2023 Freshwater Report Card – Methodology Report

Tamar Estuary and Esk Rivers Program

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Document Information

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1 Introduction

This report provides an overview of the methodology used to derive grades for the Tamar Estuary and Esk Rivers (TEER) Program 2023 Freshwater Report Card. The methodology may evolve over time, but the general framework and approach is expected to remain consistent.

The grade-reporting methodology presented in this report has been designed specifically for the kanamaluka / Tamar estuary and Esk rivers catchment. The methodology is based on results from a desktop review of methodologies used for some other similar publications, feedback from expert members of the TEER Freshwater Report Card Working Group (FRCWG), and analysis of available data with due consideration given to restrictions and constraints presented by spatial and temporal data coverage.

The desktop review considered the approach used for a previously published kanamaluka / Tamar estuary and Esk rivers catchment Freshwater Report Card released in 2013, similar report cards developed for other catchments and literature concerning components of conceptual models describing freshwater ecosystem health. This suite of information was presented to the FRCWG for discussion, with a preliminary reporting framework, including direction on relevant indicators to explore and develop based on feedback received. Further exploration of datasets and literature, along with periodic review and input by the FRCWG, facilitated refinement of the methodology presented in this report. The TEER Program Communications Working Group was consulted for feedback on the contents and, in particular, presentation of information in the report card.

While this report presents details concerning the final grade-derivation and reporting methodology designed through this process, it does not outline the alternative methodologies considered along the way nor the reasons for which the final approach was ultimately selected.

2 Purpose of the Report Card

Published every four years, the TEER Freshwater Report Card is a simple snapshot of freshwater ecosystem condition designed for a general community audience. It aims to educate the community about environmental and ecological factors that may affect freshwater condition, with successive report cards ultimately providing an ongoing assessment of changes in condition through time.

3 Reporting Framework

There are a range of frameworks for assessing waterway health within the literature, varying from relatively simple to extremely complex (e.g., Karr, 1999; Ladson and White, 1999; NRM South, 2009). Most of these frameworks can be distilled to three key components, as illustrated in Figure 1:

- *Aquatic habitat*, in terms of extent, condition and connectivity. This is affected by factors such as flow regime, physical form and instream physical habitat (e.g., woody debris and snags), water quality, and barriers to the movement of aquatic species.
- *Riparian (riverbank) habitat*, in terms of extent, condition and connectivity. This affects stream-bank stability, shade and water temperature, and the suitability of stream reaches to animals and plants that use the edges for all or part of their life cycle.
- *Biodiversity* of aquatic- and freshwater-dependent species. This refers to the plant and animal species that form part of the waterway ecosystem.

