Water quality

Information Sheet

Aquatic ecosystem condition reports

2012 panel assessment of creeks and rivers in the South Australian Arid Lands and Northern & Yorke NRM regions – Lake Eyre Basin and Flinders Ranges

Issued July 2013

EPA 998/13: This information sheet describes the outcome of the panel assessment of creeks and rivers sampled in the Lake Eyre Basin and Flinders Ranges in the South Australian Arid Areas and Northern & Yorke Natural Resources Management (NRM) regions, during 2012.

Introduction

The Environment Protection Authority (EPA) coordinates a monitoring, evaluation and reporting (MER) program on the aquatic ecosystem condition of South Australian creeks and rivers. This MER program is designed to meet several objectives:

- Providing a statewide monitoring framework for creeks and rivers that revolves through the NRM regions with sufficient frequency to allow for State of the Environment Reporting purposes.
- Describing aquatic ecosystem condition for broad general public understanding.
- Identifying the key pressures and management responses to those pressures.
- Providing a useful reporting format that can support environmental decision making within government, community and industry.

This information sheet provides a summary of the scientific work used in assessing monitoring data from creeks and rivers. Aquatic ecosystem science is not always rigid and precise; it is often open to different interpretations in several respects. Therefore, the EPA has decided the best way to assess the condition of streams is through an expert panel deliberation that uses a consistent descriptive modelling approach.

The panel members comprised an environmental consultant, a biologist from the bio-monitoring team at the Australian Water Quality Centre (AWQC), and two EPA biologists (the authors). All have at least 10 years experience in monitoring and assessing a range of streams across South Australia.

The panel members were:

- Peter Goonan, EPA
- Tracy Corbin, EPA
- Darren Hicks, AWQC
- Chris Madden, Freshwater Macroinvertebrates.

This information sheet is a technical document that contains relatively sophisticated concepts and content. It summarises the scientific assessment of data collected from creeks and rivers in the Lake Eyre Basin and Flinders Ranges from the South Australian Arid Areas (SAAL) and Northern & Yorke (N&Y) NRM regions during 2012.

Site selection

A total of 65 sites were sampled during 2012, comprising 11 sites from the Southern Flinders Ranges in the Northern & Yorke NRM region, and 54 sites from the mid to Northern Flinders Ranges and Lake Eyre Basin in the South Australian Arid Areas NRM region. The Flinders Ranges sites were sampled in autumn and spring to account for the expected seasonal differences in physical habitat structure and aquatic biology of streams that occur in the area. The Lake Eyre Basin sites were only sampled during one survey period due to problems associated with access (eg tracks generally accessible for western sites in autumn but not in spring, large distances between sites, and lack of seasonality in rainfall patterns and resulting aquatic biology). Sites from the western part of the basin sampled were in autumn and eastern basin sites sampled in spring.

Sites were selected either from a list of previously sampled sites or to complement recently sampled fish monitoring sites from the Lake Eyre Basin. Additional sites were also included from the Balcanoona and Nepouie creek catchments to assess the condition of reaches where Flinders Ranges Purple-spotted Gudgeon have been recorded in the recent past. The distribution of selected sites throughout each region ensured the spatial extent of the stream network that was accessible by the existing road network was sampled. A number of sites were accessed down the end of poorly defined tracks or walking trails leading off from unsealed tracks.

This sampling design provides targeted information about the fixed sites and provides an indication of the general condition of waters in each region. However, the lack of randomly selected sites in this design limits the ability to provide a statistically valid assessment of all waters in a region with a known degree of error.

The EPA has developed a stream reach database that can be used to select random sites using an unequal probability of selection criterion to ensure a similar number of sites can be generated for each stream order (Catchment Simulations Solution 2011). This would enable an assessment to be made of the kilometres or percentage of streams with different condition ratings, enriched with nutrients, dominated by fine sediments or some other disturbance measure. However, in consultation with staff from both NRM regions, the decision was made to continue to build on the limited information base for previously sampled fixed sites and to only develop a more general understanding of the regional condition of waters at this stage.

It is important to note here that unlike other regions in South Australia, the remote location and generally limited road network throughout the Lake Eyre Basin and parts of the Flinders Ranges have resulted in the collection of only sparse datasets detailing the aquatic biology, water chemistry, sediment and habitat measures of rivers and creeks in these regions. Consequently, extending the limited knowledge base about the few fixed sites that have been sampled in the past remains the logical focus of current work in each region, although future assessments may include a subset of random and fixed sites to provide greater flexibility in the way the overall findings can be reported.

The assessment

Members of the expert panel individually rated each site using a descriptive model for interpreting change in aquatic ecosystems in relation to increasing levels of disturbance (Davies and Jackson 2006). The assumption in this assessment is that biological (ecological) condition deteriorates as the degree of human disturbance in the catchment increases, and conversely, the best condition occurs where there is little to no human disturbance of the environment (Figure 1).

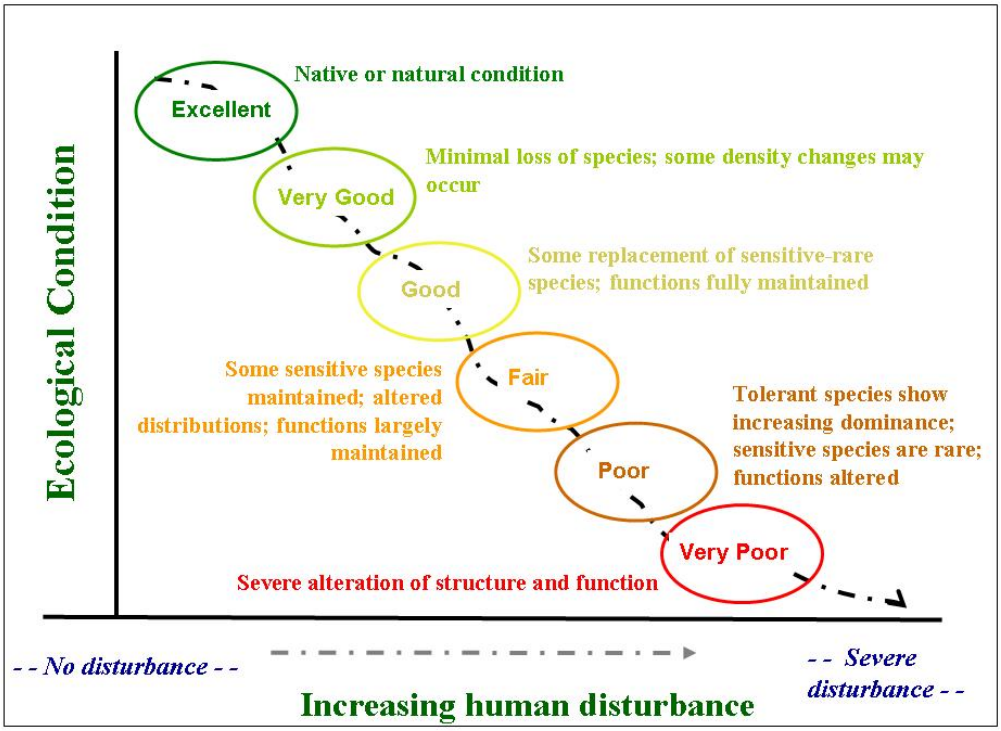

Figure 1 **Human disturbance gradient showing the six different ecological condition grades or ratings ranging from Excellent (best) to Very Poor (worst) with a brief definition of each condition**

The process used to grade or rate sites involved the following steps:

1 Conceptual models describing the ecological responses to general disturbance gradients were developed, reviewed and updated by the panel; separate models were developed for the Flinders Ranges and Lake Eyre Basin to represent the different stream types that occur in the Far North of South Australia (Tables 1–2).

2 Species lists were compiled for each model from the data collected in 2012 that described the expected biotic assemblage for each of six possible condition ratings; separate species lists were developed for the Flinders Ranges and the Western and Eastern Lake Eyre Basin to describe the obvious biotic differences that occur across each region (Tables 3–5).

3 Each site was given a rating based on the macroinvertebrate communities, vegetation assemblages, water chemistry and sediment features that were recorded during autumn and spring sampling periods. Note that for sites that were consistently dry, only the vegetation data, sediment and habitat features were used to provide a rating; during wetter periods, many of these sites would probably rate differently but the assessment was based on the conditions that occurred during 2012.

