Aquatic ecosystem condition reports

2018 panel assessment of creeks and rivers from Kangaroo Island and the Adelaide and Mount Lofty Ranges NRM regions

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EPA 1110/20: This information sheet describes the outcome of the panel assessment of creeks and rivers from Kangaroo Island and the Adelaide and Mount Lofty Ranges Natural Resources Management (NRM) regions, which were sampled in spring 2018.

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. The EPA has decided that 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 and two EPA biologists (the authors of this assessment). All have at least 20 years' experience in monitoring and assessing a range of streams across South Australia.

The panel members were:

- Peter Goonan, EPA
- Tracy Corbin, EPA
- 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 throughout Kangaroo Island and the Western Mount Lofty Ranges during 2018.

Site selection and sampling design

A total of 30 sites were sampled during spring 2018, comprising 15 sites from Kangaroo Island and 15 sites from the Western Mount Lofty Ranges. In previous years, sampling was also carried out in autumn to provide data from what is often the most water stressed season but the decision was made in 2018 to omit the autumn sampling period because most of the pattern in the assessments were evident using just the spring data.

Sampling on Kangaroo Island was carried out from 12–16 November 2018 and sites from the Western Mount Lofty Ranges were sampled from 21–30 November 2018.

Kangaroo Island NRM region

The Kangaroo Island sites were selected, in consultation with the Kangaroo Island NRM (KINRM), from a list of previously sampled (fixed) sites throughout the island to ensure that the spatial extent of the stream network accessible by roads was sampled. Sites were also located across the elevational gradient (eg lowland, mid-reach and upper reach) from the Cygnet River (five sites) and Middle River (three sites) catchments to assist with future water resource modelling for the island. Additional sites were also included from near pristine (Rocky River), well vegetated (South-West River, Stun Sail Boom and Harriet River) and cleared agricultural catchments (Timber Creek and Willson River) to support validating the models beyond the Cygnet and Middle Rivers.

Adelaide and Mount Lofty Ranges NRM region

A series of fixed sites were selected for sampling from the region, in consultation with staff from the Adelaide and Mount Lofty Ranges NRM (AMLR NRM) and Department for Environment and Water (DEW), which focused on biodiverse streams from the Fleurieu Peninsula (Boat Harbor, First, Callawonga and Tunkalilla Creeks) and streams from the Southern Mt Lofty Ranges that included high quality sites (First and Sixth Creeks) through to a highly disturbed site (eg Pedler Creek).

Fixed sites versus random site selection

It is important to note that fixed sites provide targeted information about the sampled sites and a broad indication of the general condition of waters in a catchment or region. The lack of randomly selected sites limits the ability for this sort of study design to provide a statistically valid assessment of all waters in a region with some measure of known error (Stevens and Olsen 2004).

The EPA has developed a database covering all stream reaches found in South Australia that can be used to identify randomly selected sites (Catchment Simulations Solution 2011), which would allow the findings to be statistically scaled up to report on the number or proportion of stream reaches in different condition classes or subject to a water quality or habitat disturbance. If this type of information is required in the future then sites can be selected using this approach but as part of negotiations with partner organizations, the above fixed and selected site sampling approach was endorsed and used in sampling streams from each NRM region in 2018.

Sampling strategy

Each site comprised a 100-m section of stream which was selected to represent the typical physical conditions present in the stream to be assessed. Site coordinates were taken from the middle of each site using a Garmin GPS.

Aquatic macroinvertebrates (invertebrates visible to the naked eye) were sampled using a 250-µm meshed triangular dip-net to sample non-flowing edge habitat and fast-flowing riffle habitat, whenever they extend over at least 10 metres within the site to be sampled. The majority of South Australian streams have edge or pool habitats present but some of the wetter catchments also maintain sufficient riffle habitat to enable an additional sample to be taken of the organisms that inhabit flowing waters. In cases where the available habitat does not meet the 10-m distance threshold, no sample is generally taken at the site but notes were recorded of the animals seen in the field with the naked eye from whatever habitat is present.

A rapid field processing method was used to identify collected macroinvertebrates, which ensures that the results are capable of being reported soon after the completion of the sampling campaign. Each sample was placed in a white tray and specimens were sorted and identified for at least 30-minutes and an estimate of the total abundance of each taxon was made at the conclusion of processing.

If a new taxon was recorded within the last 5-minute period, then an additional 5 minutes was added to the sorting period to continue to search for new species. Representative specimens of each taxon were preserved in a labelled container for each habitat and all identifications were later verified using microscopes in the laboratory soon after the completion of field sampling.

The data for each sampled habitat was entered separately onto an Excel spreadsheet which includes a possible 809 macroinvertebrate taxa listed on the current inland waters database for South Australia. Consequently, well-watered sites had data available from both edge and riffle habitats, whereas the drier sites lacked flowing water and comprised edge data taken from non-flowing connected channel or isolated pool habitats.

A total of 101 observations were also recorded of the vegetation in the channel, on the riparian edge, and from the surrounding buffer zone to provide an additional biotic data layer to contribute to any assessment of stream condition. This enables dry sites that lack aquatic macroinvertebrates to be given an interim assessment of condition based on the vegetation present at the site.

An additional 156 measurements and observations were also taken at each site comprising data about the water quality, flow rate, sediment composition, habitat extent, and adjacent land use which was used to characterise the stressors that potentially affect each sampled site; field water quality was recorded using a calibrated YSI multimeter and included measurements of the electrical conductivity (surrogate for salinity), dissolved oxygen content, pH and temperature.

A water sample is also taken at each site by compositing several 1-litre samples taken from different depths and parts of the stream site into a clean bucket. A known volume was filtered in the field, and the filter paper wrapped in alfoil and stored on ice for analysis of chlorophyll *a* and *b*. Two 125-mL PET bottles were also filled with water from the well mixed bucket; one was field filtered using a syringe and 0.45-um filter discs for dissolved nitrogen determination (part of the total nitrogen analysis) and the other was unfiltered for total nutrient analyses. All analyses were carried out by the National Association of Testing Authorities (NATA) accredited Australian Water Quality Centre.

All data collected using this approach is capable of being collected and verified within two months after the completion of sampling, which enables the results to be fully analysed and reported within a few months from collection.

