8 Summary of risk assessment results

The risk assessment results for all the LAP areas along the River Murray, Lower Lakes and Coorong are summarised in this chapter for the different environmental values and levels of risk for various types of hazards.

8.1 Summary of results by environmental value

Aquatic ecosystem environmental value

A small proportion of total risks to the aquatic ecosystem environmental value were of a high to very high level (Figure 8.1) and related to:

- Lower Murray flood irrigated (dairy farm) area discharges (eg Jervois, Woods Point, Monteith, Cowirra, Wall Flat, Neeta, Pompoota) for nutrient, organic matter and salinity stressors
- leakage from large horticultural areas (eg Waikerie, Cadell, Pike, Qualco/Sunlands) for salinity, nutrient and organic matter stressors
- large tributary river discharges (eg Marne, Angas, Bremer, Finniss, Pike) for nutrient, organic matter and heavy metal stressors (and salinity for Pike)
- Mannum and Murray Bridge WWTP effluent ponds, and the Waikerie STEDS lagoons for nutrient and organic matter stressors.

A large proportion of the total risks were of a moderate level (Figure 8.1), and generally related to:

- urban stormwater discharges (eg from Mannum, Murray Bridge, Berri, Renmark, Waikerie, Tailem Bend, Goolwa townships) for the nutrient, organic matter, turbidity, hydrocarbons, and heavy metals stressors
- septic tank leakage from dwellings/shacks, small townships, caravan parks and riverside public toilets for the nutrient and organic matter stressors
- vessel discharges at mooring areas and marinas for nutrient and organic matter stressors
- horticultural areas for leakage of heavy metal and pesticide stressors (and nutrients, organic matter and salinity stressors for smaller irrigation areas)
- creek discharge for turbidity, nutrient, organic matter and heavy metal stressors
- wetland discharges for the nutrient, salinity and organic matter stressors
- some STEDS/wastewater lagoons (eg Renmark, Paringa)
- slipways for turbidity, heavy metal and pesticide stressors.

A large proportion of total risks were also of a low level (Figure 8.1) including:

- petrol station leakage (hydrocarbons)
- boat ramps (turbidity, hydrocarbons)
- ferries (turbidity, hydrocarbons)
- unbunded pump fuel stores (hydrocarbons)
- informal camping areas (nutrients)
- wastewater infrastructure (eg STEDS pumps at shack areas).

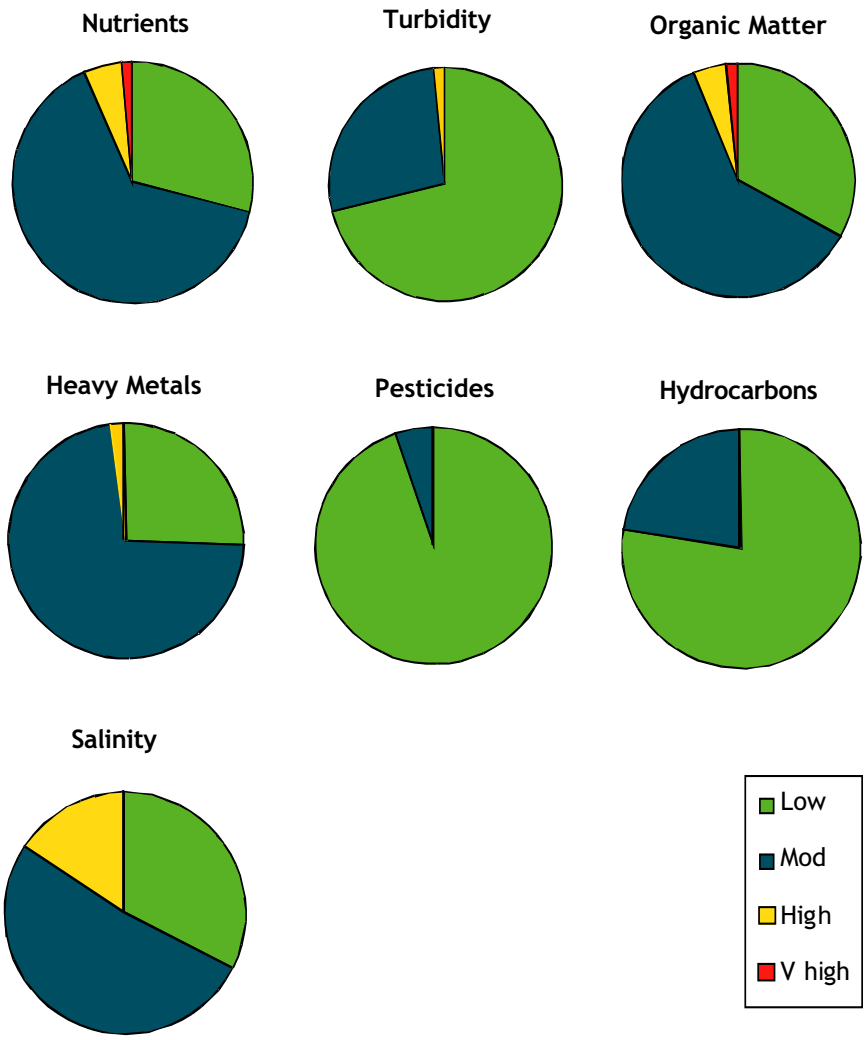

Figure 8.1 The level of risk (low, moderate, high, very high) versus proportion of total risks for stressors of the aquatic ecosystem environmental value

Raw water supply environmental value

A small proportion of total risks to raw water supply environmental values were of a high to very high level (Figure 8.2), and related to:

- discharges from flood irrigated dairy farms in the Lower Murray (Jervois, Pompoota, Mannum/Cowirra, Mypolonga and Wall Flat irrigation township water supplies) for the pathogen, nutrients, and organic matter stressors
- discharge from a major stormwater catchment in Mannum (Berryman Ave, adjacent to Mannum-Adelaide pipeline) for the pathogen, turbidity, and heavy metal stressors.

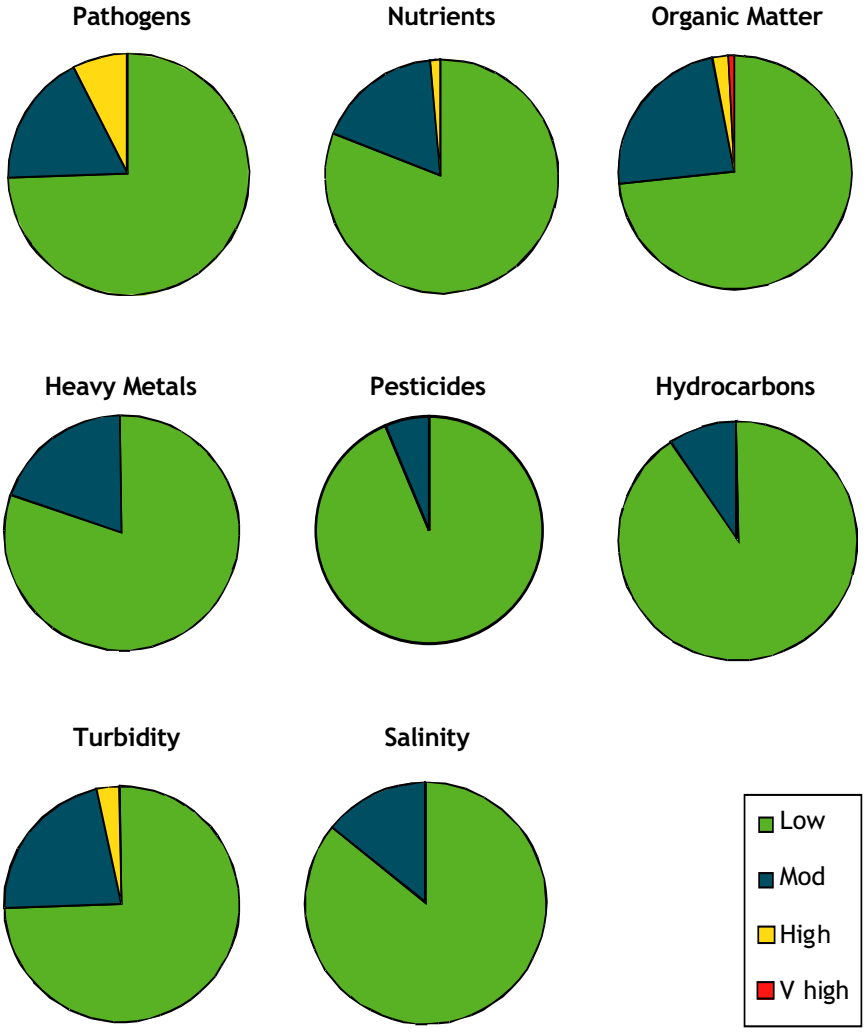

Figure 8.2 The level of risk (low, moderate, high, very high) versus proportion of total risks for stressors of the raw water supply environmental value