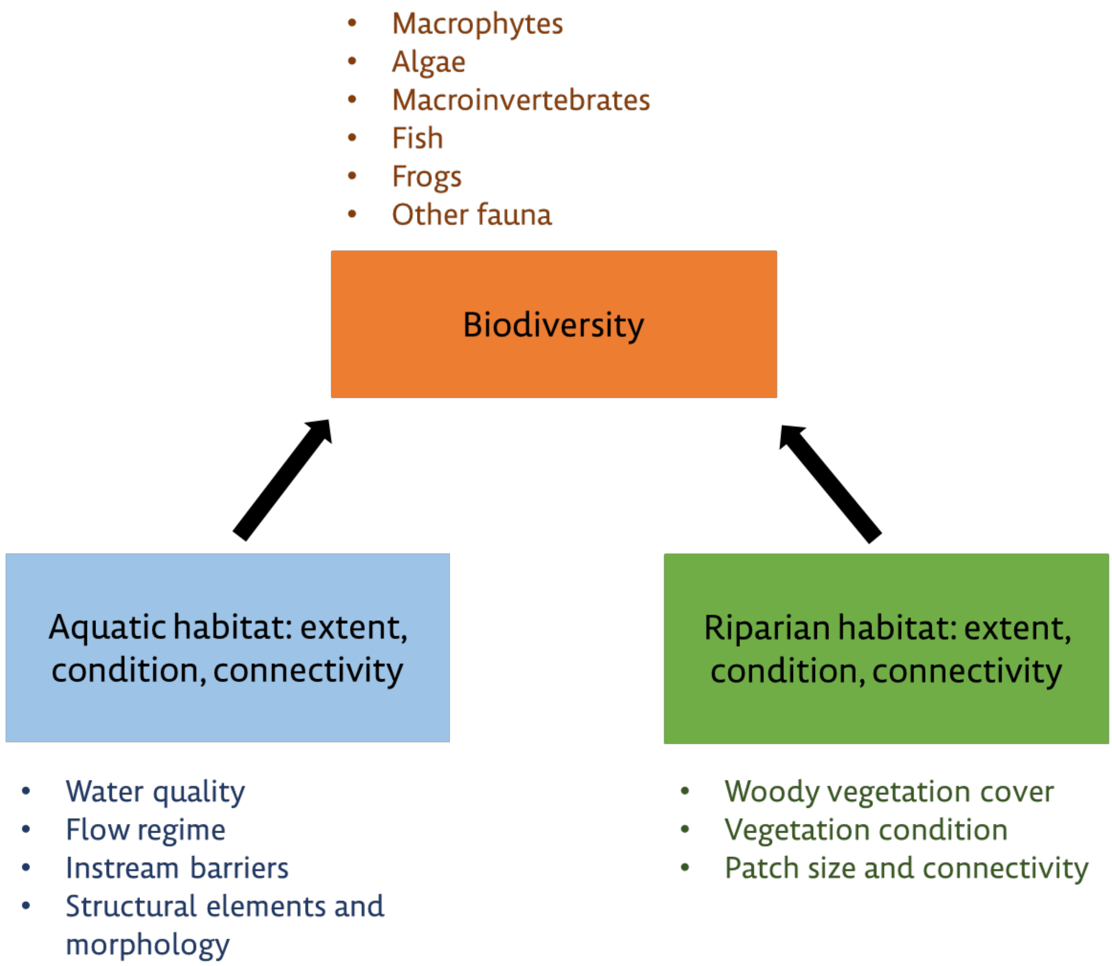

Figure 1. Key components of riverine health.

Habitat in the aquatic and riparian zones are interrelated. For example, degraded riparian zones impact on features of aquatic habitat such as water and sediment quality (including water temperature and light attenuation) and hydrology. Riparian habitat in turn relies on flow regimes, with native vegetation well adapted to a natural regime of flooding on inundation as well as periods of low or even no flow in some rivers. Key characteristics of aquatic habitat are flow regime, including frequency, duration and magnitude of flow events; water quality; the presence of instream barriers such as dams and weirs that limit movement of freshwater organisms and streamflow; and other structural elements such as substrate and the availability of woody debris. Riparian habitat is often considered in terms of width, extent, connectivity and condition of native vegetation in the riparian zone. Given the broadscale impacts of clearing and grazing on native trees within the riparian zone, most assessments of riparian condition and extent consider woody vegetation cover. Freshwater biodiversity can be considered to consist of plant and animal species that either live in the freshwater system or depend on it for much of their lifecycle. This generally includes plants and animals such as macrophytes, riverbed algae and invertebrates, and more mobile species including fish and frogs.

A comprehensive discussion concerning potential reporting frameworks and associated indicators based around the literature was undertaken by the FRCWG, with due consideration given to the compatibility and spatial coverage of kanamaluka / Tamar estuary and Esk rivers catchment data available for derivation and reporting of grades.

A general framework for reporting, consisting of the following three components, was agreed upon:

- Aquatic life
- Aquatic habitat
- Riparian habitat

Potential indicators associated with each of these components that could be assessed using existing data were considered, with chosen indicators shown in Figure 2 and defined further in the next section. Note that this framework is intended to be flexible, allowing for additional indicators to be added as data and knowledge become available.

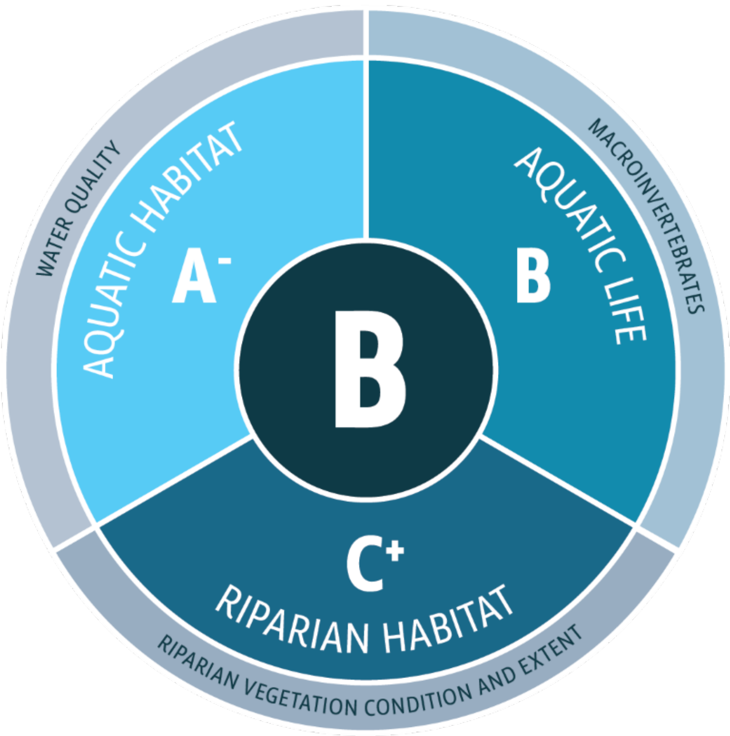

Figure 2. Framework for Freshwater Condition Assessment. Grades are assigned for each component, with the average of these resulting in the overall grade.

Other characteristics agreed to be important and which should be considered in a supporting Technical Report (see www.teer.org.au/freshwaterreportcard) for context rather than via the use of a scoring method include:

- Climatic variability over the reporting period as a driver of change. For example, describing variations in rainfall, temperature, and evaporation prior to and during the reporting period would provide important context.
- Naturalness of flow regime and barriers to movement such as weirs and dams. This would be considered using an analysis of spatial data to characterise the abundance and extent of barriers and their impact on connectivity, as well as a simple description of the role of flow releases and extractions in modifying flows in different areas of the kanamaluka / Tamar estuary and Esk rivers catchment.
- Land use which links to land clearance and native vegetation extent, runoff, water quality and other drivers of ecosystem health such as stock access to streams.