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).

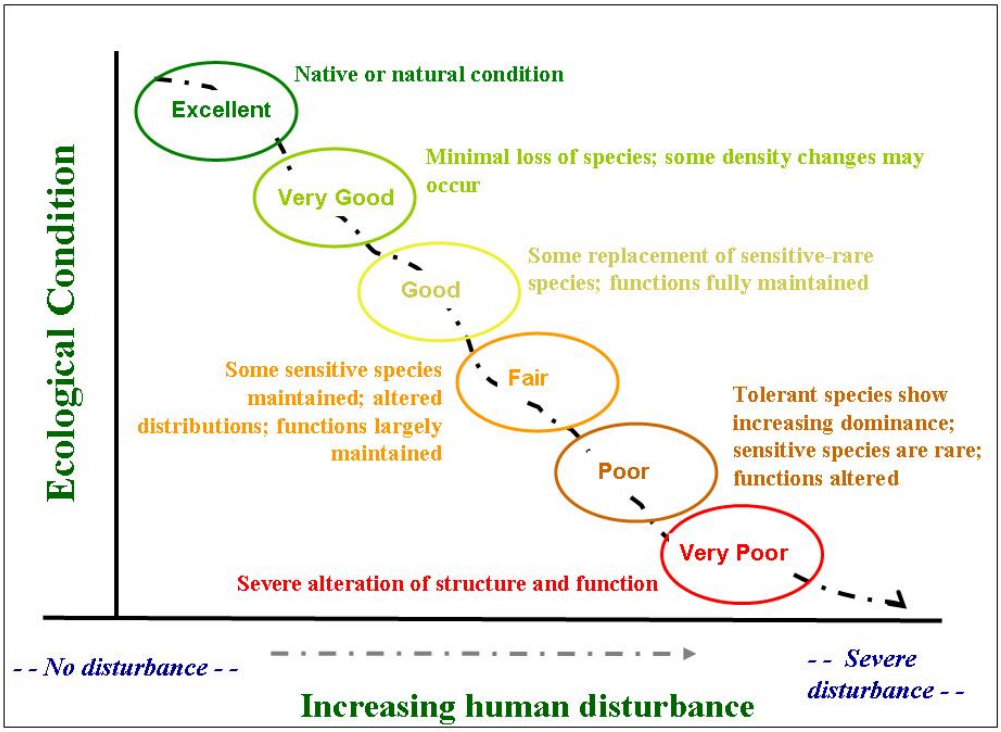

Figure 1 **Human disturbance gradient showing the six different ecological condition grades or ratings ranging from excellent (best) to very poor (worst) with a brief definition of each condition**

The process used to grade or rate sites involved the following steps. Firstly, a conceptual model describing the biological and environmental responses to a general disturbance gradient was developed, reviewed and updated by the panel (Table 1). Secondly, species lists were compiled which described the expected biotic assemblage for up to six potential condition ratings, based on the data that was collected in 2018 (Table 2). Thirdly, each site was given a rating based on the macroinvertebrate communities, vegetation assemblages, water chemistry and sediment features that were recorded during the spring sampling period (Table 3). Lastly, the individual ratings derived by the panel members were combined to produce an overall, or final, rating for each site (Table 3).

The final reported ratings were derived by determining the mode (ie the most common rating from the panel ratings for each site). In the interests of being transparent about the final ratings derived using this process, all results have been included in Table 3 to show where the panel agreed or showed some difference of opinion in terms of rating individual sites.

The ratings in the model range from Excellent to Very Poor. However, given the extent of vegetation clearance, land-use modifications, widespread grazing by stock and feral animals, and presence of introduced aquatic species in the region, the panel considered that Excellent probably no longer occurs and was certainly not evident from the sites sampled in 2018.

The panel members were also provided with an estimate of the expected condition of the sampled stream reaches using a newly developed machine learning approach called boosted regression trees (Edith *et al* 2008, Waite and Van Metre 2017) as part of the assessment process. The expected ratings (called Tier 1 assessments) were generated by identifying the most significant map-based variables (eg land use, climate, soils) that correlated with previous condition assessment ratings, and using the predictor variables to estimate the condition of unsampled reaches[1].

[1] https://www.epa.sa.gov.au/files/14069_inland_waters_methods.pdf

Results and discussion

Table 4 provides a summary of the overall condition rating for each site sampled in 2018. No sites were in an Excellent or Very Poor condition but 16 sites (ie 53%) were given either a Very Good or Good rating and the remaining 14 sites (47%) were given either a Fair or Poor rating due to their generally degraded condition.

It is *important to emphasise* here that these results do not indicate that streams from the Mount Lofty Ranges were in better condition than those from Kangaroo Island. The Adelaide and Mount Lofty Ranges NRM wanted more information collected from several known high quality streams from the Fleurieu Peninsula, so using fixed sites in this context effectively biased the results towards better ratings compared to the more spatially distributed sites that were sampled from Kangaroo Island.

The sites that were assigned a Very Good rating included Rocky River from East Melrose Track in Flinders Chase National Park on Kangaroo Island, and First Creek from Tunkalilla Rd and Callawonga Creek north from Taylors Rd on the Fleurieu Peninsula, and First Creek upstream from the waterfall in Cleland Conservation Park within the Mount Lofty Ranges. These streams were characterised by the large amount of native vegetation remaining within their catchments, presence of flowing freshwater habitats, lack of significant signs of human disturbance affecting each stream, and by the large number of rare, sensitive and flow-dependent macroinvertebrates that were recorded from each site.

Sites assigned to the Good rating included a site from the South West River, North East River in the Stun'Sail Boom catchment and two sites upstream from the reservoir on Middle River on Kangaroo Island. Sites assigned the same rating from the Mount Lofty Ranges included Boat Harbor Creek, Callawonga Creek at Callawonga, three sites from Tunkalilla Creek, First Creek downstream from the waterfall in Cleland Conservation Park, Sixth Creek and Brownhill Creek downstream from Tilleys Road. These sites showed evidence of slight nutrient enrichment but were characterised by the presence of large areas of native vegetation within their catchments, functioning riparian zones, and each provided habitat for several rare, sensitive and flow-dependent macroinvertebrates.