A significant proportion of the total risks were of a moderate level (Figure 8.2) and related to:

- creeks/rivers (eg Ral Ral Creek–Renmark off-take)
- urban stormwater discharges (eg Renmark, Swan Reach, Mannum, Berri (Crawford Tce))
- STEDS (eg Cadell, Waikerie)
- informal camping (eg Wall Flat, near Swan Reach–Stockwell pipeline off-take)
- vessel wastewater discharges
- Blanchetown river vessel waste disposal station (pathogens)
- wetlands/lagoons (Cobdogla and Loveday basins, South Portee wetland, Yatco and Jaeschke lagoons)
- nutrient and salinity leakage from horticultural areas (eg near Waikerie, Cadell, Gerard)
- grazing (on banks of river and lakes).

Low-level risks made up a large proportion of total risks (Figure 8.2) and related to a variety of hazards.

Recreational environmental value

A small proportion of total risks to recreational environmental values were of a high to very high level (Figure 8.3), and related to Lower Murray flood irrigated (dairy farm) area discharges (pathogen risks to recreational zones between Mannum and Wellington)

A significant proportion of the total risks were of a moderate level and related to:

- septic tank leakage from shacks and townships for the pathogen stressor
- informal camping areas (eg Overland Corner, Rilli Island, Moorook, Big Bend, Walker Flat, Boggy Lake, Duthalong) for the pathogen stressor
- greywater and blackwater discharges from multiple vessel moorings and marinas for the pathogen stressor
- risk of spillage of pathogens at river vessel waste disposal stations (eg Mannum, Murray Bridge, Goolwa)
- urban stormwater discharges (eg Berri, Mannum, Murray Bridge) for pathogen and turbidity stressors
- leakage from large horticultural areas (mostly in Riverland) for nutrient stressor
- discharges of nutrients from the Lower Murray flood irrigated areas
- creeks/rivers (eg Angas river)
- wetland/lagoon (eg Yatco, Banrock, Watchels, Mark's landing, Devon Downs, Rocky Gully) nutrient/algal discharges and in some cases potentially pathogens (where associated grazing and/or urban stormwater hazards are present)
- grazing (on banks of river and lakes).

A large proportion of total risks were of a low level and related to:

- vessel launching and mooring areas (nutrient, turbidity, hydrocarbon stressors)
- vessel launching areas (turbidity and hydrocarbon stressors)
- ferry operations
- STEDS infrastructure
- irrigation pump fuel stores (hydrocarbon stressor)
- wash down from slipways (turbidity stressor).

It is also noted that the ambient turbidity level in the river greatly increases the risk of injuries and drowning because there is not sufficient visibility of submerged hazards(ANZECC (2000) recommends visibility of >1.2 m). The Darling River contributes most turbidity (MDBC 1988).

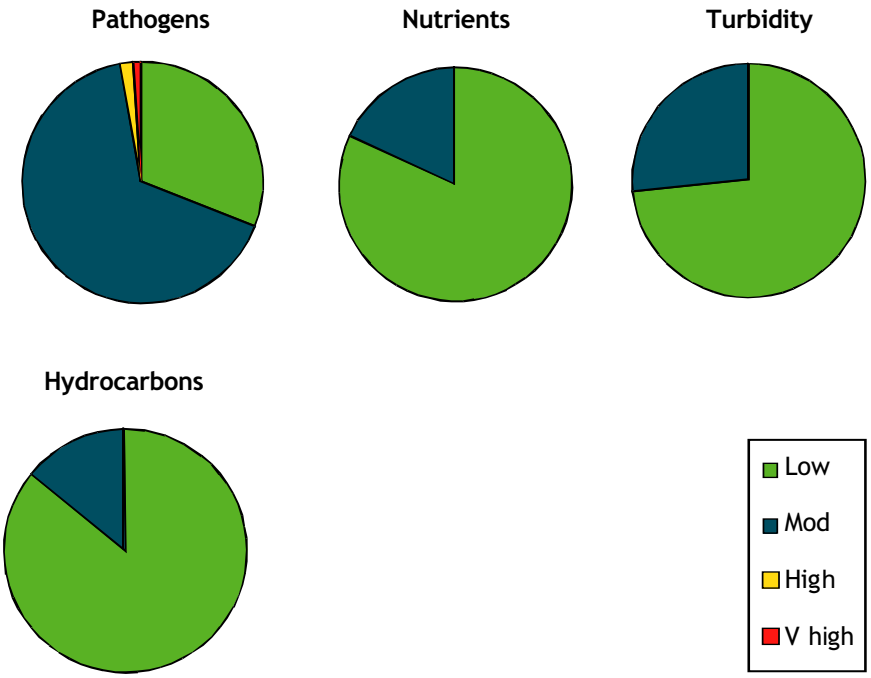

Figure 8.3 The level of risk (low, moderate, high, very high) versus proportion of total risks for stressors of the recreational environmental value

8.2 Summary of results by hazard type

A total of 935 different hazards were identified in the study. Their frequency and 'average' level of risk to water quality are shown in Table 8.1 by LAP area. More hazards were identified in the mid-lower Murray (MM & MW LAPs) and Lakes/Coorong (GW & CD LAPs) areas than in the Riverland LAP areas (RB, BB & LB, RW LAP areas). The high risk hazards were concentrated in the Riverland LAP areas for horticulture, flood-irrigation drainage discharges in the Mannum to Wellington LAP area, and in various LAP areas for creek/river inputs. Septic tank hazards were highest in frequency in the MM LAP area. Wastewater infrastructure (eg STEDS schemes) generally posed a low average level of risk although some sites (eg Renmark, Paringa, Waikerie, Mannum, Murray Bridge) were of moderate to high risk. Stormwater risks were relatively few in the RW and MM LAP areas due to the smaller townships (without formal stormwater infrastructure). Marinas and other vessel mooring areas posed a moderate level of risk along the river and lakes corridor but the highest numbers were present in the MM, MW, and GC LAP areas. Informal camping areas posed a moderate level of risk and were concentrated in the BBLB, RW, and MM LAP areas.

