

3 Berri-Barmera and Loxton-Bookpurnong LAP areas assessment

3.1 Description of the area

The Berri-Barmera and Loxton-Bookpurnong (BB & LB) Local Action Planning (LAP) areas are located in the South Australian Riverland, approximately 220 kilometres north-east of Adelaide (Figure 3.1). The boundaries are directly aligned with those of the Berri Barmera Council above the River Murray and part of the Loxton Waikerie Council below. The LAP area north of the river (between the Lyrup ferry and Overland Corner) includes the townships of Berri, Barmera, Glossop, Cobdogla, Winkie, Monash and Gerard. South of the river the area includes Loxton, Moorook and Kingston-on-Murray.

Land and groundwater salinisation is a major problem in the area, largely the legacy of historical vegetation clearance in the regional catchment. The problem has been exacerbated in some locations by irrigated horticulture creating a 'groundwater mound' and increasing saline groundwater flows. Large areas of the region are currently used for viticulture and citrus horticulture, which employ drip and/or under-canopy irrigation (see Croucher 2005). Irrigation practices are much improved from historical methods, although both natural and irrigation-induced groundwater flows are highly saline at both Berri and Loxton. Often the river floodplain intercepts the salt load, which threatens floodplain health (AWE 2001a). The salt trapped on the floodplain may enter the river through natural or artificial flooding.

The BB & LB Local Action Planning Committees have identified water quality as a key issue in each of their local action plans. The committees work with a number of other agencies on various programs to help manage water quality in the region: water quality monitoring of Lake Bonney; stormwater management in Berri, Barmera and Loxton; provision of education programs for irrigators to improve irrigation practices and reduce drainage; revegetation initiatives and waste disposal upgrades.

Generally, water quality within the BB & LB LAP region is fair compared to the rest of the river (EPA 2001a). Regular monitoring is carried out on a wide range of parameters at Berri, Loxton and Lock 3. The 'run of the river' and other salinity surveys (by DWLBC) have identified areas of the river receiving large salt inputs from groundwater (eg Gurra Gurra Lakes area) and modelled the impacts to the river and floodplain (CSIRO 2003). In terms of this project's framework, saline groundwater inputs were quite difficult to define for a precise hazard location, as they diffuse into the river to varying degrees along its whole length. Please refer to DWLBC 'run of the river' and 'nano-TEM' salinity monitoring data for indications of the magnitude of these salt inputs and their impacts on river salinity. Specific salinity risks that could be attributed to defined source locations (eg large horticultural areas, saline creek/drainage discharges) are included in this report.

Dissolved nutrient (oxidised nitrogen and phosphate) and *E coli* levels are on average lower in this reach of the river than in the Lower Murray (EPA 2001a). However, dissolved nutrients may be used rapidly by algae and average *Anabaena circinalis* (blue-green algae) levels are often elevated at Lock 3. It has been suggested that this is due to outflows from Watchel's lagoon, which receives significant horticulture drainage inputs (EPA 2001a). Total heavy metal readings recorded at the river monitoring stations in this LAP area were generally at a low level and pesticides were generally at, or below, detection levels. Some lagoons in the area (eg Watchel's and Yatco) are also very saline (EPA 2001a). Turbidity levels are high along the river's whole South Australian length. They are significantly influenced by contributions from the Darling River (which has a high clay colloid level) and flood events (MDBBC 1988).

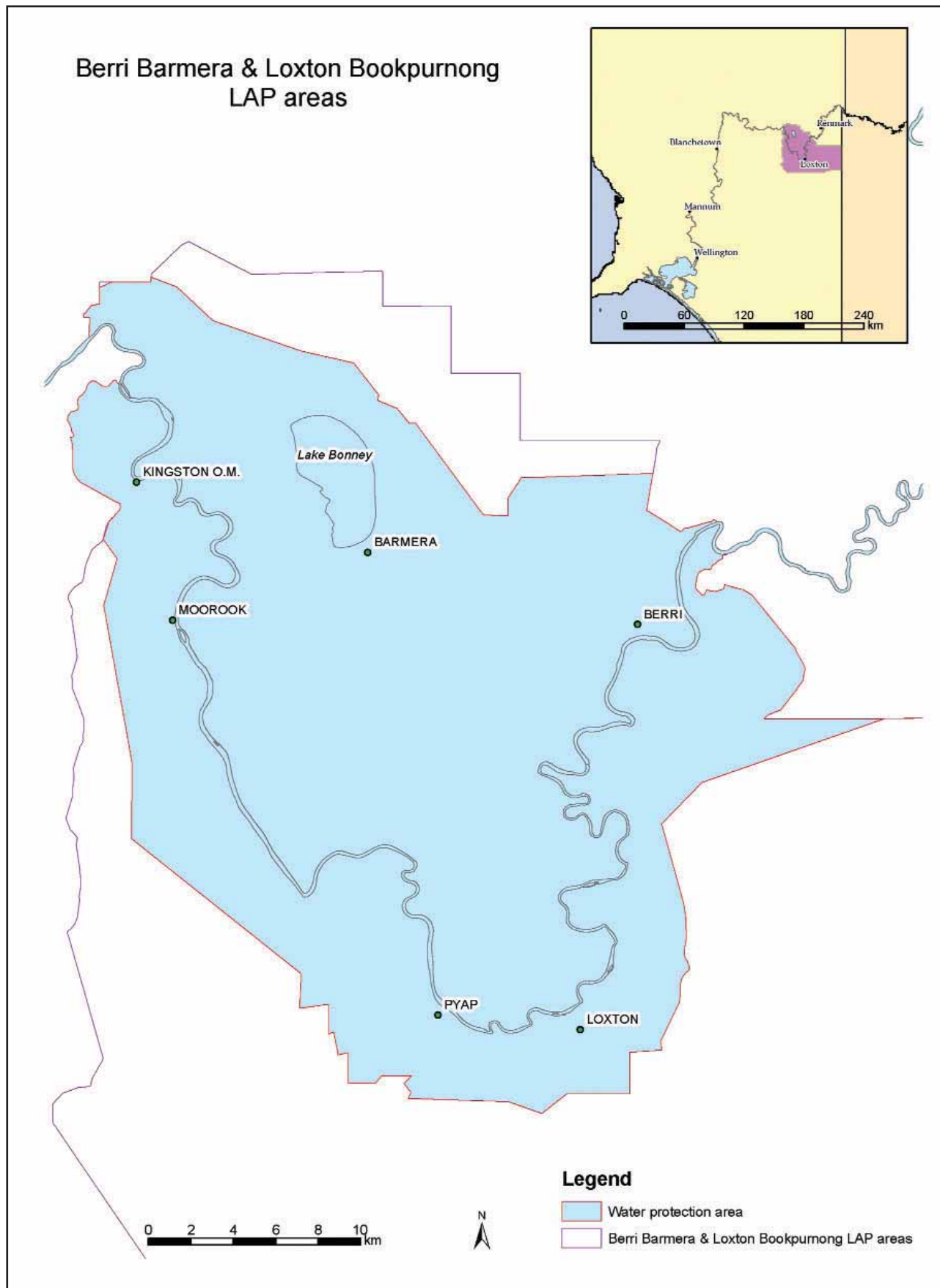


Figure 3.1 Berri-Barmera and Loxton-Bookpurnong LAP areas

3.2 Environmental value zones

Spatial zones assigned for each environmental value allowed hazards to be identified and assessed for risk in manageable amounts.

Aquatic ecosystem zones

Risks to aquatic ecosystem health were assessed in arbitrary three kilometre zones for the length of the river, a total of 39 zones in the BB & LB LAP areas.

Raw water supply zones

Six raw water supply zones (from 500 m downstream to three kilometres upstream of each potable water off-take) were identified in the BB & LB LAP areas:

BLRAW001	Berri raw water off-take
BLRAW002	Loxton raw water off-take, which also supplies the townships of Noora, Pata and Taplan
BLRAW003	Gerard raw water off-take, a private system (ie not SA Water operated)
BLRAW004	Moorook raw water off-take (unfiltered)
BLRAW005	Barmera-Cobdogla raw water off-take, which supplies the townships of Cobdogla and Barmera
BLRAW006	Kingston-on-Murray raw water off-take (unfiltered).

Recreation zones

Nine recreation zones were identified in the BB & LB LAP areas:

BLREC001	Berri and surrounds (9.8 km long)
BLREC002	Salt Creek discharge to Ajax Achilles Lake (2.5 km long)
RLREC003	Lock 4 (Bookpurnong) to Clarky's (north) camping area (5.7 km long)
BLREC004	Rilli Reach camping area to Clarky's (south) (4.3 km long)
BLREC005	Rilli Island and downstream (4.5 km long)
BLREC006	Loxton and surrounds (8 km long)
BLREC007	Forby's Island (downstream of Pyap) (0.4 km long)
BLREC008	Yatco lagoon discharge to Kingston-on-Murray (16.4 km long)
BLREC009	Overland Corner and surrounds (6.9 km long).

3.3 Hazard identification process

A community consultation workshop was held with representatives from the Berri-Barmera and Loxton-Bookpurnong LAP office, Berri Barmera and Loxton Waikerie local councils, Riverland Tourism Association, Central Irrigation Trust, DWLBC, Murray Darling Association and Overland Corner wetland programs. The workshop identified the nature and location of potential water quality hazards and recreation zones, and provided useful information for the subsequent risk evaluation process.

3.4 Risks to water quality in the Berri-Barmera and Loxton-Bookpurnong areas

A total of 143 hazards were identified in the BB & LB LAP areas. The highest frequency hazards were informal camping areas (no sanitation facilities), horticulture drainage, wastewater infrastructure (eg STEDS pumps), vessel launching facilities (boat ramps), toilets/septic tanks, and vessel moorings (Figure 3.2).

Frequency (occurrence) does not necessarily indicate risk—a hazard may have a high frequency but a low risk. The cumulative impacts of low-risk activities will be considered and assessed as part of mitigation strategy development.