4 Spatial scales for reporting

Grades are reported across 10 zones in the kanamaluka / Tamar estuary and Esk rivers catchment (Figure 3), based on its five major sub-catchments:

- Brumbys-Lake
- Macquarie
- Meander
- North Esk (including Launceston Urban)
- South Esk

No grade is derived for the Tamar foreshore sub-catchment due to insufficient data. The five sub-catchments included are further divided into upland and lowland sections, with the section boundaries based on an elevation of approximately 400 m. In general, upland areas are typically characterised by a dominance of forested areas (native and/or production and plantation forests), while lowland areas tend to be used primarily for agriculture. Launceston's urban catchments are included as a separate reporting zone. Given this urban catchment region comprises the majority of the North Esk lowlands sub-catchment, the remaining areas within the North Esk sub-catchment are treated as another separate distinct zone.

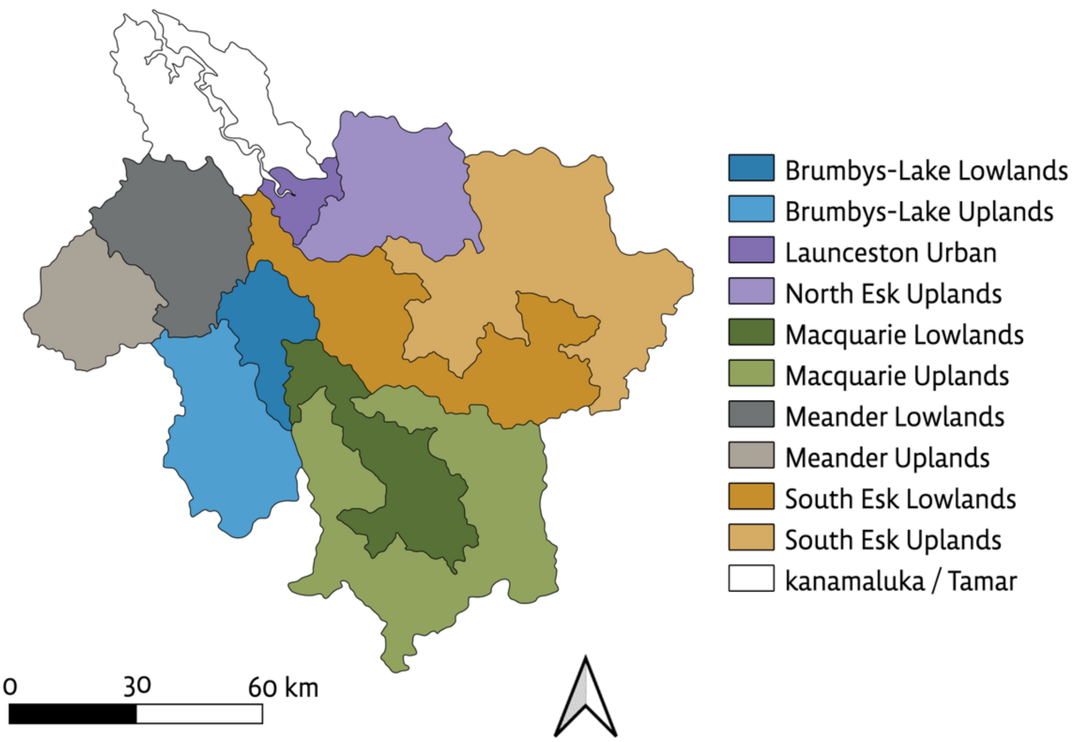

Figure 3. Spatial scales for reporting in the TEER Freshwater Report Card.

5 Criteria for selecting indicators

The final agreed approach used for assessing and reporting on freshwater ecosystem health in the kanamaluka / Tamar estuary and Esk rivers catchment was designed considering the following criteria:

- The approach should measure and report on freshwater health across the three key components – aquatic habitat, riparian habitat, and aquatic life – and provide a 'big picture' assessment of river health across the catchment. The role and importance of these components in waterway health, along with gaps not captured by the reporting methodology due to insufficiency of data, should also be clearly communicated.
- Indicators should be available to be reported across a whole zone, with site-based indicators representative of condition across that zone.
- Minimal resources are available for additional field studies or monitoring so, where possible, datasets used to calculate report card grades should be collected on an ongoing basis and made freely available to the TEER Program, either as open data or through a data sharing agreement.
- Datasets should be collated to facilitate production and publication of a report card on a three-to-five-yearly basis, allowing comparisons with previous periods and for trends in condition and extent over time to be considered.
- The indicators selected and reporting methodology used should allow for simple, clear communication to the community of any changes in river health.