The Fair sites included eight sites from Kangaroo Island and three sites from the Adelaide Hills. The former included four sites from the Cygnet River catchment, a site downstream from the Middle River reservoir on Middle River, and a site each from Harriet River, Timber Creek and Willson River. The latter included Brownhill Creek downstream from the caravan park, Little Para River and the North Para River. These sites all showed evidence of significant nutrient enrichment, several were affected by moderate to high salinity, a number of streams had degraded riparian zones, and each only provided habitat for a limited number of significant aquatic species.

The Poor streams included a tributary of Cygnet River at Bark Hut Road and Gum Creek on Kangaroo Island, and Pedler Creek off Stump Hill Road in McLaren Vale, south from Adelaide. The Kangaroo Island sites were located in largely cleared grazing land on the northern part of the island and Pedler Creek was located in a mixed agricultural and rural residential catchment. These streams showed evidence of either significant nutrient enrichment or were salinised, had limited native vegetation remaining in their catchments, ineffective riparian zones dominated by introduced grasses and weeds, and supported a sparse community of pollution tolerant macroinvertebrates.

Variability in panel member ratings

The results in Table 3 show that the expert panel members assigned the same condition rating to 21 of the 30 sites sampled (70%) and the remaining sites only differed by one condition rating of each other. Sites from Kangaroo Island were less consistently rated the same by the panel than the sites from the Mount Lofty Ranges, possibly due to the inclusion of sites throughout the island rather than focusing on sampling many of the better streams on the Fleurieu Peninsula and Southern Mt Lofty Ranges. Nevertheless, this shows that there was considerable consistency for rating the condition of sites using this approach and that the conceptual model provided an accurate representation of the range of streams that occurred in each region in 2018.

It is important to note that it would be unrealistic to expect to obtain 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 classifying sites using indices or models based on the reference-based concept, gradient analysis, comparisons against guidelines)

due to the problems associated with separating groups along a continuum of possible groups, using environmental data that is often inherently highly variable.

Comparison of field-based condition ratings and map-based Tier 1 expected condition ratings

The expected condition ratings were comparable to the assigned panel assessment ratings, with all sites matching or differing by the one condition rating of each other (Table 3). The latter comprised mostly sites that were in better condition than indicated by the map-based variables (8 of 10 sites rated poorer with Tier 1 assessment compared to panel ratings using field collected data). Further refinement of the Tier 1 approach will include evaluating if new variables (eg using the newly released Australian Landscape Water Balance Model: AWRA-L v6[2]) can improve the ability to accurately predict stream condition using remote mapping tools.

Water chemistry of South Australian streams

Table 5 provides a statistical summary of the major chemistry and algal biomass (estimated using chlorophyll measurements) parameters taken at each site in spring. The median values indicate that most streams were fresh to moderately fresh (salinity 187–2,289 mg/L based on converting electrical conductivity units x 0.6), alkaline (pH 7.4–7.5), moderately to well oxygenated (5.1–9.3 mg/L), enriched with moderate concentrations of phosphorus (0.03 mg/L) and higher nitrogen concentrations (0.7–0.9 mg/L), and with a low chlorophyll content (<2 ug/L). Kangaroo Island streams were more enriched with nitrogen and more saline than the streams sampled from the Western Mount Lofty Ranges.

There are only a few undisturbed streams covered in remnant native vegetation that can provide a benchmark or reference for the water quality of streams in each region. They include streams located within nature conservation reserves (eg First Creek in Cleland Conservation Park and parts of Sixth Creek in Montacute Conservation Park in the Western Mount Lofty Ranges, and Rocky and Breakneck Rivers in Flinders Chase National Park on Kangaroo Island) in often upland, rocky, steeply sloping landscapes that have historically been unsuitable for development. However, there are too few of these streams distributed across the region and none located in mid to lowland reaches that could provide an undisturbed reference for the many streams that occur among catchments that were substantially cleared and modified for agriculture and residential housing over 100 years ago.

To overcome this type of problem, the USEPA (2000) advocated using the 25th percentile of all data from a region to help set nutrient thresholds, which were expected to approximate the tipping point where streams were likely to be at increased risk of being degraded by excess nutrients. Using this approach, the data provided in Table 5 indicates that the nutrient thresholds for the two NRM regions sampled in spring 2018 were as follows:

	Western Mount Lofty Ranges	**Kangaroo Island**
Total nitrogen (TN)	0.3 mg/L	0.8 mg/L
Total phosphorus (TP)	0.02 mg/L	0.02 mg/L

These concentrations are within the same order of magnitude to those cited in the scientific literature using the same statistical criterion (see Chambers *et al* 2012 and Smucker *et al* 2013) and similar to the trigger values of TN = 0.5 mg/L and TP = 0.02 mg/L that were proposed for the protection of sensitive mayflies and stoneflies from South Australian waters (Corbin and Goonan 2010).

Recent analyses of macroinvertebrate community thresholds associated with nutrients have shown that the change points were 0.3 mgTN/L and 0.01 mgTP/L for Kangaroo Island streams and 0.3 mgTN/L and 0.006 mgTP/L for Southern Mount Lofty streams (EPA unpublished data). The lower TN value for Western Mount Lofty Ranges streams using spring 2018 data is probably more an artefact from sampling known high quality streams rather than providing a representative nutrient threshold for the region.

[2] http://www.bom.gov.au/water/landscape/

Previous thresholds using this same statistical approach for sites sampled from the same regions in recent years have showed some minor variation with TN but a consistent TP value. For example, the 25th percentile TN concentrations from streams sampled in the Western Mount Lofty Ranges have included values of 0.45 mg/L (38 sites sampled in 2016), 0.37 mg/L (17 sites sampled in 2015) and 0.6 mg/L (46 sites sampled in 2013); the 25th percentile TP concentration has consistently been 0.02 mg/L. In contrast, the last time Kangaroo Island was surveyed was in 2013 when 31 streams were sampled, and the 25th percentile TN and TP concentrations were 0.67 mg/L and 0.01 mg/L, respectively.

