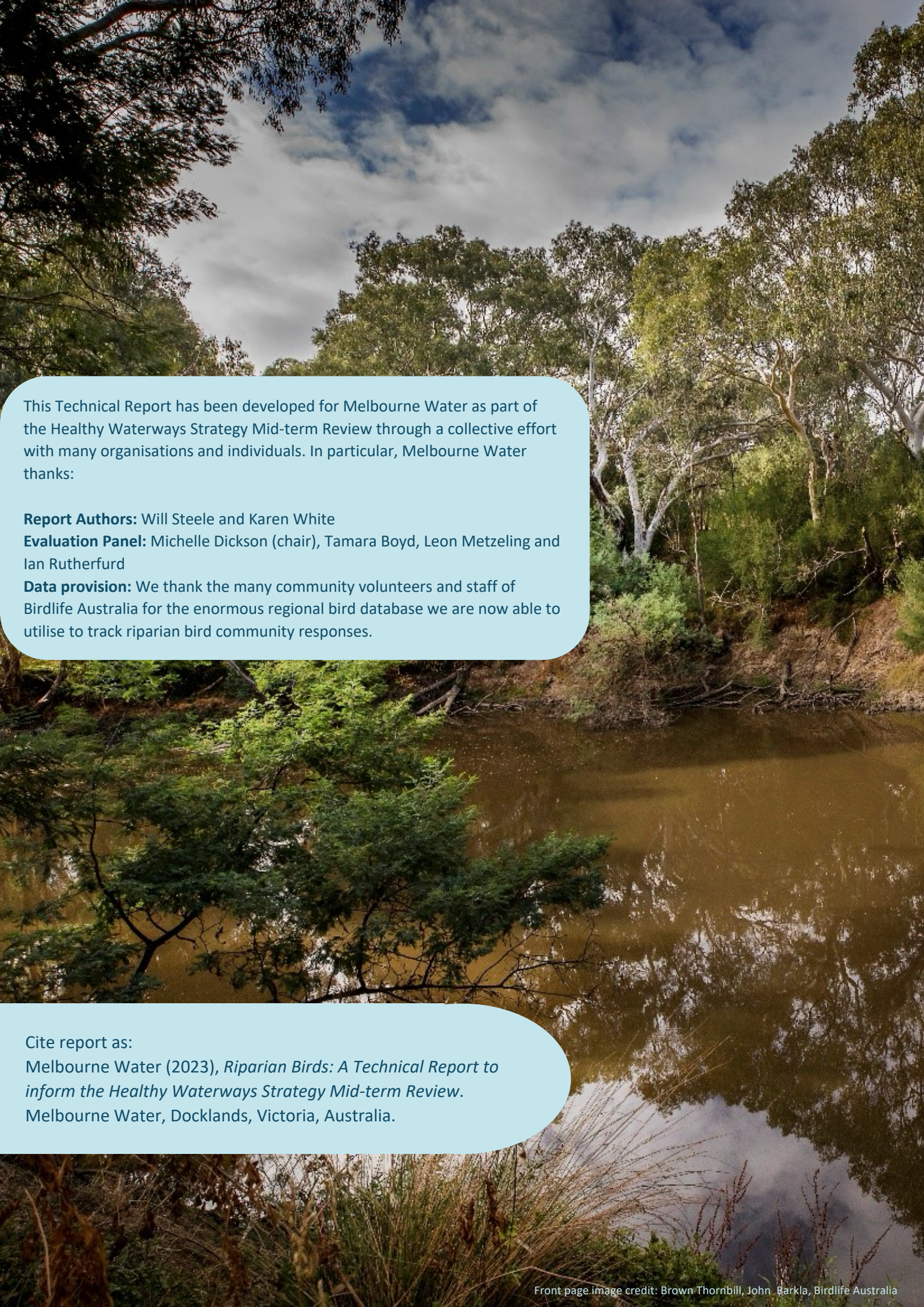
Healthy Waterways Strategy 2018-2028
Port Phillip & Westernport, Victoria

Riparian Birds

A Technical Report to inform the Healthy Waterways Strategy Mid-term Review



This Technical Report has been developed for Melbourne Water as part of the Healthy Waterways Strategy Mid-term Review through a collective effort with many organisations and individuals. In particular, Melbourne Water thanks:

Report Authors: Will Steele and Karen White
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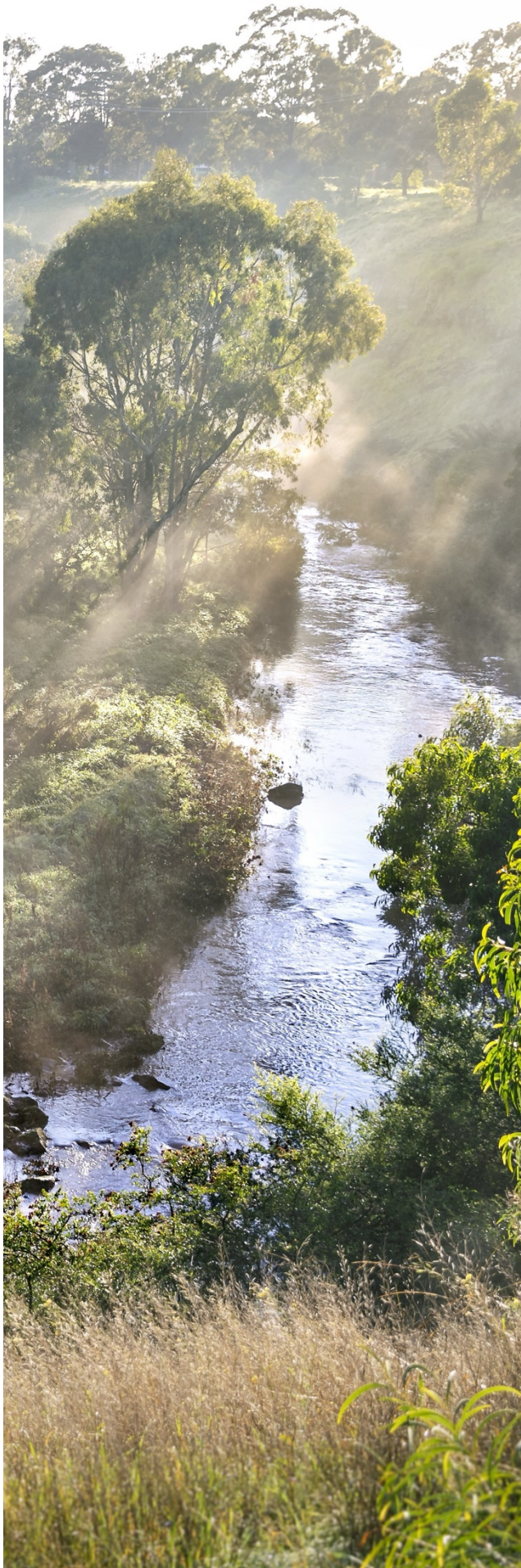
Glossary of terms and abbreviations

eDNA	environmental DNA
EPBC	Environment Protection and Biodiversity Conservation Act
HSM	habitat suitability model
HWS	Healthy Waterways Strategy 2018
FFG	Flora and Fauna Guarantee Act
Strategy	refers in this instance as the Healthy Waterways Strategy 2018

Acknowledgement of Traditional Owners

The rivers, wetlands and estuaries of the Port Phillip and Westernport region are part of Country belonging to the Bunurong, Gunaikurnai, Taungurung, Wadawurrung and Wurundjeri Woi-wurrung peoples. These Traditional Owners have lived in and been connected to the land, water, plants and animals of this area for many thousands of years, and we offer our respect to their Elders past and present.



Evaluation overview

The 2018 *Healthy Waterways Strategy* "bird value" is treated as riparian or wetland bird values separately (Melbourne Water 2018, 2019, 2020a, 2020b). Each of these bird communities requires data collection for two distinct purposes:

- region-wide monitoring (to inform high-level indices for reporting and tracking) and
- targeted, works-evaluation studies (to improve our understanding of bird community responses to management and other influences, improve conceptual models and guide management investment) (Figure 1).

The wetland bird community has seen more work in both areas, but particularly the latter. The Ramsar sites at the Western Treatment Plant and Edithvale-Seaford Wetlands have hosted numerous works evaluation and other studies (Ecology Australia 2008, 2012; Loyn et al. 2014b; Rogers & Hulzebosch 2014; Clark et al. 2015; Greet & Rees 2015; Rogers et al. 2015, in prep.; Schmidt et al. 2015; Jacobs 2021; Birdlife Australia 2022a). Wetlands have also seen trials of eDNA to improve bird detection, and Habitat Suitability Models for wetland species are being developed by the University of Melbourne's Waterways Ecosystem Research Group (WERG).

Melbourne Water commissioned monitoring of birds at wetlands long before riparian birds were considered (Tzaros et al. 2004, 2005; Silcocks et al. 2007; Silcocks & O'Connor 2007, 2008, 2009, 2010, 2011; Lau 2008, 2009, 2011a, 2011b; Silcocks 2013a, 2013b; Purnell 2013, 2014, 2015; Loyn et al. 2014a, 2014b; Menkhorst et al. 2014, 2015, 2017, 2018, 2019, 2020, 2021; Herman & Purnell 2016; Herman 2017, 2018; Birdlife Australia 2020a, 2020b, in prep.), and it has proved easier to recruit community volunteers to survey wetlands than it has to direct volunteers to consistent and standardised bird surveys of riparian areas.