6 Indicators

Indicators of freshwater ecosystem health used within the reporting framework are outlined below. An Ecological Health Index (EHI) is calculated for each indicator. The spatial profile of data available for each indicator is expected to vary among report cards as new monitoring sites are developed and old sites are abandoned. Specific spatial information concerning monitoring sites and data used for the 2023 Freshwater Report Card is documented in greater detail in the 2023 Freshwater Report Card Technical Report.

6.1 Macroinvertebrates

Macroinvertebrates are sampled regularly following AUSRIVAS protocols at various sites across the 10 zones included in the TEER Freshwater Report Card by one or more organisations, including the Department of Natural Resources and Environment Tasmania (NRE Tas), TasWater, Tasmanian Irrigation, Petuna Aquaculture, Hydro Tasmania, and City of Launceston. For each macroinvertebrate sample at each site, report card scores are allocated values corresponding with AUSRIVAS band assessments as shown in Table 1.

Table 1. AUSRIVAS bands and relationship to report card site scores.

AUSRIVAS Band	TEER Score	Description
X	4	Richer than reference. Very high occurrence of expected families - high level of biodiversity
A	4	Similar to reference site. Disturbance having minimal impact on macroinvertebrate families
B	3	Poorer than reference site. Several expected families not found - impacted by water quality or habitat quality
C	2	Much poorer than reference. Many expected families not found. Substantial impairment of water quality or habitat quality

D	1	Far poorer than reference. Very few expected families found. Severe impairment of water quality or habitat quality

For each monitoring site in each report card zone, Observed/Expected scores during the reporting period are averaged, providing a final report card score for that site. The final macroinvertebrates EHI for each zone is then calculated as the average of scores at sites in each zone, divided by four. This can be represented by the formula:

$$EHI_{Mac} = \frac{\sum_{v=1}^{V} \bar{s_v}}{V} \Big/ 4$$

where $\bar{s_v}$ is the average of report card site scores for each macroinvertebrate sampling at each site v (i.e., the report card site score), and V is the total number of sites in the zone.

6.2 Water Quality

The FRCWG recommended that the five water quality parameters most relevant to freshwater ecosystem health for which sufficient data is available for reporting are:

- Nutrients (total nitrogen (TN), total phosphorous (TP) and nitrate + nitrite (NOx),
- Turbidity, and
- Dissolved oxygen (DO – % saturation).

A range of Default Guideline Values (DGVs) have been developed for full- and part-year timescales for spatial scales varying from the whole of Tasmania, to hydrological regions and individual catchments (EPA, 2020). These DGVs for protection of the ecosystem are the most conservative for these indicators and would be used in the setting of Water Quality Objectives (WQOs). The TEER Freshwater Report Card calculates scores using thresholds based on full-year H1 Hydrological Region DGVs (EPA, 2021).

Scores are assigned based on slight to moderately disturbed (SMD) percentiles. The values of the thresholds and their basis are described below for each water quality indicator.

6.2.1 Nutrients

Thresholds for nutrients use SMD percentiles with 'best condition' (score=5) being median observed values are at or below the 60th percentile. Thresholds for transitioning between integer values of the score (e.g., from 5 to 4) are based on other SMD percentiles with scores trending down as summarised in Table 2. Score values are interpolated between these thresholds based on the relative distance of the median to relevant threshold values.

Table 2. Nutrients –threshold value and basis for score range.

Score	Basis	TN	TP	NOx
0	≥ maximum SMD value	4.600	1.000	1.100
1	95th percentile	2.000	0.123	0.320
2	90th percentile SMD	1.600	0.078	0.273
3	80th percentile SMD	0.673	0.029	0.208
4	70th percentile SMD	0.530	0.019	0.154
5	≤60th percentile SMD	0.458	0.015	0.121

The way in which report card scores for a site are calculated using linear interpolation is demonstrated for NOx in Figure 4. The report card score at a site is calculated using the median of all observations of a given water quality parameter during the reporting period and the relationship demonstrated in Figure 4 using linear interpolation between score threshold values. The report card scores for each nutrient parameter (TN, TP, and NOx) are then averaged across all sites in the reporting zone and an EHI for the zone calculated as outlined Section 6.3.