Table 8.1 The number and 'average' level of risk of different types of hazards in LAP areas

Hazard type	RB	BBLB	RW	MM	MW	GC	Total
ANIMAL HUSBANDRY		3	2		3		8
CHEMICAL STORE	1		1	1			3
CREEK/RIVER	9	6	6	2	2	7	32
DAIRY FARMS (LOWER LAKES)						15	15
DRAINAGE DISPOSAL SITE	2	9	3			2	16
DREDGING SITE					3	11	4
FERRY	1		3	3	4	1	12
FLOOD-IRRIGATED AREA DISCHARGE					25		25
FUEL STORE	13	1	2	8	15	1	40
GRAZING (UNRESTRICTED)			4	6		14	24
HORTICULTURE	10	19	16	4	6	4	59
INDUSTRY	2	3	2		2		9
INFORMAL CAMPING	9	24	10	21	2	2	68
LANDFILL	1	3	1	1	4	2	12
MARINA	1	2	2	4	4	7	20
PETROL STATION	3	3	4	1	6	3	20
QUARRY		2	1		2		5
REFUELLING FACILITY	1		1	1	3		6
SLIPWAY	1	1		3	1	1	7
STORMWATER INFRASTRUCTURE	14	6	1	4	24	34	83
TOILETS/SEPTIC TANKS	5	12	23	38	18	32	128
TRANSPORT INFRASTRUCTURE	1	4	2		3		10
VESSEL LAUNCHING/BOAT RAMP	8	14	14	32	11	15	94
VESSEL MOORING(S)	10	9	13	19	12	4	67
VESSEL WASTE DISPOSAL STATION	3	3	3	1	2	1	
WASTEWATER DISPOSAL AREA	1		1			1	3
WASTEWATER INFRASTRUCTURE	6	14	10	24	18	13	85
WETLAND/LAGOON	3	5	20	17	16	6	67
TOTAL	**105**	**143**	**145**	**190**	**186**	**166**	**935**

(high or very high, moderate, low)

RB—Renmark-border; BBLB—Berri-Barmera, Loxton-Bookpurnong; RW—Riverland West; MM—Mid Murray; MW—Mannum to Wellington; GC—Goolwa to Wellington, Coorong District

9. Risk management options

The River Murray and Lower Lakes catchment risk assessment for water quality project partners—the EPA, SA Water and the SAMDB NRMB—plan to use the results to develop and implement management strategies in coordination with other relevant agencies and organisations (eg DWLBC, community, LAP groups, councils, Department of Health).

Risk management involves identifying and assessing potential mitigation options, and preparing and implementing mitigation strategies. The individual LAP area chapters in this report provide suggestions on potential risk management options (Tables 2.7, 3.7, 4.7, 5.7, 6.7, 7.5) and this section describes risk management options and recommendations to be considered for adoption during Stage III of the project. Proposed management options and stakeholder responsibilities are being examined in more detail following further consultation and in-depth examination of priority risks. Uncertainties in the risk assessment rankings may also need to be addressed before some management decisions can be made. Some management strategies would need funding and the sources of these funds are yet to be determined.

The *National Water Quality Management Strategy* implementation guidelines (ARMCANZ and ANZECC 1998) provide guidance on methods of risk management, such as:

- examining in more detail the different options for mitigating priority risks, and the potential costs and benefits (eg environmental, economic) of these options
- identifying any priority areas for focusing of management efforts
- consulting with the community to set environmental values and water quality targets
- formulating and implementing management strategies and plans to mitigate risks.

Management option 1	The general framework of the *National Water Quality Management Strategy* implementation guidelines (ARMCANZ and ANZECC 1998) be adopted and used by the project and other stakeholders to guide Stage III of the risk assessment project. Areas of uncertainty for priority risks identified in Stage II of the project should be examined to confirm that risk management should be undertaken. ***Status of implementation**: In planning, funding secured for project officer position*

9.1 Specific management options by hazard type

Potential management options for each hazard type in a 'whole-of-river' strategic context are set out below in general order of risk level (high->low) and discussed. Many risk management strategies are already being implemented.

Flood-irrigated areas (Lower Murray)

***Typical risk level**: high-very high*
***Possible options**: capital works, monitoring, capacity building, enforcement, planning*
***Suggested lead stakeholders**: EPA, DWLBC, irrigators representative bodies and SA Water*

Excess surface irrigation discharges from flood-irrigated dairy farm areas were identified as a high risk to river water quality in the region between Mannum and Wellington. A current substantial government and farming community rehabilitation program in the Lower Murray is aiming to reduce the return of pollutant loads to the river. New irrigation and drainage infrastructure is being constructed, runoff reuse systems installed and farm management practices improved. DWLBC has set the objective of metering all water off-takes by July 2006. The EPA has set the objective of no discharge of surface irrigation runoff to the river after July 2008, and retention of a portion (50,000 L per ha) of stormwater runoff. Environment Improvement and Management Programs (EIMPs) have also been implemented for every farm and audits are ensuring compliance with the EPA's *Code of Practice for Milking Shed Effluent Management*. A water quality monitoring program is ascertaining the outcomes of the rehabilitation process in reducing pollutant loads returned to the river.

A number of dairy farms in the LMRIA are also being retired from dairy farming, especially in areas with visible evidence of soil salinisation. Future land management of these areas should be designed to protect water quality. Revegetating the floodplain may be possible in some areas and may bring positive outcomes for the environment and the community (improved amenity values).

Management option 2	The EPA and DWLBC continue to work with irrigators to achieve the key objectives (water metering and runoff reuse) of the Lower Murray flood-irrigated area rehabilitation program and other environmental improvements (eg dairy milking shed audits). SA Water is to closely monitor implementation of this program, acting as a collaborative partner where appropriate. ***Status of implementation**: Under full implementation, completion target mid 2008.*

Several risks to raw water supplies were posed by discharges from the Lower Murray flood-irrigated areas. The very high risk from the Jervois irrigation discharge to the Jervois unfiltered supply is currently being addressed by SA Water. Capital works are underway to divert the Tailem Bend water supply to Jervois via an under-river pipeline. The drainage discharge point has been moved to the back channel of the Jervois irrigation area which discharges several kilometres downstream of the off-take. This significantly reduces the level of risk until the pipeline has been constructed. Improvements and investigations also underway in other locations include examining treatment options for small township supplies and relocating other high risk discharge sources.

Management option 3	SA Water is to complete capital and any other necessary works to reduce risks to Jervois and other small township supplies. ***Status of implementation**: Under full implementation, capital works underway at Jervois and planning underway for other supplies.*

***Uncertainties in the risk assessment**: No data was obtained on the concentration of pesticides in discharge water from the Lower Murray flood-irrigated areas. There is also relatively little information on pathogen levels in LMRIA drainage channels and the survival rate of these pathogens in the river is unknown.*

Management option 4	Selected monitoring of pesticides and pathogens could be undertaken in some drainage channels by SA Water/EPA to assess if more detailed monitoring and risk assessments are required. ***Status of implementation**: Not started*

Horticulture

***Typical risk level**: moderate-high*
***Possible options**: capital works, monitoring, capacity building, enforcement, planning*
***Suggested lead stakeholders**: SAMDB NRMB, DWLBC, irrigation trusts, SA Water, EPA*

Large amounts of water are extracted from the river to support large irrigated areas (>23,000 ha in the Riverland region). Drainage from these areas was identified as a moderate–high risk to water quality for salinity, nutrient and organic matter stressors. Efficient irrigation practices are crucial to reducing drainage volumes. Crops predominantly irrigated in the Riverland region include vines (~9700 ha), citrus (~3000 ha) and vegetables (~2500 ha) and these are irrigated by drip (32%), overhead (18%), under-canopy (16%), pivot (13%), micro-sprinkler (5%) and flood (0.6%) systems (Croucher 2005).

DWLBC manages the water allocations and checks water efficiency targets in the River Murray Irrigation Management Zone. Irrigation efficiency improvements are being made in many areas; computerised and piped systems mean allow water to be ordered on demand. Moisture sensors at different depth levels in the soil, which have also been installed on some areas, enable irrigation to be stopped once applied water has passed the root zone (little excess drainage water generated). This can halve the water use of traditional water delivery and irrigation methods but there is higher potential for a salt accumulation layer to establish at the base of the root zone. The higher value of water and opening up of the trade market give more incentive for growers to be efficient (excess water can be temporarily traded).

Management option 5	SAMDB NRMB, DWLBC, LAP groups, and irrigation trusts are to continue to work to improve water efficiency and reduce drainage from horticultural areas including compliance and enforcement of water efficiency targets, education of irrigators and upgrading of systems (eg conversion to dripper irrigation) ***Status of implementation**: Ongoing, existing programs being undertaken*

Several major strategies are in place to reduce the effects of horticultural drainage on the river (eg Noora disposal basin, Waikerie and Bookpurnong salt interception schemes). Further salt interception schemes (eg Loxton) are under construction. These schemes help mitigate and significantly delay the effects of drainage discharges on the river.