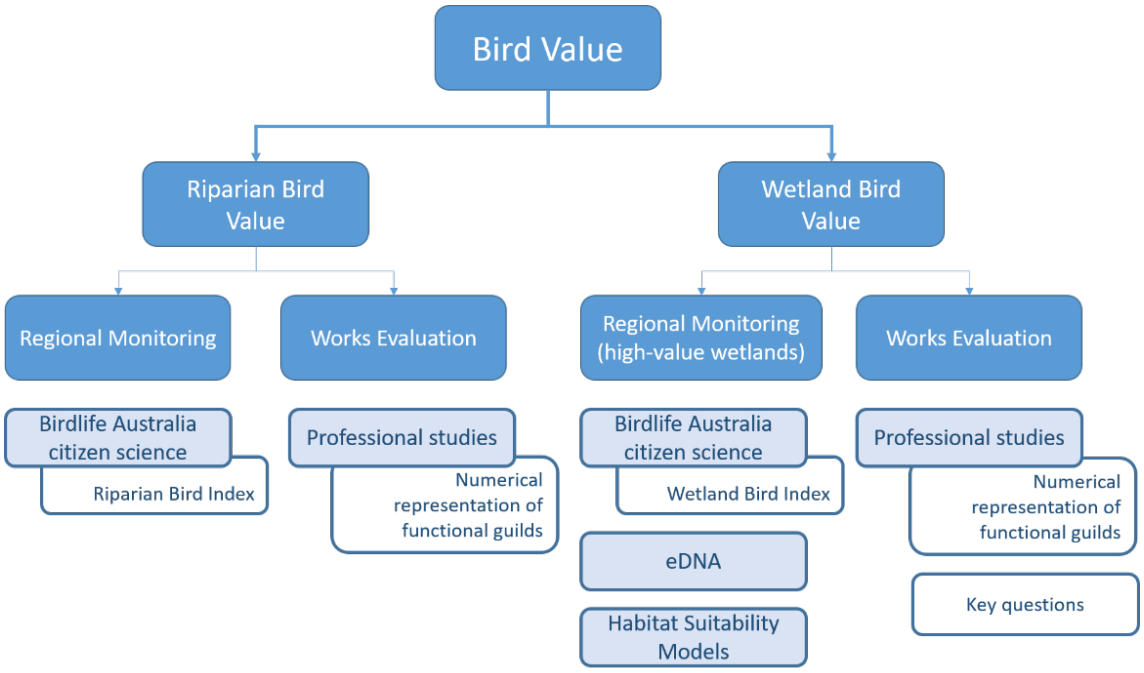


Figure 1. *Schematic representation of the Bird value approach.*

This point is emphasized to explain why relatively little attention has been given to detailed riparian bird studies to date. This report addresses only the riparian bird value work, while wetland birds are to be assessed in a separate mid-term wetland technical paper (Melbourne Water, 2023a) .

This report focuses on two key evaluation questions (KEQs), and their sub-KEQs, from the Healthy Waterways Strategy Monitoring, Evaluation, Reporting and Improvement Framework, version 1.1 (Melbourne Water 2019):

- KEQ 3- What is the state of waterway values?
    - 3a. To what extent are key values on the target trajectory?
    - 3b. What other spatial and temporal trends and patterns for key values are of significance for implementation?

- KEQ 2- To what extent has progress been made towards the longer-term environmental condition targets for rivers, wetlands and estuaries?
    - 2a. What environmental conditions (e.g. water quality) and external conditions (e.g. policy) help explain current key value trends?

Background and contextual information is presented relating to the HWS development and implementation to date along with an overview of how each of the KEQs is evaluated with respect to riparian birds (Table 1).

Table 1. *Summary of the mid-term evaluation KEQs and the extent to which they are presented in this report.*

KEQ	Sub-KEQ	Evaluation Approach
1 – To what extent have the performance objectives of the Strategy been achieved?	1a. To what extent has collaboration and co-delivery contributed to achieving the Performance Objective targets so far?	The bulk of the bird data are collected by an extensive network of community volunteers organised by Birdlife Australia, with which we have a close and longstanding relationship. This sub-KEQ is to be addressed as part of the Implementation Inquiry (Melbourne Water, *in prep*)
	1b. To what extent is strategy delivery on track to achieve the Performance Objective targets by 2028?	There are no HWS Performance Objectives specific to riparian birds. General objectives, such as implementation of the Sites of Biodiversity Significance Program (SoBS), vegetation and stormwater performance objectives support riparian birds. We have recently undertaken surveys of large forest owls (focussed on the riparian and listed Powerful Owl) across SoBS, in working towards one of these more general objectives, and found this species is still present.
3 – What is the state of waterway values?	3a. To what extent are key values on the target trajectory?	This question is evaluated for riparian birds in Section 4. The majority of our sub-catchments (34 of 45 assessable) are 'on track' to meeting HWS targets. Seven sub-catchments are 'slightly off-track' and four are 'off-track'. These latter sub-catchments are: Bayside, Watsons Creek, Bunyip Middle & Upper and Mornington Pen. SE Creeks.
	3b. What other spatial and temporal trends and patterns for key values are of significance for implementation?	This question is evaluated for riparian birds in Section 4. Annual rainfall influences riparian bird community health and this effect is apparent in our data.

