Contents

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1. Introduction and Background

1.1 Background to the Project

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 about rapid expansion of urban areas into adjacent irrigated lands and the need for a coordinated approach to drainage, Mildura Rural City Council has identified a need to prepare a Sunraysia Drainage Strategy.

The principal output of the Strategy is a master plan outlining how urban development and the existing irrigation development will be serviced with surface and sub-surface drainage to the year 2050. Other outputs 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.
- Outline designs and costings for proposed works.
- A 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 Quality 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 Quality Management Plan (USWQMP) component of the Project.

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

Elements of the plan 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 Sunraysia Drainage Strategy Report

This report documents the Sunraysia Drainage Strategy. The first volume is the Strategy itself. The second volume is a compilation of supporting information comprising reports, issues papers and plans prepared during the course of the Project, and comprises:

- the Current Situation Report, which is a compilation of background information on drainage systems, growth rates, planning zones, current management and ownership, and existing issues;
- Background Issues Paper, which outlines a broad range of background information and issues;
- Excerpts from Volume 2 of the Urban Stormwater Quality Management Plan Report. This documents the economic, social and environmental values, and stormwater drainage threats, associated with significant waterbodies of relevance to the Project;
- Year 2050 Scenario Issues Paper. This develops and documents the adopted year 2050 development scenario, proposed drainage design standards, and existing and future drainage volumes, and salt and nutrient loads;
- Scope Drainage Management Options Issues Paper, which provides preliminary discussion and assessment of drainage disposal options; and
- Drainage Management Options Assessment Issues Paper. This recommends drainage disposal measures, and provides discussion of institutional, tariff and cost sharing arrangements.

1.3 Project Management

Mildura Rural City Council appointed a Task Force to oversee development of the Sunraysia Drainage Strategy. The Task Force then recognised the advantages in concurrently preparing the Mildura Urban Stormwater Quality Management Plan. The Task Force formed a Steering Committee to guide the Sunraysia Drainage Strategy. The EPA process for development of the USWQMP required this to be undertaken in consultation with a Project Reference Group, and a Project Working Group.

The Project was therefore undertaken under the direction of, and in consultation with, three groups as follows:

- Project Steering Committee;
- Project Reference Group; and
- Project Working Group.

Each of these groups included representatives from each of the key stakeholder organisations. Membership of each group is documented in Appendix A.

Part A – Current Situation

2. The Study Area

2.1 Overview

The Study Area is shown on Figure 2-1. 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).

The Study Area is characterised by undulating topography. Many parts of the area are landlocked with no natural gravity drainage outfalls. With existing drainage systems, around 40% of the area drains to the River or floodplain, and the remainder to inland water bodies.

2.2 Urban Development

Areas of urban development in 2000 were as follows:

Mildura/Irymple	1609 ha (ref 1)
Merbein	145 ha
Red Cliffs	285 ha

The rate of urban development in the Mildura/Irymple area has been around 40 ha/yr over the past 14 years. There has been very little new development in Red Cliffs and Merbein, and the growth rate in these centres has been less than 1 ha/yr.

2.3 Irrigation Development

Grapevines are by far the predominant irrigated land use. Summary land use statistics for irrigated areas are presented in Table 2-1. Furrow irrigation methods still predominate, although there is a gradual move to overhead and drip methods, particularly in the Red Cliffs and Mildura Districts. Summary statistics on irrigation method are presented in Table 2-2.

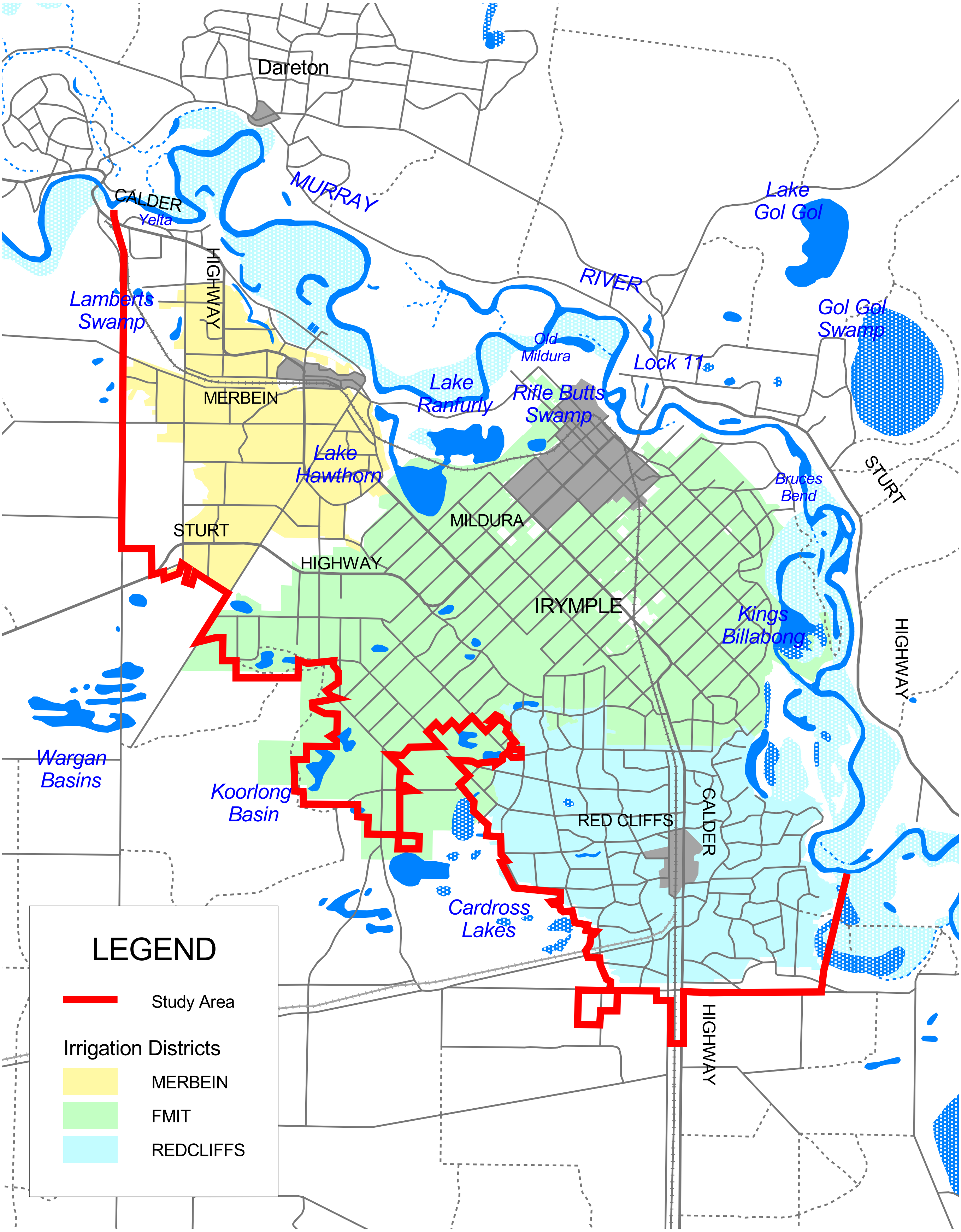
■ Table 2-1 Summary of Irrigated Land Use (after ref 2)

Irrigation District	Crop Area (ha)							
	Grape-vines	Citrus	Field crop /pasture	Vege-Tables	Fruit/nut tree	Other	Vacant/ not surveyed	**TOTAL**
Mildura (1997)	5186	165	164	39	71	83	850	**6558**
Merbein (1997)	2592	233	8	46	91	6	241	**3217**
Red Cliffs (1997)	3899	132	37	161	100	37	327	**4693**
Private diverters (1997)	640	62	17	0.5	3	13	424	**1158**
TOTALS	**12317** **78.8%**	**592** **3.8%**	**226** **1.4%**	**246.5** **1.6%**	**265** **1.7%**	**139** **0.9%**	**1842** **11.8%**	**15626**

■ Table 2-2 Summary of Irrigation Methods (after ref 2)

Irrigation District	Irrigation Method (ha)						
	Flood	Furrow	Overhead	Drip	Under tree	Other	Not Surveyed
Mildura (1997)	16	2498	1391	130	536	94	1518
Merbein (1997)	0	1298	259	29	214	62	1322
Red Cliffs (1999)	0	1882	1309	342	388	139	462
Private diverters (1997)	0	120	211	75	63	15	674
TOTALS	**16** **0.2%**	**5798** **52.4%**	**3170** **28.6%**	**576** **5.2%**	**1201** **10.8%**	**310** **2.8%**	**3976**

FIGURE 2.1 - STUDY AREA



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3. Existing Drainage System

3.1 Introduction

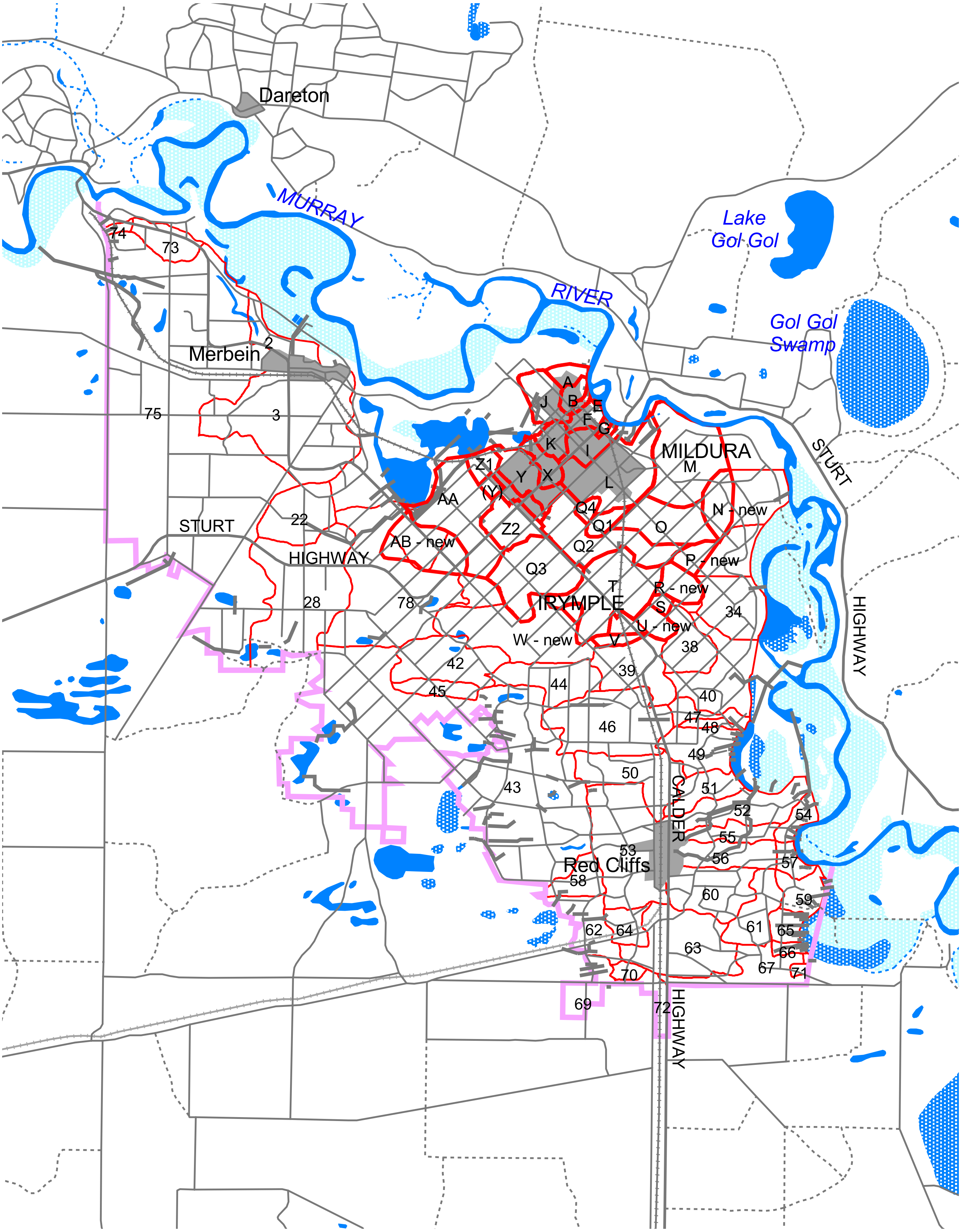
Existing drainage systems serving the Study Area are summarised in the following sections.

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 3-1.

Much of the irrigation area is serviced by subsurface drains, which discharge to either the Murray River/floodplain, or inland basins and lakes. Subsurface drainage catchments for the irrigation area are shown on Figure 3-2.

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

FIGURE 3.1 - SURFACE CATCHMENTS (URBAN AND RURAL)



LEGEND

Rural and Urban Surface Catchments

Drainage Outfalls

Study Area

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2 0 2 4 Kilometres

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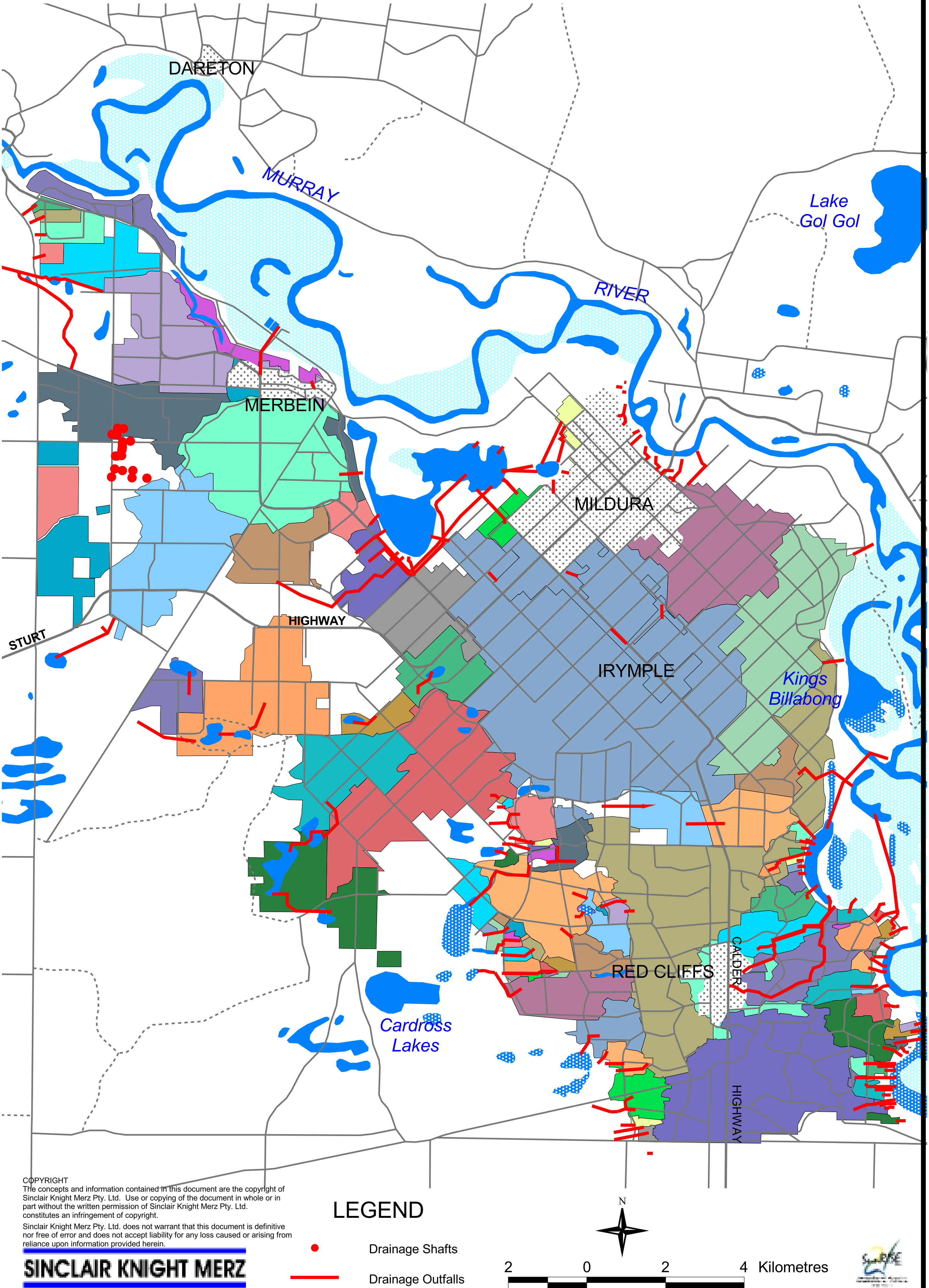
FIGURE 3.2 - SUBSURFACE CATCHMENTS