Management option 6	Continued implementation of salt interception and other drainage schemes in priority areas (eg Pike/Murtho) to reduce groundwater/drainage inputs to the river. ***Status of implementation**: Feasibility study underway for Pike/Murtho areas*

***Uncertainties in the risk assessment**: Recent information on the relative influence of groundwater transport of pollutants from horticulture land uses on the water quality of the River Murray was lacking for parameters except salinity. Monitoring in other areas of the state has identified high nutrient, organic matter and heavy metal levels.*

Management option 7	Monitoring of selected salt interception scheme drainage and/or selected groundwater boreholes for nutrients, organic matter, heavy metals and pesticides. Input of these constituents to the river may be able to be estimated using existing salinity input models. ***Status of implementation**: Not started*

Creeks/rivers

***Typical risk level**: moderate–high*
***Possible options**: monitoring, policy/planning, compliance, research and development*
***Suggested lead stakeholders**: EPA, DWLBC, SAMDB NRMB, LAP groups*

The larger tributary rivers and creeks (eg Marne, Angas, Bremer, Finniss, Pike, Ral Ral, Salt) were identified as a high risk to water quality for various stressors, and smaller creeks typically recorded a

moderate rating. Many creeks and rivers received horticultural drainage (particularly those in the Riverland) and other inputs (eg stormwater, waste water, mining discharges). River and creek discharges were risk assessed as a point sources but assessment of activities in their entire catchments was considered outside the scope of this stage of the study. The moderate-high risk levels suggest that further investigation of hazards in their catchments is required before detailed management strategies can be developed.

Management option 8	Further investigation of land uses and hazards to water quality in creek and river catchments, possibly extending the risk assessment to these areas (SAMDB NRMB, EPA, DWLBC, SA Water). ***Status of implementation**: Not started but ongoing individual agency work in some areas*

Reducing horticulture drainage impacts on creeks and rivers (eg through more efficient irrigation practices) is also important. Work is underway on the water allocation planning/ prescription process for the Eastern Mount Lofty Ranges which will provide better understanding of the flows from Marne, Angas, Bremer and Finniss rivers. It includes upgrading of instrumentation and performing flow ratings.

Management option 9	DWLBC should complete water allocation and prescription process and water use and efficiency targets should be strictly enforced for all areas. ***Status of implementation**: Underway and ongoing*

Salt Creek was identified as a moderate nutrient and organic matter risk although there was some uncertainty as to the ecological impact on the Coorong. Current DWLBC monitoring and ecological risk assessment work will enable this assessment to be refined. Increased tidal flushing is seen as critical for improving the water quality of the Coorong, and plans are currently being implemented (MDBC 2005).

Management option 10	DWLBC to continue to monitor Salt Creek discharge and perform ecological risk assessment research. DWLBC, DEH, EPA to continue to monitor Coorong water quality. ***Status of implementation**: Monitoring program fully implemented by DWLBC, risk assessment framework to be finalised*

***Uncertainties in the risk assessment**: Large rainfall events in creek and river catchments are likely to result in the input of large loads of contaminants to the river and/or lakes but the relative influence of these events on water quality or environmental values was uncertain.*

Toilets/septic tanks

***Typical risk level**: moderate*
***Possible options**: capital works, policy/planning, research, review of standard operating procedures (SOPs)*
***Suggested lead stakeholders**: Department of Health, SAMDB NRMB, local councils, EPA*

Septic tank leakage from several shack areas, townships, public toilets and caravan parks was identified as a moderate risk to river water quality. For new systems, the South Australian Health Commission Code for Wastewater Disposal Systems (SAHC 1995) states that septic tank effluent must be disposed of at least 100 m from the pool level for the River Murray and Lower Lakes, and above the 1956 flood level. This separation distance is primarily designated to reduce pathogen risks and the large number of historical but currently used systems that do not fit this criteria is concerning.

The pathogen risk from the locations on the river floodplain may be mitigated somewhat by pathogen attenuation due to its typical heavy clay soils, relatively low rainfall rates and low groundwater pressure heads/flows (Allen 1998a, b). Nitrate and ammonia export may be of greater concern (Allen 1998a) although field evidence is lacking. Many ageing septic tank systems have been identified by local council bodies and are in the process of being upgraded to STEDS. However, several systems, many of which are located on the floodplain of the river, have yet to pass the planning and approval stages.

Management option 11	Auditing of all septic tank systems/locations identified as moderate or a greater level of risk in this study. The audit would be led by councils and/or Department of Health, with collaborative partners including the EPA, SA Water and SAMDB NRMB. It is recommended that the SAMDB NRMB produces an update on the status of implementation of conversion to STEDS of riverfront areas remaining on septic tanks. Compliance by councils/Department of Health using the *Public and Environmental Health Act 1987* or the EPA using the Water Quality EPP where necessary. ***Status of implementation**: Not started*

In the River Murray Water Protection Area, consideration should also be given to the density (ie number per unit area) of septic tank soakage trenches that may cause a risk to river water quality by contaminating groundwater that is generally moving towards and discharging into the river. Reports suggest that groundwater may be contaminated at septic tank densities exceeding 1–1.5 per hectare (MDBC 1993; SADHS 2004) which is greater than many land allotment sizes in the River Murray region. If soakage trench density is significantly greater than this in the River Murray Water Protection Area, it is recommended the location be serviced by a STEDS or an alternative advanced treatment system installed. 'Consideration of ongoing growth and use of the catchment area should be included to ensure ongoing protection of receiving water quality' (SADHS 2004). It is also important that the capacity of current systems is taken into account when assessing new applications for development to avoid overloading.

***Uncertainties in the risk assessment**: The degree to which pathogens or nutrients are reaching the river and/or lakes (following passage through soil/groundwater) was uncertain.*

Vessels/vessel moorings

***Risk level**: moderate*
***Possible options**: capital works, capacity building, compliance, policy/planning*
***Suggested lead stakeholders**: EPA, DTEI, BIASA, Houseboat Hirers Association, marina and vessel owners, DWLBC, Planning SA*

Vessel mooring areas (including marinas) were identified as a moderate risk to water quality through greywater and blackwater discharges from moored vessels. There are approximately 800 houseboats on the river in South Australia and over 1000 vessels on the Lower Lakes (BIASA 2001; MDA 2001). Vessels discharge greywater directly to the river and large houseboats may input high volumes of potential pollutants (contained in sink, shower, washing machine, dishwasher wastewater). It is currently an offence to dispose of blackwater into the River Murray and this is considered to occur much less frequently. The EPA is finalising the *Code of Practice for Vessel and Facility Management: Marine and Inland Waters*, which will be used to ensure sound environmental management of vessels and facilities on inland waters. All vessels, depending upon their sources of greywater, will be required to implement management strategies to minimise environmental harm. These strategies will range from on-board containment or treatment to behavioural practices for those small craft with limited structural capabilities.

Management option 12	The Code of Practice for Vessel and Facility Management: Marine and Inland Waters is implemented and enforced on the River Murray and Lower Lakes. ***Status of implementation**: Not started, awaiting finalisation*

Currently, commercial houseboats are required to be slipped and surveyed by DTEI. A working party has been established to examine the possibility of private slipways conducting wastewater system audits for all vessels, including those privately operated. It is anticipated that compliance certificates may be issued to coincide with vessel registration. These initiatives will take some years for development before they can be implemented.

Management option 13	A methodology be devised for ensuring compliance of all inland waters vessels with the requirements of *the Code of Practice for the Management of Black and Greywater*. ***Status of implementation**: Preliminary discussions being held between stakeholders*

Vessels that are moored and occupied as permanent dwellings were also a common community and boating industry concern. Although some may be managing their wastes adequately, such as using waste contractors to remove their wastewater, there is still no active compliance checking or controls on where vessels may be moored. The possible cumulative risk of multiple vessel moorings per riverfront allotment is also of concern in many locations (eg Mannum). A number of illegal moorings have been noted along the river, including some on Crown Lands.