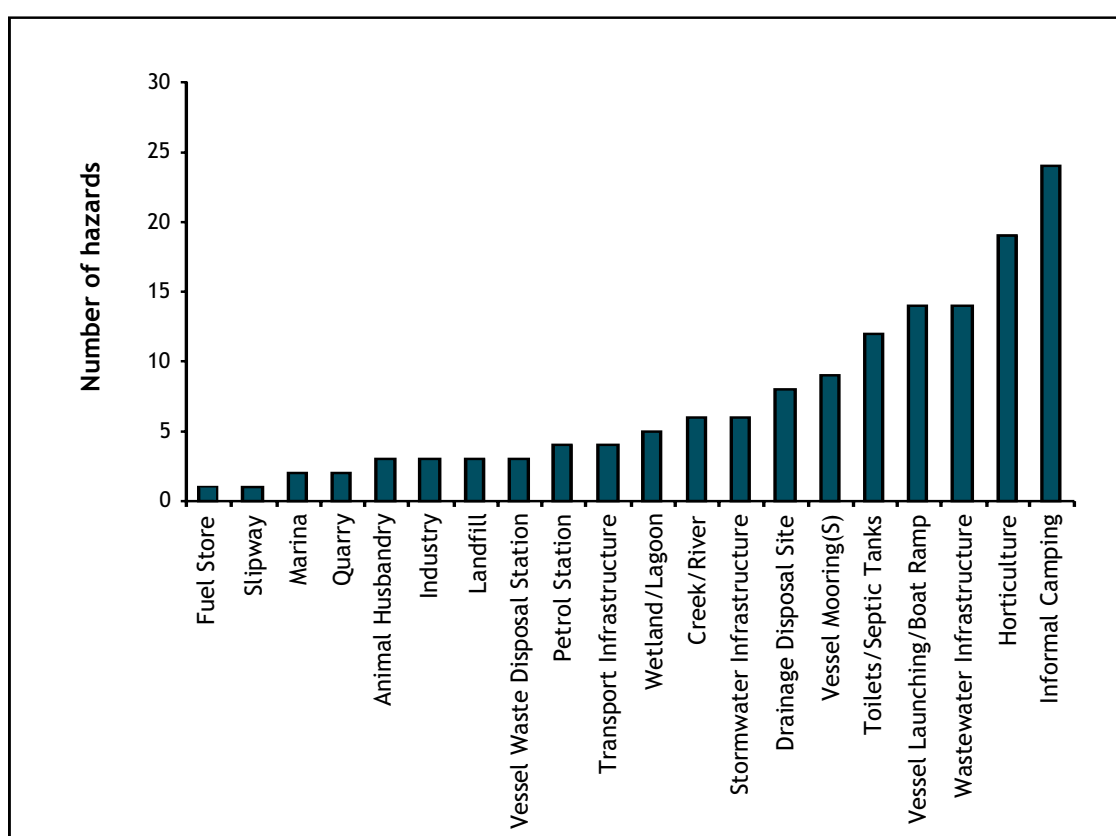
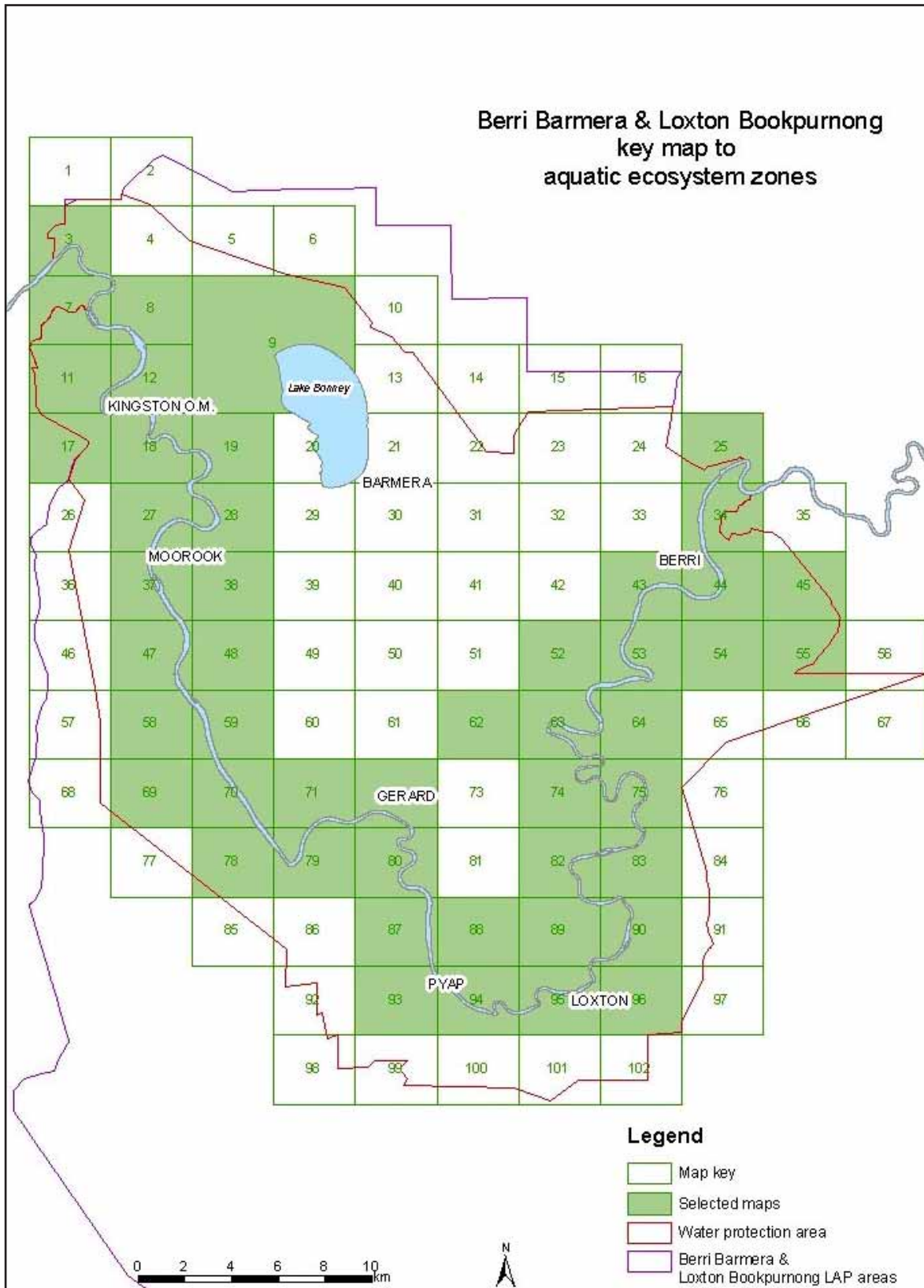


Figure 3.2 Frequency of hazards to water quality, BB & LB LAP areas

Risks to aquatic ecosystem health

Figure 3.3 is the key map for the risks to the aquatic ecosystem environmental value in the BB & LB LAP area. The attached CD has individual maps numbered according to the key map.

The summary of identified risks to aquatic ecosystem health for the various water quality stressors (Table 3.1) shows that nutrients have the highest frequency, followed by organic matter, turbidity, hydrocarbons and salinity. Most of the risks were rated as low (233) or moderate (174), but a number of high-level (12) risks were recorded.



Note: shaded maps included on attached DVD; not all maps have hazards associated with them

Figure 3.3 Key map for aquatic ecosystem zones, BB & LB LAP areas

Table 3.1 Frequency of risks to aquatic ecosystem health, BB & LB LAP areas

Risk	Stressor							Total risks
	NU	TU	OR	HM	PE	HY	SA	
Low	52	37	51	1	41	39	12	233
Moderate	60	13	61	9	1	8	22	174
High	5	0	0	0	0	0	7	12
Very high	0	0	0	0	0	0	0	0
Total	117	50	112	10	42	47	41	419

NU—nutrients; TU—turbidity; OR—organic matter; HM—heavy metals; PE—pesticides; HY—hydrocarbons; SA—salinity

The aquatic ecosystem risks identified in the BB & LB LAP area are summarised in Table 3.2 and discussed in more detail below for each stressor.



Figure 3.4 Example of hazard in the BB & LB LAP areas: river vessel waste disposal station

Salinity

Large areas of land adjacent to the river or backwaters are used for irrigated horticulture in the BB & LB LAP area. Groundwater leakage from several horticultural areas (Overland Corner, Kingston, Loxton, Cobdogla, Moorook and Berri) and lagoons (Yatco, Pyap, Watchel's and Banrock) contributed most high salinity risk ratings. Horticultural drainage is also a large contributor (along with regional groundwater discharges) to a high risk of leakage from Gurra Gurra Lakes and discharge from its outlet to the river (Salt Creek). Salt Creek is quite saline (2000-6000 EC) compared to the river and any drop in Lock 4 levels causes flow, which draws high salt concentrations out of the lake into the river. The creek/discharge from Lake Bonney also received a moderate risk ranking. This creek has low discharge but any drop in Lock 3 levels tends to draw high salt concentrations out and increased ambient river water salinities have been observed downstream of Lock 3. There is some uncertainty about the ecological impact of saline discharges to the river, as salinity levels have historically been variable (MDBC 1988).

A winery and associated wastewater disposal area near Loxton received a moderate risk ranking, as did the pipeline taking saline drainage under the river to Berri evaporation basin. Potential leakage/discharge from evaporation basins (Loveday, Overland Corner, Cobdogla) received a moderate risk ranking although there was some uncertainty as to the impact of these basins on the river. They receive or have previously received (Loveday) irrigation drainage for horticultural areas but it appears that groundwater generally tends to flow from the river towards them. The risk level for possible future artificial flushing is unclear but warrants further investigation.

Several major strategies are in place to reduce the effects of saline drainage on the river (AWE 2001a). Much of the area's irrigation drainage is collected in district caissons and pumped to regional disposal basins (eg drainage from Berri is pumped away from the river to Noora disposal basin 20 km east of Loxton), where evaporation reduces seepage back into groundwater. This has presumably also reduced nutrient inputs, but evaporation lagoons at Loxton, Cobdogla and Berri have been identified as 'at capacity' with a potential for leakage and overflowing. SA Water recently constructed a salt interception scheme at Bookpurnong, which prevents large amounts of salt entering the river. The \$21.4-million salt interception scheme being constructed at Loxton could remove an additional 66 tonnes of salt from the River Murray each day⁶. Irrigation practices have improved substantially in recent times in the BB & LB LAP areas and flood irrigation is now rarely practised. An on-ground water efficiency project is currently being employed to inform irrigators and increase awareness of best-practice land management. A management plan and conceptual salt models have been developed for the Loveday wetland and DWLBC and the SAMDB NRMB are investigating its rehabilitation. A wetland management plan is currently being developed for the Cobdogla basin, and capital works with flow regulators and an upgrade of a pipe through the causeway are already in progress at this site.

Saline impacts on floodplain vegetation and wetlands are also a major concern in the area. Basic monitoring recently conducted at wetlands in this area as part of the River Murray Wetlands Baseline Survey, surveyed Gurra Gurra Lakes, Rilli lagoons, Loveday swamp and Cobdogla basin. A subsequent survey is currently being carried out on another set of wetlands. Data collected in the survey relates to site physical characteristics, water quality, groundwater inputs, vegetation, fish, birds, frogs and macro-invertebrates. It will be used to identify conservation values and management objectives for each

⁶ See <www.sawater.com.au/SAWater/Environment/TheRiverMurray/Salt+Interception+Schemes.htm>

wetland. The BB & LB LAP areas are also part of the combined Riverland network, where several small-scale projects are in place to monitor discharges from lagoons and wetlands within the region. The Riverland revegetation incentive scheme, also in operation, encourages groups or individual landholders to rehabilitate wetlands and other native vegetation sites within their property, and should bring positive water quality benefits in the future.

Nutrients

Groundwater leakage from several large horticultural areas (Overland Corner, Kingston, Loxton, Cobdogla, Moorook and Berri) was classified as a high nutrient risk, as were discharges from Watchel's and Banrock lagoons, which receive nutrient inputs from horticulture drainage. Watchel's lagoon has had blue-green algal problems in the past (EPA 2001a). The recent rehabilitation of Moorook irrigation area should reduce water quality impacts on this lagoon in the future. Several other smaller horticulture areas received a moderate risk ranking, as did Yatco and Pyap lagoons where inputs of irrigation drainage and low water exchange may create favourable conditions for algal growth.

Monitoring studies have noted significant saline groundwater inputs in the BB & LB LAP region and although there was some uncertainty about nutrient levels in this groundwater, it was assumed to be significant and this contributed to the moderate-high risk rankings for these horticultural areas. Several management strategies are in place to reduce the amount of horticultural drainage reaching the river (see above).