Variations in climate probably contribute to this pattern, in part, because hot dry years with below average rainfall recorded in 2018 and 2015 coincide with the lowest 25th percentile TN values from the Mount Lofty Ranges of 0.3–0.37 mg/L, and the wet and average rainfall years in 2016 and 2013 were characterised by a higher 25th percentile of 0.45 mg/L[4].

Drier periods probably result in less runoff entering streams from adjacent agricultural lands, and wet years would result in more runoff and sediment entering waters during parts of the year. In contrast, Kangaroo Island streams were consistently higher with 25th percentile TN concentrations ranging from 0.67 during the average rainfall year of 2013 to 0.8 mg/L during the dry 2018. These streams are generally smaller and local factors presumably contribute to higher nitrogen concentrations than streams from the Western Mount Lofty Ranges.

Conceptual model issues

A central assumption of the conceptual model is that the high nutrient concentrations (eg nitrogen and phosphorus) recorded from many South Australian streams originates from human activities in each catchment, rather than from a natural source (NLWRA 2001). This is consistent with the general poor nutrient status of ancient Australian soils and the need for native plants to conserve and recycle nutrients, rather than allow the regular export of nitrogen and phosphorus from the land into streams, where the nutrients may eventually be deposited many kilometres away further downstream.

Consequently, it was assumed that historical and present stock and feral animal grazing land uses and cropping activities since European settlement have contributed towards the nutrient enrichment of many streams in each region in modern times. This may be evident through measuring higher than expected concentrations of nutrients in water samples (eg TN >0.5 mg/L or TP >0.02 mg/L as described earlier) and/or noting signs of enrichment due to the presence of large growths of phytoplankton, filamentous algae or aquatic plants.

Under such conditions, a generalist assemblage of aquatic macroinvertebrates typically dominates because they are capable of exploiting the high plant productivity and tolerating occasional poor water quality events that often occur in such streams. In contrast, few if any, of the regionally rare, sensitive and/or habitat specialists would be expected to occur in such streams, and never in large numbers. These types of enrichment responses have subsequently been incorporated into the conceptual models to represent the biological and chemical patterns that have been described in the scientific literature for over 100 years.

Similarly, another assumption of the model is that the high salinity of some streams has been caused, or at least exacerbated, by the extent of native vegetation clearance and replacement by cropping and grazing practices in some catchments in the past. Such practices have often created conditions that promoted the secondary salinisation of streams due to inflow of saline groundwater.

High salinity has been recognised as a major factor for the loss of salt-sensitive species and creation of conditions that favour only the more salt-tolerant species to be able to colonise and subsequently complete their life cycles. Recent research indicates that most freshwater species are generally replaced by salt-tolerant species when salinities exceed about 5,000–10,000 mg/L, and different threshold effects are evident with different taxonomic groups at often lower concentrations (eg Nielsen *et al* 2008, Kefford *et al* 2011).

[4] Bureau of Meteorology website: http://www.bom.gov.au/climate/current/statement_archives.shtml and http://www.bom.gov.au/climate/current/

While it is possible that some streams from parts of the Mount Lofty Ranges and Kangaroo Island may have approached or exceeded this salinity range prior to European settlement, it was assumed as part of this assessment that the extensive land-use changes brought about by farming has mobilised more salt into each affected stream than would have occurred if the landscape had remained unchanged. Streams with a salinity at or above 5,000 mg/L represent a highly disturbed state in the conceptual model for each of the sampled regions.

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Further information

Legislation

Online legislation is freely available. Copies of legislation are available for purchase from:

Service SA Government Legislation Outlet
Adelaide Service SA Centre
108 North Terrace
Adelaide SA 5000

Telephone: 13 23 24
Facsimile: (08) 8204 1909
Website: https://service.sa.gov.au/12-legislation
Email: ServiceSAcustomerservice@sa.gov.au

General information

Environment Protection Authority
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Freecall: 1800 623 445 (country)
Website: https://www.epa.sa.gov.au
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Table 1 Conceptual model of ecological responses to a disturbance gradient in the Kangaroo Island and Adelaide and Mount Lofty Ranges NRM regions

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
Stressor description	As naturally occurs: probably no longer present in either region due to the level of vegetation clearance and landscape modification. Streams with large areas of remnant natural vegetation (eg Flinders Chase National Park streams; First Creek, part of Sixth Creek, and low order streams in the upper South Para River in the Adelaide Hills; coastal creeks such as Aaron, Callawonga, First and Tunkalilla creeks on the southern Fleurieu Peninsula), may represent this state on occasions but the presence of introduced species and nutrient enrichment associated with human uses in each catchment precludes rating sites in the region as Excellent.	Least impacted streams with largely natural vegetation and low levels of human disturbance are not common in the region and may only include Flinders Chase National Park streams; First Creek, part of Sixth Creek, and low order streams in the upper South Para River in the Adelaide Hills; coastal creeks such as Aaron, Callawonga, First and Tunkalilla creeks on the southern Fleurieu Peninsula. These streams have relatively few introduced species present and usually show little sign of nutrient enrichment or other forms of human disturbance.	Best condition sites showing initial signs of enrichment: likely to occur in streams with large areas of natural vegetation remaining in their catchments and generally characterised by permanent/near permanent, flowing, freshwater habitats but may also include more ephemeral habitats. Numerous streams in the watersheds of all the water reservoirs in the region would be expected to represent this condition in most years. Elsewhere the extent of vegetation clearance and associated agricultural development are likely to cause significant nutrient enrichment and sediment effects, and result in poorer ratings being assigned.	Moderate nutrient enrichment: likely to commonly occur in the region due to the extent of vegetation clearance and associated agricultural development.	Gross nutrient enrichment or degradation: likely to commonly occur in the region due to the extent of vegetation clearance and associated agricultural and urban development. Ephemeral and saline streams in the region are likely to show extensive enrichment effects due to the lack of substantial dilution flows in most years.	Severely altered: may occur in the region in urban stream reaches, downstream from wastewater discharges and highly degraded ephemeral and more permanent streams in extensively cleared agricultural settings. Sites assigned to this rating will be affected by a toxicant or other disturbance that significantly limits the diversity and abundance of aquatic life present in a stream.