Management option 14	Establish a planning strategy and guideline for marinas and houseboats on the River Murray in South Australia that addresses the issue of vessel moorings and sets a framework for development assessment. Illegal moorings should be assessed and removed if necessary. ***Status of implementation**: Planning SA coordinating consultation and developing draft strategy*

Non-commercial houseboat construction is also unregulated in South Australia. Most other forms of development in the River Murray corridor are regulated in some way. Standards and/or control over houseboat/residential vessel construction could help address potential risks before vessels are launched.

Management option 15	Relevant agencies (eg Planning SA, councils, EPA, DWLBC, DTEI) and groups (eg BIASA, Houseboat Hirers Association) to investigate the concept of an approval process and standards for houseboat construction. ***Status of implementation**: Not started*

Vessel wastewater discharges were also identified as a moderate pathogen risk to raw water supply environmental values in some locations. The risk is considered to be greatest for unfiltered supplies. There was some uncertainty as to the magnitude of this problem.

Management option 16	The DTEI, SA Water, councils and EPA discuss the issue of houseboat mooring areas identified in the risk assessment as being in close proximity to raw water off-takes. Possible zoning regulations should be considered. ***Status of implementation**: Not started*

***Uncertainties in the risk assessment**: Some water quality and quantity data for greywater discharges from vessels was available but this was not comprehensive.*

Marinas

***Risk level**: moderate*
***Possible options**: capital works, capacity building, compliance, and policy/planning*
***Suggested lead stakeholders**: EPA, DTEI, BIASA, Houseboat Hirers Association, marina and vessel owners*

Marinas were identified as a moderate risk to water quality due to potential wastewater discharges, fuel spills and in some cases slipway wash off. Few marinas identified in the study (eg Hindmarsh Island) were

EPA licensed but several were noted to be over the 50-vessel threshold for licensing. Resources have been allocated within the EPA to address the licensing of such operators.

Management option 17	The *Code of Practice for Vessel and Facility Management: Marine and Inland Waters* is implemented and enforced on the River Murray and Lower Lakes, including auditing (and licensing where applicable) of marinas and other multiple vessel moorings ***Status of implementation**: Not started, awaiting finalisation*

***Uncertainties in the risk assessment**: Water quality data from most marinas was not obtained.*

River vessel waste disposal stations

***Risk level**: moderate*
***Possible options**: capital works, capacity building, compliance, policy/planning*
***Suggested lead stakeholders**: DWLBC, EPA, DTEI, BIASA, Houseboat Hirers Association*

Vessel wastewater disposal stations were assessed as a moderate risk to water quality (through accidental spillage of blackwater). The number of vessel wastewater disposal stations on the river is clearly inadequate and large distances separate some stations (eg 96 km between Mannum and Swan Reach). It is unreasonable to expect boat owners to travel such large distances and this, coupled with the current inadequate enforcement checks, leads to an increased risk of wastewater discharge into the river or onto its banks in some locations.

Management option 18	Further river vessel wastewater disposal stations should be installed, in particular the proposed Walker Flat station, a station at Wellington and additional shore-based (portable toilet) facilities on the Lower Lakes. ***Status of implementation**: Planning started for Walker Flat station (subject to funding availability) with DWLBC coordinating*

Wastewater infrastructure (STEDS pumps and wastewater lagoons)

***Typical risk level**: typically low-moderate, high for Mannum and Murray Bridge WWTP lagoons and Waikerie STEDS lagoons*
***Possible options**: capital works, policy/planning, research, review of SOPs*
***Suggested lead stakeholders**: EPA, Department of Health, SAMDB NRMB, local councils*

Several wastewater lagoons (eg at Waikerie and Paringa) and STEDS pumps are located in close proximity to the river and posed a risk through leakage to groundwater (lagoons with no lining or leaking lining) and/or failure of infrastructure (pumps, pipework failure, lagoon overflow).

Management option 19	The EPA to audit STEDS/wastewater lagoons and infrastructure identified as a risk in this assessment and enforce licence conditions and Water Quality EPP if necessary. ***Status of implementation**: Not started*

The Mannum and Murray Bridge WWTP effluent ponds located on the floodplain immediately adjacent to the river were noted to pose a high risk. Some concerns were also noted with associated effluent pumps leading to the Murray Bridge plant.

Management option 20	SA Water to assess the risk of the Mannum and Murray Bridge WWTP lagoons (and associated effluent pumps) on the River Murray floodplain and consider whether risk reduction measures are required. ***Status of implementation**: Not started but sites have Environmental Management Systems in place*

***Uncertainties in the risk assessment**: The site-specific risk of flooding and/or failure of lagoons on the floodplain was somewhat uncertain.*

Stormwater infrastructure

***Risk level**: moderate-high*
***Possible options**: monitoring, capital works, capacity building*
***Suggested lead stakeholders**: SAMDB NRMB, local councils, SA Water, EPA*

Most stormwater discharges were typically assigned a moderate risk level but some in close proximity to water off-takes were rated as a high risk (eg Mannum, Renmark, Swan Reach). Several townships (eg Renmark, Mannum and Murray Bridge) have a large number of discharge points within a small area, and the cumulative effect of these is of potential concern. Some areas have gross pollutant traps (GPTs) or other stormwater management systems (eg diversion to wetland areas) for their stormwater discharges. GPTs only trap sediments and large debris, and some pollutants will still reach the river. A number of stormwater management plans have been created for river and lake councils (see Rural City of Murray Bridge 1998; Kinhill 1999 & 2000; Alexandrina Council 2003; Coorong District Council 2004) but the degree of implementation planned and funded is uncertain. It may be difficult to retro-fit treatment systems to existing outlets, and for sedimentation basins or wetlands to be economic. Reasonably large areas of land are required near current discharge points. In many cases councils are constrained by the historical design of the systems. Stormwater management must also be focused on reducing inputs of contaminants to the stormwater system, through education of industry and the community. The EPA produces a number of stormwater guidelines and codes of practice for various industries.

Management option 21	SAMDB NRMB to review progress of implementation of stormwater management plans. ***Status of implementation**: Not started* Funding options should be explored to assist councils to undertake necessary capital works for priority locations. ***Status of implementation**: Underway and ongoing* SA Water should further assess stormwater risks to water off-takes and consider supporting mitigation options to reduce risks where necessary. ***Status of implementation**: Not started*

Management option 22	Agencies (eg SAMDB NRMB, EPA and LAP groups) collaborate to put an increased focus on community education and industry auditing to achieve behaviour change to minimise inputs of pollutants to the stormwater systems in river and lake townships. ***Status of implementation**: Not started*

Incorporating water sensitive urban design (WSUD), including best practice stormwater management, into new developments would be beneficial to reduce stormwater inputs of pollutants to the river and lakes.

Management option 23	New developments should incorporate WSUD eg grass swales instead of gutters, rainwater storage tanks, retention basins and wetlands. Council development plans should be amended to reflect the importance of a more rigorous approach to dealing with stormwater. ***Status of implementation**: Not started*

***Uncertainties in the risk assessment**: Certainty was low for some stormwater discharge points of concern near raw water off-takes due to a lack of water quality and flow data; some limited water quality data exists for Murray Bridge (Jaensch Rd), Mannum and Berri outfalls.*

Management option 24	Further monitoring of stormwater quality for discharges near raw water off-takes in Mannum, Renmark, Berri and Swan Reach ***Status of implementation**: Some current monitoring underway and a report in production (by SAMDB NRMB) for Berri and Mannum discharges*

Informal camping areas

Risk level: *low-moderate*
Possible options: *capital works, capacity building, policy planning*
Suggested lead stakeholders: *Murray Darling Association, local councils, SAMDB NRMB, EPA, Department of Health, SA Tourism Commission*

Capacity building and construction of sanitation facilities is recommended for several informal camping zones along the river (subject to necessary development and other approvals). Site closures may be required in some other locations. The Sustainable Recreation Strategy (2005) is currently prioritising recreation sites along the River Murray and Lower Lakes that require rehabilitation and/or additional recreation facilities. Permit systems may be one way to raise revenue to provide sanitation and other facilities at informal camping areas.