4 The individual ratings derived by the panel members were combined to produce an overall, or final, rating for each site (Table 6).

The final reported ratings were derived by initially determining the mode rating (most common rating from the panel ratings for each site), and in cases where two possible ratings were reached, a precautionary philosophy was used to select the poorer rating. For a few cases where three possible ratings were assigned by panel members, the final rating was determined by omitting the best and worst ratings and selecting the worst rating from the remaining results.

The ratings in the model range from Excellent to Very Poor. However, given the extent of stock and feral animal grazing in each region, the panel considered that Excellent probably no longer occurs and was certainly not evident from the sites sampled in 2012. Similarly, the Very Poor rating was also unlikely to occur because it typically applies to severely altered streams in urban areas or downstream from mines leaking metals, acid or salt into local waterways. Neither situation was expected to occur in the Lake Eyre Basin or Flinders Ranges given the limited extent of urban centres and the location and type of mines in each region.

Table 1 Conceptual model of ecological responses to a disturbance gradient in the Flinders Ranges.

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
Stressor description	As naturally occurs with native vegetation and no pest or introduced species present. Given the historical sheep and cattle stocking practices in region from the 1800s–mid 1900s, ongoing damage caused by pest species (eg goats, donkeys rabbits, and mosquito fish in some catchments), occasional grazing of refuge springs and waterholes by stock and feral animals and presence of weeds across much of the Flinders Ranges, ***this rating may no longer exist in the region***.	Least impacted streams with largely natural vegetation communities, such as surrounding the permanent and semi-permanent springs and streams around Mount Remarkable in the south, Flinders Ranges National Park in the central region, and the Gammon Ranges National Park and Arkaroola–Mount Painter Sanctuary in the north. Very few introduced species present, habitat structure unaltered by human activities and little evidence of nutrient enrichment or riparian disturbance caused by human activities. May also apply to more ephemeral and naturally saline streams that lack any recent indications of stock damage or nutrient enrichment effects.	Slightly modified and likely to be showing initial signs of enrichment and some modification of natural habitat features. Likely to occur in springs and streams with large areas of natural vegetation remaining. Generally only applies for well vegetated, permanent or near permanent freshwater habitats but may also include more ephemeral waters with only minor habitat changes and evidence of slight addition of nutrient and fine sediment from the surrounding landuses.	Moderate changes to native vegetation and habitats but retains major natural features present in watercourses from the region. Some localised nutrient enrichment and fine sediment additions likely to occur due to the extent of stock and feral animals accessing the site.	Substantially modified and likely to retain only limited areas of native vegetation and show evidence of clearly altered habitats. Damage from stock and feral animal grazing of riparian habitats likely to be widespread and evidence of large amounts of nutrients and possibly fine sediment being added to sites from local sources. May occur near urban centres, mines or major roads, areas where historical damage to springs and creeks may have occurred in the past and contributed to the poor condition of individual reaches or springs. May also occur at springs and waterholes damaged by leaking septics from nearby rural homesteads or where stock concentrate near waters due to local farming practices.	Severely altered and likely to only occur in the region in urban stream reaches. Sites assigned to this rating will typically be affected by a toxicant or other disturbance that significantly limits the diversity and abundance of aquatic life present in a stream. Past work focused on current and disused mines in the region, failed to show any evidence of significant sediment or contaminant damage of streams but it is possible that localised reaches or future tailings dam failures could result in major environmental damage. However, given the existing land-uses in the Flinders Ranges, ***this rating is unlikely to occur in the region.***

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
Biological assemblages	Native assemblages of plants and animals, as naturally occurs for the landscape. Typically native gum tree overstorey with range of native understorey plants, including different age classes but no introduced species. More saline landscapes may lack gum trees and often comprise paperbarks or acacia overstorey species. Aquatic macroinvertebrate assemblages usually comprise some flow dependent species and non-insect groups, and a wide range of insect species. No obvious symptoms of stress or presence of any introduced aquatic species. Include a range of short and long-lived life history strategies, and wide range of traits which confer local ecosystem resilience to disturbance. More permanent habitats likely to provide a significant refuge but more	Least disturbed assemblages. Vegetation largely native trees over predominantly native understorey but typically includes some introduced species. Aquatic macroinvertebrate assemblages typically with high richness; intolerants and specialist taxa often dominate abundances but more ephemeral habitats include rich insect fauna; may include some introduced species present in low abundances.	Good richness; generalist assemblage that includes at least some non-insect species for the permanent springs and creeks but more ephemeral habitats may only support aerially dispersed insects such as beetles, waterbugs and dipterans; emerging symptoms of stress in relation to nutrient enrichment evident due to the dominance by organic feeders; vegetation is slightly altered from the natural assemblage expected for the landscape, comprising predominantly native trees with a few weeds and introduced species present; extent of the well vegetated bank cover typically >50%.	Impaired assemblages; generalists and tolerant taxa dominate numbers which usually includes some very abundant taxa; more sensitive and rare taxa, if present, only occur in very low numbers; absence of some taxa expected for the available habitats present; vegetation showing obvious change from natural assemblages in the landscape, comprising at least some trees present in or near the riparian zone that is dominated by introduced plants; extent of the moderately well vegetated bank cover typically <50%.	Degraded assemblages; tolerant and generalist insect taxa dominate but numbers usually reduced, although 1–2 generalist taxa may be present in high abundances; only 1–2 rare or non-insect species present in low abundances or absent; often few or only 1–2 scattered trees occur as small patches over an understorey dominated by introduced plants; extent of the poorly bank vegetative cover typically <25% cover.	Severely degraded assemblages with few taxa and generally low abundances; may have large numbers of one or two tolerant taxa such as oligochaetes, mosquito larvae or midges (eg *Chironomus, Procladius* and *Tanytarsus)*; vegetation typically expected to comprise introduced species with little to no remnant native vegetation.

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
	ephemeral and naturally saline waters will typically be dominated by a range of generalist insects. Abundances of all aquatic species generally low.					
Water chemistry conditions	As naturally occurs; no human contaminants present and stock or pest species elsewhere in the catchment not impacting on the local water quality (eg nutrients, hormones).	Least disturbed with high proportion of natural features. Water likely to be naturally fresh (salinity <3,000 mg/L) apart from the Willochra catchment and some low-lying streams along the eastern side of Lake Eyre that are possibly naturally saline. Streams are also typically well oxygenated and show no evidence of significant eutrophication effects (eg large algal or plant growths, blackened sediments due to organic enrichment).	Largely unremarkable water quality but with at least some nutrients present at higher than expected concentrations, coupled with at least one plant indicator showing emerging signs of enrichment effects (eg either chlorophyll *a* >10 ug/L, macrophyte cover >10% cover and/or filamentous algae >35% cover) but site not overwhelmed.	Fair water quality with generally saturated dissolved oxygen (when sampled during the day), nutrients present at high concentrations and corresponding high levels of algal and plant growths (eg chlorophyll a >10 ug/L, macrophyte cover >10% cover and/or filamentous algae >35% cover) evident on occasions.	Poor water quality with generally saturated dissolved oxygen (when sampled during the day), nutrients present at very high concentrations and high plant productivity evident throughout the site (eg chlorophyll a >10 ug/L, macrophyte cover >10% cover and filamentous algae >35% cover most of the time).	Very poor water quality with at least one parameter at a toxicant concentration that limits aquatic diversity; often very low dissolved oxygen and may be saline and enriched in nutrients but algal and plant growth limited.
Physical habitat and flow patterns	Natural habitat and flow patterns; no dams or abstractions present; range of sediment types typically present and not always anaerobic.	Near natural habitat and flow regimes; mostly well vegetated catchments with few dams present; range of sediment types present and not always anaerobic.	Good habitat structure and flow patterns; extent of dam development has not caused an obvious loss of riffle habitats; range of sediment types	Fair habitat structure and flow patterns; many small dams may be present in the catchment; anaerobic fine sediments usually present, except for	Poor habitat structure and flow patterns; may have many dams present in the catchment; anaerobic fine sediments usually present except when large algal growths are present and	Severe modifications to physical habitat and flow patterns; may have many dams present in the catchment; generally cleared agricultural or