KEQ	Sub-KEQ	Evaluation Approach
		Our vegetation management is critical in maintaining riparian bird habitat condition and extent.
2 – To what extent has progress been made towards the longer-term environmental condition targets for rivers, wetlands and estuaries?	2a. What environmental conditions (e.g. Water quality) and external conditions (e.g. policy) help explain current key value trends?	Riparian bird responses to management/ improvement in supporting environmental conditions (as per our conceptual model) could lag by several years. We will only be able to study this relationship in detail in a number of years, after collecting the required data on our management, conditions, and riparian birds. At present we do not have the necessary data to investigate this question. Changes to external conditions, such as policy, is to be investigated later through a separate piece of work.
	2b. To what extent have projected known and emerging future threats changed from 2018? Have any assumptions about impacts to key values changed?	This is being addressed through a separate Technical Paper about threats (Melbourne Water 2023b).
4 -To what extent have the delivery methods of the Strategy been appropriate, effective, and efficient?	4a. To what extent are interventions appropriate and effective for achieving outcomes?	This is partially covered in Section 5. While we have few works evaluation studies, we can show willow removal and revegetation leads to a more natural riparian bird community. There is a very large body of research – not commissioned by Melbourne Water – showing the benefits of vegetation management to increase riparian bird habitat condition and extent.
	4b. What are the key remaining knowledge gaps that need to be addressed in the next 5 years to improve strategy delivery or prepare for the next HWS?	Key knowledge gaps identified are: • Quantifying the effects of our revegetation, relative to the natural variation caused by rainfall fluctuations. • The nature and extent of the threat posed to insectivorous birds by pesticides in the environment, particularly newer persistent compounds. • The nature and extent of the threat posed to riparian bird communities by increased human visitation to waterways (a key HWS objective). These are presented alongside knowledge gaps for other values in Part F of the Science Inquiry (Melbourne Water 2023c)
	4c. How can collaborative governance enable effective and efficient delivery of the Strategy?	This is addressed in the Implementation Inquiry report (Melbourne Water, *in prep*)

1. Overview of riparian bird value

Defining the riparian bird value

The 2013 *Healthy Waterways Strategy* (Melbourne Water 2013) separated the community's Bird Value into "wetland birds" and "riparian birds". The 2018 HWS defines the community value of riparian birds to be the pleasure these bring through their colour, calls, flight and other behaviours. Ecosystem functions, such as pollination, seed dispersal and regulation of some insect populations are important but probably not recognised by most residents of Melbourne. Therefore, the riparian bird value is taken to be **native species richness and abundance**. This incorporates underlying factors such as the need for persistent populations that are resilient and self-sustaining in the long-term, through drought, storm, flood, fire, epidemics and climate change.

Analysis and modelling of Birdlife Australia's extensive bird data set was used to derive a list of expected riparian species for each of our major catchments (Appendix Table A1; AECOM 2012a). These expected species are our "value".

Threats to our bird value

The following list of threats and threatening processes to riparian birds was compiled from environmental legislation (EPBC Act and FFG Act) and the *National Action Plan for Australian Birds* (Garnett & Crowley 2010).

- Land clearance causing habitat loss and fragmentation.
- Degradation of remaining habitat, especially native riparian vegetation along rivers, through weed encroachment, litter, loss of coarse woody debris, etc.
- A lack of nesting sites, particularly the loss of hollow-bearing trees from native forests.
- Introduced predators – such as Red Fox and feral Cats – depredating eggs, chicks or adult birds.
- Alteration to the natural flow regimes of waterways through regulation, modification or extraction.
- Disturbance by humans and their pets.
- Inappropriate fire regimes causing disruption to sustainable ecosystem processes and resultant loss of biodiversity.
- Pollution of waterways by organotins, hydrocarbons and other toxic substances.
- An incomplete knowledge of ecosystem functioning, and their thresholds for resilience.
- Use by the feral Honeybee *Apis mellifera* of nesting hollows and floral resources.
- Psittacine Circoviral (beak and feather) affecting endangered parrot species.
- Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant Noisy Miners (*Manorina melanocephala*)

A 2017 expert elicitation process, in which a questionnaire was sent to 85 ornithologists and experienced birdwatchers, with 39 respondents, recognised ten additional threats to our regional bird communities (Steele 2019). These can be grouped under climate change, urbanisation, vegetation management and hydrology:

- Climate change and urban warming effects
- Climate change

- Lack of climate refugia
- Sea level rise due to climate change
- Coastal erosion
- Urbanisation
- Urban sprawl - lack of education amongst community
- Excessive grass mowing and cutting on waterway reserves for fire breaks, roads and for amenity.
- lack of natural regeneration due to browsing pressure (including both wallabies and rabbits)
- Lack of water in the creeks – too many hard run-off areas and fast flows over short spells

Riparian bird data

Melbourne Water works with Birdlife Australia to ensure streamside and wetland sites in our region are visited by birdwatchers trained to report the results of their bird surveys. Birdlife Australia recruit teams of volunteer birdwatchers for nominated sites, when possible, and produce training materials, and collate and audit their data before sending this to Melbourne Water.

Data selected from the Birdlife Australia database for this mid-term review includes the results of 27,887 daytime surveys of suitable standard centred within 80 m of a stream centreline, between 1 July 1998 and 31 December 2021. There are 488,942 species records and 320 bird taxa recorded.

As part of this regional data collection program, targeted, quantitative bird counts by qualified personnel have been conducted at as many works and control sites as could be arranged. This work mostly focusses on willow removal effects, and builds on the 2011-2013 AECOM study of willow removal along Yarra tributaries (AECOM 2012b, 2013).

Riparian bird index

Birds have been suggested to be good indicators of riparian and stream condition (e.g. Brooks & Croonquist 1990; Croonquist & Brooks 1991, 1993; Bryce et al. 2002; Larsen et al. 2010). There are several possible indices, or indicators, for riparian bird community health (see Table A2 in appendices). The best condition metric would be based upon quantitative count data communities. But, for high level reporting, we have decided to use summed reporting rate of expected species of bird (see Steele 2011, 2019; Melbourne Water 2020a, 2020b). This allows us to use bird surveys with presence/absence data and so many more bird surveys are included than would otherwise be possible.