Management option 25	Stakeholders to investigate issues and risk in more detail, including feasibility of providing sanitation facilities or closing some sites on Crown Land. The camping permit system concept should be further explored. Audits could be conducted of private campgrounds and the *Public and Environmental Health Act 1987* applied if necessary. ***Status of implementation***: *Some facilities being constructed as part of Sustainable Recreation Project activities*

Pathogen risks arising from informal camping sites near some of SA Water's raw water supply off-takes were identified.

Management option 26	SA Water, councils, Department of Health and EPA to ascertain whether zones prohibiting informal camping around SA Water off-takes could be established. ***Status of implementation***: *Not started*

Uncertainties in the risk assessment: *Water quality and sanitary conditions near high-use recreational areas has not been monitored leaving some question as to actual risk levels.*

Dairy farms (Lower Lakes)

***Risk level**: moderate*
***Possible options**: capital works, capacity building, compliance*
***Suggested lead stakeholders**: local councils, EPA, DWLBC*

Dairy farms in the Lower Lakes were considered a moderate risk to water quality through risk of leakage to groundwater (in particular nitrate). These relatively common farms in this area irrigate using centre pivots (note: flood-irrigated dairy farms in the Lower Murray are treated separately. Riparian grazing risks also existed for some farms.

Management option 27	The EPA should undertake audits of dairy farms in the Lower Lakes to ensure compliance with the *Code of Practice for Milking Shed Effluent 2003* and other general environmental duties required under the legislation. ***Status of implementation**: A few dairy audits have been completed, more are planned*

Grazing (unrestricted access to river, lakes, wetlands, backwaters)

***Risk level**: low-moderate*
***Possible options**: capital works, capacity building, monitoring*
***Suggested lead stakeholders**: SAMDB NRMB, EPA, LAP groups*

Stock had open access to the river, lakes and wetlands in several locations (for feed, weed control and drinking water). This grazing was assessed as a significant pathogen risk to raw water supplies and recreational values in some locations, and was noted as being culturally inappropriate to the Ngarrindjeri. Current Australian-based research indicates that high levels of pathogens are found in livestock, in particular juvenile cattle (EPA 2002; CRC Water Quality and Treatment 2004). Allowing animals or their faeces to enter water may also be in breach of the recently enacted *Environment Protection (Water Quality) Policy* (EPA 2003c) legislation (requirement to 'take all reasonable and practicable measures' to avoid waste entering water or land where it is likely to enter water). Fencing off riparian zones and/or supplying alternate water sources are recommended best practices to reduce this risk (CRC Water Quality and Treatment 2004).

Management option 28	The SAMDB NRMB and EPA should engage and consult with farmers who graze riparian margins on methods of managing water quality risks. LAP and other locally based groups could be funded in order to continue to provide incentives for fencing and alternative watering points. ***Status of implementation**: Not started*

***Uncertainties in the risk assessment**: Water quality before and after grazing has not been monitored leaving some question as to the actual risk level. Research suggests that there is a risk (EPA 2002; CRC Water Quality and Treatment 2004).*

Slipways

***Risk level**: low-moderate*
***Possible options**: capital works, compliance*
***Suggested lead stakeholders**: local councils, EPA, BIASA, boating industry*

Slipways were rated a moderate risk from wash-off of sediment, heavy metals and pesticides (found in some antifouling paints). Slipways are currently not inspected nor audited on a regular basis. It is likely that the majority of slipways along the river are required to be licensed by the EPA but this has not been undertaken to date.

Management option 29	The EPA to audit slipways (and license those captured by the Environment Protection Act 1993 Schedule 1 definition) to ensure compliance with the new *Code of Practice for Vessel and Facility Management: Marine and Inland Waters*. ***Status of implementation**: In planning*

***Uncertainties in the risk assessment**: No monitoring data on slipway runoff or its effects was obtained leaving some uncertainty as to the risk level.*

Wetlands/lagoons

***Typical risk level**: low-moderate*
***Possible options**: monitoring, research and development*
***Suggested lead stakeholders**: SAMDB NRMB, EPA, DWLBC, DEH, SA Water*

Wetlands were identified as a low to moderate risk to water quality. Given that wetlands are a natural and intrinsically important part of the river ecosystem, they are not a 'risk' in the conventional sense. Many different types of wetlands exist along the river (see the River Murray wetland baseline survey and Thompson 1986 for more detail on individual wetland characteristics). In general the wetlands present today are typically not the type or form of wetlands along the River Murray channel before the 'locking of the river' and other activities like irrigation drainage discharges. A number of ephemeral floodplain/wetland areas (eg Chowilla) have been affected by salt and other pollutants which build up over time without natural flushing. These types of wetlands may release salt and contaminants during artificial flushing practices or following large localised rainfall events. However, when the river floods, nutrient and other contaminant concentrations in wetlands are generally diluted (AWQC 1993). Wetland management should be focused on reducing inputs of contaminants from wetland catchments and ensuring artificial flushing strategies are properly managed to minimise any effects on river water quality or raw water off-takes. Grazing is also an issue around some wetlands.

***Uncertainties in the risk assessment**: No data was obtained for water quality exiting wetlands as a result of localised storm events or artificial flushing. Some ambient water quality data has recently been collected during the River Murray baseline wetland survey.*

Management option 30	Stakeholders to review baseline wetland study water quality data and undertake literature research on wetland dynamics. Consider whether a detailed outflow and water quality monitoring program may be beneficial in some priority locations (eg Swan Reach complex, South Portee wetlands near water off-takes) ***Status of implementation**: Baseline study data being collated*

Wastewater/drainage disposal areas

***Risk level**: low-moderate*
***Possible options**: capital works, capacity building*
***Suggested lead stakeholders**: EPA, facility owners/operators*

Disposal of drainage (predominantly in the Riverland, eg Lyrup, Chaffey irrigation areas) and wastewater was identified as a low-moderate risk to water quality. Some sources of wastewater (eg wastewater treatment plants) were EPA licensed and existing management controls are in place. The other non-licensed sites are a high priority for further examination.

Management option 31	EPA to audit drainage/wastewater disposal sites to ensure the disposal is not contaminating ground or surface water ***Status of implementation**: Not started*

***Uncertainties in the risk assessment**: Individual sites were often not inspected leaving some uncertainty as to the risk level.*

Industry (eg wineries, abattoirs, fruit processors)

***Risk level**: low-moderate*
***Possible options**: capital works, capacity building*
***Suggested lead stakeholders**: EPA, industry owners/operators*

Several industries (eg wineries, abattoirs, fruit processors) were identified that were a potential risk to water quality. However, most were EPA licensed and existing management controls were in place.

***Uncertainties in the risk assessment**: Individual sites were often not inspected leaving some uncertainty as to the risk level. Licence coordinators provided information in some cases.*

Animal husbandry (piggeries, feedlots)

***Risk level**: low-moderate*
***Possible options**: capital works, research*
***Suggested lead stakeholders**: EPA, facility owners/operators*

Animal husbandry activities were identified as a potential risk to water quality. However, most were EPA licensed and existing management controls were in place.
***Uncertainties in the risk assessment**: Individual sites were not inspected leaving some uncertainty as to the risk level. Licence coordinators provided information in some cases.*

Ferry operations

***Typical risk level**: low*
***Possible options**: capital works, policy/planning, compliance, capacity building*
***Suggested lead stakeholders**: DTEI, EPA, SAMDB NRMB*

Ferry operations on the river were identified as a low risk to water quality. DTEI is currently monitoring deck runoff and consulting with the EPA on the outcomes of this research. New ferries will be constructed with pollutant retainment/treatment systems incorporated on-board. Sweeping and collection of material from ferry decks is the current preferred method for cleaning although some ferry decks are still washed down.