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
			present and not always anaerobic.	coarse sandy sediments or when large algal growths oxygenate the sediments.	aerate the sediments.	urban sites; anaerobic fine sediments often dominate.
Human activities and sources in the catchment	No obvious human disturbances.	No significant human disturbances but may include some rural housing, unsealed roads and disused mines; no point source discharges and diffuse pollution not obviously affecting the aquatic ecosystem, due to the extent of native vegetation and natural habitats surrounding each spring or stream.	Effects of human disturbance becoming obvious; good buffer zones and/or riparian vegetation present that help to mitigate diffuse pollution effects from surrounding landuses (eg stock and feral animal grazing, tourism).	Diffuse source enrichment effects evident; riparian zone not effective at mitigating local addition of nutrients and fine sediment from entering these waters.	Obvious diffuse source enrichment effects present; unbuffered waterway with ineffective or no riparian vegetation remaining other than introduced grasses; major changes to catchment land use with little remnant vegetation remaining and agricultural grazing dominating local landuse.	Severe point and/or diffuse source effects that may include toxicant responses; effects dominate water quality and biological response with little evidence of the original waterway evident; unbuffered channel that has undergone extreme modifications due to the adjacent agricultural or urban setting.

Table 2 Conceptual model of ecological responses to a disturbance gradient in the Lake Eyre Basin.

Rating	Excellent	Very good	Good	Fair	Poor	Very Poor
Stressor description	As naturally occurs with native vegetation and no pest or introduced species present. Given the historical cattle stocking practices in region from the 1800s–mid-1900s, ongoing damage caused by pest species (eg camels, pigs, rabbits, mosquito fish and goldfish in some catchments), occasional grazing of waterholes by cattle and presence of weeds across much of the arid landscape, ***this rating may no longer exist in the region***.	Least impacted streams with largely natural vegetation communities, such as occurs surrounding the permanent and semi-permanent waterholes on Cooper and Diamantina creeks. Very few introduced species present, habitat structure unaltered by human activities and little evidence of nutrient enrichment or riparian disturbance. May also apply to more ephemeral waterholes and sites that lack any recent indications of stock damage or nutrient enrichment effects.	Slightly modified and likely to be showing initial signs of enrichment and some modification of natural habitat features. Likely to occur in streams or waterholes with large areas of natural vegetation remaining. Generally only applies for well vegetated, permanent or near permanent freshwater habitats but may also include more ephemeral waters with only minor habitat changes and evidence of slight addition of nutrient from the surrounding landuses.	Moderate changes to native vegetation and habitats but retains major natural features present in watercourses from the region. Some localised nutrient enrichment likely to occur, in addition to upstream sources, due to the extent of stock accessing the site.	Substantially modified and likely to retain only limited areas of native vegetation and show evidence of clearly altered habitats. Stock grazing damage to riparian habitats likely to be widespread and evidence of large amounts of nutrients being added to sites from local sources. May occur near urban centres or major roads, areas where historical damage to waterholes may have occurred in the past and contributed to the poor condition of individual waterholes. May also occur at waterholes damaged by leaking septics from nearby rural homesteads or where stock concentrate near waters due to local farming practices.	Severely altered and likely to only occur in the region in urban stream reaches. Sites assigned to this rating will typically be affected by a toxicant or other disturbance that significantly limits the diversity and abundance of aquatic life present in a stream. Given the landuses, ***this rating is not likely to occur in the region.***

Rating	Excellent	Very good	Good	Fair	Poor	Very Poor
Biological assemblages	Native assemblages of plants and animals, as naturally occurs for the landscape. Typically native gum tree overstorey with range of native understorey plants, including different age classes but no introduced species. More saline landscapes may lack gum trees and often comprise paperbarks or acacia overstorey species. Aquatic macroinvertebrate assemblages usually comprise some riverine species and non-insect groups, and a wide range of insect species. No obvious symptoms of stress or presence of any introduced aquatic species. Include a range of short and long-lived life history strategies, and wide range of traits which confer local ecosystem resilience to	Least disturbed assemblages. Vegetation largely native trees over predominantly native understorey but typically includes some introduced species. Aquatic macroinvertebrate assemblages typically with high richness; intolerants and specialist taxa often dominate abundances but more ephemeral habitats include rich insect fauna; may include some introduced species present in low abundances.	Good richness; generalist assemblage that includes at least some non-insect species for the permanent waterholes but more ephemeral habitats may only support aerially dispersed insects such as beetles, waterbugs and dipterans; emerging symptoms of stress in relation to nutrient enrichment evident due to the dominance by organic feeders; vegetation is slightly altered from the natural assemblage expected for the landscape, comprising predominantly native trees with a few weeds and introduced species present; extent of the well vegetated bank cover typically >50%.	Impaired assemblages; generalists and tolerant taxa dominate numbers which usually includes some very abundant taxa; more sensitive and rare taxa, if present, only occur in very low numbers; absence of some taxa expected for the available habitats present; vegetation showing obvious change from natural assemblages in the landscape, comprising at least some trees present in or near the riparian zone that is dominated by introduced plants; extent of the moderately well vegetated bank cover typically <50%.	Degraded assemblages; tolerant and generalist insect taxa dominate but numbers usually reduced, although 1–2 generalist taxa may be present in high abundances; only 1–2 rare or non-insect species present in low abundances or absent; often few or only 1–2 scattered trees occur as small patches over an understorey dominated by introduced plants; extent of the poorly bank vegetative cover typically <25% cover.	Severely degraded assemblages with few taxa and generally low abundances; may have large numbers of one or two tolerant taxa such as oligochaetes, mosquito larvae or midges (eg *Chironomus, Procladius* and *Tanytarsus)*; vegetation typically expected to comprise introduced species with little to no remnant native vegetation.

Rating	Excellent	Very good	Good	Fair	Poor	Very Poor
	disturbance. More permanent habitats likely to provide a significant refuge but more ephemeral and naturally saline waters will typically be dominated by a range of generalist insects. Abundances of all aquatic species generally low.					
Water chemistry conditions	As naturally occurs; no human contaminants present and stock or pest species elsewhere in the catchment not impacting on the local water quality (eg nutrients, hormones). Freshwater streams likely to be naturally very turbid but more saline waters will be clear and coloured.	Least disturbed with high proportion of natural features. Water likely to be naturally turbid and well oxygenated, and show no evidence of significant eutrophication effects (eg large algal or plant growths, blackened sediments due to organic enrichment).	Largely unremarkable water quality but with at least some nutrients present at higher than expected concentrations, coupled with at least one plant indicator showing emerging signs of enrichment effects (eg either chlorophyll a >10 ug/L, macrophyte cover >10% cover and/or filamentous algae >35% cover) but site not overwhelmed.	Fair water quality with generally saturated dissolved oxygen (when sampled during the day), nutrients present at high concentrations and corresponding high levels of algal and plant growths (eg chlorophyll a >10 ug/L, macrophyte cover >10% cover and/or filamentous algae >35% cover) evident on occasions.	Poor water quality with generally saturated dissolved oxygen (when sampled during the day), nutrients present at very high concentrations and high plant productivity evident throughout the site (eg chlorophyll a >>10 ug/L, macrophyte cover >10% cover and filamentous algae >35% cover most of the time).	Very poor water quality with at least one parameter at a toxicant concentration that limits aquatic diversity; often very low dissolved oxygen and may be saline and enriched in nutrients but algal and plant growth limited.