Importantly, utilising only the species presence/absence information from surveys avoids problems of observer skills and bias; and detectability issues related to wind and weather at the time of a survey. Volunteer birdwatchers are generally competent at identifying species. But their accuracy when estimating numbers of birds actually present in vegetated riparian areas will be highly variable according to their skill and experience. Therefore, the riparian bird metric in the Strategy is based on species' presence/absence information.

Development of a high-level Riparian Bird Index for regional reporting began prior to the 2013 *Healthy Waterways Strategy* (Melbourne Water 2013). Initially, the index was calculated as the summed reporting rate of a list of expected species for the Port Phillip and Westernport region (Steele 2011). During the period of the 2013 Healthy Waterways Strategy this index was tested and

refined (AECOM 2012a, 2012b; Herman & Purnell 2016; Herman 2017, 2018), and different approaches considered (e.g. Herman 2015). Despite acknowledged simplicity, the Riparian Bird Index was considered a useful high-level measure of relative riparian bird community 'health' over time. Herman (2017, 2018) criticized the use of a single list of expected riparian species of bird for the entire region. Therefore, the index was modified to consider the summed reporting rate of expected species, with different lists for each of the five major river catchments (AECOM 2012a). Subsequent, minor, modifications to the selection criteria for surveys considered eligible for inclusion in the Index calculation (Steele in prep.) are described below.

It must be emphasized that the Riparian Bird Index is intended, and designed, to be a high-level and simple reporting tool. One which presents a summary of riparian bird communities over a defined period, and large area, and which can be used to infer changes in condition ("health") of riparian bird communities. It is not a detailed or analytical tool.

A list of riparian species of bird was generated from assessment of the entire Birdlife Australia database for the Port Phillip and Westernport Region and modified in light of expert opinion. Preliminary analyses by Jamie Mathew (AECOM 2012a) show that species richness using this restricted list of species does correlate to an extent with stream condition (as defined by ISC scores).

The riparian bird index can only be calculated for areas having at least 40 relevant bird surveys since species accumulation curves suggest that 40 surveys are required to record 90% of bird species present (AECOM 2012a; Birdlife Australia 2020a).

An important consideration in deriving our condition metric was to ensure it would be of use to on-ground managers. Therefore, the reporting rate of each species is considered as a measure of frequency of use of a site. The reporting rate is simply the proportion of surveys at any site during which a species was recorded. Including the reporting rate allows site managers to improve riparian bird condition score by increasing bird usage of a site, and not only by attracting additional species.

The procedure to calculate the riparian bird index is as follows. Text in red indicates modifications incorporated since the 2018 HWS was published (Steele in prep.):

(a) Bird surveys from 1 July 1998 were selected from Birdlife Australia's Bird Atlas data for the Region because this is when the second Australian bird atlas project started (Barrett et al. 2003) and when there was a great increase in bird survey records. It was also when bird survey methods were standardised to some extent.

Five 5-year time periods are used for reporting change:

- 1 July 1998 to 30 June 2003 (Period A – Drought)
- 1 July 2003 to 30 June 2008 (Period B – Extended drought)
- 1 July 2008 to 30 June 2013 (Period C –Post-Drought recovery)
- 1 July 2013 to 30 June 2018 (Period D – variable rainfall)
- 1 July 2018 to 31 December 2021 (Period E – Generally drier than average)

(b) Surveys with certain search type codes (any code other than 1, 2 or 5) were removed from the data set. This is to ensure anecdotal and non-standardised surveys are excluded, and that all survey data included are accurate to within hundreds of metres.[1]

(c) Surveys were restricted to those conducted during daylight hours (i.e. start time <19:30) and completed within four hours, to avoid those records collected over days or weeks.

(d) Only surveys with 'no limitations' (i.e. all birds recorded, and not only certain groups) were used. Many detailed studies collect data on only selected groups of birds, e.g. the ARI bird surveys at the Western Treatment Plant between 2000 and 2022 record only waterfowl, shorebirds and some wading species. Some volunteer bird surveys of riparian sites report only target species, such as Powerful Owl, or interesting species, such as Gang-gang Cockatoo. These surveys were excluded from our analyses.

(e) Surveys centred on a point within 80 m of a waterway. Waterways included all designated waterways and all drains other than concreted ones. The waterway centre line was buffered using:

- DR_Natural Waterways Centreline
- Natural Waterways above MW limit
- DR_Channel_Centreline – but with RC (reinforced concrete), BSPTCH (bluestone pitchers), RCBST (reinforced concrete and bluestone), CONC (unreinforced concrete), CONCRCK, ~~ETHCNC (earthy and concrete)~~[2] and CONCBS (concrete and bluestone) and GALVSTEEL deleted.

(f) The selected data were used to determine the proportion of surveys during which each of the expected species was recorded, and multiplied each species by this proportion. The expected species list per catchment is defined in a 2012 AECOM report. Thus an expected riparian species recorded during 50% of surveys in an area contributes a score of 0.5. Another species, recorded on 10% of surveys, contributes only 0.1.