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
Biological assemblages	Native assemblages of plants and animals; usually with many rare, uncommon, sensitive or habitat specialist species present; typically high Ephemeroptera, Plecoptera and Trichoptera (EPT) richness; no symptoms of stress or introduced aquatic species present. Note that temporary and ephemeral habitats may have a low EPT assemblage (eg only include *Cloeon* and/or *Tasmanocoenis*) but provide habitat for a rich range of colonising insects (eg beetles, waterbugs and dipterans), with abundances of all species generally low.	Best of what is left, least disturbed assemblages; high richness; rare, uncommon, sensitive and specialist taxa may dominate abundances or be comparable to generalists and tolerant species; may include introduced species but if present, only in low abundances.	Typical assemblages for least impacted streams; good richness and abundances; generalist and tolerant species often numerically dominate the assemblage that includes at least some rare, uncommon, sensitive or specialist species in low abundances; emerging symptoms of stress in relation to nutrients and fine sediments (eg increase in organic feeding invertebrates and algal and macrophyte indicators); at least some remnant native vegetation present.	Impaired assemblages; generalists and tolerant taxa dominate and assemblage usually includes some very abundant taxa (enrichment response); specialist, sensitive, uncommon and rare taxa, if present, usually occur in very low numbers but may include a riffle specialist in high numbers; usual absence of some taxa expected for the available habitats present; at least some trees present in the local catchment and on the banks.	Degraded assemblages; tolerant and generalist species dominate but numbers usually reduced, although a few tolerant taxa may be present in very high abundances; only 1–2 rare, uncommon or sensitive species present in very low abundances or more usually absent; often only few scattered trees in the catchment and on the banks.	Severely degraded assemblages with few taxa and generally low abundances; may have large numbers of one or more tolerant taxa such as oligochaetes, mosquito larvae, amphipods (*Austrochiltonia*) or midges (eg *Chironomus, Procladius* or *Tanytarsus)*; can include organic feeders from highly polluted waters such as syrphid larvae; vegetation often completely comprised introduced species with little to no remnant native vegetation.

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
Water chemistry conditions	As naturally occurs: no human sources of contaminants present (eg nutrient enrichment, waste with high levels of hormones or traces of pharmaceuticals and artificial sweeteners) and not impacting on water quality.	Least disturbed, generally best of what is left in the region with associated good water quality; high proportion of natural features means waters are usually well oxygenated and low in nutrients and turbidity; may also be highly coloured naturally due to tannins from native vegetation (such waters usually have low pH and oxygen levels).	Largely unremarkable water quality 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 chlorophyll *a* >10 ug/L, filamentous algae >10% cover and/or macrophytes >35% cover) but site not overwhelmed.	Fair water quality with generally saturated dissolved oxygen (when sampled during the day); at least one nutrient present at high concentrations and high algal and higher plant growths (eg chlorophyll *a* >10 ug/L, filamentous algae >10% cover and/or macrophytes >35% cover) evident on occasions.	Poor water quality with generally saturated dissolved oxygen (when sampled during the day); nutrients present at high concentrations and high plant productivity always evident at the site (eg usually chlorophyll *a* >10 ug/L, filamentous algae >10% cover and macrophytes >35% cover) most of the time.	Very poor water quality with at least one parameter at a toxicant concentration that is likely to limit the aquatic diversity of the stream; often very low dissolved oxygen and may be saline and enriched with nutrients but algal and plant growth limited.
Physical habitat and flow patterns	Natural habitat and flow patterns; no or few farm dams present; range of sediment types present and not always anaerobic.	Near natural habitat and flow regimes; mostly well vegetated catchments with few dams present; range of sediment types present but may occasionally be anaerobic.	Good habitat structure and flow patterns; extent of dam development has not caused an obvious loss of riffle (flowing) habitats; range of sediment types present but may occasionally be anaerobic.	Fair habitat structure and flow patterns; many dams may be present in the catchment and likely to affect flow patterns, limiting riffle habitat extent and duration; anaerobic fine sediments usually present, except when large algal growths occur and oxygenate the sediments.	Poor habitat structure and flow patterns; may have many dams present in the catchment and obviously affect flow patterns (limited riffle extent and duration); anaerobic fine sediments usually present, except when large algal growths occur and oxygenate the sediments.	Severe modifications to physical habitat and flow patterns; unnatural flow patterns due to abstraction or discharges; little to no remnant native vegetation remaining; cleared agricultural or urban sites; anaerobic fine sediments, rip-rap or alien sediments often dominate on the margins of these stream types.

Rating	Excellent	Very Good	Good	Fair	Poor	Very Poor
Human activities and sources in the catchment	No obvious human disturbances but may include roads and sparse rural housing; no point sources or evidence of diffuse pollution detectable, largely due to the extent of native vegetation in each largely unmodified catchment.	No significant human disturbances but may include some rural housing and roads; no point source discharges and any diffuse pollution not obviously affecting the aquatic ecosystem due to the extent of native vegetation in each slightly modified catchment.	Effects of human disturbance becoming obvious on occasion; point sources may be present but do not dominate flows; good buffer zones and/or riparian vegetation present that help to mitigate diffuse pollution effects from surrounding land uses.	Point and/or diffuse source enrichment effects evident; riparian zone not as effective at mitigating nutrients and shading streams, and fine sediment typically entering these streams and smothering coarser sediment types.	Obvious point and/or diffuse source enrichment effects present; unbuffered channel with ineffective or no riparian vegetation remaining, other than introduced grasses and a sparse tree cover; major changes to catchment land use with little remnant vegetation remaining and agriculture and/or urban uses dominate.	Severe point and/or diffuse source effects that may include toxicant responses; effects dominate water quality and biological response with often little sign of the original waterway evident; unbuffered channel that has undergone extreme modifications in an agricultural or urban setting.

Table 2 List of biota expected to occur for each rating in the Kangaroo Island and Adelaide and Mount Lofty Ranges NRM regions

Streams in an Excellent condition probably no longer occur in either region but they would be expected to support some sensitive and rare species, similar to sites in very good condition, but have no introduced species present.