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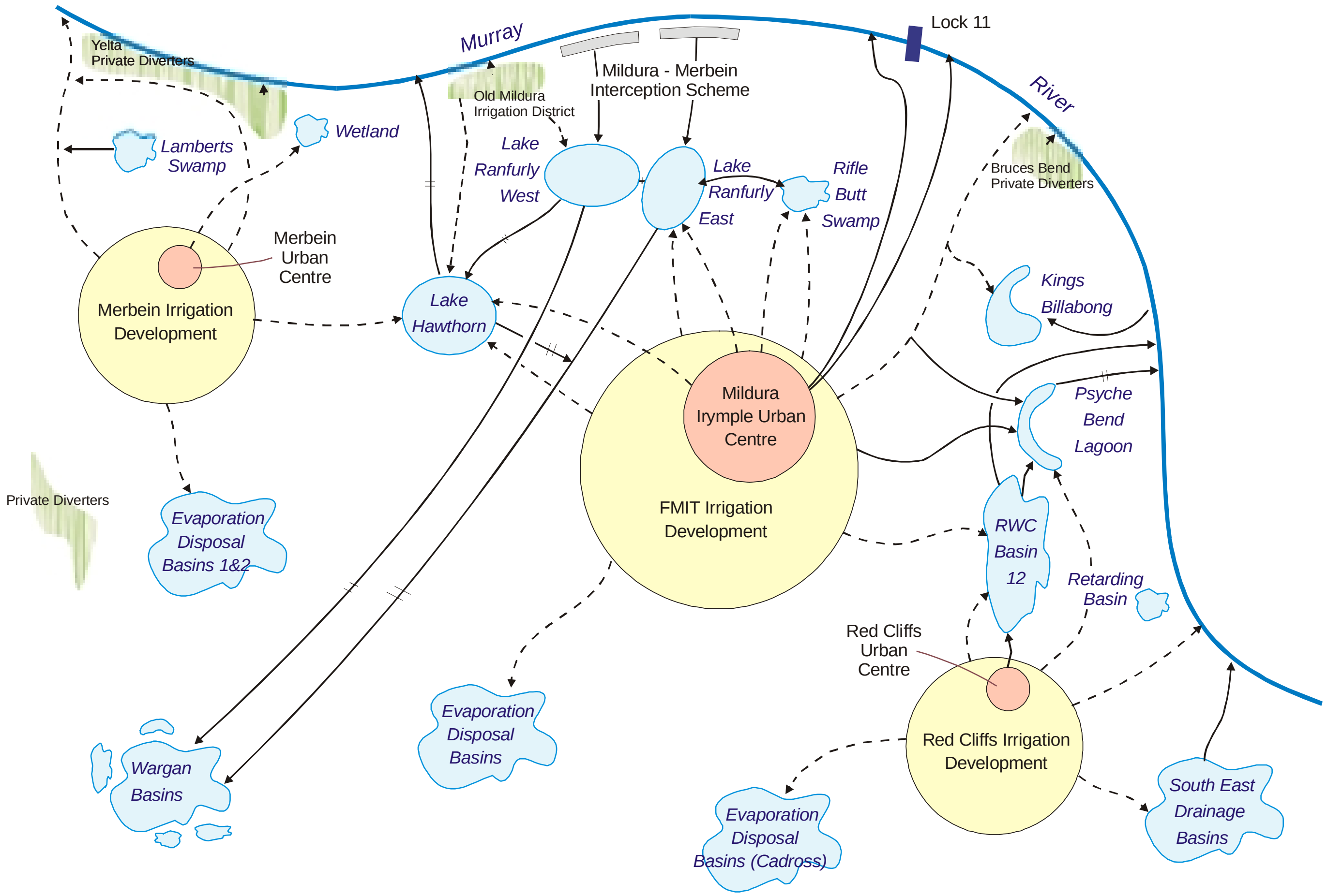
■ **Figure 3-3 Schematic of the Drainage System**



3.2 Urban Stormwater Drainage Systems

3.2.1 Current System

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 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 nine 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.

Council works, over the past 15 years, have augmented the stormwater drainage system on an ad hoc 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 from these basins into pipes which discharge into the above lakes and swamps.

In particular Surface stormwater flows, following heavy rainfall events, are a significant cause of flooding in the Irymple basin.

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 3-1 presents a summary of the urban drainage systems for Merbein, Mildura/Irymple and Red Cliffs.

- **Table 3-1 Summary of Urban Systems**

Location	Total Area (Ha)	Annual Discharge Volume (ML/yr)
Merbein [1]	145	124
Mildura / Irymple	1,609	1,815 (691 to River, 1124 to Basins)
Red Cliffs [2]	285	261

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

3.2.2 Design and Service Standards

Mildura Rural City Council currently applies the following drainage standards to new urban development:

- peak flows resulting from a 5 year average recurrence interval (ARI) storm event should be contained within the piped drainage systems;
- the floor levels of all habitable buildings should be at least 300 mm above peak flood levels resulting from a 100 year ARI storm event.

These standards are generally in accordance with current practice for residential development in other urban areas in Australia. A higher piped standard, generally the 10 year ARI event, is usually applied to commercial and industrial development, where nuisance flooding is likely to have greater impact.

Most major piped gravity drainage systems servicing existing developed areas of Mildura have capacity to accommodate less than 50% of the 5 year ARI design flow, which will generally be less than a 2 year ARI event. The two largest catchments, Etiwanda and San Mateo (I and L), have an estimated combined outfall capacity of around 520 ML/d, compared to a combined 5 year ARI design peak flow of around 1,900 ML/d.

The major landlocked catchment around Irymple has basins capable of catering for only around half the runoff volume from a 100 year ARI storm event, under existing development conditions.

3.3 Irrigation Drainage Systems (Rural)

3.3.1 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 3-3). 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 Lake Hawthorn Drainage Diversion Scheme operates to pump irrigation (and urban) drainage from Lake Hawthorn to Wargan Basins.

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 3.2 presents a summary of the irrigation drainage systems for the Study Area by location and Authority.

■ **Table 3.2 Summary of Irrigation Drainage Systems**

Location/Authority	Total Area	Actual Irrigated Area (ha)		Annual Drainage Discharge Volume (ML/yr)		Annual Salt Load (t/yr)	
		River(1)	Basin	River(1)	Basin	River(1)	Basin
SRWA (Merbein)	3,565	986	1,732	1,380	2,425	1,656	2,910
SRWA (Red Cliffs)	5,435	1,108	2,718	1,555	3,801	1,866	4,561
Total SRWA	**9,000**	**2,094**	**4,450**	**4,450**	**6,226**	**3,522**	**7,471**
FMIT	**11,597**	**1,201**	**5,080**	**1,681**	**7,112**	**2,018**	**8,534**
Yelta Irrigators	461	359	0	503	0	603	0
Merbein Irrigators	1,062	175	749	245	1,049	294	1,258
Mildura / Red Cliffs Irrigators	574	883	498	1,236	697	1,483	837
Total Private Irrigators	**2,097**	**1,417**	**1,247**	**1,984**	**1,746**	**2,380**	**2,095**
GRAND TOTAL	**22,694**	**4,712**	**10,777**	**8,115**	**15,084**	**7,920**	**18,100**

1. Discharge to River or floodplain.

3.3.2 Future Flows

Trend analyses of subsurface drainage flows in the Study Area have been undertaken as part of a current investigation of the Mildura Merbein Salt Interception Scheme for Goulburn-Murray Water. These have shown that if the effects of rainfall and supply diversion are removed, the average subsurface drainage rate in irrigated areas in 1998 was around 1.4 ML per hectare per year. This rate decreased by around 0.05 ML/ha/yr over the period of analysis (two different drainage systems analysed with periods of record respectively from 1975 to 1998, and 1988 to 1998), due presumably to improvements in irrigation practices, including conversion from furrow to sprinkler and drip irrigation.

In considering future drainage volumes, it is recommended that realistic maximum and minimum rates be adopted as follows:

- maximum practical rate, based on no reduction in the 1998 drainage rate, of 1.4 ML/ha/yr;
- minimum practical rate based on experience that it is difficult to achieve a drainage rate of less than 10% of applied water, which for grapes represents something of the order of 0.7 ML/ha/yr. This is predominantly due to salinity leaching requirements. If the trends noted in the Goulburn Murray Water study continue, this minimum value would be reached in around 15 years. Furrow irrigation still represents around 50% of total irrigation in Mildura and Red Cliffs, and more than 70% in Merbein. It is expected that only around 20% of the irrigated area in Merbein and Red Cliffs will be under furrow irrigation in 10 years time (Andrew Sinn, pers comm). It is assumed that this rate will apply to the 2050 scenario.

3.3.3 Design and Service Standards

Sunraysia Rural Water currently applies the following drainage design standards to new irrigation development:

- sprinkler irrigation – 0.19 L/s/ha; and
- drip irrigation – 0.14 L/s/ha.

Original design standards were based on draining 25% of the irrigation supply rate, on the basis of the farmer receiving water once every 28 days and applying 150 mm over the entire area. There was no allowance for stormwater (Andrew Sinn, SRWA, pers comm). Whilst this bears little resemblance to current day practices, these design rates equate reasonably closely to 25% of current day supply rates as follows:

Drip	40 mm per week peak (0.66 L/s/ha)
Low level sprinklers	55 mm per week peak (0.91 L/s/ha)

From available information, the existing subsurface drains easily cater for SRWA's design standard for sprinkler irrigation.

3.4 Rural Surface Catchments

Mildura Rural City Council currently requires culverts for cross drainage of rural roads to be designed to cater for peak flows from either the 5 or 10 year average recurrence interval storm event, depending on the importance of the road. There is however very limited surface stormwater drainage infrastructure in rural areas within the Sunraysia Region, due at least partly to the scarcity of defined rural watercourses and surface drains. 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.

3.5 Groundwater

Prior to European settlement, the regional watertables were generally 15 to 20 metres below the ground surface within the dryland areas of Mildura, 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.

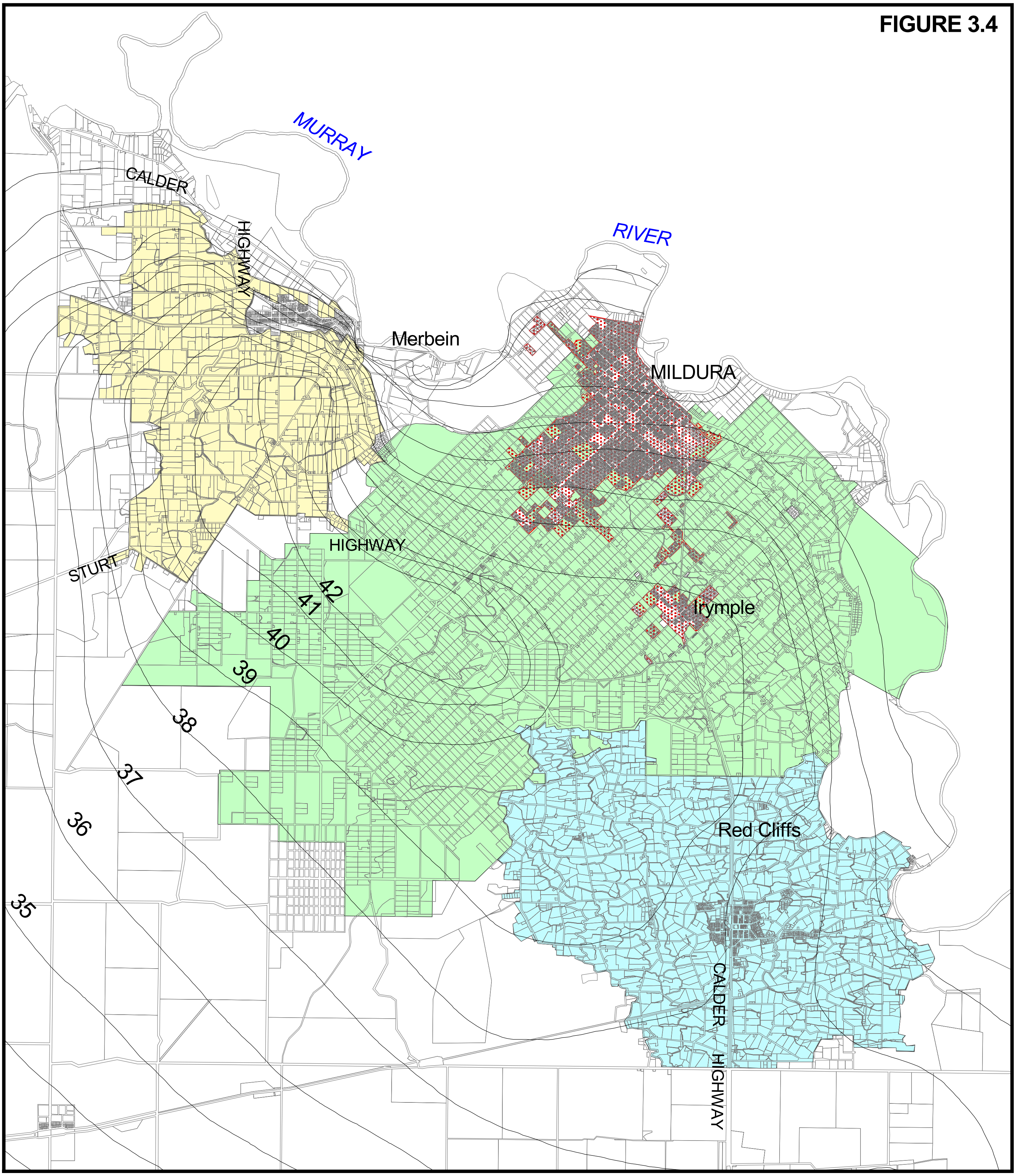
Irrigation within the Mildura area has resulted in the formation of a regional groundwater mound beneath the irrigated and urban areas. Irrigation has also caused the development of perched water tables, which subsequently recharge the regional groundwater mound. In 1987, the mound in the regional groundwater 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 15 km 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 Evaporation Basins. The combined benefit of the Mildura-Merbein and Buronga (which operates on the adjacent New South Wales side of the river) Groundwater Interception Schemes is 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. This investigation is to determine the most effective configuration for groundwater interception schemes in the vicinity of Mildura.

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, and are generally as indicated on Figure 3-4. Salinities in the aquifer range from 10,000 to 50,000 EC, and the aquifer is the major source of saline waters discharging to the Murray in the Study Area. Most of the Study Area is underlain by the relatively impermeable Blanchetown Clays, resulting in a perched watertable at around the level of the subsurface drains. At some locations, the perched shallow watertable is within two metres of the surface, potentially causing localised salinisation impacts. Windows in the Blanchetown Clays cover perhaps 15% of the Study Area, providing direct connection to the Parilla Sands aquifer.

FIGURE 3.4



SINCLAIR KNIGHT MERZ

Refer to Sinclair Knight Merz document WCMA\wc01738\gis\arcview\c01738t002.apr; Irrigation Districts (Layout)

Water Table Elevation
Existing Development (pre 2000)
Irrigation Districts
Merbein
FMIT
Red Cliffs

0 1 2 3 4 5 Kilometres

Sunraysia Drainage Strategy and Urban Stormwater Management Plan

WATER TABLE ELEVATION (metres AHD)

4. Economic, Social and Environmental Values and Impacts

4.1 Values

The values associated with the receiving water environments were assessed as part of preparation of the Urban Stormwater Quality Management Plan Project. This included consideration of irrigation drainage receiving waters. Further details are presented in Volume 2.

Relevant values include:

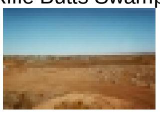
- ecological;
- cultural and heritage;
- amenity and recreational;
- economic; and
- drainage.