(g) The expected riparian species' scores were then summed to obtain the 'raw' sub-index for the selected area over the selected time period.

$$SI\ riparian\ birds = \sum_{n=\mathrm{i}}^{1} \left(\frac{n1}{n}\right), \left(\frac{n2}{n}\right), \left(\frac{n3}{n}\right) \ldots \left(\frac{ni}{n}\right)$$

The raw scores were normalised to generate a score between 0 and 1. The raw score was divided by a quarter of the number of expected species (which varies between catchments). This normalisation rule was devised after 'gaming' the raw scores against our knowledge of the maximum scores achieved for sub-catchments of known condition.

(h) Finally the resulting score was allocated to one of five categories for reporting purposes as outlined in Table 2.

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[1] Type 1 survey: 20 minute search of a 2 ha area
Type 2 survey: area search within a 500 m radius
Type 5 survey: fixed-route search (designed and generally applied to surveys of wetlands but also used for certain stream reaches).

[2] This category of drain was included in the 2018 but was dropped in the latest assessment

***Table 2**. Riparian bird condition metric description.*

Description	Very low	Low	Moderate	High	Very high
The summed reporting rate of riparian species expected in that catchment (from minimum of 40 appropriate surveys)	Very few of the expected species are recorded and these in only low numbers 0.00 to 0.10	Few of the expected riparian bird species are recorded 0.11 to 0.30	Most expected species occur but some of these are only infrequently recorded 0.31 to 0.70	Many expected species are recorded often. 0.71 to 0.90	Almost all expected species are frequently recorded 0.91 to 1.0

To explore the variability of Riparian Bird Index scores we plotted annual mean and standard deviations within 5-year time periods for those sub-catchments where sufficient robust surveys were available to permit this.

In the following graphs (Figure 2) the mean Riparian Bird Index score is indicated by blue bars, with the standard deviation indicated. The sample size (number of years within the 5-year time period for which we can calculate the index) is presented as white numbers in the base of each bar.

As might be expected there is a range of variability within the data between sites. The Cardinia, Toomuc, Deep, Ararat sub-catchments show tight data across five 5-year time periods, with a significant increase in value over time (see below). But this result is not typical. Several sub-catchments show increasing variation around the mean from Period A (1998/99 to 2002/03) onwards (e.g. Gardiners and Little River Lower sub-catchments). This might be due to two factors:

1. Later 5-year time periods may have more variable rainfall than the earlier, drought periods. The first two periods were drier than average overall whereas Period C (2008/09 – 2012/13) saw a low rainfall year followed by two high rainfall years. Period D (2013/14 – 2017/18) experienced one high rainfall year, 2016/17, followed by drier than average years.

   Rainfall is a key driver of ecosystem productivity – not only through vegetation and invertebrate productivity, but also bird productivity through triggering breeding and potentially increased breeding success. Therefore increased variability in rainfall between years seems likely to have influenced the variability in annual Riparian Bird Index scores.

2. Data are still being collected for Period E (2018/19 – 2022/23) and variation around the mean may be reduced as we collect further data.