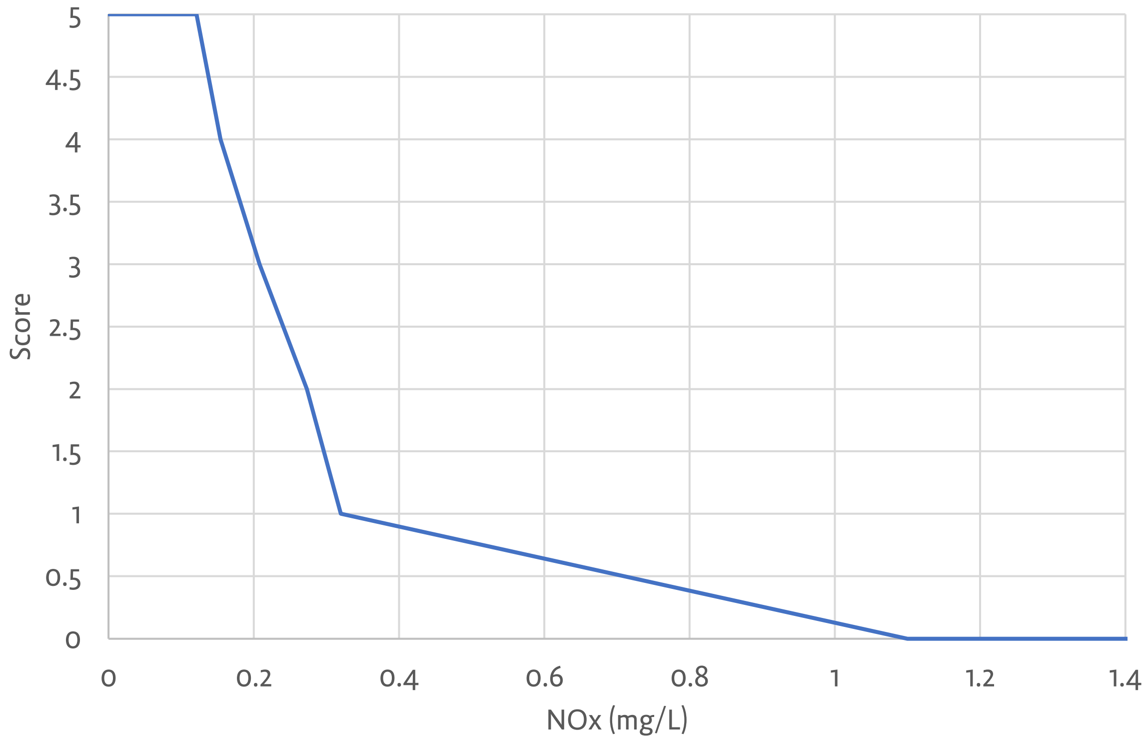

Figure 4. Relationship between report card site score and median NOx observation at site.

6.2.2 Turbidity

Table 3 shows the threshold value and basis for calculating report card site scores for turbidity. As was the case for nutrients, these are based on SMD percentiles for the H1 Hydrological Region.

Table 3. Turbidity – threshold values and basis for score range.

Score	Basis	Threshold values
0	≥maximum SMD value	>=106
1	95th percentile	20.8
2	90th percentile SMD	9.86
3	80th percentile SMD	5.63
4	70th percentile SMD	4.02
5	≤60th percentile SMD	3.04

As was the case for nutrients, a non-integer report card site score is estimated for turbidity via linear interpolation using the median of all turbidity measurements at the site during the reporting period, as show in Figure 5. This report card site score for turbidity is then used in the calculation of final water quality EHIs, as outlined in Section 6.3.

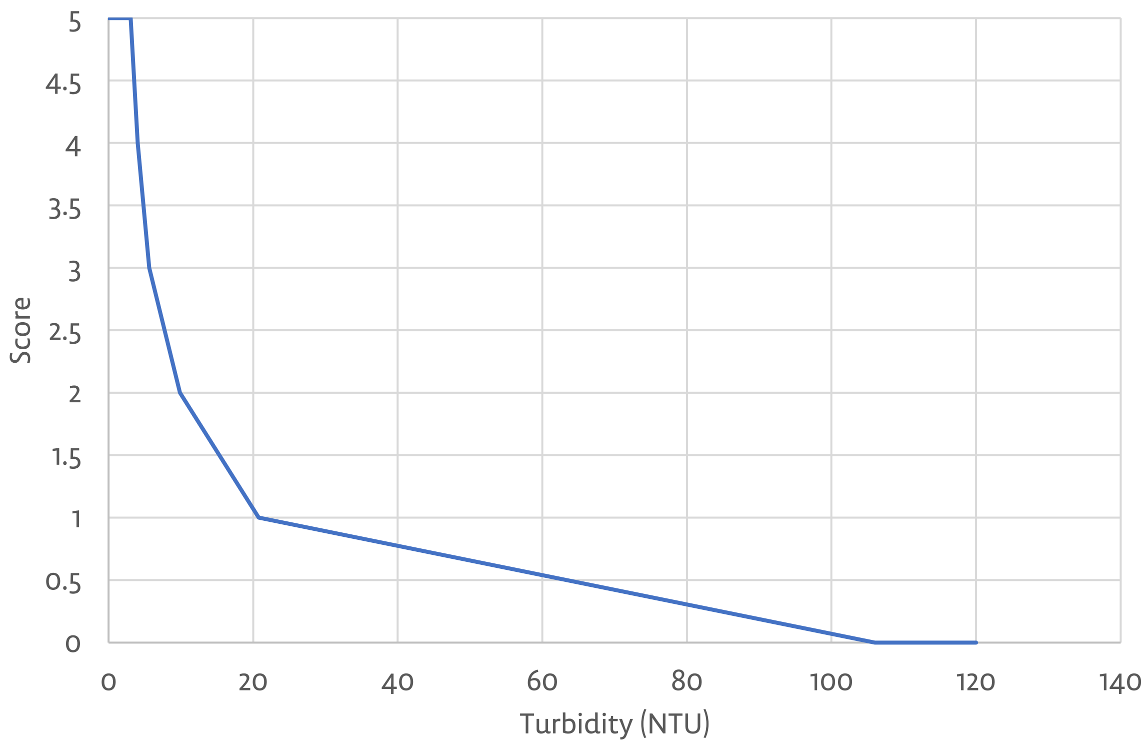

Figure 5. Relationship between report card score and median turbidity observation at site.

