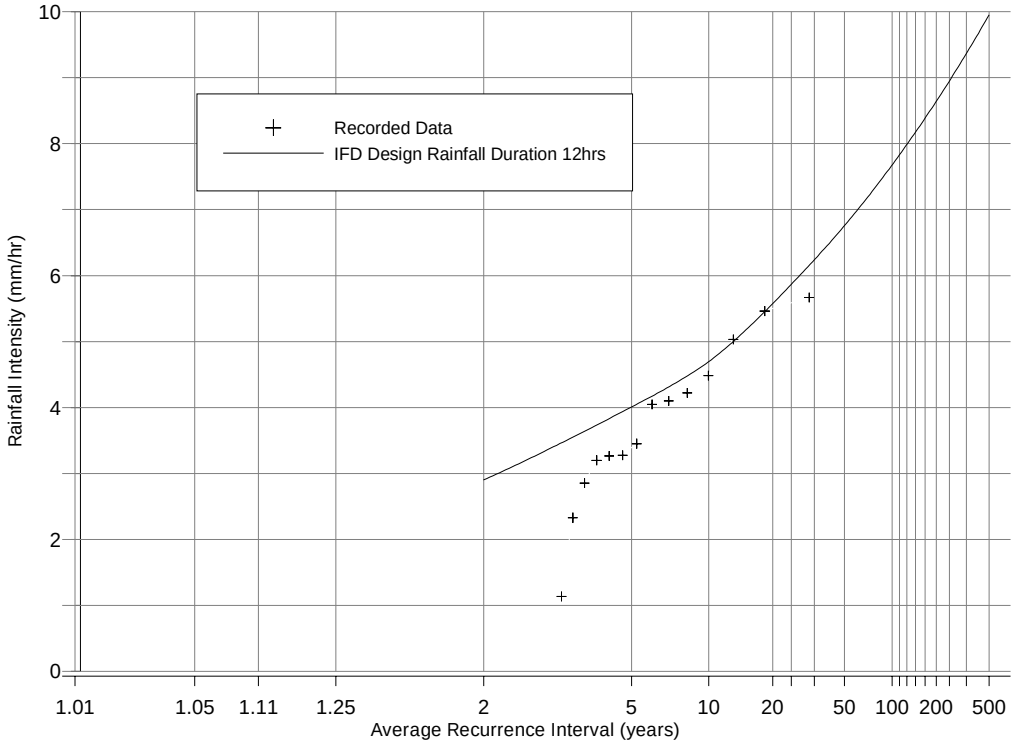
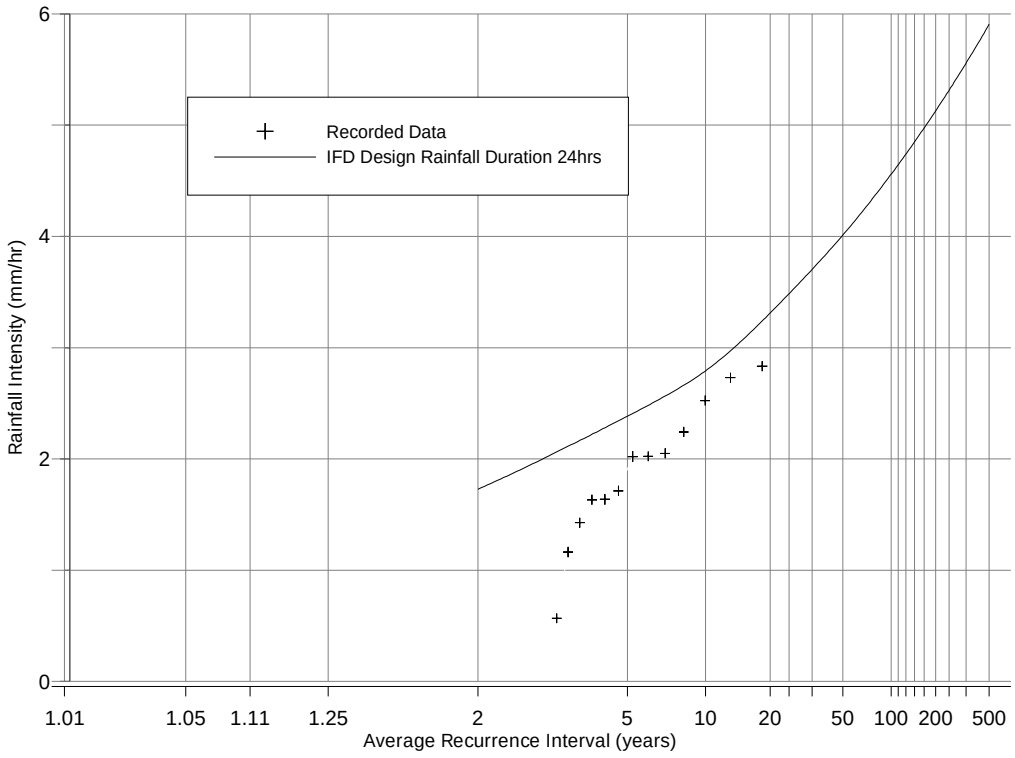
1.01
1.05
1.11
1.25
2
5
10
20
50
100
200
500
Average Recurrence Interval (years)