Greywater and blackwater discharges from marinas and other vessel mooring locations were identified as a moderate nutrient risk, as were accidental spillages from the river vessel waste disposal stations (Berri, Loxton and Lock 3 as seen in Figure 3.4). Deliberate blackwater discharge in this region seems less likely than in other stretches of the river with large distances (50-100 km) between some waste disposal stations; a recent survey of boating activity along the river indicated moderate to high frequency use of the stations (BIASA 2001).

Two of the Loxton township effluent pumps (stations 1 and 4) were classed as a moderate risk as they are located in close proximity to the river, and pump failure (and subsequent discharge) could have a moderate-high consequence for ecosystem health in the immediate vicinity. A moderate risk was also identified from septic tank systems (leakage to groundwater/river water) in several locations (eg Kingston-on-Murray caravan park, Yatco holiday units, Rili Island), public toilets (Berri Ski Club), and the township of Gerard. The townships of Berri, Barmera, Cobdogla and Loxton are already on STEDS, and upgrades are planned for other locations to connect to these systems.

Berri stormwater point discharges were identified as a moderate risk, with filtration systems (gross pollutant traps) already in place for three of the larger town catchments. Berri has five discharge points close to each other but currently most town stormwater is diverted to a retention lagoon near the caravan park. Loxton township has no discharge points directly into the river and stormwater is currently directed to retention areas on the floodplain.

Informal camping areas in general presented a low nutrient risk. The exception was Overland Corner (moderate risk) with over 300 campsites. Although a self-composting toilet is in place there, pressure is placed on the facility during peak camping periods and many people dig pit toilets.

Organic matter

Groundwater leakage from several large horticultural areas (Overland Corner, Kingston, Loxton, Cobdogla, Moorook and Berri) was classified as a high organic matter risk although there was some uncertainty to this assessment due to a lack of monitoring data. Stormwater discharges, leakage from smaller horticultural areas, lagoons, vessel and creek discharges, two of the Loxton township effluent pumps and septic tank leakage were assessed as a moderate risk for organic matter, generally because of a high likelihood but low consequence.

Turbidity

The current very high level of turbidity in the river coming into South Australia makes additional turbidity impacts on the aquatic ecosystem less likely than in many other waterbodies. The few moderate sources of turbidity risk were stormwater discharges in Berri, creeks and wash down activities at a slipway. Most turbidity risks—vessel launching/boat ramp areas, marinas, quarries and vessel waste disposal stations—were classified as low.

The community raised concerns about wake boat induced erosion but it was difficult to determine the precise location, extent or impact of this activity.

Hydrocarbons

Urban stormwater from the township of Berri contributed to moderate hydrocarbon risks. The cumulative risk of these stormwater discharges within a relatively small spatial area is of concern. The Kingston Bridge and Cobdogla causeway were also given a moderate risk ranking. While the likelihood of accidental spillage from these hazards is low, the potential consequences of a major oil spill resulted in a moderate risk to aquatic ecosystem health.

Other low hydrocarbon risks noted included accidental spills of fuel from river craft, possible leaching from petrol stations and areas that are situated on historical landfill sites (eg near Berri township) and pump fuel stores.

Heavy metals

Groundwater leakage from horticultural areas to the river was considered a moderate heavy metal risk. There was a lack of certainty to this assessment but groundwater contamination for metals such as cadmium and zinc has been reported under irrigation areas in other areas of the State (eg Northern Adelaide Plains, EPA 2003a).

Other moderate-risk sources of heavy metals included stormwater discharge points in Berri, in particular in catchments with a considerable amount of development. These metals are likely to be mostly in particulate form and therefore not immediately bioavailable or toxic, but they may be accumulating in the immediate vicinity of stormwater outfalls. Wash-off from a slipway in Berri was also classified as a moderate risk for heavy metals due to the likely blasting of metal containing products (eg vessel exterior and antifouling paints). Leaching and runoff from historical landfill areas (now informal camping areas) were also categorised as a moderate-risk although no monitoring data was obtained on which to base this assessment. Broad water quality trends (EPA 2001a) show no significant heavy metal increases in the BB & LB reach of the river, but there may be higher levels in the vicinity of the localised areas noted above.

Pesticides

Pesticide use is widespread in the area for horticulture and the risk was assessed as moderate (large irrigation areas noted above) to low (other irrigation areas). No direct monitoring data was obtained as a base for the assessment (eg in drainage from horticultural areas).

Water quality monitoring data for the region (eg SA Water data for Berri) typically shows undetectable levels of pesticides, whose use is regulated through the National Registration Scheme for agricultural and veterinary chemicals (EPA 2003d).

Table 3.2 Summary of risks to aquatic ecosystem environmental values, BB & LB LAP areas
 low=low risk, mod=moderate risk, high=high risk, v high=very high risk
 certainty value (in italics) follows each risk ranking

GEOCODE	LAP	HAZARD	EVENT TYPE	NU	TU	OR	HM	PE	HY	SA
BL091B	BBLB	ANIMAL HUSBANDRY	EVENT DISCHARGE	low 2						
BL132B	BBLB	Dog shelter, Moorook	EVENT DISCHARGE	low 2		low 2				
BL140B	BBLB	Piggery, upstream of Katarapko Creek	EVENT DISCHARGE	low 2		low 2				
		Piggery, adj Gurra Gurra Lake								
		CREEK/RIVER								
BL049B	BBLB	Creek opposite Loxton township	EVENT DISCHARGE	mod 2	mod 2	mod 2		low 2		mod 2
BL054A	BBLB	Eckert Creek	DISCHARGE	mod 2	low 2	mod 2		low 2		mod 2
BL054B	BBLB	Eckert Creek	EVENT DISCHARGE	mod 2	mod 2	mod 2		low 2		mod 2
BL061A	BBLB	Banrock Creek	DISCHARGE	mod 2	low 2	mod 2		low 2		high 2
BL061B	BBLB	Banrock Creek	EVENT DISCHARGE	mod 2	mod 2	mod 2		low 2		mod 2
BL065A	BBLB	Creek, outlet from Lake Bonney	DISCHARGE	mod 2	low 2	mod 2		low 2		high 3
BL109A	BBLB	Katarapko Creek	DISCHARGE	mod 2	low 2	mod 2		low 2		low 3
BL109B	BBLB	Katarapko Creek	EVENT DISCHARGE	mod 2	mod 2	mod 2		low 2		low 2
BL151A	BBLB	Salt Creek	DISCHARGE	mod 2	low 2	mod 2		low 2		high 2
BL151B	BBLB	Salt Creek	EVENT DISCHARGE	mod 2	mod 2	mod 2		low 2		mod 2
		DRAINAGE DISPOSAL SITE								
BL019L	BBLB	Leakage to river, Gurra Gurra Lakes	LEAKAGE	mod 2		mod 1		low 1		high 3
BL053A	BBLB	Groundwater discharge from lagoons, d/s Rilli Island	DISCHARGE	mod 2		mod 1		low 1		mod 2
BL053L	BBLB	Groundwater leakage from lagoons, d/s Rilli Island	LEAKAGE	mod 2		mod 1		low 1		mod 2
BL058L	BBLB	Groundwater discharge, near Solora	LEAKAGE	mod 2		mod 1		low 1		mod 3
BL087B	BBLB	Evaporation basin, Loveday	EVENT DISCHARGE	low 2		low 2		low 1		mod 3
BL104L	BBLB	Horticulture, Gerard	LEAKAGE	mod 2		mod 1		low 1		mod 2
BL111L	BBLB	Natural /groundwater drainage discharge, W of Berri	LEAKAGE	mod 2		mod 1		low 1		mod 2
BL119B	BBLB	Salt pan, Overland Corner	EVENT DISCHARGE	low 2		low 2		low 1		mod 2
BL125B	BBLB	Evaporation basin, Cobdogla	EVENT DISCHARGE	low 2		low 2		low 1		mod 3
		FUEL STORE								
BL050C	BBLB	Pump fuel store—private irrigation, Loxton	ACCIDENTAL SPILLAGE						low 2	
		HORTICULTURE								
BL008L	BBLB	Horticulture, u/s Berri	LEAKAGE	low 3		low 2		low 2		mod 3

GEocode	LAP	HAZARD	EVENT TYPE	NU	TU	OR	HM	PE	HY	SA
BL057L	BBLB	Horticulture/winery & oranges, Solora	LEAKAGE	mod 2		mod 2	mod 2	low 2		mod 3
BL066L	BBLB	Vineyard & winery, Loch Luna	LEAKAGE	mod 2		mod 2	mod 2	low 2		mod 3
BL074L	BBLB	Horticulture, Chambers Creek	LEAKAGE	mod 2		mod 2	mod 2	low 2		mod 3
BL075L	BBLB	Horticulture, u/s Kingston	LEAKAGE	high 2		high 2	mod 2	low 2		high 3
BL080L	BBLB	Vineyard & winery, EPA Lic #2298—Kingston Estates	LEAKAGE	mod 2		mod 2	mod 2	low 2		mod 3
BL089L	BBLB	Horticulture, Moorook	LEAKAGE	high 2		high 2	mod 2	low 2		high 3
BL099L	BBLB	Horticulture, adj Yatco lagoon	LEAKAGE	mod 2		mod 2	mod 2	low 2		mod 3
BL101L	BBLB	Horticulture, Yatco	LEAKAGE	mod 2		mod 2	mod 2	low 2		mod 3
BL102L	BBLB	Horticulture, New Residence	LEAKAGE	mod 2		mod 2	mod 2	low 2		mod 3
BL105L	BBLB	Horticulture, Seven Mile Reach	LEAKAGE	mod 2		mod 2	mod 2	low 2		mod 3
BL106L	BBLB	Horticulture, Pyap lagoon	LEAKAGE	mod 2		mod 2	mod 2	low 2		mod 3
BL107L	BBLB	Horticulture, Pyap irrigation area	LEAKAGE	mod 2		mod 2	mod 2	low 2		mod 3
BL118L	BBLB	Horticulture, Overland Corner	LEAKAGE	high 2		high 2	mod 2	low 2		high 3
BL147L	BBLB	Horticulture, Berri area	LEAKAGE	high 2		high 2	mod 2	low 2		high 3
BL178L	BBLB	Horticulture, area NE of Loxton	LEAKAGE	high 2		high 2	mod 2	low 2		high 3
BL180L	BBLB	Banrock vineyard and winery	LEAKAGE	mod 2		mod 2	mod 2	low 2		mod 3
BL181L	BBLB	Horticulture, Cobdogla	LEAKAGE	high 2		high 2	mod 2	low 2		high 3
BL041D	BBLB	Winery, EPA Lic #1838—Loxton	INFRASTRUCTURE FAILURE	low 2		low 2		low 2		low 1
BL172B	BBLB	Concrete batching plant, EPA Lic #1254—Santos	EVENT DISCHARGE		mod 2					
BL173B	BBLB	Angas Park Fruit Co, EPA Lic #1990—Loxton	EVENT DISCHARGE	low 2	low 2	low 2				
BL031G	BBLB	Permanent camping /landfill, d/s of Berri	HUMAN/ANIMAL EXCRETION	low 3		low 2				
BL034G	BBLB	Camping ground, Katarapko	HUMAN/ANIMAL EXCRETION	low 3		low 2				
BL037G	BBLB	Informal camping, Rilli reach	HUMAN/ANIMAL EXCRETION	low 3		low 2				
BL038G	BBLB	Informal camping, Eckert Creek	HUMAN/ANIMAL EXCRETION	low 3		low 2				
BL039G	BBLB	Informal camping, Rilli Island	HUMAN/ANIMAL EXCRETION	low 3		low 2				
BL048G	BBLB	Informal camping, d/s Thiele's sandbar	HUMAN/ANIMAL EXCRETION	low 3		low 2				
BL055G	BBLB	Informal camping, western side Katarapko Creek	HUMAN/ANIMAL EXCRETION	low 3		low 2				
BL056G	BBLB	Informal camping, Clarky's camp zone (u/s end)	HUMAN/ANIMAL EXCRETION	low 3		low 2				
BL060G	BBLB	Informal camping, Overland Corner	HUMAN/ANIMAL EXCRETION	low 2		low 2				
BL064G	BBLB	Informal camping, u/s Banrock	HUMAN/ANIMAL EXCRETION	low 2		low 2				