Rating	Very Good	Good	Fair	Poor	Very Poor
Attribute 1 – Rare and/or regionally endemic	Several taxa from the following list present, typically from flowing freshwater riffle habitats: **Acarina** Hygrobatidae (*Coaustraliobates*); **Ephemeroptera** *Tasmanophlebia*; **Plecoptera** *Newmanoperla thoreyi* **Trichoptera** *Ulmerochorema, Atriplectides dubius, Tasimia;* **Odonata** *Hemigomphus, Austrogomphus;* **Diptera** *Paracnephia*; Thaumaliidae (*Austrothaumalea*)	One or more taxa from the following list present, typically from flowing freshwater riffle habitats: **Acarina** Hygrobatidae (*Coaustraliobates*); **Ephemeroptera** *Tasmanophlebia*; **Plecoptera** *Newmanoperla thoreyi* **Trichoptera** *Ulmerochorema, Atriplectides dubius, Tasimia;* **Odonata** *Hemigomphus, Austrogomphus;* **Diptera** *Paracnephia*; Thaumaliidae (*Austrothaumalea*)	None present	None present	None present
Attribute 2 – Sensitive, rare or vulnerable specialist taxa with narrow environmental requirements	Several taxa from the following list present, typically from freshwater streams with a riffle-pool sequence in low to moderate numbers: **Acarina** Hygrobatidae (*Procorticacarus*); **Coleoptera** *Simsonia*; **Ephemeroptera** *Offadens*, *Nousia fuscula; Atalophlebia australasica;* **Plecoptera** *Illiesoperla* **Trichoptera**	One or more taxa from the following list present, typically from freshwater streams with a riffle-pool sequence in low numbers: **Acarina** Hygrobatidae (*Procorticacarus*); **Coleoptera** *Simsonia*; **Ephemeroptera** *Offadens*, *Nousia fuscula; Atalophlebia australasica;* **Plecoptera** *Illiesoperla* **Trichoptera**	Absent or low numbers of 1–2 taxa from the following list may be present: **Ephemeroptera** *Offadens*; *Atalophlebia australasica;* **Plecoptera** *Illiesoperla;* **Trichoptera** *Lingora* (sometimes in large numbers in riffles), *Triplectides similis, Taschorema;* **Diptera** and Chironomidae (*Riethia* and *Ablabesmyia)*	None present	None present

Rating	Very Good	Good	Fair	Poor	Very Poor
	Lingora (sometimes in large numbers in riffles), *Triplectides similis, Taschorema, Oxyethira columba;* **Diptera** and Chironomidae (*Riethia* and *Ablabesmyia*	*Lingora* (sometimes in large numbers in riffles), *Triplectides similis, Taschorema, Oxyethira columba;* **Diptera** and Chironomidae (*Riethia* and *Ablabesmyia)*			
Attribute 3 – Sensitive, ubiquitous taxa	Several taxa from the following list present, typically in low to moderate numbers: **Mollusca** *Austropygrus*; **Ephemeroptera** *Thraulophlebia, Atalophlebia australis*; **Plecoptera** *Dinotoperla, Austrocerca;* **Diptera** Dixidae (*Dixella*); Simuliidae (*Austrosimulium*), Empididae; Ceratopogonidae (*Ceratopogon, Forcipomyia*); Chironomidae (*Rheotanytarsus, Eukiefferella);* **Trichoptera** *Cheumatopsyche, Hellyethira, Lectrides*	One or more taxa from the following list present, typically in low to moderate numbers: **Mollusca** *Austropygrus*; **Ephemeroptera** *Thraulophlebia, Atalophlebia australis*; **Plecoptera** *Dinotoperla, Austrocerca;* **Diptera** Dixidae (*Dixella*); Simuliidae (*Austrosimulium*), Empididae; Ceratopogonidae (*Ceratopogon, Forcipomyia*); Chironomidae (*Rheotanytarsus, Eukiefferella);* **Trichoptera** *Cheumatopsyche, Hellyethira, Lectrides*	Absent or low numbers of 1–2 taxa from the following list may be present usually in low numbers: **Mollusca** *Austropygrus*; **Ephemeroptera** *Thraulophlebia, Atalophlebia australis*; **Plecoptera** *Dinotoperla, Austrocerca;* **Diptera** Dixidae (*Dixella*); Simuliidae (*Austrosimulium*), Empididae; Ceratopogonidae (*Ceratopogon, Forcipomyia*); Chironomidae (*Rheotanytarsus, Eukiefferella);* **Trichoptera** *Cheumatopsyche* (sometimes in large numbers in riffles), *Hellyethira, Lectrides*	Absent or low numbers of one of the following may be present: **Ephemeroptera** *Atalophlebia australis;* **Plecoptera** *Austrocerca;* **Trichoptera** *Cheumatopsyche* (sometimes in large numbers in riffles), *Hellyethira*	None present

