ISC Scoring

1. Introduction

The ISC is an integrated measure of river health and has five components (sub-indices):

- Hydrology
- Physical form
- Streamside zone
- Water quality
- Aquatic life

Each of the components is given a score between 0 and 10 based on the assessment of a number of indicators. For information on the indicators for each of the sub-indices please refer to the relevant sub-index fact sheet. The overall ISC score is the sum of the sub-index scores and is between 0 and 50; the higher scores indicating better condition.

2. Calculation of ISC score

2.1 Pro rata score calculation

It is not always possible to calculate the score for each sub-index, especially water quality and aquatic life. This is caused by the limited amount of data available. There are approximately 1100 ISC reaches across the State and 183 water quality stations and 414 sites assessed for aquatic life. When a sub-index score is not available, the overall ISC score is calculated based on those sub-index scores that are available. These missing sub-index scores are calculated based on a pro rata basis. At least three Sub-index scores are required to allow the pro rata scores to be calculated. Table 1 gives an example.

To calculate the 2 missing sub-index scores (Water Quality and Aquatic Life) in the above example, undertake the following steps:

Step 1:
Calculate total pro rata score:
Total pro rata score = 5/3 x (sum of existing sub-index scores)
Total pro rata score = 5/3 x (10 + 7 + 6)
Total pro rata score = 38.33
(If you are only missing 1 sub-index score, use 5/4 instead of 5/3 in step 1.)

Step 2:
Calculate pro rata score for Water Quality and Aquatic Life:
Sub-index Pro rata score = ((total pro rata score calculated in step 1 above) – (sum of existing sub-index scores))/2
(If you only need to calculate one sub-index score, then do not divide by 2 in step 2)
Pro rata score = ((38.33 – (10 + 7 + 6))/2
Pro rata score = 7.666

Step 3:
Round off score:
Pro rata score = 8

Therefore:
Sub-index score for:
Water Quality = 8
Sub-index score for:
Aquatic Life = 8

There are now scores for all five Sub-indices and an overall ISC score can be calculated. If a score is a pro rata score, this is always indicated by an asterix (Table 2).

2.2 Final ISC score

The final ISC score is not simply an addition of the 5 sub-index scores. A transformation known as an inverse ranking is applied to calculate the final score out of 50. The following example shows the procedure used to calculate the final ISC score, based on an inverse ranking calculation.

The inverse ranking recognises that a particularly low score in one sub-index may have a limiting effect on river health even if the other sub-indices score highly. In these cases, the inverse ranking transformation results in a lowered ISC score.

Taking the above example, the five sub-index values in table 2 are: 10, 7, 6, 8, 8. (All five sub-index scores are required to do this calculation).

Step 1:
Place the sub-index scores in ascending order. The smallest value is then multiplied by 5, the next largest value by 4… and the largest value by 1.

6 x 5 = 30
7 x 4 = 28
8 x 3 = 24
8 x 2 = 16
10 x 1 = 10

Step 2:
Add the 5 sub-index totals together and divide the grand total by 3
Final score = (30 + 28 + 24 + 16 + 10)/3
Final score = 36

Step 3
Round off final score (if necessary)

Condition class

Once the score out of 50 has been calculated, the reach can then be assigned a condition class rating (Table 3). The condition class is a summary of the overall condition of the reach. It should be noted that the condition class is useful for an overview, but it is the sub-index scores and its individual indicator values that hold the major information.

In the above example the final ISC score was 36. The condition class rating would therefore be ‘Good’.

Table 1
Example of missing Sub-index scores, (Water Quality and Aquatic Life)

Hydrology	Streamside zone	Physical form	Water quality	Aquatic life
10	7	6	–	–

Table 2
Example of reach Sub-index scores, with pro rated Water Quality and Aquatic Life scores (*pro rata scores)

Hydrology	Streamside zone	Physical form	Water quality	Aquatic life
10	7	6	8*	8*

Table 3
Overall ISC classification scheme

Overall ISC Score	Stream Condition
0-12	Very Poor
13-17	Poor
18-28	Moderate
29-36	Good
37-50	Excellent

Hydrology Sub-index

1. Hydrology indicators

The Hydrology Sub-index has 5 indicators:

- Variability
- High flow
- Low flow
- Zero flow
- Seasonality

The Hydrology sub-index involved the collection of a large amount of data. This included data on monthly streamflow (both current and natural). The derivation of this data took into consideration the impacts of all rural and urban demands (at the current level of development), private diverters, and farm dams.