GEOCODE	LAP	HAZARD	EVENT TYPE	NU	TU	OR	HM	PE	HY	SA
BL078G	BBLB	Informal camping, adj Thurk Is	HUMAN/ANIMAL EXCRETION	low 2		low 2				
BL083G	BBLB	Informal camping, Bruno Bay to Watchel's lagoon	HUMAN/ANIMAL EXCRETION	low 2		low 2				
BL090G	BBLB	Informal camping, Moorook game reserve	HUMAN/ANIMAL EXCRETION	low 2		low 2				
BL093G	BBLB	Informal camping, Moorook game reserve	HUMAN/ANIMAL EXCRETION	low 2		low 2				
BL110G	BBLB	Informal camping, Katarapko Creek	HUMAN/ANIMAL EXCRETION	low 2		low 2				
BL112G	BBLB	Informal camping, Blackfellows Creek	HUMAN/ANIMAL EXCRETION	low 2		low 2				
BL114G	BBLB	Informal camping, Loch Luna	HUMAN/ANIMAL EXCRETION	low 2		low 2				
BL134G	BBLB	Informal camping, Eckert's Creek	HUMAN/ANIMAL EXCRETION	low 2		low 2				
BL137G	BBLB	Recreation area, Quast's Bend	HUMAN/ANIMAL EXCRETION	low 2		low 2				
BL153G	BBLB	Recreation area, u/s of Loxton North	HUMAN/ANIMAL EXCRETION	low 2		low 2				
BL154G	BBLB	Informal camping, d/s of Rilli Island	HUMAN/ANIMAL EXCRETION	low 2		low 2				
BL167G	BBLB	Informal camping, western side Katarapko Creek	HUMAN/ANIMAL EXCRETION	low 2		low 2				
BL168G	BBLB	Informal camping, Clarky's camp zone (d/s end)	HUMAN/ANIMAL EXCRETION	low 2		low 2				
BL170G	BBLB	Informal camping, Rilli Reach	HUMAN/ANIMAL EXCRETION	low 2		low 2				
		LANDFILL								
BL007L	BBLB	Landfill (disused), north of Berri	LEAKAGE	mod 2		mod 2	mod 2	low 2	low 2	
BL010L	BBLB	Disused dam/received old cannery wastewater, Berri	LEAKAGE	low 2						
BL148L	BBLB	Cannery dump, u/s of Berri	LEAKAGE	mod 2		mod 2	mod 2	low 2	low 2	
		MARINA								
BL009Q	BBLB	Big River Marina, north of Berri	MARINA DISCHARGES	mod 3		mod 2			low 3	
BL025Q	BBLB	Berri Marina	MARINA DISCHARGES	mod 2		mod 2			low 2	
		PETROL STATION								
BL032C	BBLB	Petrol station—Shell, Berri	ACCIDENTAL SPILLAGE						low 3	
BL032L	BBLB	Petrol station—Shell, Berri	LEAKAGE						low 2	
BL085C	BBLB	Petrol station, Cobdogla	ACCIDENTAL SPILLAGE						low 3	
BL085L	BBLB	Petrol station, Cobdogla	LEAKAGE						low 2	
BL146L	BBLB	Petrol station, Berri (disused)	LEAKAGE						low 2	
BL177L	BBLB	Petrol station—BP, Loxton	LEAKAGE						low 2	
		QUARRY								
BL071B	BBLB	Quarry, Sugarloaf Hill	EVENT DISCHARGE						low 2	
BL149B	BBLB	Quarry, top of Gurra Gurra	EVENT DISCHARGE						low 2	

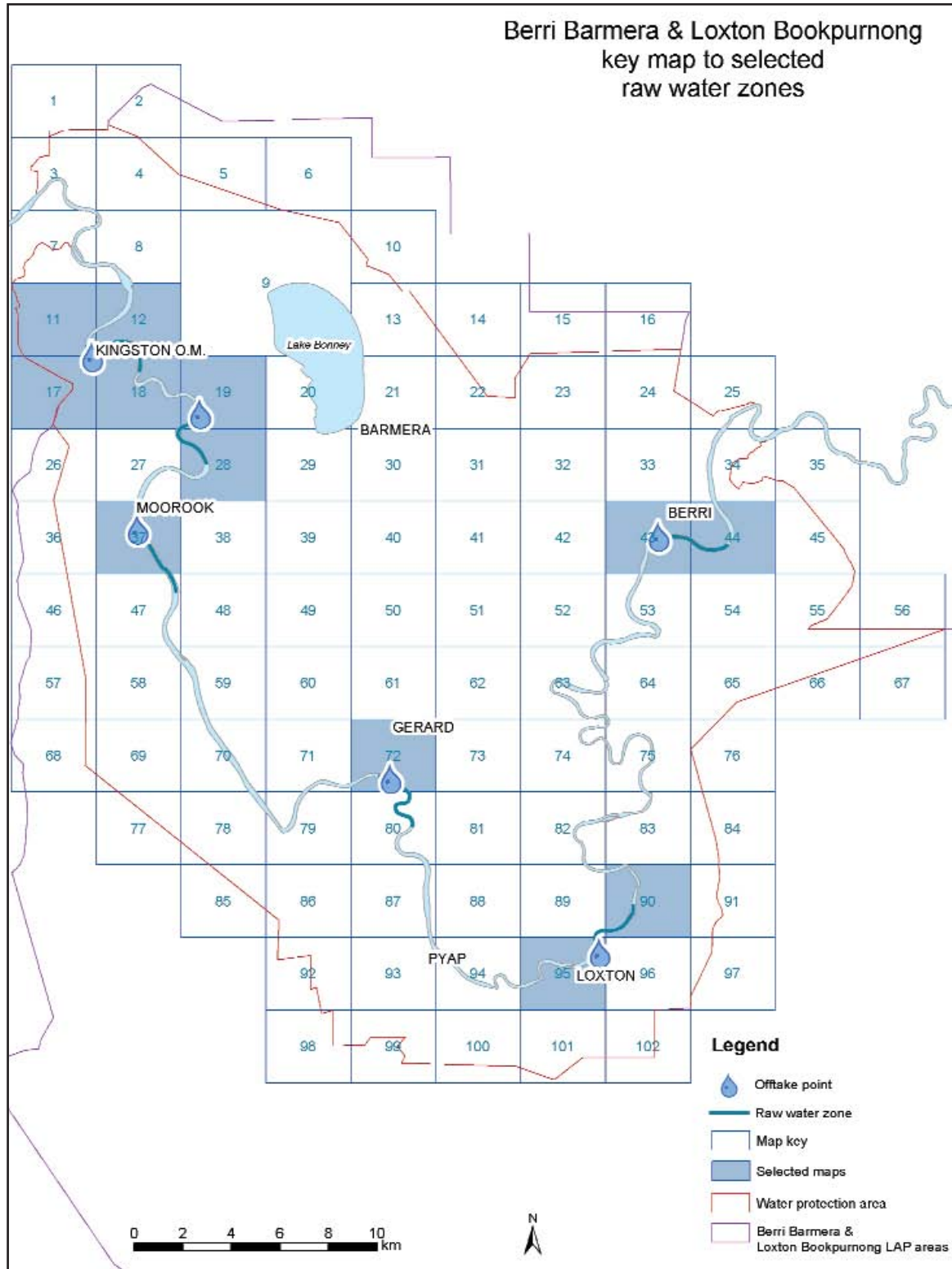
GEOCODE	LAP	HAZARD	EVENT TYPE	NU	TU	OR	HM	PE	HY	SA
		SLIPWAY								
BL030H	BBLB	Slipway, EPA Lic #1385–Berri	WASH DOWN		mod 1		mod 2	low 1	low 2	
BL027E	BBLB	STORMWATER INFRASTRUCTURE	EVENT DISCHARGE	mod 2	mod 2	mod 2	mod 2	low 1	mod 2	
BL155B	BBLB	Stormwater retention basin, Berri	EVENT DISCHARGE	mod 3	mod 3	mod 3	mod 3	low 1	mod 3	
BL156B	BBLB	Stormwater discharge, Crawford Tce, Berri	EVENT DISCHARGE	mod 3	mod 3	mod 3	mod 3	low 1	mod 3	
BL157B	BBLB	Stormwater discharge, Vaughan Tce, Berri	EVENT DISCHARGE	mod 3	mod 3	mod 3	mod 3	low 1	mod 3	
BL158B	BBLB	Stormwater discharge, Ahern St, Berri	EVENT DISCHARGE	mod 3	mod 3	mod 3	mod 3	low 1	mod 3	
BL159B	BBLB	Stormwater discharge, Berri oval	EVENT DISCHARGE	mod 3	mod 3	mod 3	mod 3	low 1	mod 3	
		TOILETS/SEPTIC TANKS								
BL021L	BBLB	Septic tanks—pubic toilet and ski club toilet	LEAKAGE	mod 2		mod 2				
BL035L	BBLB	Septic, Katarapko camping ground	LEAKAGE	low 3		low 3				
BL042L	BBLB	Septic tanks—Country Living development, Loxton	LEAKAGE	low 3		low 3				
BL052L	BBLB	Septic tanks—housing development, u/s Rili Island	LEAKAGE	mod 3		mod 3				
BL079L	BBLB	Septic tanks, Kingston-on-Murray Caravan Park	LEAKAGE	low 3		low 3				
BL094L	BBLB	Public toilet septic tanks, Moorook	LEAKAGE	low 2		low 2				
BL098L	BBLB	Septic tanks—holiday units, Yatco	LEAKAGE	mod 2		mod 2				
BL115L	BBLB	Septic tanks, Kingston-on-Murray Caravan Park	LEAKAGE	mod 3		mod 3				
BL116L	BBLB	Septic tanks, backpackers	LEAKAGE	mod 3		mod 3				
BL117D	BBLB	Toilet holding tanks, Overland Corner	INFRASTRUCTURE FAILURE	low 2		low 2				
BL130L	BBLB	Septic tanks, Gerard township	LEAKAGE	mod 3		mod 3				
BL136L	BBLB	Pit toilet, Katarapko Creek	LEAKAGE	low 2		low 2				
		TRANSPORT INFRASTRUCTURE								
BL082C	BBLB	Kingston Bridge	ACCIDENTAL SPILLAGE						mod 2	
BL084C	BBLB	Causeway, downstream of Cobdogla	ACCIDENTAL SPILLAGE						mod 2	
BL097C	BBLB	Causeway, Kingston-Loxton Rd	ACCIDENTAL SPILLAGE						low 2	
BL152C	BBLB	Causeway, Salt Creek	ACCIDENTAL SPILLAGE						low 2	
		VESSEL LAUNCHING/BOAT RAMP								
BL020S	BBLB	Recreation area, Berri ski club & boat ramp	VESSEL LAUNCHING		low 2				low 2	
BL023S	BBLB	Private boat ramp, Martins Bend	VESSEL LAUNCHING		low 2				low 2	
BL036S	BBLB	Boat ramp, u/s Lock 4	VESSEL LAUNCHING		low 2				low 2	
BL040S	BBLB	Boat ramp, Rili Island	VESSEL LAUNCHING		low 2				low 2	