6.2.3 Dissolved oxygen (% saturation)

Dissolved oxygen (DO) has both upper and lower thresholds, with median % saturation values above the upper or below the lower thresholds being cause for investigation and possible management actions. These thresholds are based on SMD percentiles for the H1 Hydrological Region (Table 4).

Table 4. Dissolved oxygen – upper and lower threshold values used to calculate score.

TEER Score	Lower thresholds		Upper thresholds	
	Threshold value (% saturation)	Basis	Threshold value (% saturation)	Basis
0	≤10	minimum	≥138.3	maximum
1	86.5	5th percentile	106.9	95th percentile
2	89	10th percentile	104.1	90th percentile
3	92	20th percentile	101	80th percentile
4	94	30th percentile	99.1	70th percentile
5	≥95.4	40th percentile	≤98	60th percentile

Similar to other water quality parameters outlined above, report card site scores for DO are calculated using linear interpolation between these thresholds using the median observed value for the site (Figure 6). The report card site score for DO is then used in the calculation of final water quality EHIs, as outlined in Section 6.3.

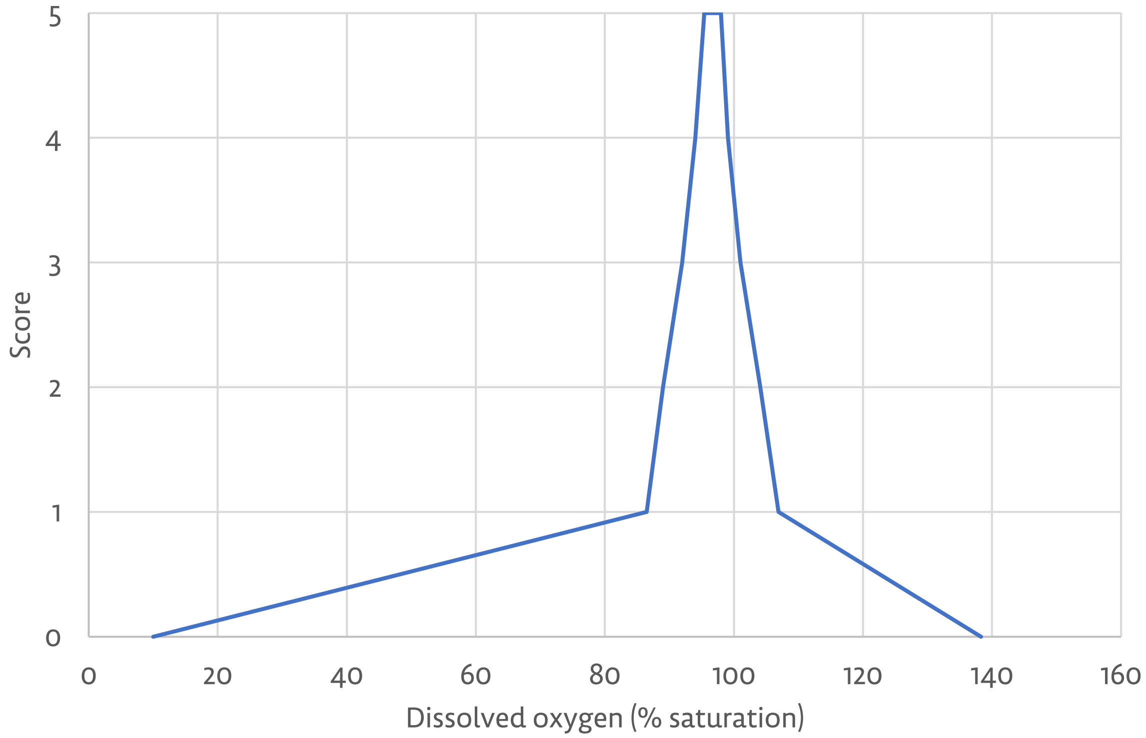

Figure 6. Relationship between score and median dissolved oxygen (% saturation) observation at site.

6.3 Calculating water quality EHI

Once report card site scores for nutrients, turbidity and DO have been generated for all monitoring sites as described above, the first step in deriving a final water quality EHI for each zone involves calculating an EHI value for each of the five parameters– TN, TP, NOx, turbidity and DO. Parameter EHIs for each zone are the average of parameter report card site scores across the zone, divided by five, that is:

$$EHI_{Par} = \frac{\sum_{v=1}^{V} \bar{s_v}}{V} \Big/ 5$$

where $\bar{s_v}$ is the report card site score for site v and V is the total number of sites in that zone.

Once the five water quality parameter EHIs for each zone are calculated, the final EHI value for water quality for a given zone is then calculated as:

$$EHI_{WQ} = \frac{EHI_{DO} + EHI_{turbidity} + EHI_{nutrients}}{3}$$

where

$$EHI_{nutrients} = \frac{EHI_{TN} + EHI_{TP} + EHI_{NOx}}{3}$$

7 Riparian habitat

The conceptual framework agreed to by the FRCWG considers riparian habitat to be a measure of the extent and condition of native riparian vegetation.