Rating	Excellent	Very good	Good	Fair	Poor	Very Poor
Physical habitat and flow patterns	Natural habitat and flow patterns; no dams or abstractions present; range of fine sediment types typically present and not always anaerobic	Near natural habitat and flow regimes; mostly well vegetated catchments with few dams present; range of fine sediment types present and not always anaerobic.	Good habitat structure and flow patterns; many small dams may be present in the catchment (highlands in Queensland); range of fine sediment types present and not always anaerobic.	Fair habitat structure and flow patterns; many small dams may be present in the catchment (highlands in Queensland); anaerobic fine sediments usually present, except for coarse sandy sediments or when large algal growths oxygenate the sediments.	Poor habitat structure and flow patterns; may have many dams present in the catchment (Queensland); anaerobic fine sediments usually present except when large algal growths are present and aerate the sediments.	Severe modifications to physical habitat and flow patterns; may have many dams present in the catchment (Queensland); generally cleared agricultural or urban sites; anaerobic fine sediments often dominate.
Human activities and sources in the catchment	No obvious human disturbances.	No significant human disturbances but may include some rural housing and unsealed roads; no point source discharges and diffuse pollution not obviously affecting the aquatic ecosystem, due to the extent of native vegetation and natural habitats surrounding each stream or waterhole.	Effects of human disturbance becoming obvious; good buffer zones and/or riparian vegetation present that help to mitigate diffuse pollution effects from surrounding land-uses (eg cattle grazing, tourism).	Diffuse source enrichment effects evident; riparian zone not effective at mitigating local addition of nutrients and fine sediment from entering these waters.	Obvious diffuse source enrichment effects present; unbuffered waterway with ineffective or no riparian vegetation remaining other than introduced grasses; major changes to catchment land use with little remnant vegetation remaining and agricultural grazing dominating local landuse.	Severe point and/or diffuse source effects that may include toxicant responses; effects dominate water quality and biological response with little evidence of the original waterway evident; unbuffered channel that has undergone extreme modifications due to the adjacent agricultural or urban setting.

Table 3 List of biota expected to occur for each rating in the Flinders Ranges in 2012

Streams in an Excellent condition probably no longer occur in the region and would be expected to support some sensitive and rare species, similar to sites in very good condition, but have no introduced species present. Similarly, streams in Very Poor condition would not be expected to occur due to the absence of large cropping or irrigated agricultural disturbance or urban centres; although may occur if a major contaminant spill occurred from a tailings dam from a mine or accident involving a tanker. Very Poor sites would be expected to only include a few tolerant species and have water quality too poor to support fish. Note that some rare and sensitive species collected in previous years were not detected in 2012, including stoneflies (*Dinotoperla evansi, Riekoperla naso* and *Leptoperla tasmanica* around Mount Remarkable) and selected caddisflies (eg *Orphninotrichia* and *Apsilochorema*).

	Very Good	Good	Fair	Poor
Attribute 1 Rare and/or regionally endemic	**Hydracarina** several families may be present in low numbers (including Limnesiidae, Unionicolidae, Pionidae, Oxidae, Hygrobatidae); **Mollusca** *Pygmanisus, Isidorella*; **Crustacea** Melitidae; **Diptera** *Harnishia;* **Fish** Flinders Purple-spotted Gudgeon (note some isolated springs are naturally fishless, so sites from the Mawson Plateau should naturally lack fish)	**Hydracarina** several families may be present in low numbers (including Limnesiidae, Unionicolidae, Pionidae, Oxidae, Hygrobatidae); **Mollusca** *Pygmanisus, Isidorella*; **Crustacea** Melitidae; **Diptera** *Harnishia;* **Fish** Flinders Purple-spotted Gudgeon	**Hydracarina** more than one family may be present (including Limnesiidae, Unionicolidae, Pionidae, Oxidae, Hygrobatidae); **Mollusca** *Pygmanisus, Isidorella*; **Crustacea** Melitidae; **Diptera** *Harnishia;* **Fish** Flinders Purple-spotted Gudgeon	None present
Attribute 2 Sensitive, rare or vulnerable specialist taxa with narrow environmental requirements	Wide range of beetles present in low numbers, including some rarely collected species (eg *Paranacaena, Necterosoma dispar, Necterosoma regulare, Hyphydrus, Berosus discolour, Berosus nutans*); several flow dependent species may be present, sometimes in large numbers (including the beetle *Platynectes,* biting midge *Forcipomyia*, blackfly *Simulium ornatipes*, fly family Dolichopodidae, chironomid *Rheotanytarsus* and caddisfly *Cheumatopsyche*);	Wide range of beetles present in low to moderate numbers, including some rarely collected species (eg *Paranacaena, Necterosoma dispar, Necterosoma regulare, Hyphydrus, Berosus discolour, Berosus nutans*); several flow dependent species may be present in generally low to moderate numbers (including the beetle *Platynectes,* biting midge *Forcipomyia*, blackfly *Simulium*	Wide range of beetles present, including some rarely collected species (eg *Paranacaena, Necterosoma dispar, Necterosoma regulare, Hyphydrus, Berosus discolour, Berosus nutans*); several flow dependent species may be present (including the beetle *Platynectes,* biting midge *Forcipomyia*, blackfly *Simulium ornatipes*, fly family Dolichopodidae, chironomid	Saline tolerant beetles with limited distribution in region may be present (eg *Necterosoma penicillatus, Spercheus, Limnoxenus zealandicus*); and at least one flow dependent species may be present in low numbers (eg *Simulium ornatipes*)

	Very Good	Good	Fair	Poor
	Ephemeroptera *Thraulophlebia inconspicua* (southern region, freshwater streams only)	*ornatipes*, fly family Dolichopodidae, chironomid *Rheotanytarsus* and caddisfly *Cheumatopsyche*); **Ephemeroptera** *Thraulophlebia inconspicua* (southern region, freshwater streams only)	*Rheotanytarsus* and caddisfly *Cheumatopsyche*); **Ephemeroptera** *Thraulophlebia inconspicua* (southern region, freshwater streams only)	
Attribute 3 Sensitive, ubiquitous taxa	**Ephemeroptera** *Cloeon* and (often in large numbers) *Tasmanocoenis tillyardi*	**Ephemeroptera** *Cloeon* and *Tasmanocoenis* (indicator permanent, freshwater with salinity <3,000 mg/L)	**Ephemeroptera** *Cloeon* and *Tasmanocoenis* (indicator permanent, freshwater with salinity <3,000 mg/L)	None present (too salty, lacks coarse sediments or too ephemeral)
Attribute 4 Opportunistic or generalist taxa	**Mollusca** several types of non-operculate molluscs (eg *Ferrissia, Glyptophysa, Austropeplea*) from permanent springs; **Diptera** wide range of families present; **Trichoptera** *Lectrides varians, Oecetis, Ecnomus* (latter often lowland streams)	**Mollusca** several types of non-operculate molluscs (eg *Ferrissia, Glyptophysa, Austropeplea*) from permanent springs; **Diptera** wide range of families present; **Trichoptera** *Lectrides varians, Oecetis, Ecnomus* (latter often lowland streams)	**Mollusca** several types of non-operculate molluscs (eg *Ferrissia, Glyptophysa, Austropeplea*) from permanent springs; **Diptera** few families present often in large numbers; **Trichoptera** *Lectrides varians, Oecetis, Ecnomus* (latter often lowland streams)	**Mollusca** none present; **Diptera** Few families present, occasionally in large numbers; **Coleoptera** Few genera typically present, sometimes present in large numbers.
Attribute 5 Tolerant taxa	**Turbellaria; Crustacea** *Austrochiltonia* (few at fresh sites, large numbers at saline sites), *Cherax destructor;* **Coleoptera** Scirtidae (often large numbers at upwelling zones), low numbers more saline tolerant beetles at freshwater sites such as *Limnoxenus zealandicus, Nectrosoma penicillatus, Sphercheus*; **Hemiptera** often several genera present including *Micronecta,*	**Turbellaria; Crustacea** *Austrochiltonia* (few at fresh sites, large numbers at saline sites), *Cherax destructor;* **Coleoptera** Scirtidae (often large numbers at upwelling zones), low numbers more saline tolerant beetles at freshwater sites such as *Limnoxenus zealandicus, Nectrosoma penicillatus,*	**Turbellaria; Crustacea** *Austrochiltonia* (few at fresh sites, large numbers at saline sites), *Cherax destructor;* **Coleoptera** Scirtidae (often large numbers at upwelling zones), low numbers more saline tolerant beetles at freshwater sites such as *Limnoxenus zealandicus, Nectrosoma penicillatus,*	**Turbellaria; Mites** Arrenuridae and Unionicolidae (*Koenikea*);**Crustacea** *Austrochiltonia* (few at fresh sites, large numbers at saline sites), *Cherax destructor;* **Coleoptera** *Limnoxenus zealandicus, Nectrosoma penicillatus, Sphercheus*; **Hemiptera** *Micronecta,*