GEOCODE	LAP	HAZARD	EVENT TYPE	NU	TU	OR	HM	PE	HY	SA
BL0515	BBLB	Private moorings & jetties, Loxton	VESSEL LAUNCHING		low 2				low 2	
BL0775	BBLB	Recreation area, Kingston-on-Murray	VESSEL LAUNCHING		low 2				low 2	
BL1085	BBLB	Boat ramp, u/s of Pyap	VESSEL LAUNCHING		low 2				low 2	
BL1135	BBLB	Recreation area, Bruno Bay	VESSEL LAUNCHING		low 2				low 3	
BL1245	BBLB	Recreation area, Kingston-on-Murray	VESSEL LAUNCHING		low 2				low 3	
BL1265	BBLB	Recreation area, Moorook	VESSEL LAUNCHING		low 2				low 3	
BL1355	BBLB	Boat ramp, Katarapko Island	VESSEL LAUNCHING		low 2				low 2	
BL1455	BBLB	Recreation area, Berri	VESSEL LAUNCHING		low 2				low 3	
BL1505	BBLB	Recreation area, d/s of Salt Creek	VESSEL LAUNCHING		low 2				low 2	
BL171R	BBLB	Loxton Council mooring area	VESSEL LAUNCHING		low 2				low 2	
		VESSEL MOORING(S)								
BL002R	BBLB	Permanent houseboats, Spring Cart Gully	VESSEL DISCHARGES	mod 3	low 2	mod 3			low 2	
BL043R	BBLB	Houseboat mooring, Loxton	VESSEL DISCHARGES	mod 3	low 2	mod 2			low 2	
BL059R	BBLB	Houseboats, Overland Corner	VESSEL DISCHARGES	mod 3	low 2	mod 2			low 2	
BL062R	BBLB	Houseboats, Banrock Creek	VESSEL DISCHARGES	mod 3	low 2	mod 2			low 2	
BL076R	BBLB	Commercial houseboats, Kingston-on-Murray	VESSEL DISCHARGES	mod 2	low 2	mod 2			low 2	
BL127R	BBLB	Houseboats, Moorook	VESSEL DISCHARGES	mod 3	low 2	mod 2			low 2	
BL129R	BBLB	Houseboats, Yatco lagoon	VESSEL DISCHARGES	mod 3	low 2	mod 3			low 2	
BL144R	BBLB	Houseboats, Berri	VESSEL DISCHARGES	mod 3	low 2	mod 2			low 2	
BL176R	BBLB	Houseboats, Berri	VESSEL DISCHARGES	mod 3	low 2	mod 2			low 2	
		VESSEL WASTE DISPOSAL STATION								
BL028C	BBLB	River vessel waste disposal station, Berri	ACCIDENTAL SPILLAGE	mod 2	low 2	low 2			low 2	
BL045C	BBLB	River vessel waste disposal station, Loxton	ACCIDENTAL SPILLAGE	mod 2	low 2	low 2			low 2	
BL122C	BBLB	River vessel waste disposal station, Lock 3	ACCIDENTAL SPILLAGE	mod 2	low 2	low 2			low 2	
		WASTEWATER DISPOSAL AREA								
BL041L	BBLB	Winery wastewater irrigation, EPA Lic #1838—Loxton	LEAKAGE	mod 2		low 2		low 2		mod 2
		WASTEWATER INFRASTRUCTURE								
BL026C	BBLB	Effluent pump station, Berri #1	ACCIDENTAL SPILLAGE	low 2		low 2			low 2	
BL029D	BBLB	Filtration wastewater lagoon, Berri	INFRASTRUCTURE FAILURE	low 3		low 2			low 2	
BL044D	BBLB	Filtration wastewater lagoon, Loxton	INFRASTRUCTURE FAILURE	low 3		low 3			low 2	
BL047D	BBLB	STEDS infrastructure, Loxton Caravan Park	INFRASTRUCTURE FAILURE	low 3		low 3			low 3	
BL063C	BBLB	Irrigation pump—fertiliser injection	ACCIDENTAL SPILLAGE	low 2		low 2			low 2	

GEOCODE	LAP	HAZARD	EVENT TYPE	NU	TU	OR	HM	PE	HY	SA
BL086D	BBLB	STEDS infrastructure, Cobdogla	INFRASTRUCTURE FAILURE	low 3		low 3				
BL123D	BBLB	STEDS infrastructure, Cobdogla Caravan Park	INFRASTRUCTURE FAILURE	low 3		low 3				
BL141C	BBLB	Pipeline, Berri evaporation basin	ACCIDENTAL SPILLAGE	low 2		low 2				mod 2
BL161C	BBLB	Effluent pump station, Berri #2	ACCIDENTAL SPILLAGE	low 2		low 2				
BL162C	BBLB	Effluent pump station, Berri #3	ACCIDENTAL SPILLAGE	low 2		low 2				
BL163C	BBLB	Effluent pump station, Loxton #1	ACCIDENTAL SPILLAGE	mod 2		mod 2				
BL164C	BBLB	Effluent pump station, Loxton #2	ACCIDENTAL SPILLAGE	low 2		low 2				
BL165C	BBLB	Effluent pump station, Loxton #3	ACCIDENTAL SPILLAGE	low 2		low 2				
BL166C	BBLB	Effluent pump station, Loxton #4	ACCIDENTAL SPILLAGE	mod 2		mod 2				
		WETLAND/LAGOON								
BL046B	BBLB	Loxton stormwater retention wetlands	EVENT DISCHARGE	mod 2	low 2	mod 2	low 2		low 2	low 2
BL081A	BBLB	Watchel's lagoon	DISCHARGE	high 2		mod 2				mod 2
BL121A	BBLB	Banrock lagoon	DISCHARGE	high 2		mod 2				mod 2
BL121B	BBLB	Banrock lagoon	EVENT DISCHARGE	mod 2	low 2	mod 2				low 2
BL128A	BBLB	Yatco lagoon	DISCHARGE	mod 2	low 2	mod 2				high 3
BL131A	BBLB	Pyap lagoon	DISCHARGE	mod 2	low 2	mod 2				high 3

Risks to raw water supplies

Figure 3.4 is the key map for risks to the raw water supply environmental value in the BB & LB LAP areas. The attached DVD has individual maps numbered according to the key map.



Note: only hazards identified in shaded areas were assessed for risk to raw water supplies

Figure 3.5 Key map for raw water supply zones, BB & LB LAP areas

The frequencies of identified risks to raw water supplies for the various water quality parameters are summarised in Table 3.3. The highest frequency of risks was for nutrients and pathogens, followed by organic matter, hydrocarbons and turbidity. Of the risks, 14 were rated as moderate with the remaining 133 classified as low level. No high or very high risks were identified.

Table 3.3 Frequency of risks to raw water supplies, BB & LB LAP areas

Risk	Stressor								Total
	PA	NU	TU	OR	HM	PE	HY	SA	
Low	27	28	13	25	8	5	25	2	133
Moderate	3	3	0	4	1	0	1	2	14
High	0	0	0	0	0	0	0	0	0
Very high	0	0	0	0	0	0	0	0	0
Total	30	31	13	29	9	5	26	4	147

PA–pathogens; NU–nutrients; TU–turbidity; OR–organic matter; HM–heavy metals; PE–pesticides; HY–hydrocarbons; SA–salinity

The raw water supply risks identified in the BB & LB LAP areas are listed in Table 3.4 and discussed in more detail below for each stressor.

Pathogens

A moderate-level risk was due to a stormwater discharge point (Crawford Terrace) in Berri, which is situated only 25 m upstream of the raw water off-take. Currently most Berri stormwater is diverted to a retention lagoon. However, in a large storm event a significant amount of water could discharge from this point and present a risk to the water treatment plant. Other stormwater outlets were assessed as low risk.

The wastewater pond for back flushed water from the filtration plant in Berri was given a moderate risk ranking due to its proximity to the off-take. Major infrastructure failure would have to occur for this risk to eventuate. The only other moderate risk identified was for informal camping areas at Moorook game reserve which extend over a kilometre upstream and downstream of the off-take. Other popular recreation areas with no sanitation facilities (eg Thurk Island, Thiele’s sandbar) were given a low risk ranking.

Other low-risk sources included vessel/houseboat waste disposal at houseboat moorings (eg Berri, Moorook, Kingston-on-Murray townships) and at Berri marina. The three river vessel waste disposal stations in the area (Berri, Loxton and Lock 3) make the likelihood low of blackwater being discharged from vessels and reaching the off-take points.

Other sources of low pathogen risk were wastewater infrastructure systems for townships (eg Gerard, Loxton, Berri effluent pump stations). Many of Berri’s effluent pumps are due to be upgraded to

telemetry to enable automatic shut-off. Toilets/septic tank systems (eg Kingston caravan park, Gerard township, Berri public toilets) also pose a low risk in some locations. A large degree of uncertainty accompanied the above risk rankings because site-specific studies could not be referenced.

Salinity

Moderate salinity risks are present as a result of discharges from Yatco lagoon (Moorook off-take) and Cobdogla and Loveday swamps/evaporation basins (Barmera and Cobdogla township off-take), and Gerard horticultural area (Gerard off-take). Loveday and Cobdogla basins evaporate irrigation and regional groundwater drainage and are in close proximity to the river and off-take. The risk ranking was assigned from an unlikely (value of 1) likelihood ranking and moderate (value of 3) consequence ranking. Future artificial flushing strategies to restore the health of the associated wetlands would need to be closely monitored to minimise potential negative effects on the water supply.

Salt inputs from several of the other larger horticultural areas, although not located in the raw water zones, are undoubtedly contributing to a higher overall risk to raw water supplies in this region. Several salt interception programs have been implemented to reduce potential future salt impacts on the raw water quality. It is expensive and difficult to remove salt in water treatment operations.

Nutrients

Moderate nutrient risks were assigned to discharge from Yatco lagoon (Moorook off-take), Gerard horticultural area, and potential discharge from Loveday and Cobdogla evaporation basins. There was some uncertainty to this assessment. Low risk hazards were assigned to stormwater discharge points in Berri and informal camping areas.

Organic matter

Moderate organic matter risks were assigned to potential discharges from Loveday and Cobdogla evaporation basins, Gerard horticultural area and stormwater discharge at in Berri (Crawford Terrace).

Turbidity

A moderate turbidity risk was assessed for the Crawford Terrace stormwater discharge 25 m upstream of the Berri raw water off-take. Highly turbid water can increase the cost of water treatment and potentially shield pathogens from treatment. Low turbidity risks included other stormwater discharge points, vessel launching areas, and Berri marina (shallow).

Hydrocarbons

Most hydrocarbon risks to raw water supplies were through stormwater discharge points in the Berri township, with the Crawford Terrace discharge receiving a moderate risk ranking. The Cobdogla causeway was also given a moderate risk ranking as in the unlikely event of a spill it is just downstream of the Cobdogla off-take. Low risk hazards included petrol stations, vessel mooring areas and boat ramps.