Rating	Very Good	Good	Fair	Poor	Very Poor
Attribute 4 – Opportunistic or generalist taxa	Not numerically dominant but may include several taxa from the following list in low to moderate numbers: **Acarina** Oxidae*, Piona,* Oribatida; **Mollusca** *Ferrissia, Glyptophysa; Posticobia;* **Ephemeroptera** *Cloeon*, *Tasmanocoenis*; **Trichoptera** *Notalina*, *Oecetis, Triplectides, Ecnomus;* **Odonata** Aeschnidae, Telephlebiidae (*Austroaeschna*)*;* **Diptera** Chironomidae *(Paralimnophyes, Thienemaniella);* **Coleoptera** low numbers of dysticid, hydrophilid, hydraenid and scirtid beetle larvae and adults may be present	May numerically dominate or co-dominate with tolerant taxa, and include moderate numbers of several taxa of the following: **Acarina** Oxidae*, Piona,* Oribatida; **Mollusca** *Ferrissia, Glyptophysa; Posticobia;* **Ephemeroptera** *Cloeon*, *Tasmanocoenis*; **Trichoptera** *Notalina*, *Oecetis, Triplectides, Ecnomus;* **Odonata** Aeschnidae, Telephlebiidae (*Austroaeschna*)*;* **Diptera** Chironomidae *(Paralimnophyes, Thienemaniella);* **Coleoptera** low numbers of dysticid, hydrophilid, hydraenid and scirtid beetle larvae and adults may be present	Often abundant representation of several of the following commonly occurring taxa: **Acarina** Oxidae*, Piona,* Oribatida; **Mollusca** *Ferrissia, Glyptophysa; Posticobia;* **Ephemeroptera** *Cloeon*, *Tasmanocoenis*; **Trichoptera** *Notalina*, *Oecetis, Triplectides, Ecnomus;* **Odonata** Aeschnidae, Telephlebiidae (*Austroaeschna*)*;* **Diptera** Chironomidae *(Paralimnophyes, Thienemaniella);* **Coleoptera** dysticid, hydrophilid, hydraenid and scirtid beetle larvae and adults may be present	Often high numbers of several of the following commonly occurring taxa: **Acarina** Oxidae*, Piona,* Oribatida; **Mollusca** *Ferrissia, Glyptophysa; Posticobia;* **Ephemeroptera** *Cloeon*, *Tasmanocoenis*; **Trichoptera** *Notalina*, *Oecetis, Triplectides, Ecnomus;* **Odonata** Aeschnidae, Telephlebiidae (*Austroaeschna*)*;* **Diptera** Chironomidae *(Paralimnophyes, Thienemaniella);* **Coleoptera** dysticid, hydrophilid, hydraenid and scirtid beetle larvae and adults may be present	Low diversity and abundance, often including the following taxon: **Coleoptera** *Necterosoma* larvae and adults
Attribute 5 – Tolerant taxa	Low numbers of several taxa, always in low numbers, from the following list: **Turbellaria**; **Nematoda; Oligochaeta; Acarina** (*Arrenurus, Koenikea*); **Amphipoda** *Austrochiltonia*; Corophiidae; **Decapoda** *Paratya, Cherax;* **Diptera** *Simulium ornatipes,* Culicidae, Ceratopogonidae	May numerically dominate or be co-dominant with generalist taxa, and include several of the following: **Turbellaria**; **Nematoda; Oligochaeta; Acarina** (*Arrenurus, Koenikea*); **Amphipoda** *Austrochiltonia*; Corophiidae; **Decapoda** *Paratya, Cherax;* **Diptera** *Simulium ornatipes,*	Usually numerically dominate the community, with at least one highly abundant taxon, from the following list: **Turbellaria**; **Nematoda; Oligochaeta; Acarina** (*Arrenurus, Koenikea*); **Amphipoda** *Austrochiltonia* (high numbers); Corophiidae; **Decapoda** *Paratya, Cherax;* **Diptera** *Simulium ornatipes*	Usually dominate the community with high abundances of several of the following taxa: **Turbellaria**; **Nematoda; Oligochaeta; Acarina** (*Arrenurus, Koenikea*); **Amphipoda** *Austrochiltonia* (often high numbers); Corophiidae; **Decapoda** *Paratya, Cherax;* **Diptera**	Dominate and often comprise the entire community, with low or high numbers of the following taxa: **Oligochaeta** (often in high numbers)**; Amphipoda** *Austrochiltonia*; **Diptera** Culicidae, Stratiomyidae, Ceratopogonidae (*Bezzia, Culicoides*), Chironomidae

Rating	Very Good	Good	Fair	Poor	Very Poor
	(*Alluauodomyia, Dasyhelea, Nilobezzia, Bezzia, Culicoides*), Chironomidae (*Procladius, Paramerina, Parametriocnemus, Cricotopus, Chironomus, Dicrotendipes);* Stratiomyidae; Tipulidae; **Hemiptera** (low numbers of *Microvelia, Micronecta, Agraptocorixa, Anisops, Enithares);* **Odonata** *Austrolestes*	Culicidae Ceratopogonidae (*Alluauodomyia, Dasyhelea, Nilobezzia, Bezzia, Culicoides*), Chironomidae (*Procladius, Paramerina, Parametriocnemus, Cricotopus, Chironomus, Dicrotendipes);* Stratiomyidae; Tipulidae; **Hemiptera** (usually low to moderate numbers of *Microvelia, Micronecta, Agraptocorixa, Anisops, Enithares);* **Odonata** *Austrolestes*	(often high numbers), Culicidae (often moderate numbers), Ceratopogonidae (*Alluauodomyia, Dasyhelea, Nilobezzia, Bezzia, Culicoides*), Chironomidae (*Procladius, Paramerina, Parametriocnemus, Cricotopus, Chironomus, Dicrotendipes);* Stratiomyidae; Tipulidae; **Hemiptera** (often moderate to high numbers of *Microvelia, Micronecta, Agraptocorixa, Anisops, Enithares);* **Odonata** *Austrolestes*	*Simulium ornatipes* (often high numbers), Culicidae (high numbers), Ceratopogonidae (*Alluauodomyia, Dasyhelea, Nilobezzia, Bezzia, Culicoides*), Chironomidae (*Procladius, Paramerina, Parametriocnemus, Cricotopus, Chironomus, Dicrotendipes);* Stratiomyidae; Tipulidae; **Hemiptera** (often moderate to high numbers of *Microvelia, Micronecta, Agraptocorixa, Anisops, Enithares);* **Odonata** *Austrolestes*	(*Procladius*, *Chironomus*; sometimes in large numbers); **Hemiptera** *Micronecta, Anisops, Enithares*
Attribute 6 – Non-endemic or introduced taxa	Absent or low numbers of the following: **Mollusca** *Physa* and *Potamopyrgus*; **Decapoda** *Cherax cainii* (previously assumed to be *C tenuimanus*)	Absent or present in low to moderate numbers of the following: **Mollusca** *Physa* and *Potamopyrgus*; **Decapoda** *Cherax cainii*	Absent or often present in moderate to high numbers of the following: **Mollusca** *Physa* and *Potamopyrgus;* **Decapoda** *Cherax cainii*; **Fish** *Gambusia*	Absent or often present in high numbers of the following: **Mollusca** *Physa* and *Potamopyrgus* in moderate to high numbers*;* **Fish** *Gambusia*	Absent or low numbers of the following: |**Mollusca** *Physa;* **Fish** *Gambusia* (rarely present due to poor water quality)

Note the following were not found in spring 2018 but have been recorded from previous sampling in the Mount Lofty Ranges and Kangaroo Island regions: **Hydracarina** *Australiobates*; **Coleoptera** *Sclerocyphon*; **Ephemeroptera** *Centroptilum*; **Plecoptera**, *Leptoperla* and *Riekoperla*; **Trichoptera** *Leptorussa, Orthotrichia* and *Apsilochorema;* **Odonata** *Synthemis, Ischnura*; **Diptera** *Simulium melatum*; and **Hemiptera** *Hydrometra.*

Table 3 Condition ratings given by each panel member and final overall rating for the 30 sites assessed from the Kangaroo Island and Adelaide and Mount Lofty Ranges NRM regions during 2018

Included for comparison are the expected condition ratings for each site based on map-based variables (Tier 1 ratings).