Recorded Data
IFD Design Rainfall Duration 6hrs
Rainfall Intensity (mm/hr)
0
4
8
12
16
20
1.01
1.05
1.11
1.25
2
5
10
20
50
100
200
500
Average Recurrence Interval (years)


Recorded Data
IFD Design Rainfall Duration 12hrs
Rainfall Intensity (mm/hr)
0
2
4
6
8
10
1.01
1.05
1.11
1.25
2
5
10
20
50
100
200
500
Average Recurrence Interval (years)


Recorded Data
IFD Design Rainfall Duration 24hrs
Rainfall Intensity (mm/hr)
0
2
4
6
1.01
1.05
1.11
1.25
2
5
10
20
50
100
200
500
Average Recurrence Interval (years)

Appendix B Details of Inland Water Bodies

Location	Basin Name	Land Tenure [1]	Managing Authority – Waterbody	Basin Inflow Source(s)
Mildura Region	Basin 1 (Rifle Butts Swamp)	FMIT/MRCC	FMIT/MRCC	☐ Irrigation drainage ☐ Stormwater (urban) ☐ G/W discharge
	Basin 2	FMIT	FMIT	☐ Irrigation drainage ☐ Stormwater (urban) ☐ G/W discharge
	Basin 3 (Lake Benetook)	FMIT	FMIT	☐ Irrigation supply
	Basin 5 (Koorlong Tank)	FMIT	FMIT	☐ Irrigation drainage ☐ G/W discharge
	Basin 6 (Irymple Tank)	FMIT	FMIT	☐ Irrigation drainage ☐ G/W discharge
	Basin 7A (Glyderfield)	C.L Drainage Purposes Reserve	FMIT	☐ Irrigation drainage
	Basin 7B (Glyderfield)	C.L Drainage Purposes Reserve	FMIT	☐ Basin 7A overflows
	Basin 7C (Glyderfield)	C.L Drainage Purposes Reserve	FMIT	☐ Basin 7B overflows
	Basin 7D (Glyderfield)	C.L Drainage Purposes Reserve	FMIT	☐ Basin 7C overflows
	Basin 8 (Timmis Swamp)	FMIT	FMIT	☐ Irrigation drainage
	Basin 9	Private	Private	☐ Irrigation drainage ☐ G/W discharge
	Basin 10	C.T. 9316/955 (Freehold to SR&WSC) C.T. 6063/573 (Freehold to SR&WSC) C.T. 8743/932 (Freehold to SR&WSC) C.T. 6089/625 (Freehold to SR&WSC) C.L. Vested SRWSC Gaz 1977.3704 C.L. Vested SRWSC Gaz 1980.1691 C.L. Vested SRWSC Gaz 1983.1396	FMIT SRWA	☐ Irrigation drainage ☐ G/W discharge
	Basin 11	FMIT	FMIT	☐ Irrigation drainage ☐ G/W discharge
	Psyche Bend Lagoon	C.L State Forest (Wildlife Reserve-Kings Billabong)	SRWA FMIT	☐ G/W discharge ☐ RWC Basin 12 outflows ☐ Irrigation drainage ☐ River Murray flood flows
	Kings Billabong	C.L State Forest (Wildlife Reserve-Kings Billabong)	FMIT	☐ Irrigation supply
	Lake Ranfurly East	Crown Grant Vol 6251 Fol 010 (Reg prop MRCC)	G-MW/MRCC	☐ Mildura Merbein Groundwater Interception Scheme ☐ G/W discharge