The key values of environments receiving urban stormwater water runoff and irrigation drainage are summarised in Table 4-1.

In accordance with the requirements of the Victorian Stormwater Committee guidelines for preparation of Urban Stormwater Quality Management Plans, values have been ranked as low, moderate, high and very high. In order to adequately determine realistic values for each environment, a set of criteria was developed (refer Volume 2). Using these criteria, specific values for each receiving environment were ranked. In addition to current values, an assessment of potential values was also conducted. This assessment was based on the potential change in values of particular environments depending on future management scenarios.

A summary of the current values for all receiving environments is shown in Table 4-2. Generally, all values associated with the Murray River and Kings Billabong are very high. The smaller terminal evaporation basins generally have low environmental value due to highly saline water and reduced volumes of water outfalling over recent years, whereas the larger terminal basins with a greater water volume have high to very high environmental values because of their significance as habitat for rare and threatened waterbirds. All basins have high drainage value, particularly those that are used to prevent saline and nutrient rich water from entering the Murray River. The highest amenity values are associated with the Murray River, however there is the potential to improve the amenity of many of the drainage basins by revegetation and enhancement of their conservation values. High economic values are associated with the Murray River and with the potential for the re-use of water from some basins depending on the ability to guarantee the quality and quantity of water.

■ Table 4-1 Summary of key values of high value environments receiving urban stormwater and irrigation drainage

Receiving Environment	Key values
Significant environments receiving urban stormwater runoff	
Murray River 	▪ The Murray River above and below Lock 11 provides significant instream and riparian habitat values. A range of threatened species are supported by the river and floodplain environments and parts of this system are listed on the Register of the National Estate and the Directory of Important Wetlands in Australia. ▪ The Murray River environment is also significant for its cultural and heritage values and there are numerous archaeological sites highlighting the links with indigenous cultures. ▪ The River environment is highly valued for its recreational, tourism and amenity values. ▪ The region is highly dependent on the River as a source of high quality water for irrigation, domestic and industrial use.
Kings Billabong 	▪ As with the Murray River, Kings Billabong has significant instream and riparian values. There is a long record of indigenous contact with the area as well as more recent non-indigenous heritage values associated with irrigation development in the region. ▪ Kings Billabong is listed on the Directory of Important Wetlands in Australia and supports a range of threatened flora and fauna. ▪ The wetlands is a popular for recreational activities including swimming, boating fishing and camping and provides high landscape amenity to rural residential development along the west shoreline. ▪ Water is pumped from the Murray River to Kings Billabong from where it is then pumped into the FMIT irrigation supply system.
Basin 12 	▪ Basin 12 provides habitat values for a range of bird species and offers visual amenity for residential areas, however more active recreational opportunities are low. ▪ Basin 12 is used for irrigation and urban stormwater drainage, however inflows appear to be declining due to improved irrigation practices.
Rifle Butts Swamp 	▪ Rifle Butts Swamp provides a moderate level of habitat for birds. ▪ If managed appropriately, Rifle Butts Swamp offers high amenity values to the community as urban development expands around the wetland. ▪ By directing urban stormwater to Rifle Butts Swamp, inputs to the Murray River are reduced. ▪ The values associated with Rifle Butts Swamp are maintained by stormwater inputs.
Lake Ranfurly 	▪ Lake Ranfurly provides significant habitat for many bird species, including species listed under State Government threatened species legislation. It is listed on the Directory of Important Wetlands in Australia for its significant bird habitat. ▪ While the area around the Lake Ranfurly is degraded, there are opportunities for improved amenity for local residential communities. ▪ By directing urban stormwater to Lake Ranfurly, inputs to the Murray River are reduced.
Lake Hawthorn 	▪ Lake Hawthorn provides habitat for birds and some fish species ▪ Lake Hawthorn also provides some recreational opportunities and visual amenity for surrounding residents. ▪ By directing stormwater runoff the Lake Hawthorn, salt and nutrient inputs to the Murray River are reduced.
Significant environments receiving irrigation drainage water	
Cardross Lakes 	▪ Cardross Lakes are significant for supporting one of the most diverse small native fish populations in the State, and in particular the endangered Purple Spotted Gudgeon. ▪ Inflows to Cardross Lakes are declining and reduced water levels in the lakes pose a threat to the native fish species present.
Wargan Basins 	▪ Wargan basins provide significant habitat for a range of bird species and offer a range of passive recreational activities such as bird watching and nature conservation. ▪ The basins are listed on the Directory of Important Wetlands in Australia and support populations of waterbird listed under international migratory bird agreements.

■ **Table 4-2 Summary of current values of environments receiving urban stormwater and irrigation drainage**

Receiving Environment	Environmental		Cultural		Amenity			Eco-nomic	Drainage	
	Instream	Riparian	Indigenous	Non-indigenous	Recreational	Amenity	Tourism	Water Supply	Flood reductions	Salt & nutrient reductions to Murray River
Environments receiving urban stormwater runoff (& irrigation drainage)										
Murray River	V high	V high	V high	V high	V high	V high	V high	V high	High	Low
Kings Billabong	V high	V high	V high	V high	V high	V high	V high	High	Low	Mod.
Basin 12	High	High	Mod.	Low	Mod.	Mod.	Low	Low	High	V high
Rifle Butts Swamp	Mod.	Mod.	Mod.	Low	Low	Mod.	Low	Low	High	Mod.
Lake Ranfurly East	V high	V high	High	Low	Low	High	Low	Low	High	V high
Lake Hawthorn	V high	V high	Mod.	Low	High	High	Mod.	Low	V high	V high
Environments receiving irrigation drainage										
Cardross Lakes	V high	V high	Low	Low	Low	Low	Low	Low	Mod.	Mod.
Koorlong Basins	Low	Mod.	Mod.	Low	Low	Low	Low	Low	Mod.	V high
Lamberts Swamp	Low	Low	Low	Low	Low	Low	Low	Low	Low	V high
Lake Ranfurly West	V high	V high	High	Low	Low	Low	Low	Low	Low	V high
Wargan Basins	V high	V high	Mod.	Low	Mod.	High	Low	Low	V high	V high
Psyche Bend Lagoon	Low	Low	Mod.	Low	Low	Low	Low	Low	Mod.	V high

4.2 Threats

The threats posed to the receiving waters by both urban stormwater and irrigation drainage were also assessed as part of preparation of the Urban Stormwater Quality Management Plan. Threats include:

- sediment;
- nutrients;
- salinity;
- litter;
- organic material;
- microbiological contamination;
- heavy metals and other contaminants;
- impacts on visual amenity;
- construction impacts on cultural sites;
- flooding; and
- erosion and turbidity in drains and around outfalls.

An assessment of the specific stormwater threats in the study area is summarised in Table 4-3. These threats are grouped according to landuse and particular catchment activities. Specific examples or locations of threats within the region are identified along with the impact expected on receiving environments. As with values, threats have been assigned a ranking according to their significance, ie Very high, High Moderate, Low. This ranking is based on the potential pollutants or impacts on the values of receiving environments. Where a particular threat is not present it has not been given a ranking.

- **Table 4-3 Threats to receiving environments from stormwater and rural drainage (na: threat not applicable to that environment).**

Activity/landuse threat	Stormwater & Irrigation Receiving Environment							Irrigation drainage Receiving Environments					
	Murray River below Lock 11	Murray River above Lock 11	Kings Billabong	Basin !2	Rifle Butts Swamp	Lake Ranfurly East	Lake Hawthorn	Psyche Bend Lagoon	Cardross Lakes	Koorlong Basins	Lamberts Swamp	Lake Ranfurly West	Wargan Basins
Residential runoff	V high	V high	High	High	V high	V high	High	Low	Low	Low	Low	Low	na
Industrial runoff	Mod.	V high	na	Mod.	Mod.	High	Low	na	Na	na	Na	Na	na
Commercial / institutional runoff	Mod.	V high	na	Mod.	High	V high	Low	na	Na	na	Na	Na	na
Construction sites – lot	High	High	High	Mod.	High	High	High	na	Na	na	Low	Low	na
Development sites	High	High	High	Low	V high	V high	V high	na	Na	na	Na	Low	na
Major highways, arterial & rural road runoff	High	V high	Mod	High	High	V high	High	na	Low	Low	Low	Low	na
Sullage and septic tank overflows	High	High	V high	High	Mod.	Mod.	High	Low	High	High	High	Low	na
Sewer overflows	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	na
Open spaces, parks and recreational areas	Mod.	High	Mod.	High	High	High	High	Low	Low	Low	Low	Low	na
Upstream inflows	High	High	High	na	Na	na	na	na	Na	na	Na	Na	V high
Irrigation drainage	V high	V high	High	V high	Mod.	V high	V high	High	V high	V high	V high	V high	Mod.
Rural surface runoff	V high	V high	High	V high	Low	High	V high	Mod	V high	V high	V high	V high	High
Unstable and degraded waterways	Mod.	High	High	Mod.	Mod.	Mod.	Mod.	High	Mod.	Low	Low	Mod.	Low

The greatest threats from stormwater and drainage water in the study area are due to:

- Excess nutrients in stormwater runoff from residential and industrial areas entering the Murray River;
- Runoff from roads;
- Septic tank effluent;
- Litter in stormwater runoff from commercial areas;
- Poor sediment control on development and construction sites; and,
- Damage to cultural sites, riverbanks, riparian vegetation and wetland areas through degradation by changed flow, erosion, uncontrolled vehicle access, vandalism and rubbish dumping.

Irrigation drainage and runoff from agricultural lands also pose a significant threat to the values of receiving environments. Agricultural runoff can carry nutrients, sediment, salt and pesticides. In the Mildura area most irrigation drainage and urban stormwater drainage systems are separate, although the receiving environments suffer from the combined impacts of stormwater and irrigation drainage water.

4.3 Water Quality

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.

The estimated total nitrogen export rate to the Murray River under existing conditions is around 17 t/yr. An analysis of limited flow and nitrogen concentration data for the Murray at Colignan showed that even low flow conditions, the nitrogen export rate from the Study Area to the Murray is only around 2% of the inflow from upstream.

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.

5. Existing Drainage Management and Cost Recovery Framework

5.1 Drainage Management

Mildura Rural City Council is responsible for providing and maintaining the urban drainage system. Council is also generally responsible for rural surface flooding at the scale of problem typically experienced in the Study Area.

FMIT and SRWA are responsible for providing and maintaining the irrigation drainage system in their respective districts. There are a number of private drainage systems within the Districts, particularly in the western part of the Red Cliffs District. Discharge from these areas is currently uncontrolled unless downstream water users are affected, in which case EPA and/or the CMA may impose conditions.

Irrigated areas outside the Districts, most of which have some form of private drainage include:

- Private diverters, grouped into Yelta, Riverside, Old Mildura, Bruce Bend (part of which is drained by a community scheme, part is undrained, and part drains to the River), and miscellaneous others scattered through the Study Area.

- Areas supplied from the Merbein system including:
  - a new irrigation area between the western boundary of the District and Meridian Road. Ten percent of this area is required to be set aside for drainage disposal in accordance with the requirements of the Nyah to the South Australian Border Salinity Management Plan;
  - properties of the north side of the Calder Highway and Chaffey Avenue, draining to the floodplain; and
  - properties on the eastern side of McEdward Street draining to Lake Hawthorn.

- A recent irrigation area on the southwest fringe of the Red Cliffs District, and supplied from the Red Cliffs system. Ten percent of this area is also required to set aside for drainage disposal in accordance with the requirements of the Nyah to the South Australian Border SMP.

The roles and responsibilities of these and other key agencies and organisations are summarised in Table 5-1.

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.

Table 5-1 Roles and responsibilities of key stakeholder groups

Organisation/Agency	Roles and Responsibilities
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 effective water quality targets, salinity strategy and other basin-wide policies. They also administer the salinity registers (as defined in the Basin Salinity Management Strategy).
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. The EPA may set and administer water quality standards for discharge to receiving waters.
Department of Infrastructure	Oversees the statutory planning requirements of the State.
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. The CMA has responsibility for and manages the salinity register for the Mallee and formulates and manages water quality design and floodplain management strategies for the region.
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 First Mildura Irrigation Trust District and is responsible for substantially managing these assets.
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 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
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.
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.
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.

■ 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	G-MW/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	

5.2.1 Water Bodies on Private Land

Some water bodies owned, managed and predominantly used by a single authority. These water bodies are on private land, and the management is the sole responsibility of the owning authority.

5.2.2 Water Bodies on Crown Land

The Land Conservation Council's Final Recommendations of 1977 and 1989 included as follows:

- That the portions of areas considered necessary for drainage disposal within Crown allotments surrounding *Wargan Basins*, *Cardross Lakes* and the *South East Drainage Basin*, continue to be used as such, under the management of SR&WSC (now SRWA and G-MW). Remaining areas within these allotments should be managed by the then Department of Conservation, Forest and Lands, now NRE, or, in the case of Wargan Basins, consideration be given to their alienation.

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. It is not always clear what is meant by management in this sense, and for what purpose the water body is managed. It is also unclear whether "areas considered necessary for drainage disposal" 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.

The Wetland Operational Plan for Kings Billabong is currently being finalised. This should be referred to when making decisions on the management of that water body.

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, to operate on behalf of government.

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. The right of SRWA to discharge irrigation drainage to the Lake is not clear.

The rights of private diverters to discharge to *Lakes Ranfurly and Hawthorn* are also unclear.

5.3 Cost Recovery Framework

5.3.1 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.

Council is currently in the process of preparing Development Contribution Plans for funding of off-site drainage works to serve future urban development.

Other drainage expenditure, viz. operations, maintenance and renewals, is generally funded from general rate revenue.

5.3.2 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 concrete lined 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.

5.3.3 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 200/01 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. Existing Issues

Drainage issues of particular significance are summarised in the following sections.

6.1 Physical Issues

6.1.1 General

- Both urban and irrigation drainage waters may be contributing significantly to algal blooms in the Murray River.

- Localised rural surface flooding is experienced in many areas, and often results from landlocked catchments, and lack of culverts and other suitable drainage infrastructure.

- Conversion of land use from irrigation to urban use, and reduction in irrigation drainage flows resulting from improved irrigation practices, may significantly reduce future inflows to Lake Hawthorn. This is likely to result in significantly higher salinities and nutrient levels, and lower operating levels.

- Inland diversion of drainage waters could potentially provide EC credits.

- Relatively little drainage water is currently reused.

- 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.

6.1.2 Urban

- There is virtually no urban drainage infrastructure in place in any of the undeveloped parts of Mildura Irymple currently zoned for urban development. This may ultimately impede development.

- The rate of urban development in the Mildura Irymple area has been 40 ha per year over the past 14 years, and is not expected to decrease in the foreseeable future. This is double the rate assumed in preparation of the Mildura Planning Scheme.

- Developers' contributions are currently inadequate to fund required offsite urban drainage works.

- Lack of masterplanning and coordination of urban drainage has often resulted in standalone subdivisional drainage systems discharging to outfalls of inadequate capacity.

- Disruption to subsurface irrigation drainage systems during subdivisional development often results in localised waterlogging.

6.1.3 Rural

- Significant salt loads and poor quality drainage waters discharge to the River from the Merbein Irrigation District drainage shafts, Lamberts Swamp and the West and North West Drains. Disposal of drainage waters to the shafts is estimated to result in an annual salt load to the River of more than 5,000 t (ref 5).

- Reduced drainage flows resulting from improved irrigation practices may have significant implications for the quantity and quality of water in inland basins, particularly Cardross Basins and Lake Hawthorn.

6.2 Institutional Issues

6.2.1 Urban and Irrigation Drainage

A clear management arrangement must be sought for assets where more than one body discharges drainage water to the same system or a system owned by another authority. This issue will arise, for example, if Council discharges urban runoff to irrigation drains that have spare capacity due to conversion of land use from irrigation to urban, or rural subsurface drains discharge to land owned by another authority. The Study Area is probably unique in Victoria with respect to the urban stormwater and subsurface irrigation drainage networks servicing the same geographical areas.

Responsibilities for urban subsurface drainage, if adopted, need to be defined.

There is currently little or no institutional control over private irrigation drainage systems outside the declared irrigation Districts. Some of the physical problems identified as being associated with these systems, eg. discharge to the floodplain, could be overcome by revised institutional arrangements.