Note: For site codes and NRM region, refer to the EPA website for the map coordinates and the reports.

[1] denotes the habitats at each site,eg if edge (E) only or if both edge and riffle (ER) aquatic habitats were present

Site code	Site name	Tier 1 rating	Habitats[1]	Very Good	Good	Fair	Poor	Very Poor	Final rating
CYR 0501.KI	Tributary of Cygnet River, Bark Hut Rd	Poor	ER			1	2		**Poor**
CYR 1301.KI	Tributary of Cygnet River, Pioneer Bend Rd	Fair	E			2	1		**Fair**
CYR 1401.KI	Cygnet River, Huxtable Forest	Fair	ER (2 m)			3			**Fair**
CYR 3501.KI	Cygnet River, Turkey Lane Crossing	Good	E			3			**Fair**
CYR 5101.KI	Gum Creek, Lower Gum Ck	Poor	E				3		**Poor**
HR 0501. KI	Harriet River, Harriet Rd	Poor	E			3			**Fair**
MR 0701.KI	Middle River, d/s reservoir	Good	E		1	2			**Fair**
MR 0901.KI	Middle River, Johncock Rd	Good	ER		3				**Good**
MR 1401.KI	Middle River, Coopers Rd	Good	ER		3				**Good**
WR 0201.KI	Wilson River, Mouth Flat Rd	Poor	ER			3			**Fair**
SWR 1101.KI	South West River, W Kelly Lodge	Fair	ER (8 m)		3				**Good**
Rocky Rvr02.KI	Rocky River, East Melrose Track	Good	ER	3					**Very Good**
CYR 0301.KI	Tributary of Cygnet River, d/s Springs Rd	Fair	E		1	2			**Fair**
TC 1201.KI	Timber Creek, South Coast Rd and Birchmore Rd	Poor	E			2	1		**Fair**
SBR 1001.KI	North-East River in Stun'Sail Boom catchment, Gosse-Ritchie Rd	Fair	ER (5 m)		2	1			**Good**

Site code	Site name	Tier 1 rating	Habitats[1]	Very Good	Good	Fair	Poor	Very Poor	Final rating
c0226. AMLR	First Creek, Tunkalilla Rd	Very Good	ER	3					**Very Good**
c0395. AMLR	Callawonga Creek, Callawonga	Good	ER		3				**Good**
c0466. AMLR	Callawonga Creek, N Taylors Rd	Good	ER (3m)	2	1				**Very Good**
c0467. AMLR	Tunkalilla Creek, private land near CP	Good	ER	1	2				**Good**
c0449. AMLR	Tunkalilla Creek, near Eric Bonython CP	Good	ER (3m)		3				**Good**
c0468. AMLR	Tunkalilla Creek, Waitpinga CP	Good	ER		3				**Good**
c0402. AMLR	Boat Harbour Creek, Boundary Track	Good	ER		3				**Good**
c0252. AMLR	First Creek, Waterfall Gully d/s waterfall	Good	ER	1	2				**Good**
c0393. AMLR	First Creek, u/s waterfall in Cleland CP	Very Good	ER	3					**Very Good**
c0248. AMLR	Sixth Creek, near Castambul	Good	ER		3				**Good**
c0391. AMLR	North Para River, u/s weir Chateau Yaldara	Fair	ER			3			**Fair**
C0464. AMLR	Little Para River, One Tree Hill Rd	Fair	ER			3			**Fair**
C0471. AMLR	Brownhill Creek, d/s Tilleys Hill Rd	Fair	ER		3				**Good**
C0394. AMLR	Brownhill Creek, d/s caravan park	Fair	E			3			**Fair**
C0401. AMLR	Pedler Creek, Stump Hill Rd	Poor	E				3		**Poor**

Table 4 Summary of condition ratings for Kangaroo Island and Western Mount Lofty NRM regions

Condition rating	Kangaroo Island # sites (%)	Adelaide and Mount Lofty Ranges # sites (%)
Excellent	0	0
Very Good	1 (7%)	3 (20%)
Good	4 (27%)	8 (53%)
Fair	8 (53%)	3 (20%)
Poor	2 (13%)	1 (7%)
Very Poor	0	0
TOTAL	15	15

Table 5 Water chemistry and algal summary statistics from sites sampled from Kangaroo Island and the Western Mount Lofty Ranges in spring 2018 (units given are mg/L unless otherwise indicated)

Parameter	Kangaroo Island (n=15 wet sites)				Western Mount Lofty Ranges (n=15 wet sites)			
	mean	25th percentile	50th percentile	75th percentile	mean	25th percentile	50th percentile	75th percentile
Chlorophyll *a* (ug/L)	3.7	0.5	1.5	5.8	1.7	0.6	1.2	1.8
Chlorophyll *b* (ug/L)	2.3	0.6	1.5	3.9	1.4	0.1	0.5	1.1
Oxidised N (NOx)	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.1
Total nitrogen	1.1	0.8	0.9	1.1	0.6	0.3	0.7	0.9
Total phosphorus	0.03	0.02	0.03	0.04	0.05	0.02	0.03	0.04
Water temperature (°C)	17.2	15.9	16.6	18.4	15.0	13.1	14.7	15.6
Conductivity (uS/cm)	5,697	1,201	3,815	8,176	645	263	312	562
Dissolved oxygen	6.2	4.5	5.1	7.7	8.7	8.5	9.3	9.6
pH (pH units)	7.4	7.2	7.4	7.6	7.6	7.4	7.5	7.7