Management option 32	DTEI to continue the implementation of ferry pollutant management systems on new ferries. Standard operating and training procedures for existing ferries and their personnel need reviewing, including the use of hydrocarbon spill kits and cleaning procedures following transport of stock. ***Status of implementation**: Underway*

Landfills

***Risk level**: low-moderate*
***Possible options**: capital works, research*
***Suggested lead stakeholders**: EPA, councils/landfill operators*

There were no currently operating landfills identified on the floodplain of the river although some closed landfills (eg Narrung, Sturt reserve) in these locations may be leaking contaminants.
***Uncertainties in the risk assessment**: Potential pollutant leakage from closed landfills was uncertain.*

Dredging

***Risk level**: low-moderate*
***Possible options**: capital works, capacity building, monitoring*
***Suggested lead stakeholders**: local councils, SAMDB NRMB, EPA, boating industry*

Habitat destruction and suspended sediment impacts may result from dredging activities. Dredging generally came out as a low-moderate risk to river water quality on the basis of reasonably infrequent occurrence, the turbid nature of the river, and the fact it is regulated by the EPA (Schedule 1 of the Environment Protection Act 1993). Most dredging operations on the river are removing willows, or clearing irrigation channels, vessel moorings and marinas. As dredging locations change constantly, the sites identified in this risk assessment should not be considered as the only areas of regular activities. Dredging impacts vary depending on the extent of sediment disturbance and sensitivity of the environment being dredged. The use of sediment curtains and other pollution prevention measures are often imposed as licence conditions in an attempt to minimise environmental harm.
Under the current Schedule 1 definition, dredging is licensable for the following applications (unless they involve the establishment of a visual aid to navigation or any lawful fishing or recreational activity): the dredging/cleaning of inlet channels and sluices to irrigation areas, marina applications, slipway and boat ramp applications, and riparian edge management (eg willow removal). The exclusions to the definition limit the EPA's ability to ensure compliance with the Act and provide a consistent approach to managing dredging. There is also currently no threshold below which a licence is not required (eg disturbing any bottom sediment is considered dredging) and dredging contractors also have concerns with the large amount of administration required to obtain licences.

Management option 33	Education of dredging operators on best management practices would be beneficial. The EPA is to investigate options to minimise administration burden and consider a review of Schedule 1 of the Environment Protection Act to ensure consistent and appropriate regulation of Schedule 1 activities. Reasonable and practicable measures to reduce environmental impacts should be made mandatory for all dredging operations. ***Status of implementation**: In planning*

***Uncertainties in the risk assessment**: Dredging impacts have not been studied in detail on the river and lakes so the risk assessment had some uncertainty.*

Vessel launching/boat ramps

Risk level: low
***Possible options**: policy planning, capacity building*
***Suggested lead stakeholders**: local councils, DTEI, DWLBC, boating industry*

Although vessel launching areas/boat ramps were rated as a low individual risk, the possible cumulative impact of boat ramps (and other structures) is of concern despite no detailed environmental impact assessment having been undertaken on this issue.

Management option 34	It is recommended that relevant agencies (eg EPA, DWLBC, Crown Lands) examine the impacts of boat ramps in more detail. It may be beneficial to only approve new applications for boat/ramps facilities if they are for public communal facilities, due to the potential cumulative risk from individual facilities. ***Status of implementation**: Not started*

Wake-induced erosion of riverbanks in high-use recreation areas was a common community concern. This was assessed as a low risk but its actual impact on recreational values was difficult to quantify and the large numbers may have cumulative impacts. Increasing the number of restricted speed (4 knot) zones on the river and creating defined wake-boarding areas are suggestions that may help to limit the damage from boat wakes. Re-establishment of reeds, trees and native vegetation to minimise bank erosion is the best management practice to prevent erosion. The use of geotextile bags for stabilising banks is also recommended. Sand dumping to create beaches in townships, recreational sites and shack areas is in breach of the Water Quality EPP (EPA 2003c), and creates an impact on the aquatic ecosystem (smothers existing habitat) and other environmental values (eg sand can migrate to block adjoining water supply channels).

Management option 35	Councils and DTEI study the erosion and turbidity impacts around high-use recreational sites in more detail and consider whether zoning would be a beneficial option. ***Status of implementation**: Not started*

Management option 36	EPA and DWLBC to undertake education, then possible enforcement action (using the Water Quality EPP and River Murray Act) on members of the community and contractors who dump sand into the river ***Status of implementation**: Not started*

***Uncertainties in the risk assessment**: Whether boat and watercraft wakes increase turbidity or erosion rates is uncertain. The extent of accidental diesel and other hydrocarbon spillage on boat ramps is also uncertain. The precise ecological impact of creation of sand beaches and general landscaping/modifying of riverbank edges is uncertain but substantial habitat destruction is likely to result.*

Fuel stores

***Risk level**: low*
***Possible options**: capital works, capacity building*
***Suggested lead stakeholders**: local councils, EPA, DWLBC*

Fuel stores and diesel motors on the edge of the river were generally rated as low risk due to the low likelihood of fuel spill; however, a large spill entering the river could have a major impact.

Management option 37	Audit to be undertaken by EPA/DWLBC on all riverside fuel stores identified as a risk in this study. Following this audit, EPA to consider whether fuel stores should be bunded or converted to electric pumping systems to minimise the risk of hydrocarbon spills. ***Status of implementation**: Not started*

Refuelling facilities (for vessels)

***Risk level**: low*
***Possible options**: capital works, capacity building*
***Suggested lead stakeholders**: EPA, facility operators*

Vessel refuelling facilities were generally rated as low risk due to the low likelihood of an accident releasing a large volume spill.

Management option 38	Auditing of vessel refuelling facilities to ensure appropriate measures in place to prevent and/or manage risks (eg bunding, spill kits) ***Status of implementation**: Not started*

Petrol stations

***Risk level**: low*
***Possible options**: monitoring*
***Suggested lead stakeholders**: EPA, petrol station owners, fuel companies*

Leakage of hydrocarbons from underground storage tanks at petrol stations was given a low risk. Stations of most concern are those in close proximity to the river. Concerns about old underground tanks were also raised but detailed information was lacking on specific risks.

***Uncertainties in the risk assessment**: It has been suggested that tanks over five years in age are probably leaking to some degree; however, no monitoring data was available to confirm this assessment.*

Management option 39	EPA to consider auditing petrol station (in close proximity to the river) records and monitoring data to assess risk of fuel leakage. ***Status of implementation**: Not started*

Transport infrastructure (bridges and causeways)

***Risk level**: low*
***Possible options**: capital works, research and development*
***Suggested lead stakeholders:** local councils, DTEI*

Bridges over the river or backwaters were generally rated as low risk due to the low likelihood of an accident that would release a fuel spill; however, a large spill entering the river may have major effects on the ecosystem or water supplies.

Management option 40	Preventative measures such as bridge cages (to prevent trucks transporting diesel and other contaminants from entering the river as result of accidents) and barriers warrant investigation, as does investigation of spill response capability. ***Status of implementation**: Not started*

Quarries

***Risk level**: low*
***Possible options**: capital works, capacity building*
***Suggested lead stakeholders**: EPA, facility owners/operators*

Few quarries were identified and the majority of these were identified as a low potential risk to water quality (through runoff of sediment to the river).

***Uncertainties in the risk assessment**: Individual sites were not inspected leaving some uncertainty as to the risk level.*

9.2 General recommendations

Several general recommendations that arose out of the risk assessment consultation and research (but were not specifically related to a particular hazard) are discussed below.

Cumulative water quality impacts

Cumulative impacts must also be considered, particularly in the current context of increasing development along the river. An example might be septic tanks on the floodplain of the river: while one septic tank may have a low overall risk, several septic tanks in a defined area could have a very detrimental impact. Alternatively, one pathogen source could have a low risk on the upper reaches of the river but further downstream pathogen risks could accumulate to create a higher overall level of risk. The end point of allowing risks to accumulate to adverse levels is 'death by a thousand cuts'. In the

current study, the GIS-based maps allow assessment of the density of risks and hazards. In the next stage of the study, the cumulative impact will be analysed in more detail and compared to water quality trends.