Heavy metals

A number of heavy metal risks to raw water supplies were found through stormwater discharge points in the Berri township, with the Crawford Terrace discharge receiving a moderate risk ranking. Low risk hazards included Berri marina and an informal camping area/old landfill downstream of Berri.

Table 3.4 Summary of risks to raw water supply environmental values, BB & LB LAP areas

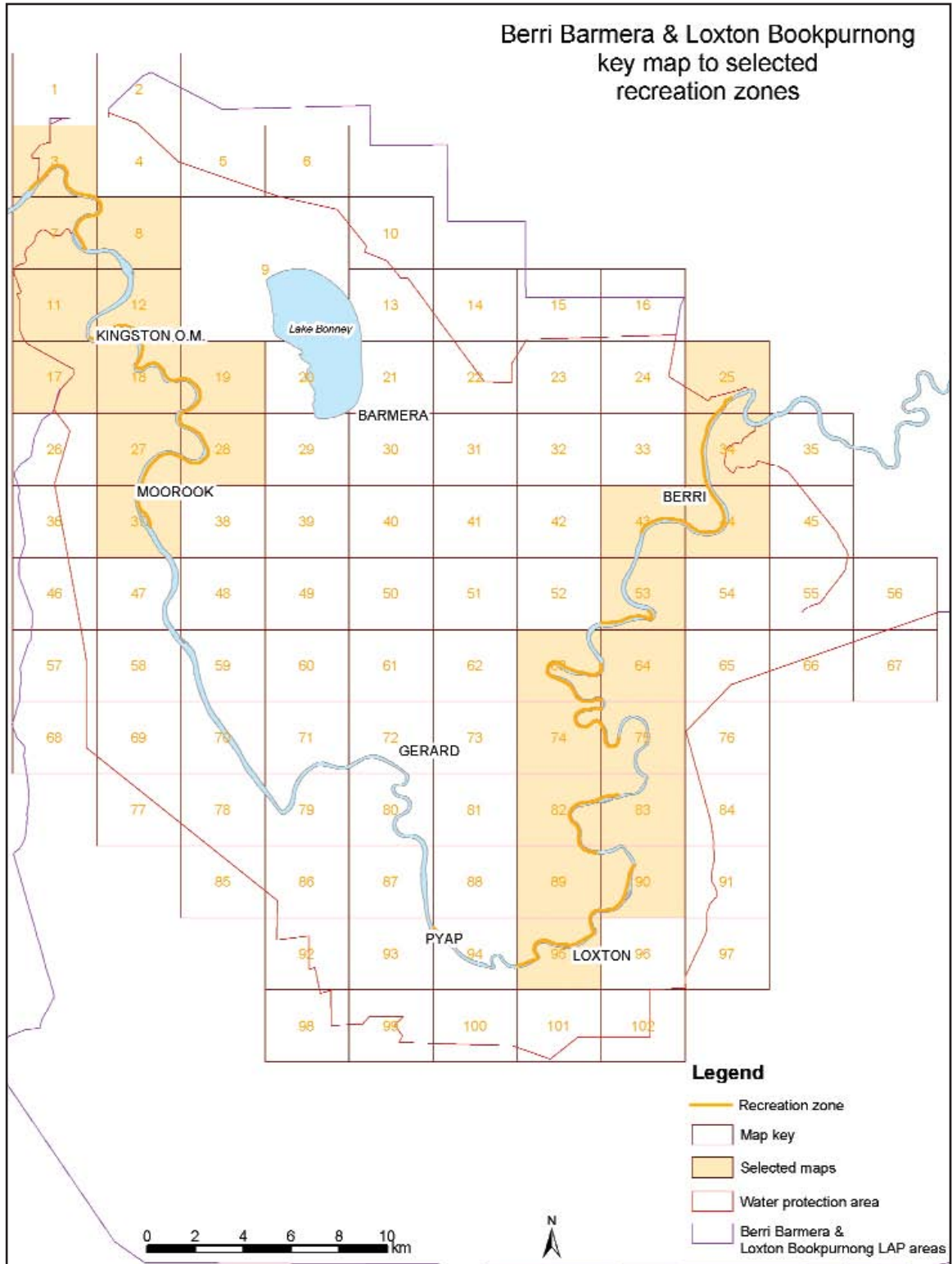
low=low risk, mod=moderate risk, high=high risk, v high=very high risk
certainty value (in italics) follows each risk ranking

GEOCODE	HAZARD	EVENT TYPE	PA	NU	TU	OR	HM	PE	HY	SA
BL087B	DRAINAGE DISPOSAL SITE	EVENT DISCHARGE		mod		mod		low	low	mod
BL125B	Evaporation basin, Loveday Evaporation basin, Cobdogla HORTICULTURE	EVENT DISCHARGE		mod		mod		low	low	mod
BL104L	Horticulture, Gerard INFORMAL CAMPING	LEAKAGE		mod		mod		low	low	mod
BL031G	Permanent camping / landfill, d/s of Berri	HUMAN/ANIMAL EXCRETION	low	low		low	low	low	low	low
BL048G	Informal camping, d/s Thiele's sandbar	HUMAN/ANIMAL EXCRETION	low	low		low	low	low	low	low
BL078G	Informal camping, adj Thurk Island	HUMAN/ANIMAL EXCRETION	low	low		low	low	low	low	low
BL093G	Informal camping, Moorook game reserve	HUMAN/ANIMAL EXCRETION	mod	low		low	low	low	low	low
BL025Q		MARINA DISCHARGES	low	low	low	low	low	low	low	low
BL032C	PETROL STATION	ACCIDENTAL SPILLAGE								
BL032L	Petrol station–Shell, Berri	LEAKAGE							low	low
BL085C	Petrol station–Shell, Berri	ACCIDENTAL SPILLAGE							low	low
BL085L	Petrol station, Cobdogla	LEAKAGE							low	low
BL146L	Petrol station, Cobdogla	LEAKAGE							low	low
BL177L	Petrol station, Berri (disused)	LEAKAGE							low	low
BL177L	Petrol station–BP, Loxton	LEAKAGE							low	low
BL030H	Slipway, EPA Lic #1385–Berri	WASH DOWN					low	low	low	low
BL027E	STORMWATER INFRASTRUCTURE	EVENT DISCHARGE								
BL155B	Stormwater retention basin, Berri	EVENT DISCHARGE	low	low	low	low	low	low	low	low
BL156B	Stormwater discharge, Crawford Tce, Berri	EVENT DISCHARGE	mod	low	mod	mod	mod	mod	mod	mod
BL157B	Stormwater discharge, Vaughan Tce, Berri	EVENT DISCHARGE	low	low	low	low	low	low	low	low
BL158B	Stormwater discharge, Ahern St, Berri	EVENT DISCHARGE	low	low	low	low	low	low	low	low
BL159B	Stormwater discharge, Berri Oval	EVENT DISCHARGE	low	low	low	low	low	low	low	low
BL159B	Stormwater discharge, Berri marina TOILETS/SEPTIC TANKS	EVENT DISCHARGE	low	low	low	low	low	low	low	low

GEOCODE	HAZARD	EVENT TYPE	PA	NU	TU	OR	HM	PE	HY	SA
BL021L	Septic tanks, public toilet and ski club toilet	LEAKAGE	low 3	low 3		low 2				
BL042L	Septic tanks, Country Living development Loxton	LEAKAGE	low 3	low 3		low 3				
BL079L	Septic tanks, Kingston-on-Murray Caravan Park	LEAKAGE	low 2	low 2		low 2				
BL094L	Public toilet septic tanks, Moorook	LEAKAGE	low 3	low 3		low 3				
BL130L	Septic tanks, Gerard township	LEAKAGE	low 2	low 2		low 2				
BL082C	TRANSPORT INFRASTRUCTURE Causeway, d/s of Cobdogla	ACCIDENTAL SPILLAGE							mod 2	
BL020S	VESSEL LAUNCHING/BOAT RAMP Recreation area, Berri ski club & boat ramp	VESSEL LAUNCHING			low 2				low 2	
BL023S	Private boat ramp, Martins Bend	VESSEL LAUNCHING			low 2				low 2	
BL077S	Recreation area, Kingston-on-Murray	VESSEL LAUNCHING			low 2				low 2	
BL113S	Recreation area, Bruno Bay	VESSEL LAUNCHING			low 2				low 2	
BL124S	Recreation area, Kingston-on-Murray	VESSEL LAUNCHING			low 2				low 2	
BL126S	Recreation area, Moorook	VESSEL LAUNCHING			low 2				low 2	
BL145S	Recreation area, Berri	VESSEL LAUNCHING			low 2				low 2	
BL076R	VESSEL MOORING(S) Commercial houseboats, Kingston-on-Murray	VESSEL DISCHARGES	low 2	low 2		low 2			low 1	
BL127R	Houseboats, Moorook	VESSEL DISCHARGES	low 3	low 3		low 3			low 1	
BL144R	Houseboats, Berri	VESSEL DISCHARGES	low 3	low 3		low 3			low 1	
BL176R	Houseboats, Berri	VESSEL DISCHARGES	low 2	low 2		low 2			low 1	
BL026C	WASTEWATER INFRASTRUCTURE Effluent pump station, Berri #1	ACCIDENTAL SPILLAGE	low 2	low 2		low 2				
BL029D	Filtration wastewater lagoon, Berri	INFRASTRUCTURE FAILURE	mod 3	low 3						
BL044D	Filtration wastewater lagoon, Loxton	INFRASTRUCTURE FAILURE	low 3	low 3						
BL086D	STEDS infrastructure, Cobdogla	INFRASTRUCTURE FAILURE	low 2	low 2		low 2			low 2	
BL123D	STEDS infrastructure, Cobdogla Caravan Park	INFRASTRUCTURE FAILURE	low 2	low 2		low 2			low 2	
BL161C	Effluent pump station, Berri #2	ACCIDENTAL SPILLAGE	low 2	low 2		low 2			low 2	
BL162C	Effluent pump station, Berri #3	ACCIDENTAL SPILLAGE	low 2	low 2		low 2			low 2	
BL128A	WETLAND/LAGOON Yatco lagoon	DISCHARGE	low 3	mod 2		mod 2				mod 2

Risks to recreational values

Figure 3.6 is the key map for the risks to the recreational environmental value in the BB & LB LAP areas. The attached DVD has individual maps numbered according to the key map.



Note: only hazards identified in the shaded areas were assessed for risks to recreation

Figure 3.6 Key map for recreation zones, BB & LB LAP areas

Frequencies of identified risks to recreation for the various water quality parameters are summarised in Table 3.5. The highest frequency of risks to recreation was for nutrients and pathogens, followed by hydrocarbons and turbidity. Most risks (152) were assessed as low but a large number of (56) moderate-level risks were identified.

Table 3.5 Frequency of risks to recreational values, BB & LB LAP areas

Risk	Stressor				Total
	PA	NU	TU	HY	
Low	23	60	30	39	152
Moderate	39	9	8	0	56
High	0	0	0	0	0
Very high	0	0	0	0	0
Total	62	69	38	39	208

PA—pathogens; NU—nutrients; TU—turbidity; HY—hydrocarbons

The recreational risks identified in BB & LB LAP areas are listed in Table 3.6 and discussed in more detail below for each stressor.

Pathogens

Rainfall event discharges from creeks (Salt, Banrock, opposite Loxton township) were assessed as a moderate risk, as were Berri urban stormwater discharges. The actual risk may be lower as people would tend not to swim or ski during or immediately following rainfall events.