	Very Good	Good	Fair	Poor
	*Agraptocorixa, Anisops, Microvelia;***Diptera** Stratiomyidae, Dixidae (brackish sites); Culicidae *Anopheles;* Ceratopogonidae; Chironomidae (*Procladius, Cricotopus, Chironomus*); **Odonata** *Hemianax papuensis, Diplacodes haematodes, Hemicodulia tau;* **Trichoptera** *Triplectides australis*	*Sphercheus*; **Hemiptera** often several genera present including *Micronecta, Agraptocorixa, Anisops, Microvelia;* **Diptera** Stratiomyidae, Dixidae (brackish sites); Culicidae *Anopheles;* Ceratopogonidae; Chironomidae (*Procladius, Cricotopus, Chironomus*); **Odonata** *Hemianax papuensis, Diplacodes haematodes, Hemicodulia tau;* **Trichoptera** *Triplectides australis*	*Sphercheus*; **Hemiptera** *Micronecta, Agraptocorixa, Anisops;* **Diptera** Stratiomyidae, Dixidae (brackish sites); Culicidae *Anopheles;* Ceratopogonidae (large numbers at saline sites with large algal growths); Chironomidae (*Procladius, Cricotopus, Chironomus*); **Odonata** *Hemianax papuensis, Diplacodes haematodes, Hemicodulia tau;* **Trichoptera** *Triplectides australis*; **Fish** hardyhead species (saline sites only)	*Agraptocorixa, Anisops;* **Diptera** Stratiomyidae, Dixidae (brackish sites); Culicidae *Anopheles;* Ceratopogonidae (large numbers at saline sites with large algal growths); Chironomidae (*Procladius, Cricotopus, Chironomus*); **Odonata** *Hemianax papuensis, Hemicodulia tau;* **Trichoptera** *Triplectides australis;* **Fish** hardyhead species (saline sites only)
Attribute 6 Non-endemic or introduced taxa	**Fish** None present	**Fish** Gambusia. Past sampling in the region has included small numbers of two introduced snails (*Potamopyrgus antipodarum* and *Physa acuta*) and a nemertean that may also be an introduced species. Note also that the yabby may not naturally occur in the region but has been included in the table above as a tolerant taxon.	**Fish** Gambusia (possibly many). Past sampling in the region has included small numbers of two introduced snails (*Potamopyrgus antipodarum* and *Physa acuta*) and a nemertean that may also be an introduced species. Note also that the yabby may not naturally occur in the region but has been included in the table above as a tolerant taxon.	**Fish** Gambusia (possibly many). Past sampling in the region has included small numbers of two introduced snails (*Potamopyrgus antipodarum* and *Physa acuta*) and a nemertean that may also be an introduced species. Note also that the yabby may not naturally occur in the region but has been included in the table above as a tolerant taxon.

Table 4 List of biota expected to occur for each rating in the western side of Lake Eyre Basin 2012

Streams in an Excellent condition probably no longer occur in the region and would be expected to support some sensitive and rare species, similar to sites in Very Good condition, but have no introduced species present. Similarly, streams in Very Poor condition would not be expected to occur due to the absence of large cropping or irrigated agricultural disturbance or urban centres; although may occur if a major contaminant spill occurred from a tailings dam from a mine or accident involving a tanker. Very poor sites would be expected to only include a few tolerant species and have water quality too poor to support fish. The region lacks any stoneflies and flow-dependent species due to the lack of permanent, flowing water habitats and ephemeral nature of many of the waterholes that occur in the LEB.

Note that * is used to designate taxa that frequent temporary water habitats.

	Very Good	Good	Fair	Poor
Attribute 1* Rare and/or regionally endemic	**Hydracarina** *Unionicola, Limnesia*; **Diptera** *Coelopynia pruinosa*, *Paraborniella**; **Coleoptera** *Dineutus*	**Hydracarina** *Unionicola, Limnesia;* **Crustacea** *Conchostraca**; **Diptera** *Coelopynia pruinosa, Paraborniella*;* **Coleoptera** *Dineutus*	**Hydracarina** *Unionicola, Limnesia, Eylais*; **Crustacea** *Conchostraca*;* **Diptera** *Coelopynia pruinosa, Paraborniella**; **Coleoptera** *Dineutus*	**Hydracarina** *Eylais* (rare in region but typically occur in waterholes covered in filamentous algae); **Crustacea** *Conchostraca**
Attribute 2. Sensitive, rare or vulnerable specialist taxa with narrow environmental requirements	Regionally rare freshwater species include: **Hydrozoa** *Hydra;* **Coleoptera** *Necterosoma dispar*; **Diptera** *Larsia*, *Nanocladius*; **Trichoptera** *Oecetis, Lectrides*	Regionally rare freshwater species include: **Hydrozoa** *Hydra;* **Coleoptera** *Necterosoma dispar*; **Diptera** *Larsia*, *Nanocladius*; **Trichoptera** *Oecetis, Lectrides*	Regionally rare freshwater species include: **Hydrozoa** *Hydra;* **Coleoptera** *Necterosoma dispar*; **Diptera** *Larsia*, *Nanocladius*; **Trichoptera** *Oecetis, Lectrides*	None expected to be present due to combined effects of gross nutrient enrichment and salinisation
Attribute 3. Sensitive, ubiquitous taxa	**Ephemeroptera** *Cloeon* (often in large numbers) *Tasmanocoenis*; both taxa indicators of permanent, freshwater habitats in the region	**Ephemeroptera** *Cloeon, Tasmanocoenis*; both taxa indicators of permanent, freshwater habitats in the region	**Ephemeroptera** *Cloeon*, *Tasmanocoenis*; both taxa indicators of permanent, freshwater habitats in the region	None likely to be present

	Very Good	Good	Fair	Poor
Attribute 4 Opportunistic or generalist taxa	**Mollusca** *Ferrissia, Glyptophysa*; **Decapoda** *Macrobrachium*; **Coleoptera** typically more than 5 genera; **Diptera** rich diversity of Chironomidae (3 subfamilies typically present and include more than 7 genera); **Odonata** Coenagrionidae *Hemicordulia, Orthetrum* Aeschnidae; **Trichoptera** *Triplectides australis, Ecnomus* spp.	**Mollusca** *Ferrissia, Glyptophysa*; **Decapoda** *Macrobrachium*; **Coleoptera** typically 3–5 genera; **Diptera** Chironomidae (usually at least 2 subfamilies present and include more than 5 genera); **Odonata** Coenagrionidae, *Hemicordulia, Orthetrum,* Aeschnidae; **Trichoptera** *Triplectides australis, Ecnomus* spp.	**Mollusca** *Ferrissia, Glyptophysa*; **Decapoda** *Macrobrachium*; **Coleoptera** typically 2 or 3 genera; **Diptera** Chironomidae (usually at least 2 subfamilies present and include more than 3 genera); **Odonata** Coenagrionidae, *Hemicordulia, Orthetrum,* Aeschnidae; **Trichoptera** *Triplectides australis, Ecnomus* spp.	**Mollusca** *Ferrissia, Glyptophysa*; **Decapoda** *Macrobrachium*; **Coleoptera** typically less than 2 genera including *Necterosoma penicillatus* at saline sites; **Diptera** Chironomidae (often 2 subfamilies present and include less than 3 genera); **Odonata** *Hemicordulia*; **Trichoptera** *Triplectides australis* (not found highly saline sites)
Attribute 5 Tolerant taxa	**Turbellaria; Diptera** Culicidae *Anopheles*, Ceratopogonidae; **Hemiptera** *Micronecta; Agraptocorixa, Anisops*; **Fish** Banded Grunter, Desert Goby, hardyhead species; **Zooplankton** Copepods and cladocerans abundant and typically in 1000s	**Turbellaria; Diptera** Culicidae *Anopheles*, Ceratopogonidae; **Hemiptera** *Micronecta; Agraptocorixa, Anisops*; **Fish** Banded Grunter, Desert Goby, hardyhead species; **Zooplankton** Copepods, cladocerans and ostracods in large numbers, typically up to 1000s	**Turbellaria; Diptera** Culicidae *Anopheles*, Ceratopogonidae; **Hemiptera** *Micronecta; Agraptocorixa, Anisops*; **Fish** Banded Grunter, Desert Goby, hardyhead species; **Zooplankton** Copepods, cladocerans and ostracods in large numbers, typically in 100s to 1000s	**Turbellaria; Diptera** Culicidae *Anopheles*, Ceratopogonidae; **Hemiptera** *Micronecta; Agraptocorixa, Anisops*; **Fish** Banded Grunter, Desert Goby, hardyhead species; **Zooplankton** typically limited to variable numbers of ostracods in more ephemeral, saline sites
Attribute 6 Non-endemic or introduced taxa	**Fish** Goldfish (widespread introduced species not collected in 2012)	**Fish** Goldfish (widespread introduced species not collected in 2012)	**Fish** Goldfish (widespread introduced species not collected in 2012)	**Fish** Goldfish (widespread introduced species not collected in 2012)