General recommendation 1	The relative cumulative impact of water quality risks is examined for each environmental value during Stage III of the project. ***Status of implementation**: Underway*

Water quality information

Studies on water quality were last undertaken for the river in the period 1990–1999 (EPA 2001a), the lakes in the period 1995–1997 (EPA 1998b), and Salt Creek and Coorong up to 2005 (DWLBC 2005). Basic information on pollutant concentrations and loads from various sources (eg rivers, houseboats, stormwater, Lower Murray irrigation areas) is lacking in most cases. It would be beneficial to re-examine monitoring data, particularly exceedences for different environmental values and hazards identified in this report. This may enable a refinement of action and area priorities.

General recommendation 2	The EPA and SA Water research existing data and produce an updated water quality report for the River Murray, Lower Lakes and Coorong. Where possible this report should include basic load calculations from various inputs (eg rivers/creeks, Lower Murray flood irrigated areas, houseboats, groundwater, stormwater). Links to the risk assessment project outcomes should be explored in the data analysis. ***Status of implementation**: Not started but ongoing monitoring data collected for a number of sites and activities*

Processes affecting water quality

The fate and transformation of nutrients in the river, Lower Lakes and Coorong was largely unknown, making assessment of nutrient consequences difficult. In particular the influence of bottom sediments as a nutrient source or sink, influence of wetlands and riverbank vegetation in removing nutrients, relative importance of denitrification for removing nitrogen from the system, and cross-sectional and depth distribution of nutrient levels.

General recommendation 3	The EPA, SA Water and DWLBC to investigate uncertainties in information and options for developing a water quality model for the river. A funding submission should be prepared to federal bodies to fund more detailed water quality monitoring and construction of the model. ***Status of implementation**: A scoping-level monitoring study on horizontal and depth distribution of nutrients is underway at selected locations (SAMDB NRMB).*

Diffuse runoff from agricultural land

The impact on river water quality of diffuse runoff of pollutants (eg turbidity, pesticides, nutrients—total P) during rainfall events was generally not assessed as part of this study (unless specific information on a particular site/land use was obtained). This impact requires further research as it may make a significant contribution to total contaminant loads entering the river (although it is noted that rainfall and runoff is relatively low in many areas along the river, approximately 250–400 mm rainfall per annum on average). The methods of controlling diffuse source pollution typically relate to ensuring sustainable land management practices and creation or maintenance of existing vegetation buffers between agricultural land and waterways.

General recommendation 4	Catchment water quality modelling could be undertaken to assess influence of diffuse runoff (possibly combined with the proposed river water quality model). ***Status of implementation**: Not started*

General recommendation 5	LAP and/or other local groups could be funded to provide incentives for revegetation and creation of buffer strips for mitigation of diffuse runoff in priority areas. ***Status of implementation**: Not started*

Cause and effect relationships on aquatic ecosystem health

There was a lack of accessible and detailed information summarising the impacts of water quality hazards on aquatic ecosystem health for the River Murray in South Australia. However, macro-invertebrate data is regularly collected and the EPA has produced a summary of this information for the river and eastern Mount Lofty ranges.

General recommendation 6	A review and update of current macro-invertebrate and other monitoring data should be carried out. Links to the risk assessment project's results and water quality data should be explored. ***Status of implementation**: Not started*

Development and planning issues

Several development and planning issues arose out of both the risk assessment consultation and the EPA and DWLBC's experience in assessing referred development applications in the area. Not only are river councils inconsistent in policy and its application, so are prescribed bodies that are referred development proposals for advice or direction. The increasing development pressure in these areas make

this situation very concerning. It is also confusing for developers seeking to determine agency positions and requirements before lodging development applications. Planning SA's Better Development Plan initiative seeks to align development plan policy across the State. The EPA is developing position papers for river developments. DWLBC is currently developing River Murray Referral Assessment Policy and Neutral or Beneficial Effect Guidelines to establish a consistent policy framework for assessing referrals under the *River Murray Act 2003*, and to assist proponents when preparing an application. In addition, a working group chaired by Planning SA and comprising representatives from other agencies (eg EPA, DWLBC, DEH, DTEI), is developing a River Murray Marina Strategy (see Management Option 14 above).

General recommendation 7	Integrated and consistent planning policies and guidelines should continue to be developed by councils and agencies (eg Planning SA, EPA, DWLBC) for the River Murray and Lower Lakes region. A whole of river Plan Amendment Report may be required in the future. ***Status of implementation**: Started*

The River Murray Water Protection Area (proclaimed under the Environment Protection Act) does not include a significant area of the Coorong (southern half) and Lower Lakes (eg Goolwa, Milang area), which is thus outside EPA direction over development.

General recommendation 8	The EPA should consult relevant councils and agencies (eg DWLBC, SAMDB NRMB) and pursue a regulation change to revise the boundary of the River Murray Water Protection Area (proclaimed under the Environment Protection Act) to include the entire Lower Lakes and Coorong area. ***Status of implementation**: Preliminary planning underway by EPA*

Compliance and education on water quality issues

Community consultation in the various LAP areas raised concerns about 'no agency presence on the river'. A recent BIASA survey also reported concerns about apparent inappropriate or illegal activities along the river (Glen Jones, BIASA president, pers comm 2006). While enforcement is often seen by agencies as a last resort (unless for serious breaches of legislation) the lack of a presence is a risk to efforts to improve water quality.

General recommendation 9	Inter- and intra-agency investigation of whether more resources are required to enhance the current capabilities of agencies (eg EPA, DWLBC) dealing with River Murray compliance issues. Possible inter-agency integration of compliance capabilities should be also considered. ***Status of implementation**: Not started*

Education and awareness raising on environmental issues concerning the river may be an important first step for changing public behaviours. Comprehensive public environmental awareness strategies (specifically targeting river issues) were noted to be lacking although some groups (eg Waterwatch) are active on this issue.

General recommendation 10	EPA, DWLBC, councils and SAMDB NRMB to consider funding and coordinating a program to educate river community about their obligations for environmental management. ***Status of implementation**: Not started*

Cultural environmental values

Protection of River Murray, Lower Lakes and Coorong water quality is very important to local indigenous peoples such as the Ngarrindjeri for whom the land and waters are considered a living body (*Ruwe*). Indigenous groups were consulted as part of the project but risks to cultural water quality values was not directly assessed. This is one area requiring further consultation and engagement in the next stage of the study.

General recommendation 11	Indigenous groups are consulted on cultural environmental values of the River Murray, Lower Lakes, and Coorong. ***Status of implementation**: Not started*

River flow

This current report did not specifically look at river flow and its potential effect on water quality. However, improved flow regimes are viewed as essential for improving water quality and ecosystem health in the Lower Lakes and Coorong. The Lower Murray region of the river has been noted to have very low flows and similarly reduced tidal flushing currently impacts on the Coorong. Flows and/or tidal flushing must be sufficient to ensure flushing of sediment and other pollutants out of the river, lakes, Coorong system, at least on a periodic basis. The key environmental requirements for the main channel of the River Murray have been noted to be 40 GL/day for up to eight consecutive weeks on average every second year, with high flow events occurring in late spring (SAMDB NRM 2002).

General recommendation 12	Efforts continued to improve flows and flushing down the river, Coorong, Lakes and Murray Mouth. Monitoring of the outcomes of these initiatives and effect of changing flows on water quality. ***Status of implementation**: Not started*

Risk assessment project database management

A detailed database of water quality risk has been constructed as part of this project. It is imperative that this is maintained and updated as new information comes to hand. The South Australian Murray Resource Information Centre is currently being established in the Riverland to manage natural resource and other data for the region.

General recommendation 13	The risk assessment project database be regularly updated and information made readily available to stakeholders. Investigation should be made into potentially housing the database at the South Australian Murray Resource Information Centre, and on mechanisms for stakeholders and the community to input and/or update risk information. ***Status of implementation**: Not started*

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