Streamflow data was required to determine current and unimpacted or natural flows for each site. This data was derived from gauged records, streamflow models or rainfall runoff models developed for previous studies. Where no gauged data or model data was available for a particular site, it was transposed from another comparable site for which information was available.

A minimum of 15 years of monthly data was required.

1.1 Variability Index

This index reflects variability in monthly streamflows. Seasonal variation in flow is relatively predictable and acts as an important hydrological driver of aquatic ecosystems. Rises in water levels are known to provide important life-history cues for many plant and animal species.

1.2 High Flow Index

The high flow index measures the highest and second highest monthly flows in a year.

Flood flows determine the maximum depths, velocities and shear stresses that occur in a river system. High flows drive geomorphic process in rivers through transporting and depositing sediment and altering channel form. High flows act as a natural disturbance in river systems, removing vegetation and organic matter and resetting successional processes. A reduction in the magnitude of flood flows is likely to correspond with a reduction in overbank flows, important in providing connectivity between rivers and their floodplains.

1.3 Low Flow Index

The low flow index is a measure of the change in low flow magnitude under current and natural conditions and measures the lowest and second lowest monthly flows in a year. Low flow periods are a natural feature of Australian river systems but are generally regarded as a period of high stress for aquatic biota. Increasing the magnitude of low flows reduces the availability of in-stream habitat, which can lead to a long term reduction in the viability of populations of flora and fauna.

1.4 Zero Flow Index

This index measures the proportion of time that the stream is dry (or nearly so). Periods of zero flow are a natural feature of ephemeral rivers and creeks, however increases in the natural duration of cease to flow periods are regarded as harmful to aquatic ecosystems. In many ways they can be regarded as extreme low flow periods when habitat availability is restricted and water quality prone to deterioration. Extended cease to flow periods can result in partial or complete drying of the channel. This can lead to loss of connectivity between pools and even complete loss of aquatic habitat. Under natural conditions aquatic biota are able to recolonise dried sections of creek channels once flows return.

1.5 Seasonality Index

The seasonality index is a measure of the shift in the maximum flow month and the minimum flow month between natural and current conditions. Floods stimulate biological productivity in aquatic ecosystems, while low flows are a time of reduced biological productivity.

The timing of periods of flooding and low flow has an important influence on how floodplain and riverine ecosystems respond. In temperate Australia, plants and animals are generally adapted to the natural occurrence of floods in winter/spring and low flows in summer/autumn. Changes to these flow patterns, such has occurred though regulation, are thought to have caused significant changes in some communities.

2. Calculating the Hydrology sub-index

Each of the five index values range between 0 (stressed) and 10 (pristine). Each of the above indices can be calculated for summer, winter, and annually, except the seasonality index which can only be calculated on an annual basis. Each index compares the current condition to its natural condition.

The Hydrology Sub-index score is calculated out of 10 according to the following formulae:

Hydrology sub-index = (Low Flow + High flow + Zero Flow + Variability + 2(Seasonality))/6

The final hydrology sub-index score is based on a uniform weighting of the individual indices, except the seasonality index, which is given twice the weight of the other individual indices. The justification for adoption of the 'seasonally-weighted' score is essentially that it combines the flow stress attributes of five ecologically important flow components that have been shown to be highly correlated with a wide range of flow characteristics. The additional weighting given to the seasonality index merely ensures that highly impacted regulated rivers – that is those rivers that exhibit marked seasonal flow reversal but which still experience high flows associated with irrigation releases – are appropriately ranked.

This score is then 'standardised'. That is, a score of 7 indicates that 70% of Victorian catchments are more stressed than the catchment under consideration, and a score of 5 indicates a 'typical', or median (50%) level of hydrological stress.

Physical Form Sub-index

1. Physical form indicators

The physical form sub-index has 3 indicators:

- Impact of artificial barriers on fish migration
- Large wood
- Bank stability

1.1 Impact of artificial barriers on fish migration

Ratings for the impact of artificial barriers on fish migration (Table 1) are based on how often a barrier is drowned out (ie. has water flowing over the top of the barrier). It is measured at the reach scale.