Table 5 List of biota expected to occur for each rating in the eastern side of Lake Eyre Basin 2012

Streams in an Excellent condition probably no longer occur in the region and would be expected to support some sensitive and rare species, similar to sites in Very Good condition, but have no introduced species present. Similarly, streams in very poor condition would not be expected to occur due to the absence of large cropping or irrigated agricultural disturbance or urban centres; although may occur if a major contaminant spill occurred from a tailings dam from a mine or accident involving a tanker. Very Poor sites would be expected to only include a few tolerant species and have water quality too poor to support fish. The region lacks any stoneflies and no flow-dependent species were recorded due to the lack of permanent, flowing water habitats and ephemeral nature of many of the waterholes that typically occur in the LEB.

	Very Good	Good	Fair	Poor
Attribute 1 Rare and/or regionally endemic	**Hydracarina** *Unionicola, Limnesia*; **Mollusca** *Centrapala,* Thiaridae; **Diptera** *Coelopynia pruinosa, Harnischia*; **Ephemeroptera** *Wundacaenis*	**Hydracarina** *Unionicola, Limnesia*; **Mollusca** *Centrapala,* Thiaridae; **Diptera** *Coelopynia pruinosa, Harnischia;* **Ephemeroptera** *Wundacaenis*	**Hydracarina** *Unionicola, Limnesia, Arrenuridae* (ephemeral sites); **Mollusca** *Centrapala,* Thiaridae; **Diptera** *Coelopynia pruinosa, Harnischia*	**Hydracarina** Arrenuridae *(ephemeral sites)*
Attribute 2 Sensitive, rare or vulnerable specialist taxa with narrow environmental requirements	None present	None present	None present	None present
Attribute 3 Sensitive, ubiquitous taxa	**Ephemeroptera** *Cloeon* (often in large numbers), *Tasmanocoenis*; both taxa indicators of permanent, freshwater habitats in the region	**Ephemeroptera** *Cloeon* and *Tasmanocoenis*; both taxa indicators of permanent, freshwater habitats in the region	**Ephemeroptera** *Cloeon* and *Tasmanocoenis*; both taxa indicators of permanent, freshwater habitats in the region	**Ephemeroptera** *Cloeon* and *Tasmanocoenis*, if present, in very low numbers

	Very Good	Good	Fair	Poor
Attribute 4 Opportunistic or generalist taxa	**Mollusca** *Ferrissia, Glyptophysa, Corbiculina*; **Decapoda** *Macrobrachium*; **Coleoptera** typically more than 5 genera; **Diptera** rich diversity of Chironomidae (3 subfamilies typically present and include more than 5 genera); **Odonata** Coenagrionidae, Gomphidae; **Trichoptera** *Triplectides australis, Ecnomus*	**Mollusca** *Ferrissia, Glyptophysa, Corbiculina*; **Decapoda** *Macrobrachium*; **Coleoptera** typically at least 3–5 genera; **Diptera** Chironomidae (usually at least 2 subfamilies present and include more than 5 genera); **Odonata** Coenagrionidae, Gomphidae; **Trichoptera** *Triplectides australis, Ecnomus*	**Mollusca** *Ferrissia, Glyptophysa, Corbiculina*; **Decapoda** *Macrobrachium*; **Coleoptera** typically at least 2 or 3 genera; **Diptera** Chironomidae (usually at least 2 subfamilies present and include more than 3 genera); **Odonata** Coenagrionidae, Gomphidae; **Trichoptera** *Triplectides australis, Ecnomus*	**Mollusca** *Ferrissia, Glyptophysa, Corbiculina*; **Decapoda** *Macrobrachium*; **Coleoptera** typically less than 2 genera; **Diptera** Chironomidae (often 2 subfamilies present and include less than 3 genera); **Odonata** Coenagrionidae; **Trichoptera** *Triplectides australis*
Attribute 5 Tolerant taxa	**Diptera** Culicidae *Anopheles*, Ceratopogonidae; **Hemiptera** *Micronecta; Agraptocorixa, Anisops, Sigara, Microvelia, Enithares*; **Fish** hardyhead species (low numbers); **Zooplankton** Copepods and cladocerans abundant and typically in 1000s	**Diptera** Culicidae *Anopheles*, Ceratopogonidae; **Hemiptera** *Micronecta; Agraptocorixa, Anisops, Sigara, Microvelia, Enithares*; **Fish** hardyhead species (low numbers); **Zooplankton** Copepods, cladocerans and ostracods in large numbers	**Diptera** Culicidae *Anopheles*, Ceratopogonidae; **Hemiptera** *Micronecta; Agraptocorixa, Anisops, Sigara, Microvelia, Enithares*; **Fish** hardyhead species (low numbers); **Zooplankton** Copepods, cladocerans and ostracods in large numbers	**Diptera** Culicidae *Anopheles*, Ceratopogonidae; **Hemiptera** *Micronecta; Agraptocorixa, Anisops, Sigara, Microvelia, Enithares*; **Fish** hardyhead species (low numbers); **Zooplankton** typically limited to variable numbers of ostracods in more ephemeral, saline sites
Attribute 6 Non-endemic or introduced taxa	**Fish** Gambusia	**Fish** Gambusia	**Fish** Gambusia	**Fish** Gambusia

2012 results

Table 6 Condition ratings given by four panel members and final averall rating assigned for each of the 65 sites sampled from the Flinders Ranges and Lake Eyre Basin in 2012

Habitat descriptions: E = edge, R = riffle, ns = not sampled. For example the annotation ER, Dry indicates an edge and riffle were sampled in autumn but the site was dry in spring.

Site name	NRM/site code	Habitats	Very Good	Good	Fair	Poor	Final Rating
Willow Creek, near Willow Waters	N&Y/FR20	Dry, Dry	3	1			Very Good
Oraparinna Creek, Dingly Dell	SAAL/FR23	Dry, Dry	3	1			Very Good
Tributary of Oratunga Creek, First Spring	SAAL/FR35	Dry, Dry	3	1			Very Good
Tributary of Oratunga Creek, Snob's Hut Spring	SAAL/FR36	ER, Dry	3	1			Very Good
Balcanoona Creek, Grindell Hut Spring	SAAL/FR39	Dry, ns	3	1			Very Good
Yardaparinna Creek, Macumba	SAAL/WLEB30	E, ns	3	1			Very Good
Kanyaka Creek, Kanyaka Gauge Station	N&Y/FR17	E, E		4			Good
Pekina Creek, downstream from Pekina Reservoir	N&Y/FR27	E, E		3	1		Good
Mount Remarkable Creek, Mt Remarkable National Park	N&Y/FR32	Dry, Dry		3	1		Good
Arkaroola Creek, Nooldoonooldoona Waterhole	SAAL/FR15	ER, E		4			Good
Arkaroola Creek, Stubbs Waterhole	SAAL/FR7	E, E		4			Good
Artimore Creek, Nildottie Spring	SAAL/FR3	E, E	1	3			Good
Balcanoona Creek, Balcanoona	SAAL/FR5	Dry, Dry	2	2			Good
Balcanoona Creek, Weetootla Campground	SAAL/FR9	E, E	2	2			Good
Eregunda Creek, Eregunda Spring	SAAL/FR13	ER, ER		4			Good
Italowie Creek, Italowie Gap	SAAL/FR2	Dry, Dry	1	3			Good