Informal camping at various locations (eg Rilli island, Overland corner, Moorook) was assigned a moderate risk ranking but with some uncertainty. It was difficult to precisely assess the scale of this impact on water quality although the community has noted decreases in aesthetic value, particularly during peak holiday periods. The Sustainable Recreation Project (2005) is currently prioritising recreation sites along the River Murray and Lower Lakes that require rehabilitation and/or additional recreation facilities. This project highlighted Rilli Reserve and Overland Corner as potential rehabilitation sites and recommended installation of composting toilets, revegetation and interpretive signage.

Other moderate pathogen risks were identified as potential spills from river vessel waste disposal stations and discharges of wastewater from houseboats/vessel mooring sites (including marinas). Low risk sources included infrastructure failure leading to accidental spills of effluent from caravan park toilet facilities and town STEDS.

Nutrients

Moderate nutrient risks were assessed for discharges from lagoons (eg Banrock, Watchel’s and Yatco), creeks (eg Salt and Eckert), and horticultural areas (eg Overland corner). Watchel’s lagoon has a history of blue-green algal blooms being driven into the main river (EPA 2001a) by wind action.

The adjacent irrigation areas have been rehabilitated and this work should reduce the impact of the lagoon on the river.

Other moderate nutrient risks were the two marinas, Big River and Berri. Low nutrient risks included sources such as the numerous informal camping areas lacking sanitation facilities; stormwater discharges from Berri, and effluent discharge from wastewater pump failure in regional townships.

Hydrocarbons

All hydrocarbon risks were assessed as low and included urban stormwater discharges, fuel stores, vessel mooring areas and marinas (accidental spillages). The actual risk would probably be to aesthetic values only, as people would tend not to swim or ski in areas that have oil slicks.

Turbidity

The highly turbid nature of the river already poses a risk to recreation, as there is generally no visibility at a depth of 1.2 m (ANZECC 2000). Event discharges from stormwater outlets and creeks pose a moderate turbidity risk to recreational values. People are likely to avoid swimming/water-skiing during rainfall conditions so the risk may be mainly to aesthetic values. 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.

Table 3.6 Summary of risks to recreational environmental values, BB and LB LAP areas
 low=low risk, mod=moderate risk, high=high risk, v high=very high risk
 certainty value (in italics) follows each risk ranking

GEocode	HAZARD	EVENT TYPE	PA	TU	NU	HY
BL049B	CREEK/RIVER Creek, opp Loxton township	EVENT DISCHARGE	mod	mod	low	2
BL061A	Banrock Creek	DISCHARGE	low	low	mod	2
BL061B	Banrock Creek	EVENT DISCHARGE	mod	low	mod	2
BL151A	Salt Creek	DISCHARGE	low	low	mod	2
BL151B	Salt Creek	EVENT DISCHARGE	mod	low	low	2
BL087B	DRAINAGE DISPOSAL SITE Evaporation basin, Loveday	EVENT DISCHARGE		low	low	2
BL119B	Salt pan, Overland Corner	EVENT DISCHARGE		low	low	2
BL125B	Evaporation basin, Cobdogla	EVENT DISCHARGE		low	low	2
BL050C	FUEL STORE Pump fuel store,private irrigation, Loxton	ACCIDENTAL SPILLAGE				low 2
BL008L	HORTICULTURE Horticulture, u/s Berri	LEAKAGE			mod	3
BL080L	Vineyard and winery, EPA Lic #2298–Kingston Estates	LEAKAGE			mod	2
BL118L	Horticulture, Overland Corner	LEAKAGE			mod	2
BL147L	Horticulture, Berri area	LEAKAGE			mod	2
BL180L	Banrock vineyard & winery	LEAKAGE			mod	2
BL041D	INDUSTRY Winery, EPA Lic #1838–Loxton	INFRASTRUCTURE FAILURE			low	2
BL172B	Concrete batching plant, EPA Lic #1254–Santos	EVENT DISCHARGE		low	low	2
BL173B	Fruit processing, EPA Lic #1990–Angas Park Fruit Co, Loxton INFORMAL CAMPING	EVENT DISCHARGE			low	2
BL031G	Permanent camping /landfill, d/s of Berri	HUMAN/ANIMAL EXCRETION	mod		low	2
BL037G	Informal camping, Rilli reach	HUMAN/ANIMAL EXCRETION	mod		low	2
BL039G	Informal camping, Rilli Island	HUMAN/ANIMAL EXCRETION	mod		low	2
BL048G	Informal camping, d/s Thiele's sandbar	HUMAN/ANIMAL EXCRETION	mod		low	2
BL056G	Informal camping, Clark's camp zone (u/s end)	HUMAN/ANIMAL EXCRETION	mod		low	3
BL060G	Informal camping, Overland Corner	HUMAN/ANIMAL EXCRETION	mod		low	2

GEOCODE	HAZARD	EVENT TYPE	PA	TU	NU	HY
BL064G	Informal camping, u/s Banrock	HUMAN/ANIMAL EXCRETION	mod	2	low	2
BL078G	Informal camping, adj Thurk Is	HUMAN/ANIMAL EXCRETION	mod	2	low	2
BL083G	Informal camping, Bruno Bay to Watchel's lagoon	HUMAN/ANIMAL EXCRETION	mod	2	low	2
BL090G	Informal camping, Moorook game reserve	HUMAN/ANIMAL EXCRETION	mod	2	low	2
BL093G	Informal camping, Moorook game reserve	HUMAN/ANIMAL EXCRETION	mod	2	low	2
BL137G	Recreation area, Quast's Bend	HUMAN/ANIMAL EXCRETION	mod	2	low	2
BL153G	Recreation area, u/s of Loxton North	HUMAN/ANIMAL EXCRETION	mod	2	low	2
BL154G	Informal camping, d/s of Rilli Island	HUMAN/ANIMAL EXCRETION	mod	2	low	2
BL168G	Informal camping, Clarky's camp zone (d/s end)	HUMAN/ANIMAL EXCRETION	mod	2	low	2
BL170G	Informal camping, Rilli reach	HUMAN/ANIMAL EXCRETION	mod	2	low	2
	LANDFILL					
BL007L	Landfill (disused), north of Berri	LEAKAGE			low	2
BL010L	Disused dam—received old cannery wastewater	LEAKAGE			low	2
BL148L	Cannery dump, u/s of Berri	LEAKAGE			low	2
	MARINA					
BL009Q	Big River marina, north of Berri	MARINA DISCHARGES	mod	2	mod	3
BL025Q	Berri marina	MARINA DISCHARGES	mod	2	mod	2
	PETROL STATION					
BL032C	Petrol station—Shell, Berri	ACCIDENTAL SPILLAGE				low
BL032L	Petrol station—Shell, Berri	LEAKAGE				low
BL085C	Petrol station, Cobdogla	ACCIDENTAL SPILLAGE				low
BL085L	Petrol station, Cobdogla	LEAKAGE				low
BL146L	Petrol station, Berri (disused)	LEAKAGE				low
BL177L	Petrol stationBP, Loxton	LEAKAGE				low
	SLIPWAY					
BL030H	Slipway, EPA Lic #1385—Berri	WASH DOWN		low		low
	STORMWATER INFRASTRUCTURE					
BL027E	Stormwater retention basin, Berri	EVENT DISCHARGE	mod	2	mod	2
BL155B	Stormwater discharge, Crawford Tce, Berri	EVENT DISCHARGE	mod	2	mod	3
BL156B	Stormwater discharge, Vaughan Tce, Berri	EVENT DISCHARGE	mod	2	mod	3
BL157B	Stormwater discharge, Ahern St, Berri	EVENT DISCHARGE	mod	2	mod	3
BL158B	Stormwater discharge, Berri oval	EVENT DISCHARGE	mod	2	mod	3
BL159B	Stormwater discharge, Berri marina	EVENT DISCHARGE	mod	2	mod	3

GEOCODE	HAZARD	EVENT TYPE	PA	TU	NU	HY
	TOILETS/SEPTIC TANKS					
BL021L	Septic tanks—public toilet and ski club toilet	LEAKAGE	mod	3	low	3
BL035L	Septic, Katarapko camping ground	LEAKAGE	low	3	low	2
BL042L	Septic tanks—Country Living development, Loxton	LEAKAGE	low	2	low	2
BL079L	Septic tanks, Kingston-on-Murray Caravan Park	LEAKAGE	low	2	low	2
BL094L	Public toilet septic tanks, Moorook	LEAKAGE	low	2	low	2
BL115L	Septic tanks, Kingston-on-Murray Caravan Park	LEAKAGE	mod	2	low	2
BL116L	Septic tanks, backpackers	LEAKAGE	mod	2	low	2
BL117D	Toilet holding tanks, Overland Corner	LEAKAGE	low	2	low	2
	TRANSPORT INFRASTRUCTURE					
BL082C	Kingston Bridge	INFRASTRUCTURE FAILURE				
BL084C	Causeway, downstream of Cobdogla	ACCIDENTAL SPILLAGE				low 2
	VESSEL LAUNCHING/BOAT RAMP					low 2
BL020S	Recreation area, Berri ski club & boat ramp	VESSEL LAUNCHING		low 2		low 2
BL023S	Private boat ramp, Martins Bend	VESSEL LAUNCHING		low 2		low 2
BL036S	Boat ramp, u/s Lock 4	VESSEL LAUNCHING		low 2		low 2
BL040S	Boat ramp, Rilli Island	VESSEL LAUNCHING		low 2		low 2
BL051S	Private moorings & jetties, Loxton	VESSEL LAUNCHING		low 2		low 2
BL077S	Recreation area, Kingston-on-Murray	VESSEL LAUNCHING		low 2		low 2
BL113S	Recreation area, Bruno Bay	VESSEL LAUNCHING		low 2		low 2
BL124S	Recreation area, Kingston-on-Murray	VESSEL LAUNCHING		low 2		low 2
BL126S	Recreation area, Moorook	VESSEL LAUNCHING		low 2		low 2
BL145S	Recreation area, Berri	VESSEL LAUNCHING		low 2		low 2
BL150S	Recreation area, d/s of Salt Creek	VESSEL LAUNCHING		low 2		low 2
BL171R	Loxton Council mooring area	VESSEL LAUNCHING		low 2		low 2
	VESSEL MOORING(S)					
BL002R	Permanent houseboats, Spring Cart Gully	VESSEL DISCHARGES	mod	3	low	2
BL043R	Houseboat mooring, Loxton	VESSEL DISCHARGES	mod	3	low	2
BL059R	Houseboats, Overland Corner	VESSEL DISCHARGES	mod	3	low	2
BL062R	Houseboats, Banrock Creek	VESSEL DISCHARGES	mod	3	low	2
BL076R	Commercial houseboats, Kingston-on-Murray	VESSEL DISCHARGES	mod	2	low	2