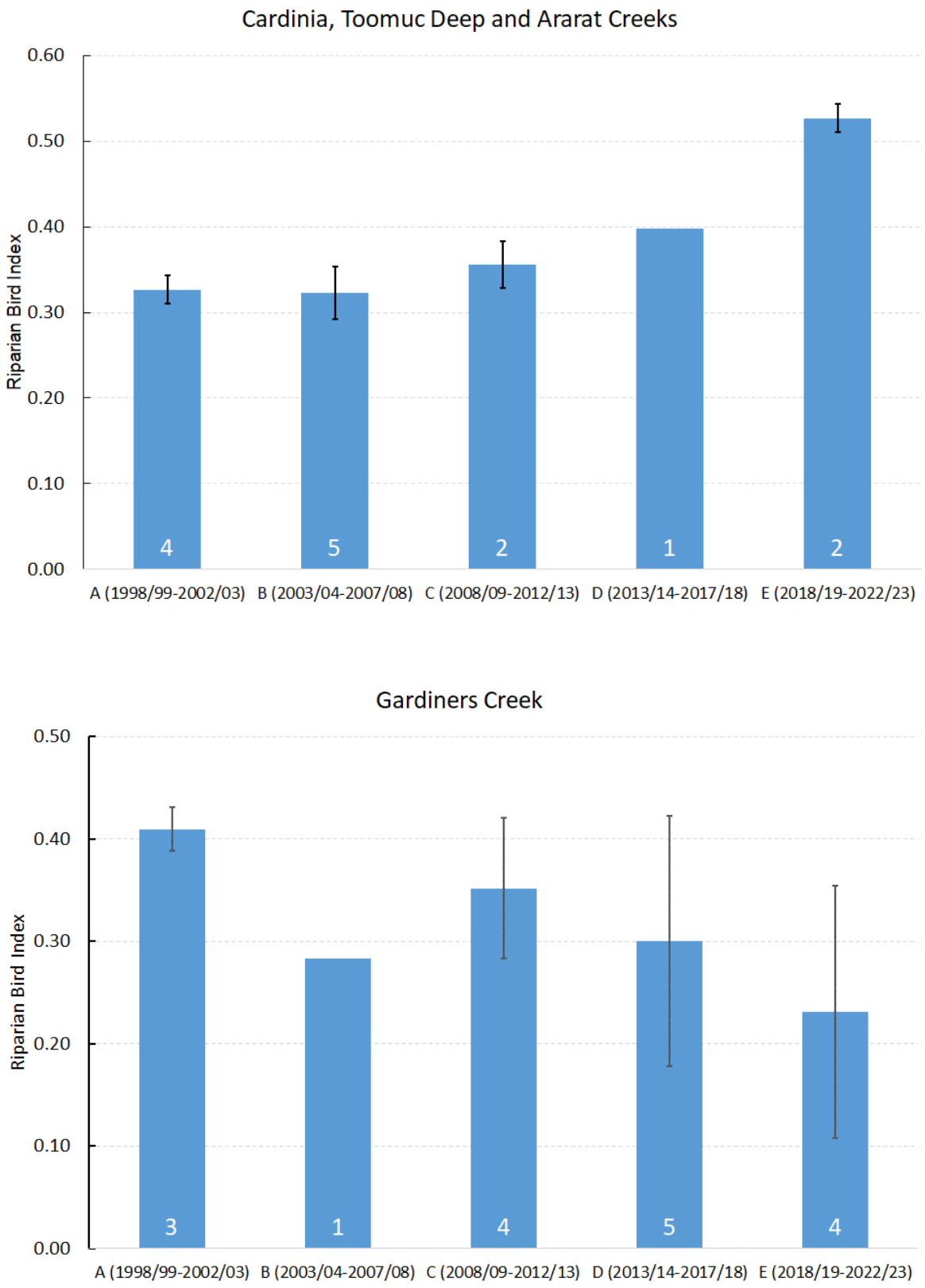
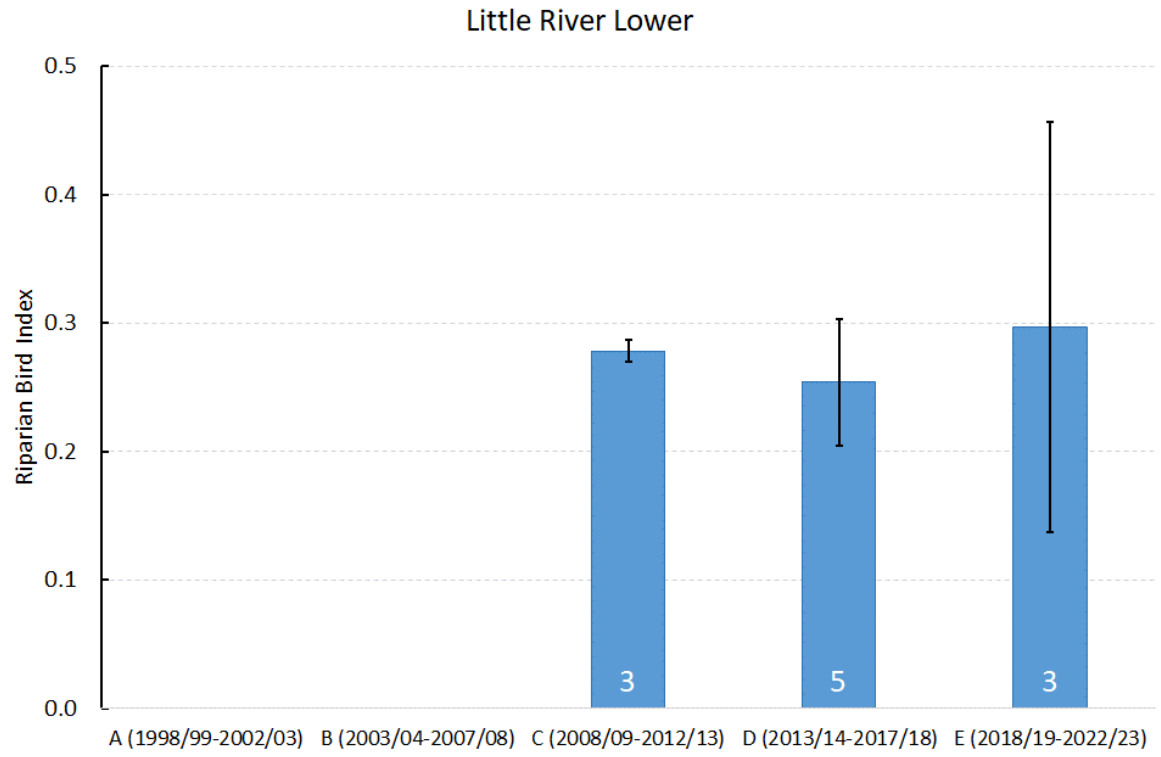


Figure 2. *Mean annual Riparian Bird Index scores (and standard deviation) for sub-catchments over five 5-year periods.*