Site name	NRM/site code	Habitats	Very Good	Good	Fair	Poor	Final Rating
Munyallina Creek, Munyallina Spring	SAAL/FR1	ER, Dry	1	3			Good
Paralana Creek, Paralana Hot Springs	SAAL/FR8	ER, ns	1	2	1		Good
Wilpena Creek, Wilpena Pound	SAAL/FR6	Dry, Dry		4			Good
Yadnapunda Creek, Matthewson Spring	SAAL/FR10	Dry, Dry		4			Good
Cooper Creek, Cullyamurra Waterhole	SAAL/ELEB12	ns, E		3	1		Good
Cooper Creek, Innamincka	SAAL/ELEB13	ns, E		4			Good
Warburton Creek, Yelpawaralinna Waterhole	SAAL/ELEB18	ns, E		3	1		Good
Diamantina River, Birdsville Gauge Station	SAAL/ELEB26	ns, E		3	1		Good
Cooper Creek, King's Marker Waterhole	SAAL/ELEB27	ns, E		4			Good
Cooper Creek, Scrubby Camp Waterhole	SAAL/ELEB31	ns, E	1	3			Good
Diamantina River, Pandie Pandie Waterhole	SAAL/ELEB5	ns, E		3	1		Good
Warburton Creek, Cowarie Crossing Waterhole	SAAL/ELEBCC	ns, E		4			Good
Brachina Creek, Brachina Gorge	SAAL/FR24	ER, E		4			Good
Parachilna Creek, Mount Mary	SAAL/FR26	ER, ER		3	1		Good
Bunyeroo Creek, Bunyeroo Gorge	SAAL/FR30	Dry, Dry	2	2			Good
Puttapa Creek, Puttapa Springs	SAAL/FR38	ER,E		3	1		Good
Weetootla Creek, Weetootla Gorge	SAAL/FR41	ns, E	1	2	1		Good
Hamilton Creek, Ethawarra Waterhole	SAAL/WLEB1	E, ns		3	1		Good
Neales Creek, Stewart	SAAL/WLEB10	E, ns		3	1		Good

Site name	NRM/site code	Habitats	Very Good	Good	Fair	Poor	Final Rating
Waterhole							
Lindsay Creek, Eringa Waterhole	SAAL/WLEB21	E, ns	2	2			Good
Neales Creek, Hookeys Waterhole	SAAL/WLEB22	E, ns		4			Good
Coongra Creek, Road Crossing	SAAL/WLEB25	E, ns	2	2			Good
Spring Creek, near Wilmington	N&Y/FR18	E, Dry		2	1	1	Fair
Willochra Creek, Partacoona	N&Y/FR19	E, E			3	1	Fair
Beautiful Valley Creek, near Horrock's Pass	N&Y/FR33	Dry, Dry		2	1	1	Fair
Willochra Creek, downstream from junction with Castle Springs	N&Y/FR34	E, E		1	3		Fair
Wirreanda Creek, near Springfield	N&Y/FR37	Dry, Dry		2	2		Fair
Baratta Creek, Baratta Springs	SAAL/FR11	E, E		1	3		Fair
Mount Chambers Creek, Mt Chambers Gorge	SAAL/FR4	ER, E			4		Fair
Reedy Creek, Reedy Springs	SAAL/FR12	E, E		1	3		Fair
Wirrealpa Creek, Wirrealpa Spring	SAAL/FR14	E, Dry		1	3		Fair
Cooper Creek, Minkie Waterhole	SAAL/ELEB11	ns, E		2	2		Fair
Cooper Creek, Embarka Waterhole	SAAL/ELEB14	ns, E		2	2		Fair
Cooper Creek, Coongie Crossing Waterhole	SAAL/ELEB16	ns, E		1	3		Fair
Derwent Creek, Mungeranie Waterhole	SAAL/ELEB19	ns, E		1	3		Fair
Diamantina River, Clifton Hills Outstation Waterhole	SAAL/ELEB28	ns, E		2	2		Fair
Derwent Creek, Cowarie Waterhole	SAAL/ELEB29	ns, E		1	3		Fair

Site name	NRM/site code	Habitats	Very Good	Good	Fair	Poor	Final Rating
Cooper Creek, Kudramitchie Waterhole	SAAL/ELEB8	ns, E		2	2		Fair
Hookina Creek, Mayo Gorge Waterhole	SAAL/FR21	E, E			4		Fair
Aroona Creek, downstream from Aroona Dam	SAAL/FR22	E, E		1	3		Fair
Tributary of Oratunga Creek, Third Spring	SAAL/FR25	E, E		1	3		Fair
Nilpena Creek, Nilpena	SAAL/FR31	E, ER		1	3		Fair
Nepourie Creek, Nepourie Spring	SAAL/FR40	E, Dry	1	1	2		Fair
Woolridge Creek, Murdarinna Waterhole	SAAL/WLEB3	E, ns			4		Fair
Neekena Creek, Winkies Waterhole	SAAL/WLEB4	E, ns		1	3		Fair
Wild Dog Creek, north from Murray Town	N&Y/FR28	Dry, Dry			2	1 Poor/ 1 Very Poor	Poor
Pekina Creek, Pekina	N&Y/FR29	Dry, Dry			2	2	Poor
Neales Creek, Algebuckina Waterhole	SAAL/WLEB23	E, ns		1	1	2	Poor
Peake Creek, Peake Crossing	SAAL/WLEB24	E, ns			1	3	Poor

The results provided in Table 6 can be summarised by condition rating and NRM region and are presented in Table 7.

Table 7 Summary of condition assessment

Condition rating	NYNRM sites	SAALNRM sites	Total number of sites
Excellent	0	0	0
Very Good	1	5	6
Good	3	29	32
Fair	5	18	23
Poor	2	2	4
Very Poor	0	0	0

The sites that were assigned the Very Good rating included Willow Creek (FR20) from the N&YNRM region, and Oraparinna Creek (FR23), tributaries of Oratunga Creek at both First Spring (FR35) and Snob's Hut Spring (FR36), Balcanoona Creek at Grindell's Hut Spring (FR39) from the Flinders Ranges and Yardaparinna Creek (LEB30) from the

Western Lake Eyre Basin within the SAAL NRM region. Most of these sites were dry and rated highly due to the good habitat structure provided by the surrounding riparian vegetation and sediment composition, and lacked evidence of large numbers of stock or feral animals visiting each waterway. The exceptions included Snob's Hut Spring site which had riffle and pool habitats in autumn but was dry in spring and Yardaparinna Creek site which had shallow pool habitats when sampled in autumn.

The Poor sites included two dry streams from cleared agricultural country in the upper Willochra catchment (Wild Dog Creek (FR28) and Pekina Creek near Raval (FR29)) and two Western Lake Eyre Basin sites that had only a few aquatic species present and appeared to be significantly affected by nutrients [Neales Creek, Algebuckina Waterhole (LEB23)] and/or high salinity (Peake Creek LEB24).

The majority of sites were assigned to the Good or Fair category and showed slight to moderate nutrient enrichment effects during at least one of the sampling periods sampled. It should be noted that a central assumption of the conceptual models for each region was that high levels of nutrients such as nitrogen and phosphorus originated from human activities in each catchment rather than from some unknown natural source (eg NLWRA 2001 and SAAL NRM 2010); this is consistent with the general poor nutrient status of ancient Australian soils and the need for arid-zone plants to conserve and recycle nutrients rather than allow the regular export of nutrients from the terrestrial landscape into a waterway where the nutrients may be deposited tens to hundreds of kilometres away. Consequently, it was assumed that historical and present stock and feral animal grazing landuses and cropping activities in some upper catchment streams contributed towards the high concentrations of nutrients in water samples taken from many sites in the Flinders Ranges and Lake Eyre Basin and/or led to obvious enrichment effects such as large growths of phytoplankton, filamentous algae or aquatic plants.