7.1 Identifying native vegetation in the riparian zone

A National Forest and Sparse Woody Vegetation Data layer[1] has been produced and is updated annually by the Commonwealth Department of Environment and Energy. It is provided for open access through the National Inventory. This dataset uses Landsat data of 25-m grid-cell resolution to classify the landscape into three classes:

1. Non-woody vegetation
2. Sparse woody vegetation
3. Woody vegetation

Woody vegetation or forest is defined as woody vegetation with a minimum of 20% canopy cover, at least 2 m high and a minimum area of 0.2 ha. Sparse woody vegetation is defined as woody vegetation with a canopy cover of between 5% and 19%. Non-woody landcover is all other areas and includes bare soil.

The dataset does not differentiate native versus non-native vegetation so, for example, plantation forest and native forest are both classified as woody vegetation. There are no remote sensing methods currently able to accurately differentiate native and non-native vegetation.

TASVEG is a polygon layer that classifies vegetation types across the landscape into 11 vegetation categories:

1. Dry eucalypt forest and woodland
2. Highland and treeless vegetation
3. Modified land
4. Moorland, sedgeland and rushland
5. Native grassland
6. Non eucalypt forest and woodland
7. Other natural environments
8. Rainforest and related scrub
9. Saltmarsh and wetland
10. Scrub, heathland, and coastal complexes
11. Wet eucalypt forest and woodland

It can be assumed that all groups represent native vegetation, except areas of modified land. The modified land group is further split into five sub-categories:

1. Agriculture
2. Cleared
3. Plantation
4. Urban
5. Weeds

Combining the woody vegetation and TASVEG data allows classification of the landscape into native and non-native vegetation using some simple assumptions:

- All TASVEG classes except modified land are native vegetation.
- For modified land, plantation and weeds are non-native vegetation.

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[1] https://data.gov.au/data/dataset/national-forest-and-sparse-woody-vegetation-data-version-5-2020-release

- For the other 3 modified land categories (agriculture, cleared, urban) the woody vegetation data can be used to find areas that most likely consist of native vegetation by assuming that 'woody' vegetation is native vegetation in these areas. Note that 'sparse woody' vegetation in these areas is assumed to be non-native.

Using this approach, a spatial dataset classifying the kanamaluka / Tamar estuary and Esk rivers catchment into native and non-native vegetation has been developed. A native riparian vegetation dataset has been created using a 30 m buffer zone either side of watercourses in urban areas and a 50 m buffer elsewhere around CFEV rivers to clip this constructed native vegetation layer.

7.2 Selection of metrics

Michaels *et al.* (2010) conducted a regional assessment of Tasmania's native vegetation using TASVEG data and by applying a conceptual model of landscape modification based on native vegetation developed by McIntyre and Hobbs (1999). This model is shown in Figure 7 and uses a measure of native vegetation extent to assess the level of modification and fragmentation of the landscape. This model describes four distinct levels of modification based on the proportion of native vegetation remaining in the landscape: intact (>90%), variegated (60-90%), fragmented (10% to 60%) and relictual (<10%).

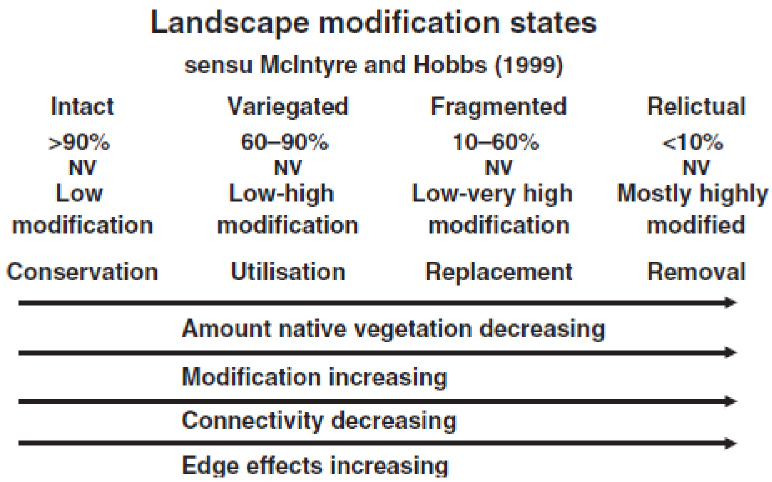

Figure 7. Conceptual model of landscape modification based on native vegetation developed by McIntyre and Hobbs (1999) and applied to TASVEG data by Michaels et al. (2010).

7.3 Estimating scores for riparian habitat extent and condition

The conceptual model of landscape modification developed by McIntyre and Hobbs (1999) contains thresholds for transition of the landscape between four states ranging from intact (>90%) to relictual (<10%)[2] based on the extent (%) of native vegetation. This model provides a useful set of thresholds for assigning report card scores for riparian habitat extent and relating them to condition. The thresholds used for report card scores for riparian habitat extent and condition are shown in Table 7.

[2] Relictual refers to a condition where very little of the original vegetation remains and what is there is surrounded by a highly modified landscape.