1.2 Large Wood

The large wood ratings (Table 2) take into account the presence of in-stream large wood (logs or trees that have fallen into the stream), by taking note of how much large wood there is and whether it is native or exotic (such as willows). Native large wood is more valuable than exotic large wood as it breaks down slowly and provides a more natural instream habitat. It is measured at the measuring site scale.

1.3 Bank stability

Bank stability ratings (Table 3) take into account the amount of bare banks, amount of erosion as well as the bank shape and density of exposed roots. It is measured at the transect scale.

2. Calculating the Physical Form Sub-index score

Step 1
Determine the fish barrier rating for the reach.

Step 2
Calculate the average large wood score.

Step 3
Determine the minimum bank stability score from the transect scores (to ascertain the worst case scenario for the site). This score is used to represent bank stability for the measuring site.

Step 4
Calculate the physical form score for the reach out of 10 using the following formulae:

Physical form sub-index = 10/8 x (((large wood score + fish barrier score)/2) + bank stability score)

Table 1
Ratings for the impact of artificial barriers on fish migration indicator

Category	Rating
In a typical year, no artificial barriers in the basin downstream of the reach interfere with the migration of any indigenous fish species endemic to the stream. Artificial barriers may be present if they are: • dams or weirs with well functioning fishways; or • instream structures (e.g. a low level rock ford) that are always drowned out for at least at some stage of each day (e.g. every tidal cycle).	4
In a typical year, at least one artificial barrier in the basin downstream of the reach completely blocks the migration of indigenous fish species. Examples of artificial barriers in this category include: • high dams without fishways; and • straightened concrete-lined channels in which the flow is always too shallow or too fast for fish to migrate.	0
Situations where there are artificial barriers in the basin downstream of the reach that do not fit into the above two categories. Examples of artificial barriers in this category include: • fishways that only provide intermittent opportunities for fish passage; • weirs or grade control structures that can be drowned out during higher flows in a typical year; and • concrete-lined channels in which the flow is sometimes deep and slow enough to allow indigenous fish to migrate.	2

Table 2
Ratings for the Large Wood indicator.

Description	Rating
Excellent habitat Typical features: abundant wood from indigenous species. Site probably never desnagged and streamside vegetation probably never cleared.	4
Good habitat Typical features: numerous pieces of large wood from indigenous species. Perhaps limited large wood from exotic species present also. Limited impact of desnagging or streamside vegetation clearing.	3
Moderate habitat Typical features: moderate visible pieces of large wood from indigenous species in channel, or abundant pieces of exotic large wood in channel; moderate impact of desnagging or streamside vegetation clearing.	2
Poor habitat Typical features: few visible pieces of large wood in channel (either from indigenous or exotic species).	1
Very poor habitat Typical features: no large wood visible.	0

Table 3
Ratings for assessing bank stability

Description	Rating
Stable Typical features: very few local bank instabilities, none of which are at the toe of the bank' continuous cover of woody vegetation; gentle batter; very few exposed roots of woody vegetation; erosion resistant soils.	4
Limited erosion Typical features: some isolated bank instabilities, though generally not at the toe of the bank; cover of woody vegetation is nearly continuous; few exposed roots of woody vegetation.	3
Moderate erosion Typical features: some bank instabilities that extend to the toe of the bank (which is generally stable); discontinuous woody vegetation; some exposure of roots of woody vegetation.	2
Extensive erosion Typical features: mostly unstable toe of the bank; little woody vegetation many exposed roots of woody vegetation.	1
Extreme erosion Typical features: unstable toe of bank; no woody vegetation; very recent bank movement (trees may have recently fallen into stream); steep bank surface; numerous exposed roots of woody vegetation; erodible soils.	0

Streamside Zone sub-index

1. Streamside zone indicators

The streamside zone has 9 indicators:

- Width
- Large trees
- Understorey lifeforms
- Recruitment
- Longitudinal continuity
- Tree canopy
- Litter
- Logs
- Weeds

The streamside zone assessment is based on a comparison between the current condition of a site compared with its Ecological Vegetation Class benchmark (EVC). An EVC is a vegetation community that is defined by its plant species and its location in the landscape, and is what it would look like in its long undisturbed condition. In other words, the EVC benchmark is the reference condition for the vegetation being assessed. The ISC is only concerned with riparian EVCs. The EVCs for Victoria are available on the internet; go to www.dse.vic.gov.au and click on the Conservation and Environment Link.

1.1 Width

Width of the streamside zone is assessed in relation to the width of the stream. The wider the stream, the wider the streamside zone would be in its natural condition.