Under such conditions, a more generalist assemblage of aquatic macroinvertebrates capable of exploiting the resulting high plant productivity and tolerating occasional lowering of oxygen levels when plants die and decay would be expected to dominate in-stream aquatic habitats. In contrast, few sensitive or rare habitat specialists would be expected to occur and would certainly not dominate aquatic communities. These nutrient enrichment responses were subsequently incorporated into the conceptual models to represent the commonly described patterns that have regularly been described in the scientific literature for over 100 years.

Similarly, the models assumed that high salinity has been exacerbated by historical disturbances to vegetation changes associated with human cropping and grazing practices in the Willochra catchment and some parts of the Western Lake Eyre Basin. High salinity has also been recognised as a major driver for limiting aquatic communities to only the most salt tolerant species, particularly when salinities exceed 5,000 mg/L (eg Nielsen *et al* 2008; Kefford *et al* 2011). It is possible that some streams in the Flinders Ranges and Far North, particularly the lower reaches of the Willochra Creek, may have approached or exceeded this general threshold prior to European settlement but it was assumed as part of this assessment that the extensive landuse changes brought about by farming practices in the past has mobilised more salt into each affected stream than would have occurred if the landscape had remained unchanged.

Further work is needed to confirm if these assumptions are appropriate or whether the conceptual models developed as part of this assessment should be amended. Targeted studies of historical diatom assemblages in sediment cores taken from selected in-stream waterholes in each region may provide the best means of confirming whether there has been an increase in the frequency and dominance of nutrient-favouring species and/or saline tolerant species since European settlement, or whether diatom communities have remained largely unchanged over the past few hundred years.

If increasing nutrient and salinity levels are evident then further work could be directed towards reviewing and possibly refining the thresholds used in the conceptual models (eg enrichment evident when 100m area of site has >10% macrophytes and/or >35% filamentous algae when nutrient concentrations are >1 mg/L nitrogen and >0.1 mg/L phosphorus; refer to Table 8 for a simple statistical breakdown of the nutrient and phytoplankton algal indicators from the data collected in 2012 which demonstrates that Lake Eyre Basin streams are more enriched with nutrients than Flinders Ranges streams. The table also includes simple descriptive ranges that were used in the site condition reports to distinguish low, moderate and high values relating to general water chemistry and algae). Alternatively, if salinity and nutrient changes are not supported further work is needed to clarify the source and movement of these chemicals into waters because they still have the potential to degrade aquatic habitats whenever they occur in high concentrations.

Finally, it should be noted that the ratings for the dry sites in particular, may vary when water is present but this should be considered within the broader context of the variability that will occur in any arid-zone stream in response to differences in the frequency and timing of floods and droughts, differences in the distribution and abundance of stock and feral animals, and other biological, chemical and physical habitat changes that can undoubtedly occur both seasonally and annually. Despite this, the ratings assigned in this report provide an accurate condition assessment of sites sampled in 2012 using the conceptual models that were specifically developed for both the Flinders Ranges and Lake Eyre Basin areas.

Variability in panel member ratings

The results in Table 6 show that the panel members assigned the same condition rating to 14 sites and differed by one rating class of each other for another 45 sites, indicating that there was considerable consistency for rating 91 percent of the sampled sites. The results for the remaining six sites were, however, more variable with the panel assigning three possible ratings to two sites from the N&YNRM region and four sites from the SAALNRM region; this indicates that the conceptual models may require further modifications to remove possible ambiguity between some of the response measures or panel members inconsistently applied some of the criteria in assigning ratings for some sites.

Given the variability of stream types across each region (eg differences in the presence of water and flowing habitats, seasonal differences in hydrology, variable salinity patterns and climatic influences), it would be unrealistic to expect to see complete agreement in rating sites using an expert panel approach or indeed any other means of integrating and reporting on measures of stream condition (eg indices or models based on the reference-based concept, gradients, comparisons against guidelines), largely because of the boundary or edge effects that invariably occur whenever environmental data is grouped using what are typically simple algorithms and associated criteria.

Table 8 Nutrient and phytoplankton statistics from sites sampled in 2012. Chlorophyll units in µg/L but other parameters in mg/L

Parameters	General statistics for sites sampled from the Flinders Ranges (FR), Western Lake Eyre Basin (WLEB) and Eastern Lake Eyre Basin (ELEB)							Possible simple descriptive criteria		
	Mean	Standard Deviation	Median	25th percentile	75th percentile	Maximum	Minimum	Low (0–median)	Medium (median–75th percentile)	High (>75th percentile)
FR (n=47)										
Chlorophyll a	3.76	4.93	1.91	0.63	4.79	24.00	0.10	0-2	2-5	5+
Chlorophyll b	0.62	0.51	0.47	0.24	0.75	1.92	0.00			
NOx	0.31	1.01	0.01	0.01	0.02	6.23	0.00			
TN	0.95	1.16	0.58	0.32	1.11	6.45	0.10	0-0.6	0.6–1	1+
TKN	0.64	0.75	0.40	0.27	0.78	4.94	0.09			
TP	0.03	0.03	0.02	0.02	0.04	0.17	0.01	0-0.02	0.02–0.04	0.04+
WLEB (n=10)										
Chlorophyll a	18.87	24.59	9.45	5.44	16.80	82.00	3.16	0-10	10–17	17+
Chlorophyll b	1.95	2.52	1.18	0.52	1.36	7.62	0.10			
NOx	0.02	0.03	0.01	0.00	0.01	0.08	0.00			
TN	1.68	0.67	1.45	1.29	2.03	2.76	0.66	0-1.5	1.5–2	2+
TKN	1.67	0.67	1.43	1.28	2.01	2.76	0.66			
TP	0.10	0.06	0.09	0.06	0.13	0.24	0.04	0-0.1	0.1–0.13	0.13+
ELEB (n=15)										
Chlorophyll a	18.02	15.45	10.80	8.27	26.60	51.80	2.79	0-11	11–27	27+
Chlorophyll b	2.33	2.77	1.24	0.64	2.92	8.56	0.00			
NOx	0.51	0.46	0.40	0.08	0.80	1.28	0.01			
TN	2.95	1.19	2.81	2.32	3.35	5.19	0.75	0–2.8	2.8–3.4	3.4+
TKN	2.44	1.22	2.05	1.75	2.63	5.18	0.74			
TP	0.56	0.27	0.53	0.45	0.64	1.15	0.07	0–0.5	0.5–0.6	0.6+

References

Catchment Simulations Solutions 2011, *Spatially balanced sampling site selection for streams in South Australia: Pilot project for Adelaide and Mount Lofty Ranges region*, unpublished report to the EPA, Revision 2.

Davies SP and SK Jackson 2006, 'The biological condition gradient: a descriptive model for interpreting change in aquatic ecosystems', *Ecological Applications,* Volume 16, pp 1251-1266.

Kefford BJ, Marchant R, Schafer RB, Metzeling L, Dunlop JE, Choy SC and P Goonan (2011), 'The definition of species richness used by species sensitivity distributions approximates observed effects of salinity on stream macroinvertebrates', *Environmental Pollution* ,Volume 159, pp. 302–310.

National Land and Water Resources Audit 2001, *Nutrient balance in regional farming systems and soil nutrient status*, Final report NLWRA.

Nielsen, DL, Brock MA, Vogel M and R Petrie 2008, 'From fresh to saline: a comparison of zooplankton and plant communities developing under a gradient of salinity with communities developing under constant salinity levels', *Marine and Freshwater Research*, Volume 59, pp. 549–559.

South Australian Arid Lands Natural Resources Management Board 2010, *Regional natural resources management plan for the SA arid lands natural resources management region, Volume 1 Ten-year Strategic Plan*, SAAL NRM, Adelaide.

Disclaimer

This publication is a guide only and does not necessarily provide adequate information in relation to every situation. This publication seeks to explain your possible obligations in a helpful and accessible way. In doing so, however, some detail may not be captured. It is important, therefore, that you seek information from the EPA itself regarding your possible obligations and, where appropriate, that you seek your own legal advice.

Further information

Legislation

Legislation may be viewed on the Internet at: <www.legislation.sa.gov.au>

Copies of legislation are available for purchase from:

Service SA Government Legislation Outlet	Telephone:	13 23 24
Adelaide Service SA Centre	Facsimile:	(08) 8204 1909
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