Table 7. Proposed scores and threshold levels for riparian habitat extent as measured by % native vegetation.

State	Min %	Max %	Score at upper threshold
Intact	90%	100%	5
Variegated	60%	90%	4
Fragmented – better condition	35%	60%	3
Fragmented – worse condition	10%	35%	2
Relictual	0%	10%	1

The report card score for each zone is based on the relevant interpolated value given riparian habitat extent, as shown in Figure 8.

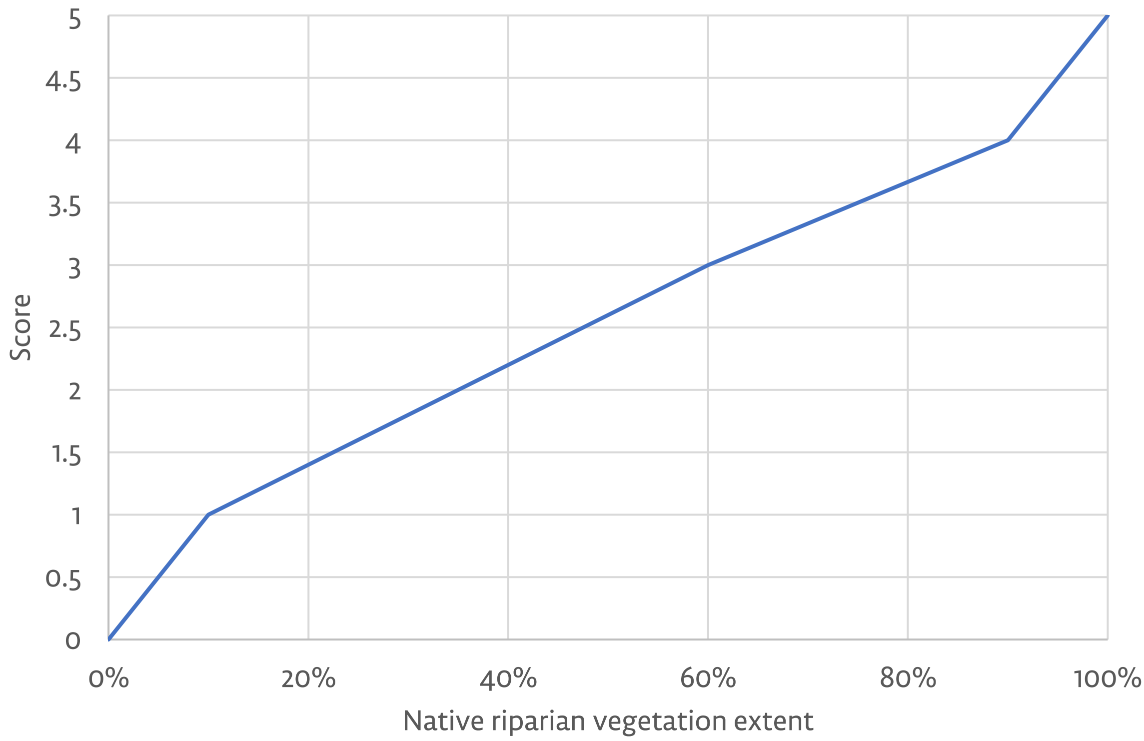

Figure 8. Relationship between native riparian vegetation extent and report card score used in the TEER Freshwater Report Card.

Riparian habitat EHI for a given zone is then represented as the interpolated report card score value divided by 5.

8 Calculating grades

For each of the 10 zones, a grade (A+ to E-) is allocated for each of the three ecosystem components (aquatic habitat, aquatic life, riparian habitat) and for overall ecosystem health. The EHI used to derive the overall grade for a given zone is calculated as the average of the three component EHIs. Grades are then allocated based on the thresholds shown in Table 8. For example, an EHI greater than 0.95 is allocated a grade of A+, an EHI of 0.72 would correspond to a grade of B- and an EHI less than 0.3 to a grade of E-.

Table 8. Range of EHI values corresponding to letter grades

Condition	Description	Letter Grade	Range of EHI values
Excellent	Conditions at most monitoring sites or for the majority of river reaches reflect high conservation status and/or show minimal impacts of disturbance.	A+	>0.95
		A	0.90 – 0.95
		A-	0.85 – 0.90
Good	Most sites or river reaches have some impairment or disturbance impacts, but the condition represents a healthy modified condition.	B+	0.8 – 0.85
		B	0.75 – 0.8
		B-	0.7 – 0.75
Fair	Most but not all sites or reaches have a substantial level of disturbance or impairment with the zone having a mix of healthy, minimally impacted areas and degraded reaches.	C+	0.65 – 0.7
		C	0.6 – 0.65
		C-	0.55 – 0.6
Poor	Sites or reaches are a mix of substantially and severely impacted with very few sites or reaches in a healthy condition.	D+	0.5 – 0.55
		D	0.45 – 0.5
		D-	0.4 – 0.45
Very poor	Most sites or reaches have severe impairment or are severely degraded through disturbance.	E+	0.35 - 0.4
		E	0.3 – 0.35
		E-	<0.3

9 References

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