1.2 Large trees

The number of large trees within the streamside zone are counted. Large trees are defined by a minimum trunk diameter, which is given in the EVC benchmark.

1.3 Understorey lifeforms

The understorey indicator is an estimate of the understorey diversity of native plants. Life forms are defined as groupings of plant species that share a similar three-dimensional structure and overall dimensions. The ISC uses 16 lifeform groupings.

1.4 Recruitment

Recruitment is a measure of the number of immature plants in relation to the number of mature plants. For recruitment to be considered present, the number of immature plants must equal at least 10% of the number of mature plants.

1.5 Longitudinal continuity

Longitudinal continuity has two components:

(a) proportion of stream bank length which is vegetated (includes native and exotic vegetation); and

(b) the number of significant discontinues per unit length. A significant discontinuity is defined as a gap in the streamside vegetation of 10m or greater.

1.6 Tree canopy

Canopy trees are defined as the uppermost stratum of woody vegetation that contributes to or forms the vegetation 'canopy'. Trees contributing to the canopy layer are defined as those reaching 80% or more of their mature height, which is defined within the EVC benchmark.

1.7 Organic litter

Litter is defined as any organic material detached from the parent plant, including both coarse and fine plant debris, and material such as fallen leaves, twigs and small branches less than 10cm diameter present at ground level.

The organic litter indicator is the percentage cover of organic litter on the ground within the streamside zone. Litter from native species is more important than litter from exotic species.

1.8 Logs

Logs are defined as fallen timber on the ground (substantially detached from the parent tree) with a diameter greater than 10cm.

The logs indicator is the total cumulative length of logs in the streamside zone.

Large logs are also considered in addition to overall log length and are defined as logs that have a diameter of at least half the large tree diameter.

1.9 Weeds

The cover of weeds (exotic or non-native vegetation) is assessed in each of the three structural layers of vegetation (i.e. tree layer, shrub layer and ground layer).

2. Calculating the Streamside Zone Sub-index

2.1 Weightings

Not all the streamside zone indicators carry the same weight in the calculation of the sub-index. The weightings for each variable is given in Table 1.

The Streamside zone sub-index score is calculated out of 10 using the following formulae:

SZ = (US + W + LC + Wd + LT + R + TC + LIT + LOGS) / 10

2.2 Cleared reaches

Some reaches are assessed as 'cleared'. This means that they are largely devoid of native vegetation and their EVC can not be determined. In these cases only 3 indicators are measured: Width, Longitudinal Continuity, and Weeds. The maximum score possible for cleared reaches is 4 and the following formulae is used:

SZ = (W + LC + Wd) / 10

2.3 Reaches which contain an EVC with no large trees.

For reaches which contain an EVC with no Large Trees then the following Streamside Zone parameters do not apply: Large Trees, Tree Canopy, and Logs. The following formulae is used:

SZ = (US + W + LC + Wd + R + LIT) / 8

Table 1
Weightings for the streamside zone variables

Component	Code	Weighting (%)
Understorey	US	25
Weeds	W	15
Longitudinal Continuity	LC	12.5
Width	Wd	12.5
Large Trees	LT	10
Recruitment	R	10
Tree (Canopy) Cover	TC	5
Organic Litter	LIT	5
Logs	LOGS	5
Total		100

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Water Quality Sub-index

1. Water Quality indicators

The Water Quality Sub-index has four indicators:

- Total Phosphorus
- Turbidity
- Electrical Conductivity (EC)
- pH

The water quality sub-index assessment is based on five years of monthly water quality sampling. The water quality data is taken from the Victorian Water Quality Monitoring Network (VWQMN). The network has 183 water quality stations across the State.

2. Regionalisation

The EPA has divided the State into regions based on specific water quality indicators. The regionalisation process involved the classification of sites using a combination of numerical and qualitative (expert judgement) methods. The regionalisation for each of the four water quality indicators is given in Figures 1-4.

Following the development of the regionalisation, water quality objectives were developed for each region based upon the minimally impacted or best available reference sites from each region.

3. Ratings

Ratings or scores are determined by comparing measurements of actual stream water quality with defined 'reference' water quality for the relevant region. The greater the departure from reference conditions the lower the rating.

4. Calculating the Water Quality Sub-index

The water quality rating for a monitoring site uses the 75th percentile for total phosphorus, turbidity and EC and the 25th and 75th percentiles for pH.