There is a lack of general coordination of drainage between MRCC, FMIT and SRWA.

Future urban growth around Mildura and Irymple will result in take up of land currently used for irrigated agriculture. This will potentially impact on the viability of FMIT's business.

6.2.2 Inland Water bodies

<u>Water bodies on Crown Land</u>

The wildlife reserve, including Kings Billabong, is managed by NRE (unlike the other basins that were intended to be managed by SR&WSC where responsibility now rests with either SRWA or G-MW). This water body is however still used for water supply and drainage purposes. 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.

Mildura Merbein Groundwater Interception Scheme and Lake Hawthorn Drainage Diversion Scheme

There is a lack of record of formal agreements between the various water bodies.

- SRWA discharges to Lake Hawthorn, which is an FMIT basin. There appears to be no agreement on the volume, timing and quality of water discharged. Urban drainage will soon become a similar issue for MRCC.
- G-MW does not appear to have any agreement to operate levels in Lake Hawthorn.

G-MW pumps irrigation drainage and urban stormwater from Lakes Ranfurly and Hawthorn to Wargan Basins, without charging any fee from SRWA, FMIT or Council. Local landowners discharge directly to Lake Ranfurly East without any formal agreement.

6.2.3 Overall Strategy and Coordination

There is no overall drainage strategy for the Study Area, and a lack of coordination between the various authorities with drainage related functions. The Drainage Task Force has recognised this, and has taken the lead role in developing the Strategy. It also has a keen interest in seeing the Strategy implemented. The Task Force may however have limited future funding options.

Part B – Future Arrangements

7. Year 2050 Development Scenario

7.1 Urban Development

7.1.1 Mildura/Irymple

The Mildura Planning Scheme (ref 3) documents existing land use zonings for the entire municipality. The Scheme includes Town Structure Plans for each of Mildura, Irymple, Red Cliffs and Merbein. These define three stages of future development as follows:

> Stage 1 – zoned Residential 1 and has immediate access to all services, and can be developed immediately;
> Stage 2 – zoned Residential 1 and has access to some but not all services. Stage 2 land can be released when Stage 1 land has reached 50% capacity; and
> Stage 3 – zoned Rural and nominated for future residential development. Stage 3 land can be released when Stage 2 land has reached 50% capacity.

The Scheme indicates availability of 80 ha of Stage 1, 400 ha of Stage 2 and 150 ha of Stage 3 land in Mildura. Locations of Stages 1, 2 and 3 land shown on the four Town Structure Plans are shown on Figure 7-1.

The Scheme has allowed for approximately 160 to 250 additional dwellings per annum over the next ten years, which it has equated to development of approximately 20 ha of additional residential land per annum.

Council's Planning Department has also provided a preliminary indication of where it sees the next areas of potential development in Irymple and Mildura may occur beyond the three Stages indicated in the Town Structure Plans. These comprise:

- In-fill of area bounded by Riverside Avenue, Seventeenth Street, Cowra Avenue and Fifteenth Street;
- Small area around Flora Avenue;
- Area bounded by Cureton Avenue, Cowra Avenue, Sandilong Avenue and Eleventh Street. Council has noted with respect to this area that it is not proposed to extend it south due to the likely recommendations of the North West Freight Strategy;
- Area to the north of Stage 1 and 2 area in Irymple, south of Fourteenth Street between Karadoc Avenue and Irymple Avenue; and
- Small area to the south of Irymple fronting the east side of Sandilong Avenue.

As noted previously, the actual growth rate in Mildura Irymple over the past 14 years has been around 40 ha per year, and thus much greater than assumed in the Planning Scheme. A similar figure appears to have been adopted by Lower Murray Water in its water supply planning for the next 40 years, in which it has assumed an additional area of 1506.5 hectares, or 37.7 hectares per year.

For the purposes of the Drainage Strategy, the Steering Committee and Reference Group have resolved to adopt a maximum feasible 2050 development scenario. This has been rationalised to catchments as shown on Figure 7-2, taking account of:

- the Planning Scheme;
- advice from Council's Planning Department;
- existing infrastructure; and
- planned future infrastructure, particularly that of Lower Murray Water.

This represents a total increase in urbanised area in Mildura/Irymple of nearly 2,300 ha.

7.1.2 Red Cliffs and Merbein

Both Merbein and Red Cliffs have experienced very slow urban growth in recent years, and it is likely that there is sufficient residential land available in both townships to cater for development to 2050.

7.2 Irrigation Development

Future urban growth around Mildura and Irymple will result in take up of land currently used for irrigated agriculture. There is some scope for minor expansion of the Merbein Irrigation District along the western boundary of the Study Area, and it is assumed that this will be taken up within the next ten years. There is relatively little scope for expansion of the irrigated area in the Red Cliffs District. It is assumed that expansion of the FMIT Irrigation District will be predominantly by in-fill development.

Parts of the Study Area that could potentially be taken up for irrigation development by 2050 are shown on Figure 7-3.

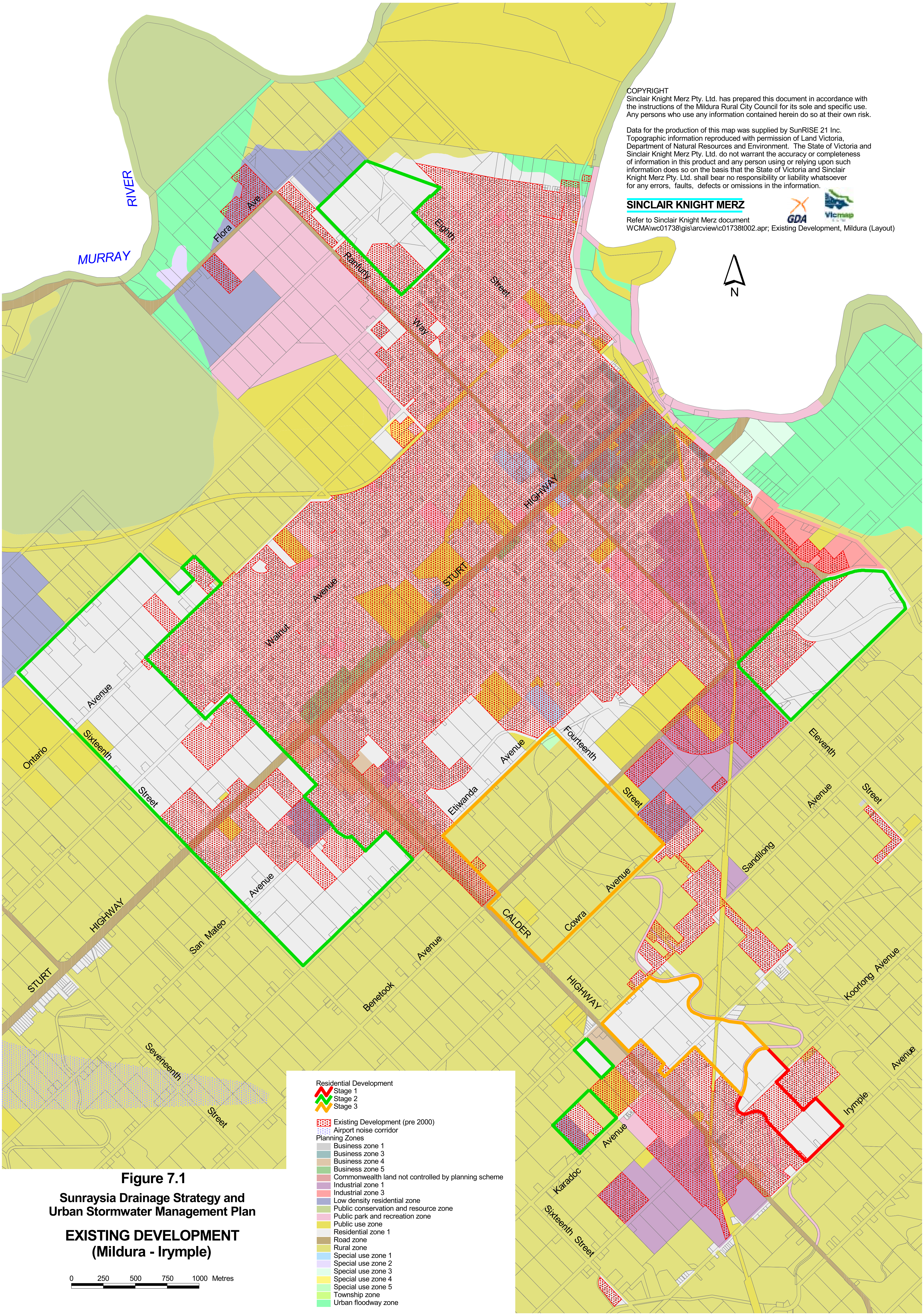


Figure 7.1

Sunraysia Drainage Strategy and Urban Stormwater Management Plan

EXISTING DEVELOPMENT (Mildura - Irymple)

FIGURE 7.2 - ADOPTED 2050 SCENARIO

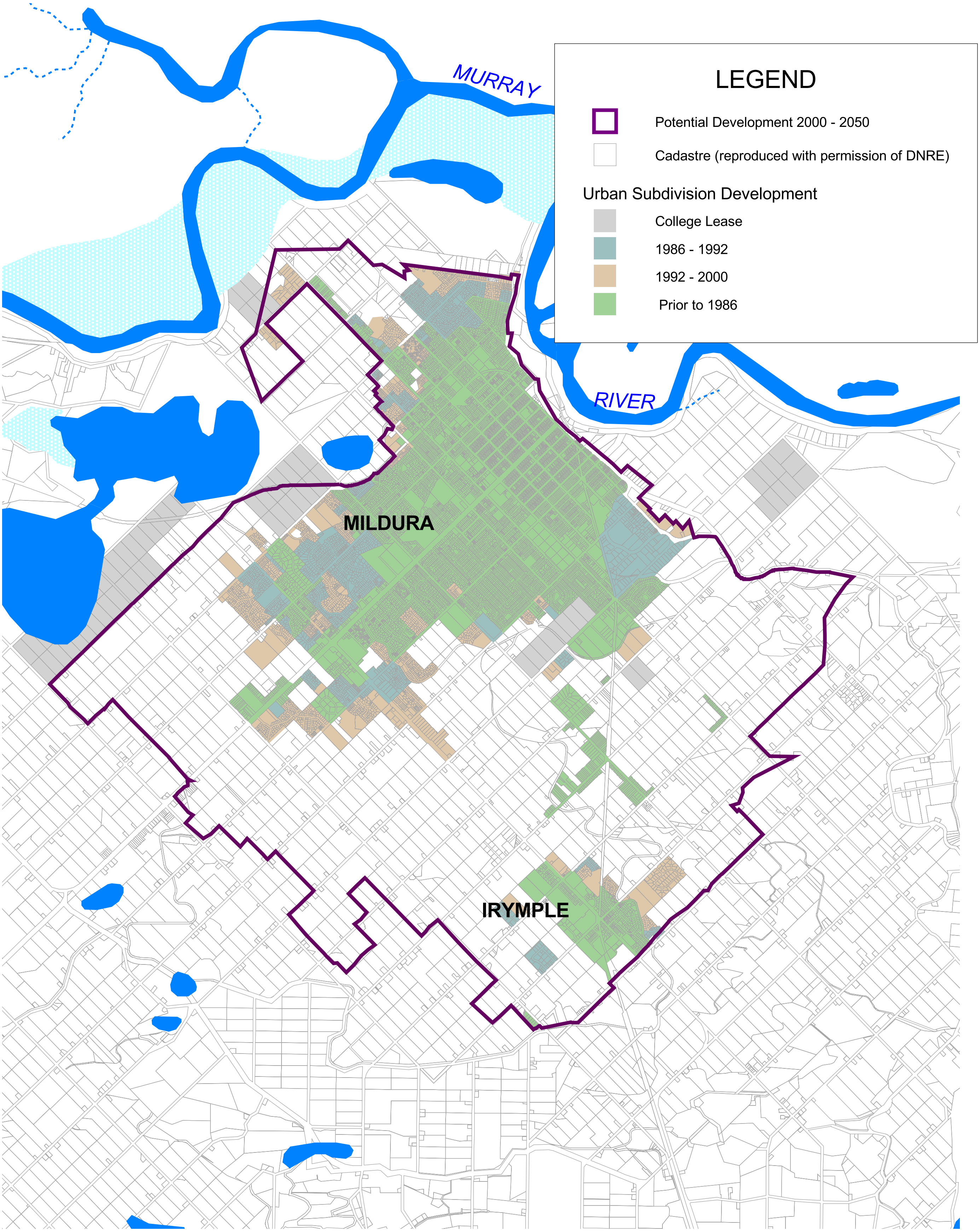


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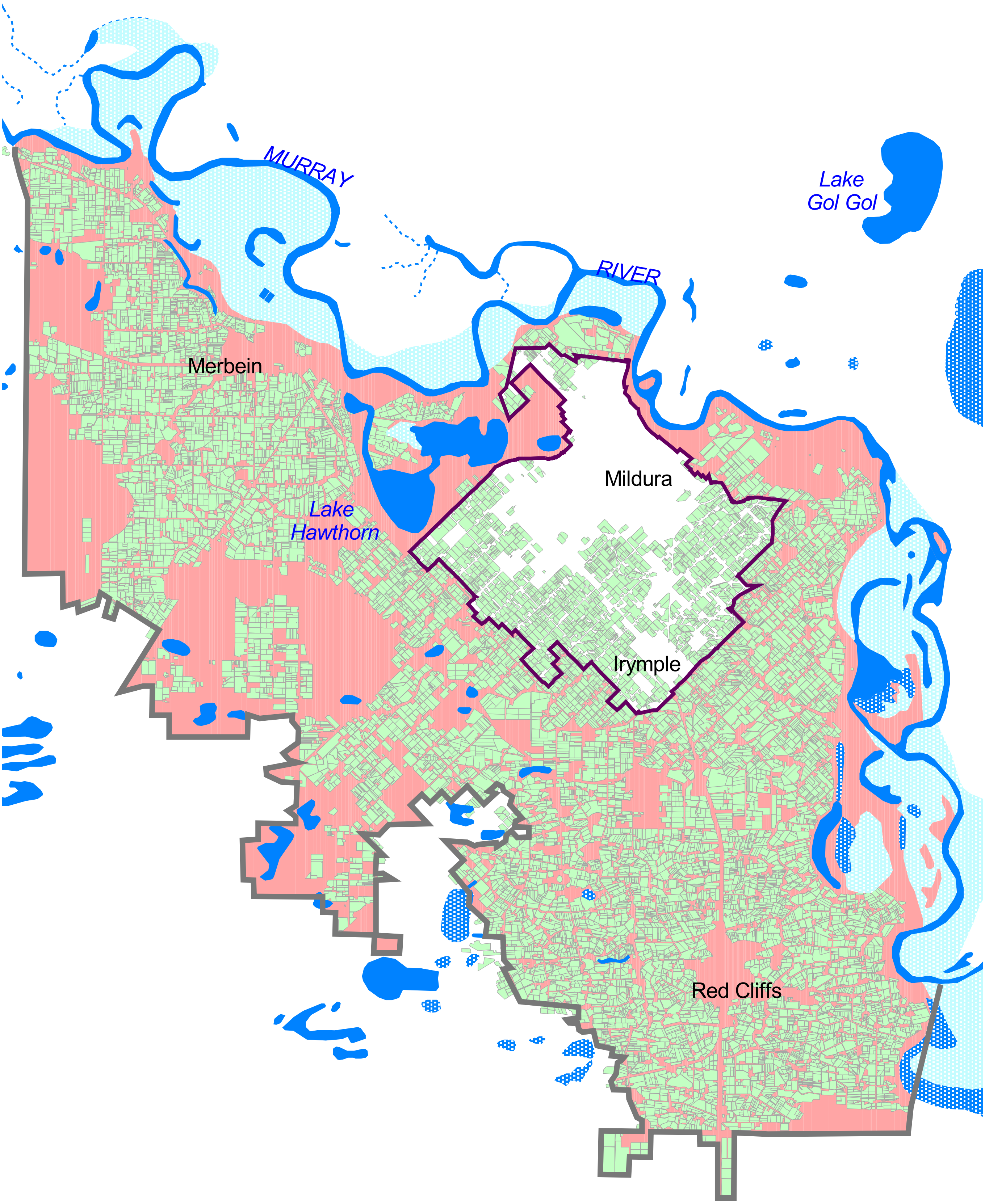
FIGURE 7.3 - IRRIGATION DEVELOPMENT



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8. Standards of Service

8.1 Urban Drainage

It is recommended that the following drainage design standards be adopted for future urban development:

- minor drainage system standard: peak flows should be contained within the piped drainage system as follows:
    - residential development – 5 year ARI storm event; and
    - industrial and commercial development – 10 year ARI storm event;
- major drainage system standard: the floor levels of all habitable buildings should be at least 300 mm above peak flood levels resulting from the 100 year ARI storm event.