Location	Basin Name	Land Tenure [1]	Managing Authority – Waterbody	Basin Inflow Source(s)
				☐ Stormwater (urban)
	Lake Ranfurly West	Crown Grant Vol 6251 Fol 010 (Reg prop MRCC)	G-MW/MRCC	☐ Mildura Merbein Groundwater Interception Scheme ☐ G/W discharge
	Lake Hawthorn	C.T. Vol 6453 Fol 483 (Reg prop FMIT), College lease	G-MW/FMIT	☐ Irrigation drainage ☐ Stormwater (urban) ☐ G/W discharge
Merbein Region	Dow Avenue Woodlots	FMIT	FMIT	☐ G/W discharge
	Mercer Street Basin	FMIT	FMIT	☐ Irrigation drainage ☐ G/W discharge
	Coars Swamp	Crown Land appropriated by SRWSC	SRWA	☐ Irrigation supply overflow ☐ Irrigation drainage ☐ G/W discharge
	Wren's Swamp	C.L. Drainage Reserve Gaz 1956.2925	SRWA FMIT	☐ Irrigation drainage
	Lambert's Swamp	C.L Drainage Reserve Gaz 1989.1032	SRWA	☐ Irrigation drainage ☐ Stormwater (rural) ☐ G/W discharge
	Brickworks Billabong	Crown Land	Parks Victoria	☐ Yelta Irrigation drainage
	Cowanna Billabong	Crown Land	Parks Victoria	☐ Yelta Irrigation drainage
	Wargan Basin 1	C.L. Water Supply Reserve & Freehold	G-MW	☐ Lake Hawthorn ☐ Lake Ranfurly East and West
	Wargan Basin 2	C.L. Water Supply Reserve & Freehold	G-MW	☐ Lake Hawthorn ☐ Lake Ranfurly East and West
	Wargan Basin 3	G-MW	G-MW	☐ Wargan Basin 2 overflow
	Wargan Basin 4	G-MW	G-MW	☐ Wargan Basin 3 overflow
	Wargan Basin 4A	G-MW	G-MW	☐ Wargan Basin 3 overflow
	Wargan Basin 5	C.L. Water Supply Reserve & Freehold	G-MW	☐ Wargan Basin 4 overflow
Red Cliffs	Cardross Basin A	C.L Drainage Reserve (591C)	SRWA	☐ Irrigation drainage
	Cardross Basin B	C.L Drainage Reserve Gaz1982.494 (630)	SRWA	☐ Irrigation drainage
	Cardross Basin C	C.L Water Supply Purposes Reserve	SRWA	☐ Irrigation supply ☐ Irrigation drainage
	Cardross Basin D	C.L Water Supply Purposes Reserve	SRWA	☐ Overflow from RWC Basin C
	Cardross Basin E	C.L Water Supply Purposes Reserve	SRWA	☐ Overflow from RWC Basin D
	Cardross Basin 4	C.L Water Supply Purposes Reserve	SRWA	☐ Irrigation drainage
	Cardross Basin 1,2 and 3	C.L Water Supply Purposes Reserve	SRWA	☐ Irrigation drainage ☐ Basin overflows from Basins C, D, E, 4, 2 and

Location	Basin Name	Land Tenure [1]	Managing Authority – Waterbody	Basin Inflow Source(s)
				3
	Cardross Basin 1A	C.L Water Supply Purposes Reserve	SRWA	☐ RWC Basin 1 overflows
	Cardross Basin 13	Unreserved Crown Land	SRWA	☐ Relift from RWC Basin 1,2 and 3
	Cardross Basin 14	Unreserved Crown Land	SRWA	☐ RWC Basin 13 overflow
	Cardross Basin 15	Unreserved Crown Land	SRWA	☐ RWC Basin 13 overflow
	Cardross Basin 16	Unreserved Crown Land	SRWA	☐ RWC Basin 13 overflow
	Cardross Basin 17	SRWA	SRWA	☐ Irrigation drainage
	RWC Basin 5	Unreserved Crown Land	SRWA	☐ Irrigation supply ☐ Irrigation drainage
	RWC Basin 6	Unreserved Crown Land	SRWA	☐ Irrigation supply ☐ Irrigation drainage ☐ RWC Basin 5 (seepage)
	RWC Basin 7	Unreserved Crown Land	SRWA	☐ RWC Basin 6 overflow
	RWC Basin 8	Unreserved Crown Land	SRWA	☐ Irrigation supply ☐ Irrigation drainage
	RWC Basin 9	Unreserved Crown Land	SRWA	☐ Irrigation drainage (private)
	RWC Basin 10	SRWA	SRWA	☐ Irrigation drainage
	RWC Basin 11	SRWA	SRWA	☐ RWC Basin 10 overflow
	RWC Basin 12	SRWA	SRWA	☐ Irrigation drainage ☐ Stormwater (urban)
	RWC Basin 18	Unreserved Crown Land	SRWA	☐ RWC Basin 5 overflow
	RWC South East Drainage Basin	Unreserved Crown Land and State Forest	SRWA	☐ Irrigation drainage

[1] Information on Crown Land tenure provided by SRWA