The percentile value for each indicator is assigned a rating by comparison to reference condition for its water quality region using the ratings given in Table 1.

The total sub-index score is a score out of 10 and is calculated by summing the scores (0-4) for each of the 4 indicators as in the following formula:

Water quality sub-index = 10/16 x (Total Phosphorus rating + Turbidity rating + EC rating + pH rating)

Table 1
Five point rating system

Category	Rating
High quality reference state	4
Acceptable reference state	3
Moderate modification from reference state	2
Major modification from reference state	1
Extreme modification from reference state	0

Figure 1
Regionalisation for EC

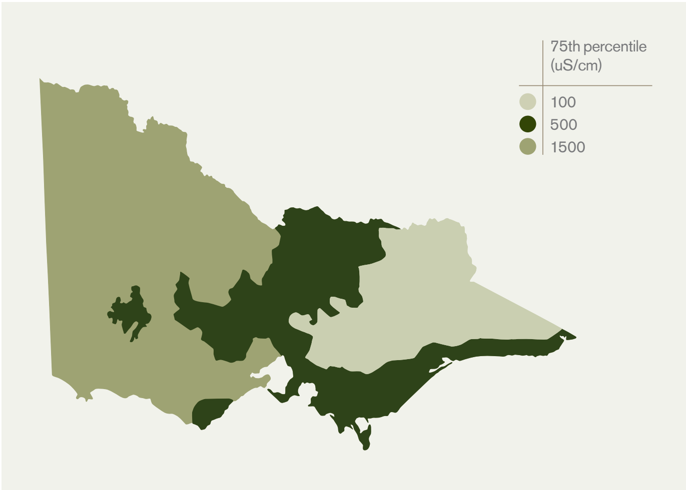

Figure 2
Regionalisation for Turbidity

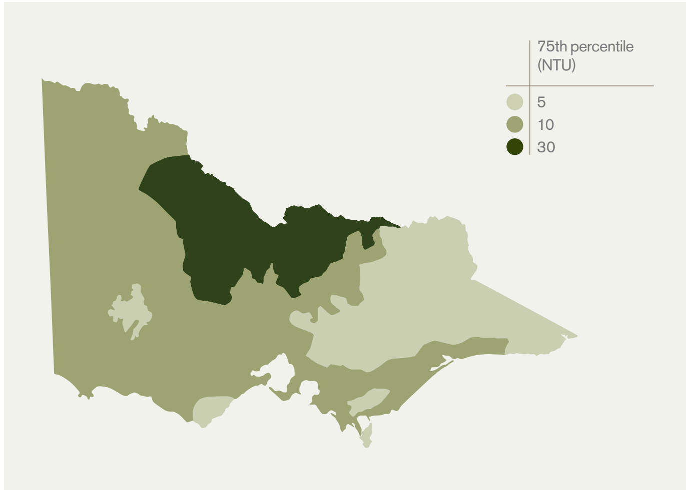

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Figure 3
Regionalisation for pH

25th percentile	75th percentile
6.4	7.7
6.5	8.3

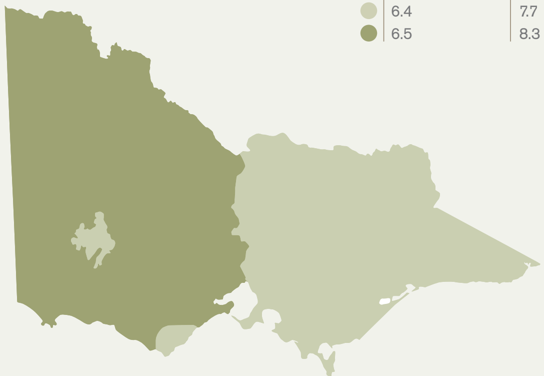
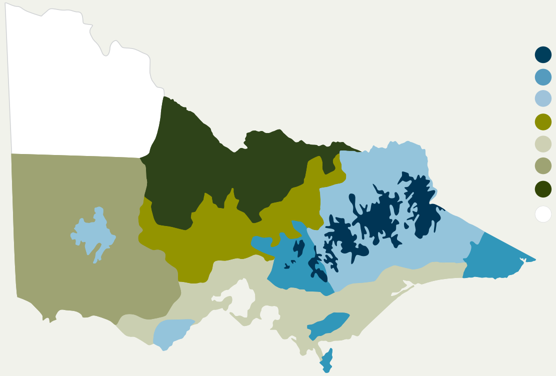