The risks associated with adoption of lower standards of service for both major and minor drainage systems are summarised in Table 8-1. Adoption of lesser standards for new development will generally result in a standard of service that is less than normal industry practice and this could potentially leave Council open to a legal challenge for provision of substandard drainage.

8.2 Irrigation Drainage

Risk factors and associated consequences associated with adoption of lesser than existing irrigation drainage standards are summarised in Table 8-1.

It has occasionally been suggested that subsurface drainage might not be required in the Sunraysia District. A continuation of the current practice of installing subsurface drainage systems is required to prevent exacerbation of risk factors listed in Table 8-1.

Subsurface drains, particularly off-farm, are often very deep, and pipe supply costs would then generally be a relatively small proportion of total drainage system construction costs. The construction cost savings to be gained by adoption of a lesser design standard would therefore generally be relatively small.

The design life of subsurface drains is understood (Andrew Sinn, pers comm) to be of the order of 100 years. Subsurface drainage system were first installed in the area in the 1930's, so in theory most drains have at least 30 years remaining design life, and many much longer, provided they are adequately maintained. Root intrusion is the predominant cause of any damage. Consideration of a lesser design standard for most of the Study Area is then largely irrelevant when looking at a year 2050 scenario, as the majority of the drainage system will not require replacement over this period. Nevertheless, for the drains that will require replacement, the current design standards are considered adequate.

Most of the Study Area is underlain by relatively impermeable Blanchetown Clays, resulting in a perched watertable at around the level of the subsurface drains. There are however understood to be "windows" within these Clays, covering perhaps 15% of the Study Area, providing direct connection to the Parilla Sands aquifer. Depending on location and topography, a reduction in subsurface drainage service standard could then potentially result in some additional accessions to the Parilla Sands, which would then in turn result in displacement of an equivalent volume of highly saline groundwater to the Murray River. Watertable levels within the Parilla Sands aquifer have been relatively stable in recent years.

It is therefore recommended that the current drainage standards be adopted.

8.3 Rural Surface Drainage

As noted previously, Mildura Rural City Council currently requires culverts for cross drainage of rural roads to be designed to cater for peak flows from either the 5 or 10 year average recurrence interval storm event, depending on the importance of the road. Current practice in Australia is for culverts for cross drainage of major highways and railways to be designed to cater for peak flows from either then 50 or 100 year average recurrence interval storm event. These standards are generally considered adequate, and it is recommended that they continue to be applied. It should be remembered however that there is a scarcity of defined rural watercourses and surface drains within the municipality. Many of the drainage problems identified in rural areas are along roads, and are likely to be a result of either lack of culverts or inadequate culvert capacity.

There may be situations in landlocked catchments, where installation of culverts under roads will only serve transfer a flooding problem from an upstream to a downstream landholder. Council may then need to consider additional options for mitigating the impact on the downstream landholder(s).

Other risk factors are summarised in Table 8-1.

■ Table 8-1 Drainage Service Standard Risk Factors

Risk associated with lower standard of service	Likelihood	Consequence
Urban Drainage		
Minor (piped) drainage system		
Increased frequency of nuisance flooding and associated property access difficulties	Very high	Moderate
Major (overland) drainage system		
Increased frequency of above floor flooding and associated flood damage costs	Very high	High
Increased flooding of streets	Very high	High
Increased flood safety risk	Very high	High
Subsurface Irrigation Drainage		
Increased groundwater accessions	Very high	Low
Loss of production due to waterlogging	Moderate	High
Property access difficulties	Low	Moderate
Rural Surface Drainage		
Reduced road access	Very high	Moderate
Safety of traffic and pedestrians	High	Moderate
Above floor flooding of upstream buildings	Low	High
Flooding of upstream land	Very high	Moderate

9. Drainage Management Measures

9.1 Drainage Disposal Measures

9.1.1 Assessment Methodology

Existing drainage systems currently discharge to either the Murray River or inland water bodies. A range of future disposal options was considered. Many of the benefits of these options cannot be meaningfully expressed in economic terms. This particularly applies to the environmental and amenity values of inland water bodies. A multi-criteria analysis methodology was therefore used to assess the options. Criteria used in the analysis were as follows:

Cost criteria:
- Capital cost.
- Recurrent costs.

Benefit criteria:
- Reduction in salt loads to the Murray River.
- Reduction in algal blooms in the Murray River.
- Environmental enhancement of inland water bodies.
- Enhancement of amenity values of inland water bodies.
- Reuse opportunities.

The adopted method entails assigning a score between 0 and 1 to each criterion for each option. A pseudo benefit cost ratio is then determined by dividing the weighted sum of the benefit criteria scores, by the weighted sum of the cost criteria scores. The weightings were assigned based on an averaging of weightings provided by relevant stakeholder organisations.

9.1.2 Recommended Disposal Measures

Options were selected based on application of the methodology outlined above. Some of the options were then modified slightly to provide a better outcome for receiving waters. Adopted disposal measures were as follows:

-
- The majority of runoff from the Irymple Basin should be pumped to Lake Hawthorn (Measure 1 in Table 9-1).
- Urban runoff discharging to Lakes Hawthorn (Measure 1) and Ranfurly East (Measure 2) should be treated in wetlands prior to discharging to these two water bodies. The existing disused sewerage lagoons on the shores of Lake Ranfurly East should be retrofitted to form the wetland required to treat runoff to this water body.
- Runoff from the urban drains servicing the Etiwanda and San Mateo catchments of urban Mildura, should be treated in a wetland prior to discharging to the Murray River (Measure 3).
- Flows from Lamberts Swamp, Merbein West and North West Drains, and the drainage shafts, should be pumped back to Wargan Basins (Measure 4).
-
- Irrigation drainage from part of existing Red Cliffs catchment 1 should be pumped back to Cardross Lakes (Measure 5).

- Irrigation drainage from the remainder of FMIT catchment 7 should be redirected to a wetland at the northern end of Kings Billabong. Subject to detailed studies on the watering requirements of flora and fauna in around this wetland, it may also be necessary to include provision for discharge directly to the Billabong (Measure 6).
- Outfall from the Merbein town drainage system should be connected directly to the River, via an ephemeral wetland (Measure 7).

These measures are shown on Figure 9-1 and Figure 9-2.

Further, more detailed, investigations will be required prior to implementation of any of these measures. These should take account of economic, social and environmental issues, and include development of detailed business cases. The detailed investigations will also need to consider the need for economic, social and environmental tradeoffs between competing needs for a number of the inland water bodies.

All of the measures are also subject to detailed investigations of impacts on water bodies, and some will depend on the outcomes of other investigations. For example, the future of salt interception schemes in the Mildura region is the subject of a current investigation, and this will potentially impact on Lake Hawthorn, Lake Ranfurly, and the evaporative capacity of Wargan Basins.

Where drainage is disposed to the River, existing and new pipes should generally extend completely to the waterline, in accordance with the recommendations of the Draft Nyah to the South Australian Border Salinity Management Plan (ref 6).

9.2 Rural Surface Drainage

A number of sites around Mildura are subject to rural surface flooding, and these have been identified in the Current Situation Report (ref 1, Figure 3). Common factors in many of these areas are:

- the landlocked nature of many of the catchments; and
- a lack of culverts under roads, railway lines and irrigation channels.

Whilst the total number of properties and buildings affected by these problems might be relatively large across the entire Study Area, only a relatively small number of properties is generally affected at each site. In many cases, particularly where the affected properties are at the low points of landlocked catchments, pumped disposal to remote sites, and other similar solutions that might be considered in urban areas, will not be cost effective. It is recommended that each case be considered on its merits. Measures that should be considered either alone or in combination might include:

- installation of culverts. Care needs to be taken that this won't just transfer the problem downstream;
- small, property scale, on-site detention facilities in the catchment upstream of the obstruction, to reduce peak flows;
- construction of evaporative disposal basins at the low points of landlocked catchments. There may be some potential for reuse of stormwater runoff in such instances;

- allowing landholders to dispose of stormwater to the subsurface drainage system. This would need to be carefully controlled and monitored to ensure that discharge is only allowed when capacity is available, and that any adverse downstream water quality impacts are minimised;
- construction of low levees or floodwalls around individual houses. Small pumps would also be required to discharge stormwater from inside the floodwall/levee;
- raising of buildings to above flood levels. This will clearly not be practical for slab-on-ground construction;
- building relocation; and
- property acquisition.

Known and expected flood levels and extents should be clearly identified and documented by Council. Council should then ensure that new buildings are either:

- not located in areas of known or expected rural surface flooding; or
- have their habitable floor levels constructed at least 300 mm above known or expected flood levels.

In cases where rural surface drainage discharges to the floodplain, the need to connect this directly to the River will need to be assessed on a case by case basis. Issues to take into account will include cost and potential EC impacts.

9.3 Urban Subsurface Drainage

Conversion of irrigation to urban use will lower the drainage requirement. In areas of poor natural deep drainage it is unclear as to whether this reduction would be enough to avoid the need for sub-surface drainage.

Conversion of rural land to urban use in the Mildura region results in at least partial disruption of the sub-surface drainage network. Garden watering in urban areas has the potential to cause significant groundwater accessions. Hence there is a need to consider the potential need for sub-surface drainage in urban Mildura, particularly in low lying areas.

If sub-surface drainage is still required, then the disruption of existing drains may lead to waterlogging and salinisation in low lying parts of the urban development. It may not be immediately obvious as to whether any one development needs to retain sub-surface drains. It is therefore prudent to assume that some sub-surface drainage will be required.

Sub-surface drains in urban areas should:

- Provide relief from waterlogging caused by urban irrigation and rainfall
- Protect building structures from rising damp
- Protect soil from salinisation
- Protect urban infrastructure from salt / waterlogging damage

There is therefore considered a need for some sub-surface drainage to be allowed for in urban areas.

Areas where urban subsurface drainage might be required will include:

- areas of known groundwater discharge and waterlogging; or
- topographic low points and swales; or
- areas where there is relatively little topsoil over the underlying clay (these will often be topographic low points)

In areas where the Blanchetown Clay is present. (The Blanchetown Clay covers the majority of the area of potential development to 2050 in Mildura/Irymple.)

It is expected that no more than about a third of the urban area will require subsurface drainage. This cost should be included as part of the developers' costs.
In areas of new development, it is recommended that developers be required to commission a risk assessment to determine the need for subsurface drainage. This should be undertaken by a suitably qualified and experienced hydrogeologist or irrigation engineer.

In areas of existing development, subsurface drainage will generally only be required in known problem areas. The cost of this should be met as a project under this strategy and be funded by the relevant stakeholders.

Areas that might require urban subsurface drainage will generally comprise parts of the FMIT Irrigation District that are excised for urban development. Reasonable attempts should be made to locate existing tile, collector and trunk subsurface drains, and to use these where possible. To assist with this, it is recommended that a planning permit be required for removal of irrigated crops. Any new subsurface drains should be connected to the existing subsurface drainage system wherever practical, and preferably discharge to existing subsurface outfall drains. This may require pumping in some instances.

It is considered essential that new subsurface drains be located in street reserves, as this will avoid the problems associated with drains on private property, viz easements, access, maintenance difficulties, etc. Subsurface drainage rates in urban areas will typically be less than rates required in irrigation areas. Good subdivision design practice dictates that streets should generally be located in low points and grade towards drainage discharge points, such that they can act as floodways for flows in excess of the capacity of the piped stormwater drainage system. Streets will thus generally be ideally located for new subsurface drains. It may be necessary to lay sub-surface drains on both sides of the street reserve, and pumped outfall may be required in some instances. Tree planting should be controlled to reduce accessions and avoid blockages.

9.4 Impacts of Proposed Measures

A preliminary assessment of the likely impacts of the strategy on key water bodies is provided below. A more detailed assessment of the biodiversity values, and a qualitative assessment of the projected impacts of each of the proposed drainage water management actions are required. These should be undertaken under the auspices of the Wetland Operational Plans.

9.4.1 Lake Hawthorn

Conversion of irrigation to urban land use, and future reduction in irrigation drainage rates, will result in a nett decrease if flows to Lake Hawthorn, and an increase in salinity.

MDBC has proposed that the operating rules for the Lake Hawthorn Drainage Diversion Scheme (LHDDS) and Mildura Merbein Groundwater Interception Scheme (MMGIS) be amended to minimise releases from Lake Hawthorn to the Murray River during periods of regulated or low flows, and maximise releases during periods of flood flows. The average salinity of Lake Hawthorn under existing inflow conditions, and assuming revised Scheme operating rules will be around 5,000 EC. Under future inflow conditions, revised Scheme operating rules, and proposed disposal measures described in Section 9.1.2 above, the average salinity of Lake Hawthorn is estimated to be around 8,000 EC without urban subsurface drainage, and 6,000 EC with urban subsurface drainage.

Lake Hawthorn has four fish species listed as having conservation significance, one of which is listed as vulnerable, and two others of which are listed under the Flora and Fauna Guarantee Act. A salinity of 8,000 EC units is likely to be marginal for the health of the fish species listed as having conservation significance. It may therefore be prudent to regularly monitor the salinity of the Lake, and top up with irrigation water if necessary.

9.4.2 Cardross Lakes

It appears very likely that, even with implementation of the disposal measures outlined in Section 9.1.2 above, reduced irrigation drainage rates resulting in significantly reduced flows to Cardross Lakes over time, will in turn result in consistently lower water levels, and higher salinities. It is almost certain that fresh water will need to be imported to Cardross to maintain water levels and salinities necessary to ensure the health of the four fish species listed under the Flora and Fauna Guarantee Act. Previous water balance modelling (ref 14) showed that with historic drainage inflows (1.45 ML/ha/yr in 1997), an additional 1,000 ML/year would be required to maintain a salinity of 6,400 EC during the critical breeding season. This is considered the absolute maximum salinity that could be tolerated by the Purple Spotted Gudgeon during this season. Drainage flows are expected to reduce significantly from 1997 levels, resulting in the need to import more additional water to maintain salinities at the required levels.

The likely volume of freshwater required to be imported to Cardross in the future will need to be confirmed by additional water balance studies. It is likely, however, that this will be significantly greater than 1,000 ML per year.

9.4.3 Murray River

The impacts of some of the options in reducing salt loads to the Murray River are very significant, particularly in the Merbein District, where the drainage shafts are currently estimated to be contributing some 5,000 tonnes of salt per year to the Murray. This load would be virtually eliminated by the proposed measures. To put this in context, the MDBC estimates (P Pfeiffer, pers comm) the total salt load to the Murray between Mildura and Lock 9 to be currently around 35,000 t per year.

As noted in Section 4.3, even under low flow conditions, the nutrient export rate from the Study Area is only around the order of 2% of the inflow from upstream. It should therefore be recognised that there is limited potential for works in the Study Area to have any significant impact on total nutrient loads to the Murray River.

However, the relationship between frequency of algal blooms and nutrient concentration is not linear, and bloom frequency is influenced by a large number of factors, including temperature, turbidity, degree of stratification, chemistry of bed sediments, and relative concentrations of phosphorus and nitrogen. It may well be therefore, that even small reductions in total export loads will have some impact in reducing bloom frequencies. It is therefore recommended that the disposal measures presented above that have been developed with the aim of reducing nutrient export to the River, be pursued, despite the analysis presented above.