GEOCODE	HAZARD	EVENT TYPE	PA	TU	NU	HY
BL127R	Houseboats, Moorook	VESSEL DISCHARGES	mod	low 2	low 3	low 2
BL144R	Houseboats, Berri	VESSEL DISCHARGES	mod	low 2	low 3	low 2
BL176R	Houseboats, Berri	VESSEL DISCHARGES	mod	low 2	low 3	low 2
BL028C	VESSEL WASTE DISPOSAL STATION	ACCIDENTAL SPILLAGE	mod	low 2	low 2	low 2
BL045C	River vessel waste disposal station, Berri River vessel waste disposal station, Loxton	ACCIDENTAL SPILLAGE	mod	low 2	low 2	low 2
BL041L	WASTEWATER DISPOSAL AREA Winery wastewater irrigation, EPA Lic #1838—Loxton	LEAKAGE			low 2	
BL026C	WASTEWATER INFRASTRUCTURE Effluent pump station, Berri #1	ACCIDENTAL SPILLAGE	low	low 2	low 2	low 2
BL029D	Filtration wastewater lagoon, Berri	INFRASTRUCTURE FAILURE	low	low 3	low 3	low 3
BL044D	Filtration wastewater lagoon, Loxton	INFRASTRUCTURE FAILURE	low	low 3	low 3	low 3
BL047D	STEDS infrastructure, Loxton Caravan Park	INFRASTRUCTURE FAILURE	low	low 2	low 2	low 2
BL063C	Irrigation pump—fertiliser Injection	ACCIDENTAL SPILLAGE			low 2	
BL086D	STEDS infrastructure, Cobdogla	INFRASTRUCTURE FAILURE	low	low 2	low 2	low 2
BL123D	STEDS infrastructure, Cobdogla Caravan Park	INFRASTRUCTURE FAILURE	low	low 2	low 2	low 2
BL161C	Effluent pump station, Berri #2	ACCIDENTAL SPILLAGE	low	low 2	low 2	low 2
BL162C	Effluent pump station, Berri #3	ACCIDENTAL SPILLAGE	low	low 2	low 2	low 2
BL163C	Effluent pump station, Loxton #1	ACCIDENTAL SPILLAGE	low	low 2	low 2	low 2
BL164C	Effluent pump station, Loxton #2	ACCIDENTAL SPILLAGE	low	low 2	low 2	low 2
BL165C	Effluent pump station, Loxton #3	ACCIDENTAL SPILLAGE	low	low 2	low 2	low 2
BL166C	Effluent pump station, Loxton #4	ACCIDENTAL SPILLAGE	low	low 2	low 2	low 2
BL081A	WETLAND/LAGOON Watchel's lagoon	DISCHARGE	mod		low 2	
BL121A	Banrock lagoon	DISCHARGE	mod		low 2	
BL121B	Banrock lagoon	EVENT DISCHARGE	low	low 2	low 2	low 2
BL128A	Yatco lagoon	DISCHARGE	mod		low 2	

3.5 Options for management of risks, BB & LB LAP areas

Several current and future potential options to manage risks identified in the BB & LB LAP areas are shown in Table 3.7 in the categories of: capital and on-ground works, capacity building, monitoring, compliance, policy planning, and research and development.

The suggestions as to which stakeholders may take responsibility for undertaking management options do not imply that they should, or will, be performed by those parties. Management options and stakeholder responsibilities will be examined in much more detail in Stage III of this project, following further consultation and more in-depth examination of priority risks.

Funding would be required for some strategies and funding sources are yet to be determined. Uncertainties in risk assessment rankings may also need to be addressed before management decisions can be made.

Table 3.7 Current and potential future options for management of risks, BB & IB LAP areas
 EV= environmental value, ECO=aquatic ecosystem EV, RAW=raw water supply EV, REC=recreational EV
 the risk management options which are already being implemented are in italics

Activity	Stressor	EV	Current and potential future options						Lead stakeholder (s)
			Capital on-ground works	Capacity building	Monitoring	Compliance	Policy planning	Research and development	
HIGH RISKS									
Horticulture irrigation drainage * Overland Corner * Moorook * Kingston irrigation area * Berri * Pyap * Cobdogla * Gerard various others	NU SA OR	ECO REC RAW	Reduce or cease irrigation drainage into river by diverting drainage to land-based disposal basins	<i>Education on sustainable irrigation practices</i>	Monitor of irrigation discharge water and groundwater quality	<i>Water use and efficiency auditing</i>	Liaison with DWLBC re: water extraction and drainage	Research whether additional salt interception schemes viable option	CIT, local irrigators, Berri Barmera and Loxton Waikerie councils, DWLBC, EPA
Creek discharges * Outlet from Lake Bonney * Salt Creek/Gurra Gurra lakes * Banrock Creek	NU SA TU OR	ECO REC	Rehabilitate vegetation in the area Divert all horticultural drainage to land-based disposal basins Plant riparian buffers where runoff risks exist	<i>Education on sustainable irrigation practices</i>	Monitoring of discharges to river	<i>Water use and efficiency auditing</i>	Liaison with DWLBC re: water extraction and drainage	Investigate land uses and catchment drainage network in more detail Catchment water quality modelling	LAP groups, irrigators, CIT, DWLBC, councils, EPA
Lagoons * Watchel's * Yatco	NU SA OR	ECO REC	Cease irrigation discharge into lagoons through disposal onto land		Monitor water quality	<i>Water use and efficiency auditing</i>	Liaison with DWLBC re: water extraction and drainage	Research key factors driving algal blooms	Loxton Waikerie Council, DWLBC, local irrigators, EPA

Activity	Stressor	EV	Current and potential future options					Lead stakeholder(s)
			Capital on-ground works	Capacity building	Monitoring	Compliance	Policy planning	
MODERATE RISKS								
Evaporation basins * Loveday * Cobdogla	SA OR NU	ECO RAW	Continue to implement established rehabilitation programs; including revegetation, surface water and groundwater modelling, installation/modification of regulators		Monitor water quality in basins and discharges to river to determine effects of flushing practices (e.g. on Cobdogla water off-take)	Enforce Water Quality EPP if required	Continue investigation of other rehabilitation options	SAMDB NRMB, DWLBC, BBdLAP, CIT, local community, EPA, Berri Barmera Council, SA Water
Houseboat/vessel mooring * Loxton * Overland Corner * Banrock Creek * Moorook * Berri * Spring Cart Gully * Yatco lagoon * Kingston-on-Murray	NU OR PA	ECO REC RAW	Education and awareness of river vessel users on blackwater disposal stations and greywater management	Monitor discharges Survey/audit how often boats move mooring locations	Audit and enforce COP for Vessel and Facility Management: Marine and Inland Waters	Introduce requirement for all houseboats (including non-commercial) to be slipped and surveyed	Develop affordable and effective greywater treatment systems	BIASA, EPA, local councils (Berri Barmera and Loxton Waikerie), DTEI, Houseboat Hires Association
River vessel waste disposal stations * Berri * Loxton * Lock 3	NU PA	ECO RAW REC	Education of vessel users on operation of stations Emergency procedures in place in event of station failure		Auditing system to record boats using the stations		Survey station use to determine if capacity is appropriate	DWLBC, BIASA, Houseboat Hires Association, local councils
Marinas * Berri * Big River	NU OR PA	ECO REC	Bund fuel storage tanks Education of boat owners and marina operators on appropriate waste disposal	Monitor nutrient levels in marina Audit frequency of pump out	Audit, license and/or enforce Code of Practice for Vessel and Facility Management: Marine and inland waters	Marina planning policy development		BIASA, marina owner/operator, EPA, DWLBC, Planning SA

Activity	Stressor	EV	Current and potential future options							Lead stakeholder (s)
			Capital on-ground works	Capacity building	Monitoring	Compliance	Policy planning	Research and development		
Stormwater * Berri * Crawford Tce (priority) * Vaughan Tce * various other	PA NU TU OR HM HY	ECO RAW REC	Divert all stormwater in Crawford Tce catchment to retention basin or ensure treatment prior to discharge. Employ treatment/reuse alternatives at other locations or GPTs	Community education on pollution of stormwater	Monitor quality and quantity of discharges (being undertaken by SAMDB NRMBA at Crawford Tce)	Audit industries within the catchment	Contingency plan for SA Water in case of a large rain event or spill in catchments (in particular Crawford Tce)	Research whether SA Water can shut down off-take during first flush periods of rainfall events (turbidity sensor?)	Berri Barmera Council, EPA, SA Water	
Toilets/septic tank systems * Gerard * Moorook & Berri ski club public toilets * Kingston-on-Murray Caravan Park * various others	NU PA OR	ECO RAW REC	Upgrade STEDS or WWTP where appropriate	Education on the importance of regular auditing and management practices	Monitor the influence of septic tank disposal trenches on groundwater contamination	Audit and enforce Public and Environmental Health Act or Water Quality EPP if necessary	Consider the density of septic tank soakage trenches in any new developments in the Water Protection Area		Berri Barmera and Loxton Waikerie councils, Department of Health, SAMDB NRMBA, EPA	
Effluent pump stations * Loxton # 1 * Loxton # 4	NU OR	ECO REC	Research whether bunding/infrastructure would be required to prevent sewage reaching the river in event of pump/pipe failure	Appropriate emergency response procedures in place					Loxton Waikerie Council, EPA	
Wetland and creek discharges * Katarapko * Banrock * Creek opp Loxton	SA	ECO	Revegetate catchments Fence to control grazing	Education on sustainable irrigation practices	Monitor water quality and flows and effects of artificial flushing practices		Develop wetland management plans	Research catchment land uses and catchment water quality modelling	DWLBC, SAMDB NRMBA, LAP groups, Irrigation trusts, EPA	

Activity	Stressor	EV	Current and potential future options						Lead stakeholder (s)
			Capital on-ground works	Capacity building	Monitoring	Compliance	Policy planning	Research and development	
Informal camping/recreational sites * Overland Corner * Rilli Island & Reach * D/s Thele's sandbar * Moorook game reserve * Clarky's campground * various others	PA NU OR	ECO RAW REC	Install additional sanitation facilities (<i>Sustainable Recreation Strategy identified Overland Corner & Rilli Island as priority sites</i>)	Education on the sustainable use of campsites	Survey of campsites of frequency of use and density of campers	Audit and enforce the Public and Environmental Health Act or Water Quality EPP if necessary	Designate camping sites that require permits, allowing greater control over use Limit access around off-takes	Berri Barmera and Loxton Waikerie councils, Department of Health, Riverland Tourism Association, MDA/Sustainable Recreation Project, campers, EPA, SA Water	
Pipeline--Berri evaporation basin	SA	ECO	Maintain pipeline regularly					DWLBC, irrigation trusts	
Winery: EPA Lic # 1838-- Loxton	NU OR	ECO				Enforce licence conditions Ensure wastewater irrigation practices are sustainable and relevant back-up systems are present		EPA, winery operators	
Infrastructure * Causeway d/s of Cobdogla * Kingston Bridge	HY	ECO RAW	Locate spill kits nearby Install appropriate roadside barriers/bridge cages	Emergency response procedures			Research location of booms and other oil spill response equipment and potential risk to off-take	Local councils, DTEI, SA Water	

Activity	Stressor	EV	Current and potential future options							Lead stakeholder (s)
			Capital on-ground works	Capacity building	Monitoring	Compliance	Policy planning	Research and development		
LOW/CUMULATIVE RISKS										
Petrol stations	HY	ECO REC		Education on emergency response procedures in event of a fuel spill Presence of spill kits		Audit fuel storage tanks		Research seepage of fuel from underground storage tanks	EPA, station operators, local councils	
Boat ramps	HY	ECO	Presence of spill kits	Education and awareness on appropriate refueling procedures			Recommend that new applications for boating facilities are only approved with communal facilities		Berri Barmera and Loxton Waikerie councils, EPA	
Bank erosion	TU	ECO		Designate specific zones for recreation river craft				Investigate the use of geo-textile bags	Berri Barmera and Loxton Waikerie councils, local community	