Figure 4
Regionalisation for Total Phosphorus

Nutrient Region	75th percentile Total P (ug/l)	75th percentile Total N (ug/l)
N1 – Highlands	20	150
N2 – Closed Forest Foothills	25	500
N3 – Open Forest Foothills	25	350
N4 – Cleared Hills	25	600
N5 – Coastal Plains	45	600
N6 – Western Plains	40	900
N7 – Murray Plains	45	900
Unclassified		



Index of Stream Condition:
The Second Benchmark of
Victorian River Condition

Aquatic Life Sub-index

1. Aquatic Life indicators

The aquatic life sub-index is based on aquatic macroinvertebrates and has two indicators: AUSRIVAS and SIGNAL.

Aquatic macroinvertebrates were collected using EPA's standard Rapid Bioassessment protocol. At each sampling site macroinvertebrates were collected from two habitats (riffle and edge) in autumn and spring. The results from the two seasons are combined.

1.1 AUSRIVAS

AUSRIVAS consists of a suite of mathematical models that predicts the macroinvertebrates that should be present in specific stream habitats under reference conditions. It does this by comparing a test site with a group of reference sites which are as free as possible of environmental impacts, but have similar physical and chemical characteristics to those found at the test site.

By comparing the macroinvertebrate families predicted to occur at a test site, in the absence of any environmental impacts, with the number of families actually found, the O/E index (observed number of families / expected number of families) can be calculated. The value of the O/E index can range from a minimum of zero (none of the expected families were found at the site) to one (all of the families which were expected were found). It is also possible to derive a score of greater than one, if more families were found at the site than were predicted by the model. A site with a score greater than one might be an unexpectedly diverse location or, more usually, the score may indicate mild nutrient enrichment, allowing additional macroinvertebrates to be present.

1.2 SIGNAL

SIGNAL (Stream Invertebrate Grade Number Average Level) has been accepted and used nationally in stream assessments. Families of aquatic invertebrates have been awarded sensitivity scores, according to their tolerance or sensitivity to various pollutants. The index is calculated by totalling these sensitivity scores and dividing by the total number of graded families present (the average score). The resulting value or SIGNAL can be used to assess a site's status in terms of pollution.

2. Calculating the Aquatic Life Sub-index score

2.1 Regionalisation

Victoria has been divided into biological regions based on aquatic macroinvertebrates (Figure 1) by the EPA. For each of the bioregions the EPA has defined the reference condition. The reference condition varies between bioregions due to natural differences in climate and topography across the state.

2.2 Rating table

For each site assessed, ratings are given to each of the two indicators (SIGNAL and AUSRIVAS). Each indicator is given a rating on a scale of 0-4 (Table 1).

The Aquatic Life Sub-index score is calculated out of 10 according to the following formulae:

Aquatic life sub-index = 10/8 (AUSRIVAS rating + SIGNAL rating)

Figure 1
Bioregions for Victoria

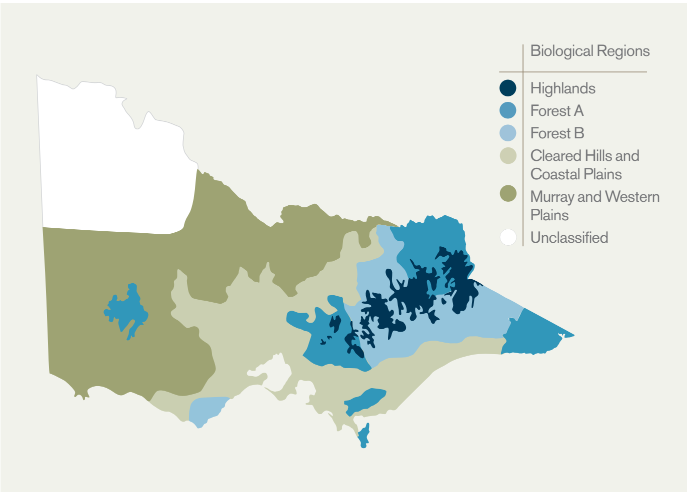


Table 1
Five point rating system for the Aquatic Life indicators

Category	Rating
High quality Reference state	4
Acceptable Reference state	3
Moderate modification from reference state	2
Major modification from reference state	1
Extreme modification from reference state	0