9.4.4 Summary

The estimated overall impacts of the proposed strategy on flows, and salt and nutrient loads to key water bodies, are summarised in Table 9-2. On the basis that 1 EC at Morgan equates to around 2,200 t per year of salt from the Study Area, implementation of the proposed disposal measures is estimated to result in salinity reductions as follows:

- Immediately following implementation 6.5 EC
- Year 2050 8 EC

The majority of the immediate impact is associated with removing the following existing salt loads, by diversion to inland water bodies:

- Merbein drainage shafts 5,400 t/yr (ref 5)
- Lamberts Swamp, Merbein West and North West Drains 7,500 t/yr (ref 5)
- 80% of Red Cliffs Catchment 1 1,500 t/yr

A significant proportion of the 2050 impact is associated with the assumed reduction in irrigation drainage rates from 1.4 ML/ha/yr to 0.7 ML/ha/yr. With the current level of irrigation development, this reduction in drainage rates alone would result in a salinity reduction of 1 EC unit.

9.5 Other Major Drainage Works

Other major trunk drainage works required to provide the recommended standard of drainage service for areas of proposed development in Mildura/Irymple are also shown on Figure 9-1.

The most significant of these is an integrated system designed to cater for existing and proposed development in the Irymple Basin and South Mildura. This concept builds on and modifies:

- the Sixteenth Street Drain concept, which had been previously developed by Council in conjunction with TGM Consultants; and
- the adopted recommendations of the Elizabeth Street – Fifteenth Street Drainage Investigation (ref 4), which included diversion of flows from the commercial area around the intersection of Fifteenth Street and Deakin Avenue, south west into the Sixteenth Street Drain catchment.

Principal elements of the concept include:

- major basins to collect and store runoff from catchments O, T, Q2, Q3 and Z2;
- a major trunk gravity drain from catchment Q3 to Lake Hawthorn. Whilst catchment Q3 is landlocked, the ridge between catchments Q3 and Z2 is relatively low, and it is feasible to construct a gravity drain connecting these two catchments;
- a system of pumping stations and rising mains to pump flows from catchments R, U, V, T, O, M, Q4, Q1 and Q2 to the basin in Catchment Q3;
- diversion of the eastern portion of Catchment Z1 south west into Catchment Z2;

- basins in Catchments Q3 and Z2 are effectively retarding basins. Although these basins discharge by gravity, outfall capacity is restricted to reduce the required sizes of downstream drains.

A preliminary concept design of this system has been prepared to enable indicative costing. The design is based on the urban drainage design standards presented in Section 8.1. Basins have generally been sized to cater for runoff from the 72 hour, 100 year ARI storm event, and assumed to empty over a period of ten days following that event. The only exception to this is the Catchment M basin, which has been sized to cater for runoff from the 72 hour, 10 year ARI event, with runoff from more severe events allowed to discharge by gravity to the River. The aim of this is to prevent nutrients and contaminants discharging to the River from this area of future development. More detailed studies are required to confirm sizing of all elements. Locations of elements are also indicative only. Further detailed work will also be required to confirm pipeline routes and basin locations, taking account of existing services, existing development, and proposed future road, subdivisional and other layouts. It may be necessary to construct the basin in Catchment Z2 at two levels to accommodate local drain inflows.

Consideration should be given to incorporating playing fields into some or all of the basins. This would require appropriate safety provisions, eg. prominent signage and safe egress paths, in recognition of the storm hazard. Consideration should also be given to incorporating additional storage within basins, for localised reuse on parks, gardens and playing fields. Neither of these items has been costed.

Subject to detailed investigation of impacts on inland water bodies, consideration should be given to maximising reuse opportunities by incorporating water sensitive urban design principles into areas of new urban development. These principles are outlined in the Victorian Stormwater Committee's publication "Urban Stormwater - Best Practice Environmental Management Guidelines" (ref 7):

> *"Water Sensitive Urban Design offers an alternative to the traditional conveyance approach to stormwater management. It seeks to minimise the extent of impervious surfaces and mitigate changes to the natural water balance, through on-site reuse of the water as well as through temporary storage."*

FMIT's Irymple Main Drain closely follows the proposed route of the main gravity drain for much of its length. The diameter of the Irymple Main Drain at its outfall is only 900 mm, compared with the two 3,000 mm diameter pipes required to cater for the peak storm capacity. It is therefore unlikely to be of any assistance in providing supplementary storm capacity, even in the short term, as it will almost certainly be running at close to capacity from irrigation drainage immediately following a major storm.

Further details of element concepts are presented in Table 9-3.

9.6 Estimated Costs

Preliminary estimates of capital and annual operating costs for major works described above are summarised in Table 9-1. Annual operating costs include pumping costs, operator attendance, and maintenance. Actual costs could vary significantly from those shown in the table due to a range of factors, including, for example, the possible need to dewater basins during construction.

It should be noted that Table 9-3 presents estimated costs for the listed major works only. It does not include any allowances for renewals, or for any other works, including:

- Subdivisional drainage works. These would normally be constructed and funded by developers;
- Drainage works connecting subdivisional drainage to the major works listed in the Table;
- Works required to augment the capacities of any existing drainage systems, to meet adopted design standards;
- Urban subsurface drainage works;
- Operating costs associated with the Merbein Mildura Groundwater Interception Scheme, and Lake Hawthorn Drainage Diversion Scheme;
- Operation, maintenance and replacement costs associated with any existing works, in both urban and irrigation areas.

Table 9-1 Summary of Costs

System	Estimated Costs		
		Annual ($/yr)	
	Capital ($)	Existing Development	2050 Development
1. 16th Street Drain (including Lake Hawthorn wetland)	$ 47,750,000	$ 450,000	$ 450,000
2. Lake Ranfurly East Wetland	$ 60,000	$ 10,000	$ 10,000
3. Etiwanda and San Mateo wetland	$ 1,200,000	$ 10,000	$ 10,000
4. Major system to service Merbein Irrigation District	$ 5,290,000	$ 130,000	$ 110,000
5. Part Red Cliffs catchment 1 to Cardross	$ 1,890,000	$ 60,000	$ 60,000
6. FMIT catchment 7 to wetland near Kings Billabong	$ 400,000	$ 10,000	$ 10,000
7. Merbein town drainage	$ 680,000	$ 20,000	$ 20,000
TOTAL	**$ 57,270,000**	**$ 690,000**	**$ 670,000**

9.7 Staging of Works

The estimated elements sizes presented in Table 9-3 are intended to cater for peak flows and runoff volumes under year 2050 development conditions. Works should be staged to cater for progressive development. Works programs should be developed in close consultation and liaison with Council's Planning Department to minimise, as far as practicable, lead times between construction of infrastructure, and development. From a purely drainage infrastructure viewpoint, development should preferably:

- commence at the downstream end of a drainage system, and proceed upstream; and
- proceed on a catchment by catchment basis, viz fully develop one catchment, before allowing any development in the next catchment.

Works programs must however recognise the need to service existing development. Whilst it is vital to reserve basin sites and drain easements immediately based on ultimate development requirements, construction of works could be staged to allow for progressive development, or to allow for development not proceeding as envisaged. For example, works with capacity to cater for development to 2010 could be constructed over the next two years, and then progressively upgraded to 2050 capacity as development proceeds. The total capital cost of a staged approach would be greater, but finance and maintenance costs would be less.

In the very short term, alternative outfall sites could be considered. For example, development is already proceeding in landlocked Catchment Q1. Whilst it is proposed that this ultimately discharge to the major drainage system to Lake Hawthorn, the required infrastructure is unlikely to be available in the short term. It may be preferable, in the interim, to pump runoff from this catchment into the Etiwanda Drain catchment (L) for gravity discharge to the River.

FIGURE 9.1 PROPOSED WORKS - MILDURA/IRYMPLE

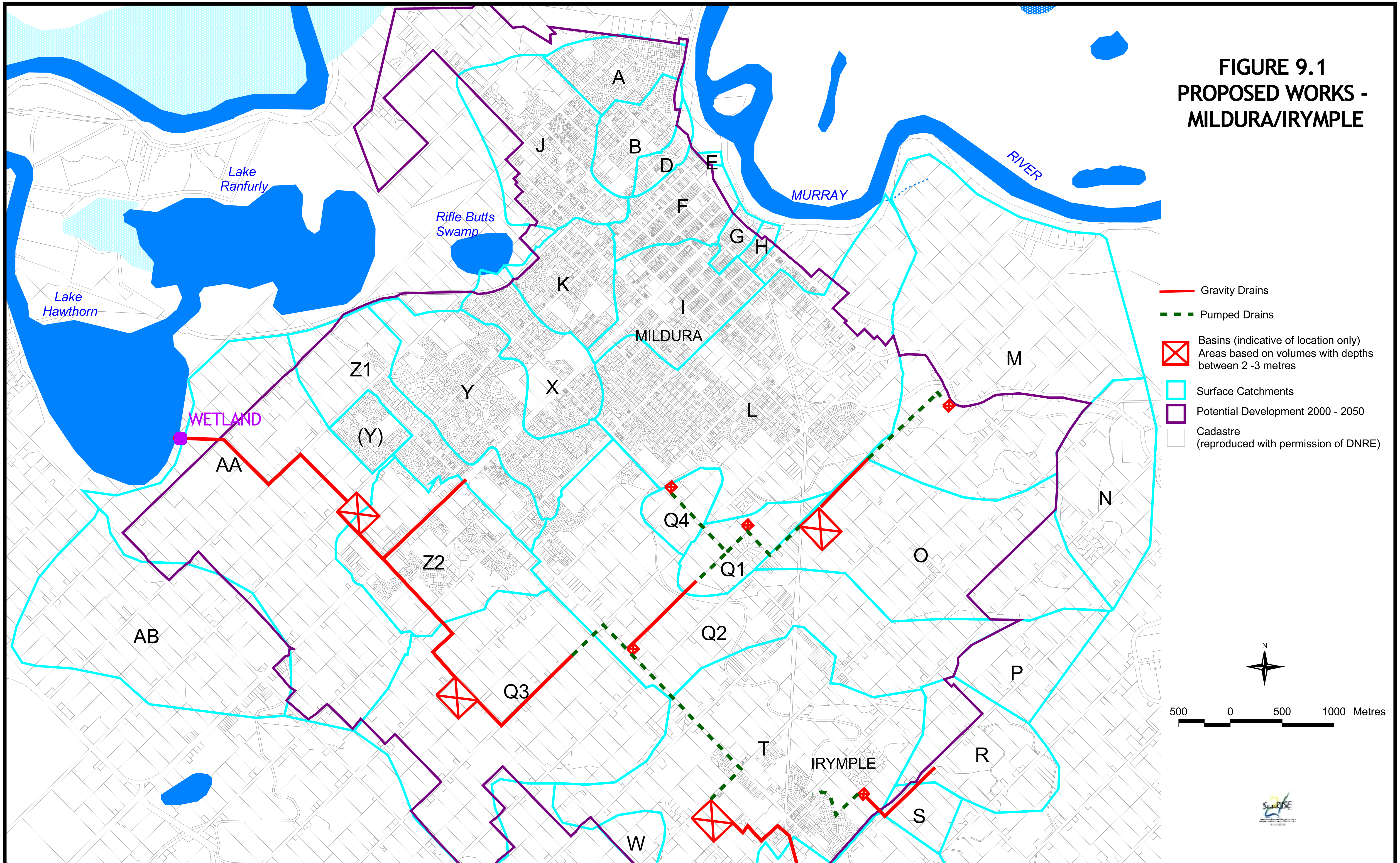

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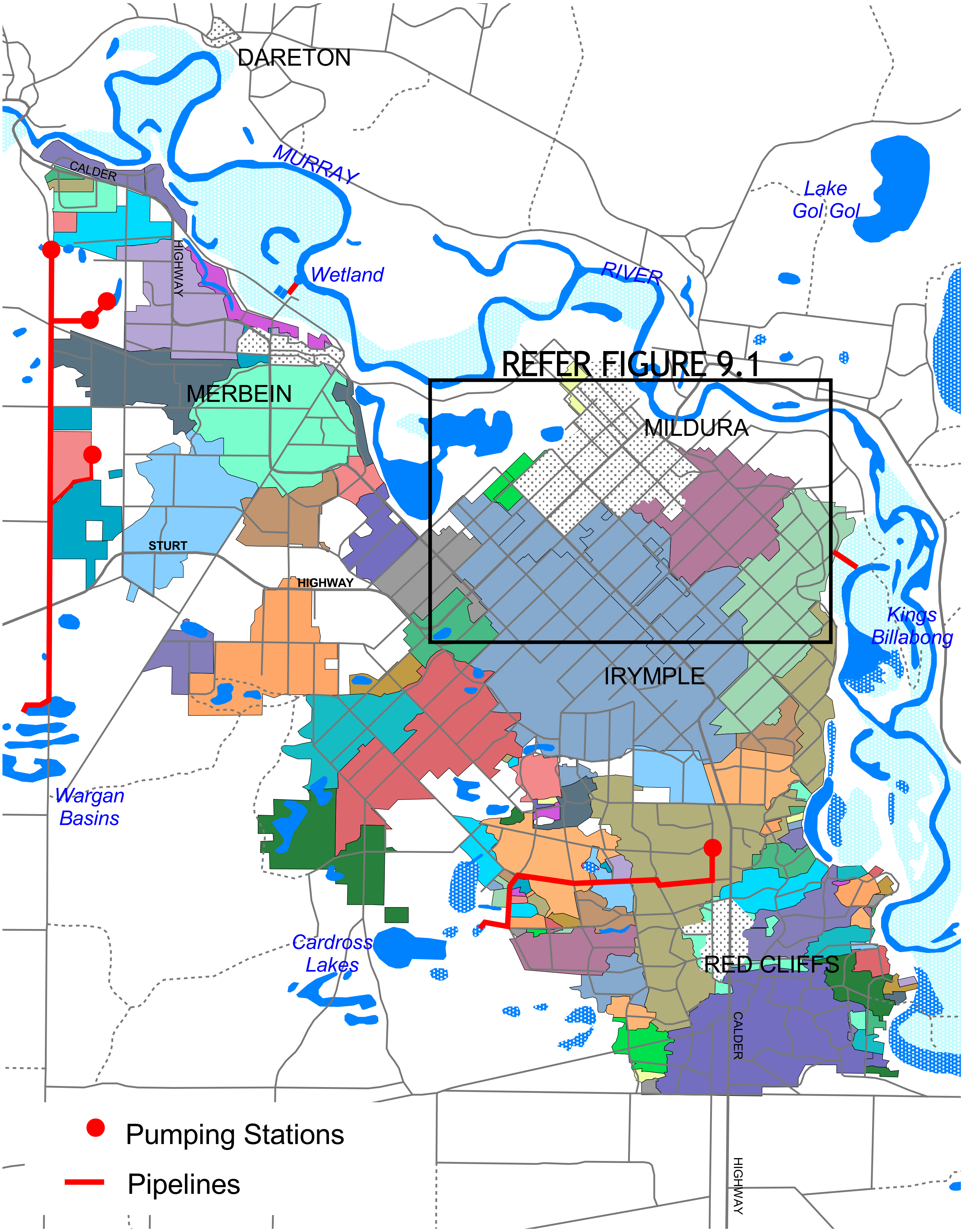
FIGURE 9.2 - PROPOSED WORKS - IRRIGATION AREAS



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■ Table 9-2 Impacts of Proposed Strategy on Flows, and Salt and Nutrient Loads to Key Water Bodies

Water Body	Existing Development						Year 2050 Development					
	Without Strategy			With Strategy			Without Strategy			With Strategy		
	Flow (ML/yr)	Salt Load (t/yr)	Nitrogen Load (t/yr)	Flow (ML/yr)	Salt Load (t/yr)	Nitrogen Load (t/yr)	Flow (ML/yr)	Salt Load (t/yr)	Nitrogen Load (t/yr)	Flow (ML/yr)	Salt Load (t/yr)	Nitrogen Load (t/yr)
Murray River	11,400	23,400	17	8,200	8,700	10	8,000	16,300	15	5,800	5,400	9
Lake Hawthorn	6,100	6,800	8	6,900	7,000	6	3,900	4,000	7	7,100	5,900	6
Lake Ranfurly	360	150	2	360	150	0.2	580	320	2	580	320	0.4
Cardross Lakes	1,800	2,200	2	3,300	4,000	3	1,100	1,300	1	2,100	2,600	2

Note: Table includes current and future loads and impacts associated with all urban, subsurface irrigation, and subsurface urban drainage in the Study Area, the Merbein drainage shafts, and Lamberts Swamp. It does not include any loads or impacts associated with the Mildura Merbein Groundwater Interception Scheme, any other regional groundwater systems, or discharges from Lake Hawthorn to the Murray River.

■ Table 9-3 Major Drainage Works Concepts

			Size				Estimated Costs		
								Annual ($/yr)	
System	Element Type	Element	Length (km)	Diameter (mm)	Capcity (L/s)	Notes/comments	Capital ($)	Existing Development	2050 Development
1. 16th Street Drain (including Lake Hawthorn wetland)	Pump Stations	From Basin T (near S) to Basin T			50		210,000		
		From Basin T to Q2			400		270,000		
		From Basin O to Basin Q1			185		230,000		
		From Basin Q1 to junction Q1			225		230,000		
		From Basin Q4 to junction Q1			20		180,000		
		From junction Q1 to start of gravity pipe			250		250,000		
		From Basin Q2 to pipe junction			495		330,000		
		From pipe junction to Basin Q3			895		410,000		
		Land acquisition					10,000		
		On-costs					590,000		
		Contingency					730,000		
		Sub Total					**3,670,000**	**140,000**	**140,000**
	Pipelines (pumped)	From Basin T (near S) to Basin T	0.7	300	50		130,000		
		From Basin T to Q2	1.9	700	400		800,000		
		From Basin M to Catchment Boundary	0.75	225	65		101,000		
		From Basin O to Basin Q1	7.5	750	185		3,380,000		
		From Basin Q1 to junction Q1	0.4	500	225		120,000		
		From Basin Q4 to junction Q1	0.6	100	20		40,000		
		From junction Q1 to start of gravity pipe	0.4	500	250		120,000		
		From Basin Q2 to pipe junction	0.1	750	495		50,000		
		From pipe junction to Basin Q3	0.6	900	895		320,000		
		Easements					50,000		
		On-costs					1,260,000		
		Contingency					1,580,000		
		Sub Total					**7,930,000**	**80,000**	**80,000**
	Pipelines (gravity)	From V to near Irymple urban	0.6	1650			500,000		
		Continues all the way to Basin T (near S)	1.2	2400			1,440,000		
		From R to Basin T (near S)	0.9	1950			880,000		
		Conects to pumped pipe - Basin Q1 to Q2	0.8	525			210,000		
		Part of pipe length b/w pumped pipe and Basin Q3	1	1050		100 year floodway above pipe	530,000		
		Rest of pipe length, to Basin Q3	0.3	2 x 2250		100 year floodway above pipe	680,000		
		From Basin Q3 to Z2 catchment boundary	0.9	1500			1,010,000		
		From Z2 boundary to Pipe junction	0.7	2 x 2400		100 year floodway above pipe	2,520,000		
		From catchment Z1 to pipe junction	1.2	1200		100 year floodway above pipe	720,000		
		From pipe junction to Basin Z2	0.3	2 x 2700		100 year floodway above pipe	1,220,000		
		From Basin Z2 towards L/ Hawthorn	0.3	1500			230,000		
		Pipe to Hawthorn	1.8	2 x 3000		100 year floodway above pipe	5,400,000		
		From catchment boundary (M) to Basin T	0.75	535			196,875		
		Easements					160,000		
		On-costs					3,880,000		
		Contingency					4,850,000		
		Sub Total					**24,390,000**	**160,000**	**160,000**
	Wetland	at entrance to L Hawthorn					**650,000**	**10,000**	**10,000**
	Basins	T (242 ML)					1,260,000		
		T (near S) (44 ML)					420,000		
		M (52 ML)					444,600		
		O (109 ML)					870,000		
		Q1 (34 ML)					330,000		
		Q2 (54 ML)					500,000		
		Q4 (19 ML)					190,000		
		Q3 (242 ML)					1,260,000		
		Z2 (122 ML)					950,000		
		On-costs					1,560,000		
		Contingency					1,950,000		
		Land acquisition					1,390,000		
		Sub Total					**11,110,000**	**60,000**	**60,000**
2. Lake Ranfurly East wetland	Wetland	**Sub Total**					**60,000**	**10,000**	**10,000**

System	Element Type	Element	Size: Length (km)	Size: Diameter (mm)	Capcity (L/s)	Notes/comments	Estimated Costs: Capital ($)	Annual ($/yr): Existing Development	Annual ($/yr): 2050 Development
4. Major system to service Merbein Irrigation District	Pumpstations	North West Drain			45		140,000		
		Lamberts Swamp			9		70,000		
		West Drain			43		140,000		
		Drainage Shafts			10		70,000		
		On-costs					110,000		
		Contingency					130,000		
		Sub Total					**660,000**	**80,000**	**60,000**
	Pipelines	Outlet to Highpoint	4.6	375			860,000		
		High point to second junction	1	375			190,000		
		Junction 2 to Junction 1	5.6	375			1,050,000		
		Drainage Shafts to second Junction	3.2	150			240,000		
		Lamberts Swamp Pump Station to West Drain PS	1.7	150			130,000		
		West Drain Power station to first Junction	0.5	300			80,000		
		North West Drain Pump Station to First junction	1.6	300			240,000		
		easements					280,000		
		On-costs					700,000		
		Contingency					870,000		
		Sub Total					**4,630,000**	**50,000**	**50,000**
5. Part Redcliffs catchment 1 to Cardross	Pumpstations	Number 1			61		160,000		
		On-costs					40,000		
		Contingency					50,000		
		Sub Total					**250,000**	**40,000**	**40,000**
	Pipelines	Cnr to Outlet	2.1	300			250,000		
		Pump station to cnr	6.1	300			730,000		
		Easements					100,000		
		On-costs					250,000		
		Contingency					310,000		
		Sub Total					**1,640,000**	**20,000**	**20,000**
6. FMIT Catchment 7 to wetland near Kings Billabong	Pipeline	Pipe			85		250,000		
		Easements					10,000		
		On-costs					60,000		
		Contingency					80,000		
		Sub Total					**400,000**	**10,000**	**10,000**
7. Merbein town drainage	Pipeline	Pipe					390,000		
		Easements					10,000		
		On-costs					100,000		
		Contingency					120,000		
		Sub Total					**620,000**	**10,000**	**10,000**
	Wetland	**Subtotal**					**60,000**	**10,000**	**10,000**
						TOTAL COST	**57,270,000**	**690,000**	**670,000**

10. Institutional Arrangements

Revised institutional arrangements are recommended to address the issues listed in Section 6.2.

10.1 Urban and Irrigation Drainage

From an institutional viewpoint, it is considered vital that the links between irrigation and irrigation drainage be retained.

The issues associated with coexisting urban and irrigation drainage infrastructure could be adequately overcome by formalised agreements between FMIT and Council. Responsibility for urban subsurface drainage could be assumed by an existing authority.

Lack of institutional control over outfalls and other off farm components of private irrigation drainage systems outside the Irrigation Districts could be overcome by the assigning responsibility for these systems to the existing irrigation authorities.

Wholesale institutional change is not therefore considered necessary, and the following institutional changes/assignments are recommended:

- responsibility for subdivision scale urban subsurface drainage should be assumed by Council. Responsibility for larger scale works should be rationalised between Council and FMIT using the principles outlined below;
- ownership and management of irrigation drains in urban areas should be rationalised between FMIT and Council. This is discussed further below. Responsibility interfaces, viz physical locations in the drainage system, should be clearly defined, and regularly reviewed. Likely future maintenance requirements should be equitably accounted for in any asset transfer arrangements;
- in cases where irrigation drainage discharges to a subsurface drain for which ownership has been transferred to Council, or where urban drainage (generally subsurface) discharges to a drain owned by FMIT, infrastructure use fees should be payable by the discharging authority to the owning authority. This fee should be based on a rate per hectare. Existing drainage standards should be maintained for current users;
- responsibility for outfalls and other off farm components of private irrigation drainage systems outside the Irrigation Districts should be investigated further. The adjacent irrigation authority could if necessary, assume this responsibility. The Old Mildura area lies between the Merbein and Mildura Districts. It already has some association with SRWA as the diversion licensee, and responsibility for irrigation drainage in that area could therefore be assumed by SRWA.

A number of factors need to be taken into account in rationalising ownership of existing subsurface irrigation drains between Council and FMIT. The capacity of these drains will generally only be sufficient to cater for urban subsurface drainage. Peak design storm flows from urban catchments will generally far exceed available capacity, with the occasional minor exception of initial urban development in a large subsurface drainage catchment. Factors to be accounted for in rationalising ownership will then include:

- relative proportion of irrigation and urban land use;
- identifiability of interface points between drains owned by Council and FMIT. Interface points should be clearly identifiable physical locations, such as junction pits;
- location of drain relative to Irrigation District boundary. Segments of drain that lie within an urban area might be better owned and managed by Council, even if the catchment is predominantly irrigated;
- number of interface points. This should be minimised where practical.

10.2 Inland Water Bodies

10.2.1 Water Bodies on Private Land

Ownership of land assets associated with water bodies on private land should remain with individual authorities.

10.2.2 Water Bodies on Crown Land

More detail should be included in the agreement between NRE and SRWA / FMIT regarding uses of Kings Billabong and Basin 12 as water supply and drainage basins.

Ownership of land assets associated with water bodies on Crown Land should remain with the individual authorities, with access managed by way of agreements**.**

The obligations of the managers of each water body should be clearly defined and formalised, on a case by case basis.

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

It is important that there is a clear understanding of the current arrangements. The gaps in the current understanding appear to be:

- responsibility for management of levels in Lake Hawthorn;
- rights of private diverters to discharge to Lake Hawthorn and Lake Ranfurly; and
- rights of SRWA to discharge to Lake Hawthorn.

These “gaps” should be addressed and appropriate arrangements put in place.

There would not appear to be any pressing reasons for the schemes to be operated by other than G-MW. G-MW already has the necessary plant and equipment, and personnel with the necessary understanding and experience in operating the system. The advantage of keeping the current situation in place is that it is easy to implement, and requires few institutional changes. This does however still require many agreements between many different authorities, making arrangements and management complicated.

There would also appear to be no pressing reasons for transferring land ownership from existing authorities to G-MW. Arrangements would however need to be established between G-MW, and FMIT, SRWA and the Department of Education (College Lease Land), regarding implications of water body management on freehold land. A municipal planning scheme overlay should be developed and implemented to manage community development expectations and to secure disposal system infrastructure easements and buffer controls of relevance to the two Schemes. G-MW should be a referral authority for all planning scheme applications for developments which fall within this overlay.

It is recommended that G-MW recover the proportion of scheme operating costs that can be assigned to urban and irrigation drainage, from Council, FMIT and SRWA. This is further reason for assigning responsibility for private diverter drainage to the Irrigation Authorities. Fees should be proportional to actual annual volumes of drainage water discharged to Lakes Hawthorn and Ranfurly. This will require metering of most major drainage outfalls.

The obligations of the managers of Lake Hawthorn, Lake Ranfurly and Wargan Basins should be clearly defined and formalised, on a case by case basis. Storage management plans should be prepared for each of these water bodies, and should include all identifiable operation, maintenance and management costs including future expenditure on investigations to underpin new management regimes.

10.2.4 Overall Strategy and Coordination

It is recommended that an agreed coordinating group be appointed to provide the lead role in implementation, management and monitoring of the Strategy.

The Task Force could continue to play a lead role in implementing the Strategy in the short term, with a view to transferring this responsibility to the new coordinating group as soon as practicable. It is recommended that the Mallee CMA assists the Task Force/new coordinating group in sourcing appropriate funding for coordination of the Strategy.

The proposed relationships between the Strategy and other relevant planning and strategy documents is shown on Figure 10-1 and Figure 10-2.

Whilst some indication of the potential impacts of the Strategy on a range of water bodies was presented in Section 9.4, further detailed investigations may be undertaken under the auspices of the Mallee CMA's Wetland Operational Plans. The concept of wetland operational plan should be applied to all major water bodies relevant to the drainage network (these may be called drainage basins operational plans where the prime purpose is drainage disposal).

■ **Figure 10-1 Relationships between Sunraysia Drainage Strategy and other relevant Planning and Strategy Documents, Part 1**

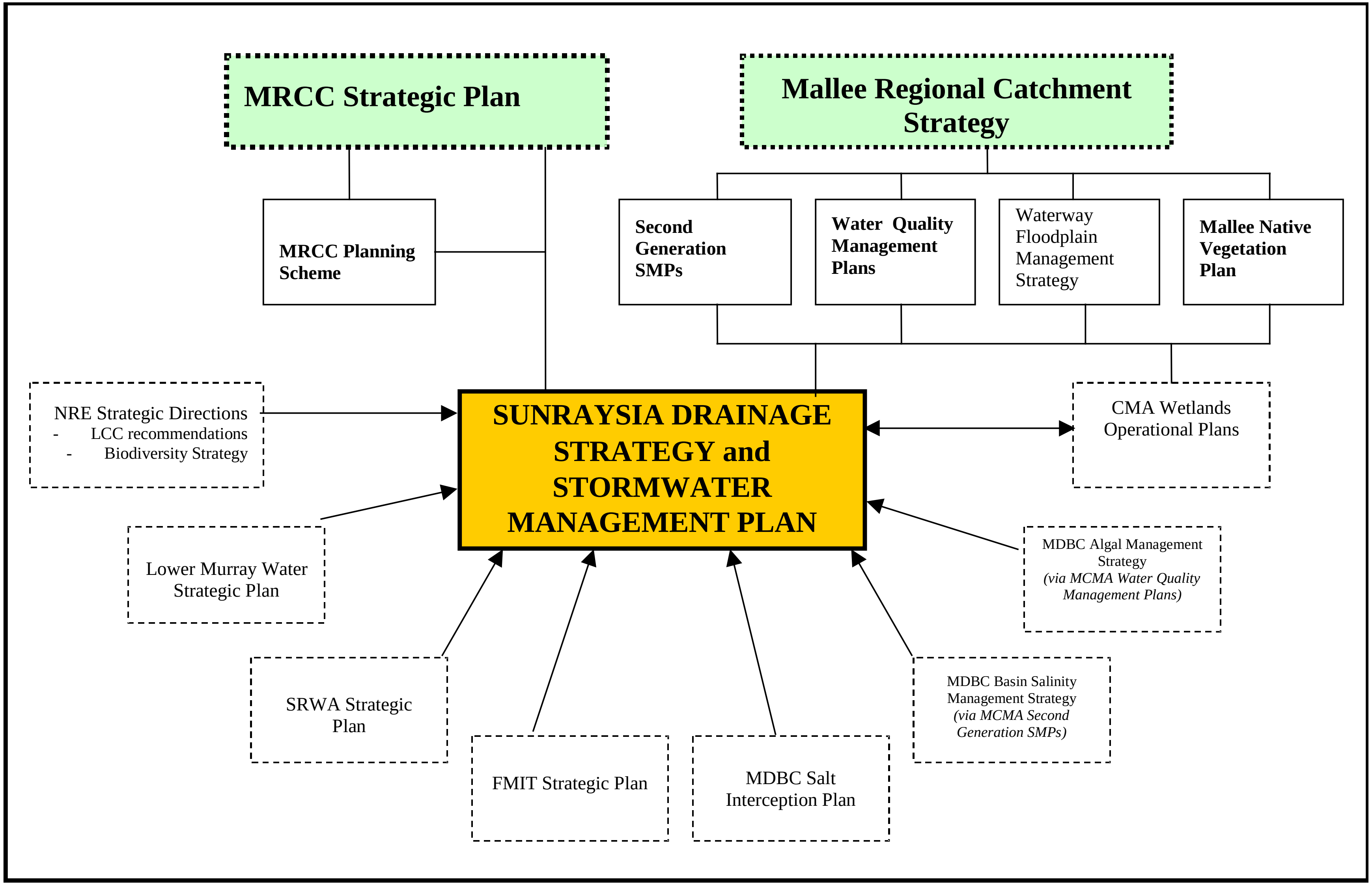
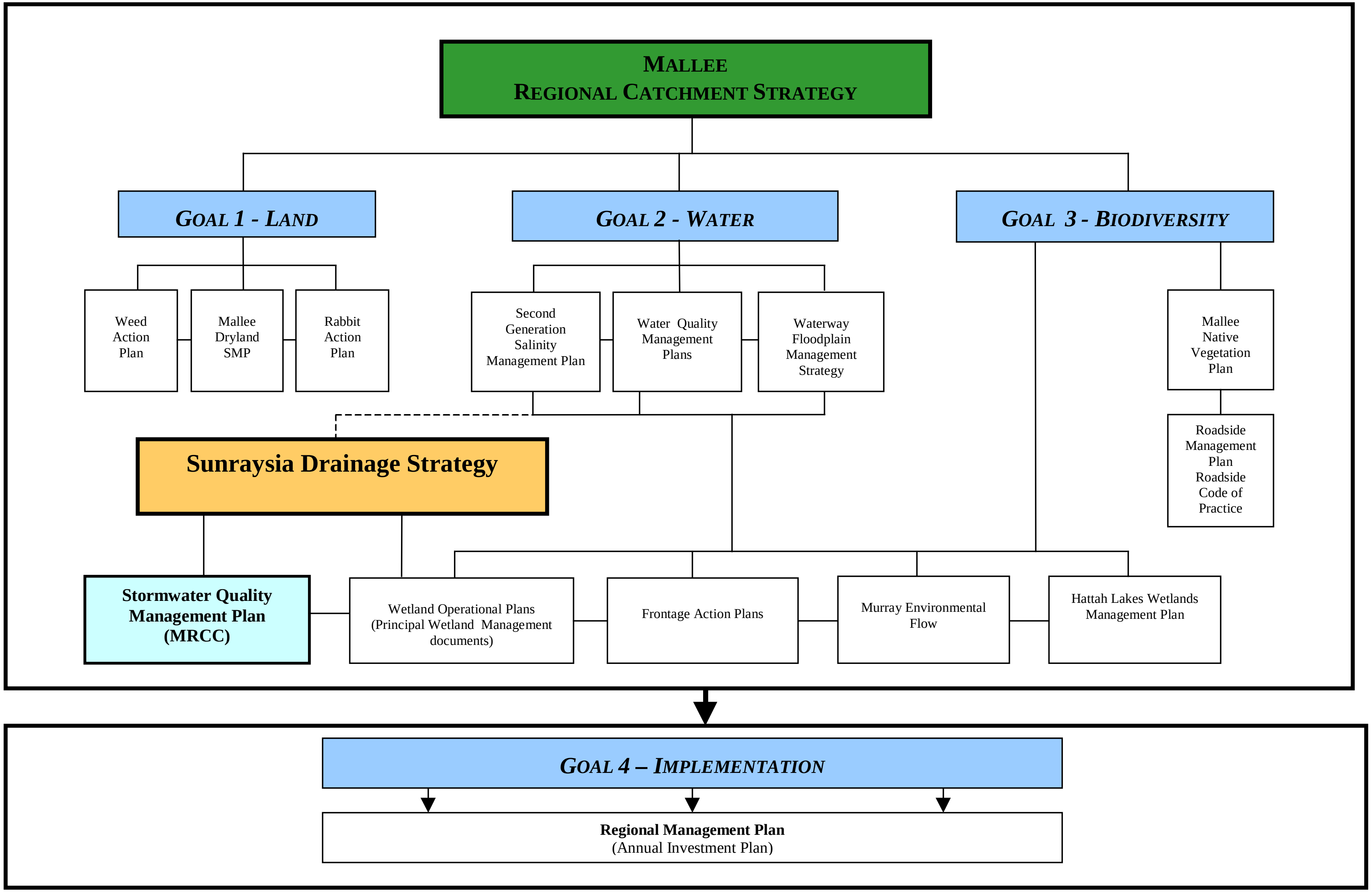


Figure 10-2 Relationships between Sunraysia Drainage Strategy and other relevant Planning and Strategy Documents, Part 2



11. Cost Sharing and Tariffs

11.1 Cost Sharing

Cost sharing arrangements should be based on the ‘beneficiary-pays’ principle.

It is recommended that benefiting landholders should bear the cost of a basic drainage service, in both irrigation and urban areas, via the relevant drainage authorities. Because standards have changed over time, two definitions of drainage service are required as follows:

Existing Development

- the adopted standard of drainage service;
- disposal to the most cost effective available outfall;
- no treatment prior to disposal; and
- no reuse facilities.

Future Development

- As for Existing Development, but with treatment to remove nutrients prior to discharge to receiving waters.

If disposal of drainage waters is to other than most cost effective outfall, this alternative outfall will generally have been selected because it provides a benefit in addition to the basic drainage service, eg environmental enhancement of an inland water body. The relevant beneficiary should then bear the incremental cost of disposal to the alternative outfall, relative to the most cost-effective outfall.

If treatment or reuse facilities have been provided, the cost of these should be borne by the relevant beneficiaries and/or polluters. The polluter pays principle would apply, for example, if wetlands have been provided to reduce algal blooms in the Murray River. A share of the incremental cost of these should be borne by the holders of the drained land, via the relevant drainage authorities.

The distinction between existing and future development provides for cost sharing for retrofitting of existing systems to provide treatment. Without this, it is unlikely that such works would be implemented.

The incremental costs over and above the costs associated with the basic drainage service need to be apportioned between relevant beneficiaries. Although clearly dependent on the disposal option being considered, it should be noted that in most cases, the majority of the total drainage cost is associated with providing the basic drainage service. Therefore, generally less than half of the total drainage cost needs to be shared between beneficiaries, other than landholders.

Sets of beneficiaries associated with each of the benefit criteria listed in Section 9.1.1, are indicated in Table 11-1. The relevant groups that could potentially share the costs associated with these benefits are also indicated.

■ **Table 11-1 Benefits and Beneficiaries**

Benefit	Beneficiaries	Costs to be shared between
Reduction in salt loads to Murray River	Region, downstream users	State government (see note 2)
Reduction in algal blooms in Murray River (see note 1)	Lower Murray Water, SRWA, FMIT, private diverters, regional recreation and tourism industries	Drainage authorities, private diverters, local government
Environmental enhancement of inland water bodies	Local and wider community	Local, State, Federal government, depending on national, state, and local significance of values protected
Enhancement of amenity value of inland water bodies	Local and wider community	Local, State, Federal government, depending on national, state, and local significance of values protected
Reuse opportunities	Reusers – might include MRCC, LMW, private landholders	Reusers

Note 1: For drains servicing new development, cost to be borne by landholders as part of basic drainage service.
Note 2: State responsibility, as proposed works are addressing the impacts of intensive development, rather than land clearance (legacy of history).

11.2 Tariffs

11.2.1 Urban Drainage

As noted previously, urban drainage works have historically been funded by a combination of general rate revenue and developers' contributions.

It is strongly recommended that Development Contribution Plans be prepared as soon as possible to ensure a flow of funds for construction of future major drainage works. The plans should set contribution rates on a catchment basis, to provide an equitable means of differentiating drainage costs between areas, particularly where pumping is required. Rates should ensure adequate capital funding for off-site drainage works. It is understood (D Fitzgerald, pers comm) that Council has already started working with consultants to prepare Development Contribution Plans. Rates should include allowances for borrowing to fund capital works.

Operation and maintenance of the drainage system could be funded either from general rate revenue, or from a specific drainage rate. General rate revenue is based on property valuation, and does not provide an equitable means of charging for drainage service. If there is a move to charge a specific drainage rate, it is recommended that this be based on property area, which is a far more relevant measure of the relative contributions of properties to drainage.

Developers' contributions cannot be used to fund future operating, maintenance and renewals costs.

11.2.2 Irrigation Drainage

Whilst the current irrigation authority tariff structure encourages irrigators to use less water, it doesn't provide any specific incentive for them to minimise drainage flows. This could best be achieved by basing the drainage tariff on actual drainage discharges from individual properties, but this is unachievable due to the impracticality of metering individual discharges.

The most equitable means of rating for drainage would involve a two-part tariff system, and it is recommended that this be considered by SRWA and FMIT for implementation:

- Service cost - a “fixed infrastructure access fee” to cover capital replacement, maintenance and administration. This should be a rate per hectare, as infrastructure is generally designed to cater for a fixed flow rate per unit area. The administration component would generally be relatively small and intended to cover preparation of rate notices and similar property related administrative items.

- An operational factor – an operational charge based on volume of water delivered per unit area. This should be on a stepped scale to encourage efficient irrigation infrastructure and practice. A certain minimum watering rate is generally required to ensure adequate leaching. Watering in excess of that rate is wasteful, and should be penalised by a higher rate per unit volume per unit area. The drainage tariff scale may need to vary across the irrigation area to account for different soil types.

  One possibility is a rate based on the equation

  $$R*S$$

  Where:

  S is an area charge
  R is a normalisation factor equal to the ratio of water applied, to what should have been applied

  Eg, if 10 ML/ha was applied, but only 8 ML/ha was required by the crop after due allowance for leaching, then R would be 1.25.

  If this method were adopted, some rationalisation would be required to ensure the authority didn’t need to keep rigorous records of crop type details, soil types, etc.

12. Implementation and Monitoring

12.1 Implementation

Required implementation measures will include as follows.

12.1.1 Financial

- Completion and implementation of Development Contribution Plans to enable adequate funding of off-site drainage works.
- Further researching of measures required for accessing of external funds for construction of major recommended works that are unrelated to urban development and which can thus proceed immediately, eg. diversion of drainage shafts to Wargan Basins, diversion of Red Cliffs Catchment 1 back to Cardross Lakes.

12.1.2 Physical and Planning

- Reservation of appropriately located land for drainage basins required for planned urban development, particularly in the Irymple Basin.
- Reservation of easements for rising mains and gravity trunk drains required to service planned urban development. This should be undertaken in consultation with Lower Murray Water and other relevant supply authorities, to minimise overall easement requirements.
- Liaison with Council to plan for release of land for urban development, as far as practical and within the constraints of the Planning Scheme, on a subcatchment basis. The aim of this will be to minimise the lead times between construction of major infrastructure, and development of land to be serviced by that infrastructure.
- Ongoing liaison with other groups to ensure consistency of major works components of the strategy with other relevant strategies, including, for example, the updated Mallee Regional Catchment Strategy, and the Second Generation Salinity Management Plan.
- Planning, additional studies, design and construction of major works unrelated to urban development.

12.1.3 Institutional

- Agreement amongst stakeholders regarding preferred institutional arrangements. It is acknowledged that this may take some time, and require significant consultation beyond Steering Committee level.
- Assuming the recommendations presented in Section 10 are accepted and adopted, other implementation activities will include:
  - researching the most appropriate mechanism to enable the appointed coordinating organisation to take the lead role in implementation, management and monitoring of the Strategy;
  - rationalisation of ownership and management of subsurface irrigation drains in and around urban areas, between Council and FMIT;

- Clarification, further detailing, and establishment, where required, of agreements between authorities regarding management of drainage, including
  - arrangements between G-MW, and FMIT, SRWA, Council and Department of Education for management of the Mildura Merbein Groundwater Interception Scheme, and Lake Hawthorn Drainage Diversion Scheme;

- agreements between NRE, and FMIT/SRWA regarding use of Kings Billabong and Basin 12 as water supply and drainage basins;
- agreements between Council and FMIT for discharge of drainage to existing subsurface drains.

12.2 Monitoring

12.2.1 Institutional

It is recommended that the appointed coordinating organisation regularly monitors and reviews the Strategy to:

- assess progress in implementing the Strategy relative to agreed timetable;
- monitor success of implemented measures. Key performance indicators should be established at the outset; and
- if necessary, amend the Strategy in accordance with outcomes of reviews.

12.2.2 Physical

Monitoring of the quality and quantity of water in drains and receiving water should aim to:

- establish long term trends in flows per unit area, nutrient loads and salt loads in major drains, and whether these are in accordance with assumptions used in preparing the strategy. This will need to be taken into account in periodical reviews of the strategy;

- establish long term trends in levels, salinity and nutrient concentrations in key receiving waters, particularly Lake Hawthorn, Cardross Lakes, Kings Billabong, and Lake Ranfurly. This will again confirm whether these are consistent with assumptions used in preparing the strategy. More frequent monitoring will also be required to establish need to purchase water to top up and dilute waterbodies with high environmental and amenity values, or where possible to amend operating rules;

- establish effectiveness of wetlands in removing nutrients. If wetlands are not as effective as expected, it will be necessary to establish possible reasons for this. These might include inadequate maintenance, short circuiting, higher than expected inflow loadings. Remedial measures might include improved maintenance, or capital modifications;

- establish urban and irrigation drainage flows to Lakes Hawthorn and Ranfurly, to enable G-MW to equitably charge relevant authorities for operation of relevant proportions of the Mildura Merbein Groundwater Interception Scheme, and Lake Hawthorn Drainage Diversion Scheme.

13. Further Investigations and Studies

Investigations are required to confirm:

- Sizing, routes, locations and levels of elements of the proposed drainage system to serve the Irymple basin and south Mildura. This will require hydrologic and hydraulic modelling of a range of design 100 year ARI storm durations.

- Likely future additional water requirements of Cardross Lakes, to meet environmental requirements. This will require water balance modelling.

14. References

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2. Sunrise (1999), “Sunraysia Land Information System, Horticulture of the Lower Murray Darling, Irrigated Crops Report”, November 1999.

3. Mildura Rural City Council (2001), “Mildura Planning Scheme”, March 2001.

4. TGM (2001), “Elizabeth Street – Fifteenth Street Drainage Investigation”, for Mildura Rural City Council, April 2001.

5. Sunrise 21 (1997), “Merbein Integrated Development Scheme, Feasibility Study and Cost Benefit Analysis”, by PJ Hallowes and Associates in association with Gutteridge Haskins and Davey, March 1997.

6. Nyah to the South Australian Border Community Salinity Group (1992), "Draft Salinity Management Plan from Nyah to the South Australian Border", May 1992.

7. Victorian Stormwater Committee (1999), "Urban Stormwater - Best Practice Environmental Guidelines".

Appendix A Steering Committee, Reference Group and Project Working Group Membership

A.1 Steering Committee

Cr Brian Grogan	Mildura Rural City Council (Chairman)
Ron Dudley	Mildura Rural City Council (Executive Officer)
Peter Alexander	Hydro Environmental
Dr John Cooke	Natural Resources and Environment
Ross Davies	Natural Resources and Environment
John Ginnivan	Goulburn-Murray Water
Peter Hammond	First Mildura Irrigation Trust
David Jeffrey	Goulburn-Murray Water
Barrie MacMillan	Mallee Catchment Management Authority
Glenn Milne	Lower Murray Water Authority
Phillip Pfeiffer	Murray Darling Basin Commission
Stan Pickering	Sunraysia Rural Water Authority
John Williamson	Environment Protection Authority

A.2 Project Reference Group

Cr Brian Grogan	Mildura Rural City Council (Chairman)
Sue Argus	Sunrise 21
Leonie Burrows	Mildura Rural City Council
Dr John Cooke	Natural Resources and Environment
Ron Dudley	Mildura Rural City Council
John Ginnivan	Goulburn-Murray Water
Brent Godkin	Sunraysia Rural Water Authority
Gavin Hanlon	Mallee Catchment Management Authority
Garry Healy	Mildura Rural City Council
Miriam Hopkins	Natural Resources and Environment
Ron Leamon	Lower Murray Water Authority
John Tesoriero	First Mildura Irrigation Trust
John Williamson	Environment Protection Authority

A.3 Project Working Group

Sue Argus	Sunrise21
Michelle Bald	Murray Darling Freshwater Laboratories
Don Brown	
Ivan Bryce	Lower Murray Water Authority
Paul Dixon	Mildura Rural City Council
Ron Dudley	Mildura Rural City Council
Peter Ebner	Lower Murray Water
Ken Evans	Sunraysia Rural Water Authority
Darryl Fitzgerald	Mildura Rural City Council
Malcolm Hare	Mildura Rural City Council
Victor Hurley	Natural Resources and Environment
Lee Jones	Mildura Rural City Council
Trevor Kolpin	Goulburn-Murray Water
Kevin Murphy	Lower Murray Water Authority
Mahinda Perrara	First Mildura Irrigation Trust
Andrew Powell	Mildura Rural City Council
Robin Ransome	Lower Murray Water
Andrew Sinn	Sunraysia Rural Water Authority
Steven Smith	Mallee Catchment Management Authority
Damien Wells	Mallee Catchment Management Authority