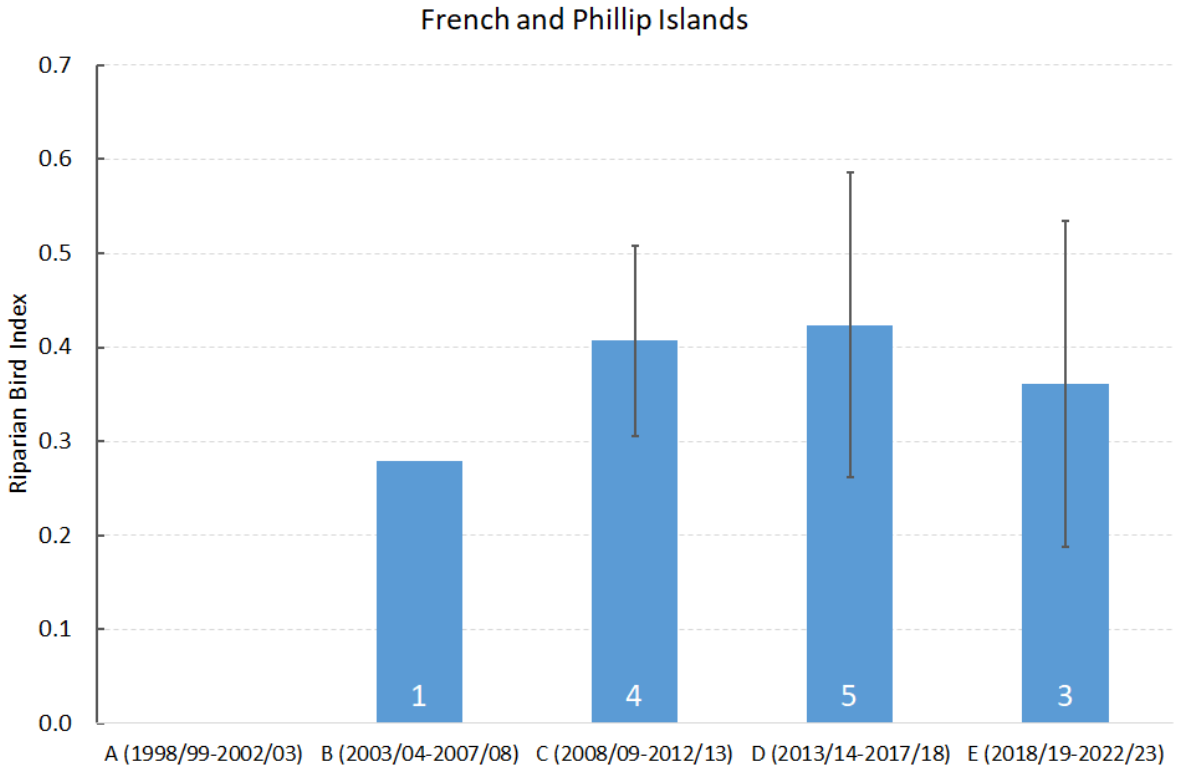
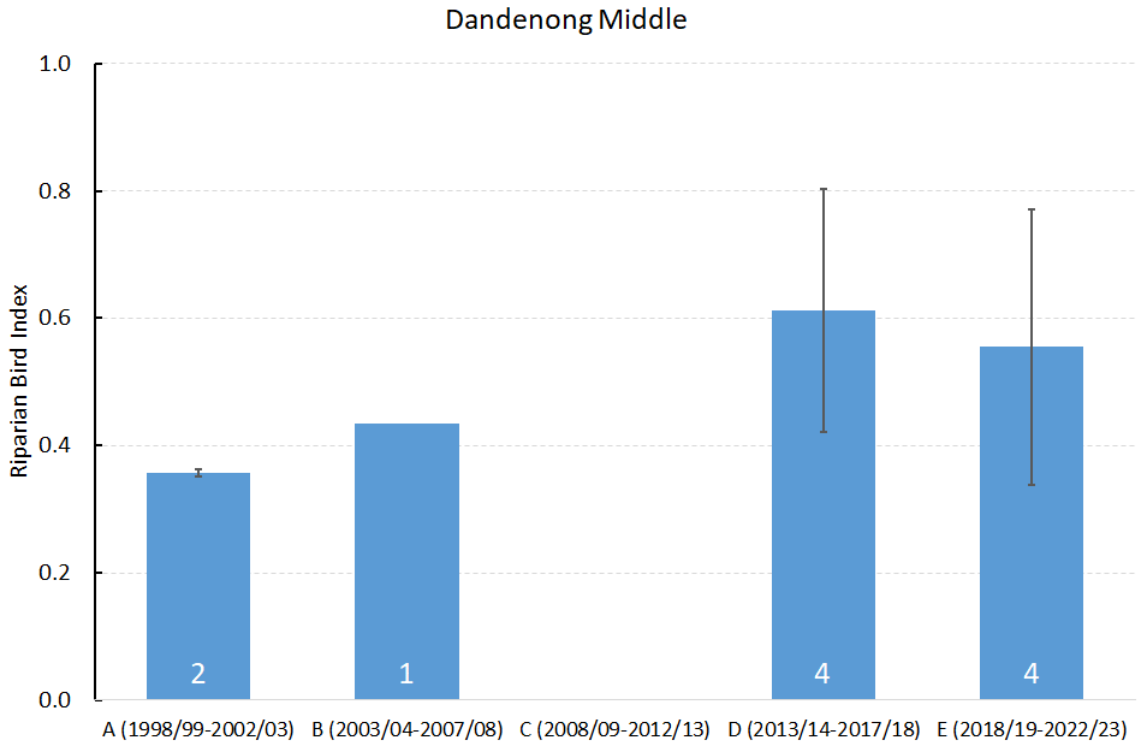


Figure 2 (cont.) *Mean annual Riparian Index scores (and standard deviation) for sub-catchments over five 5-year periods.*



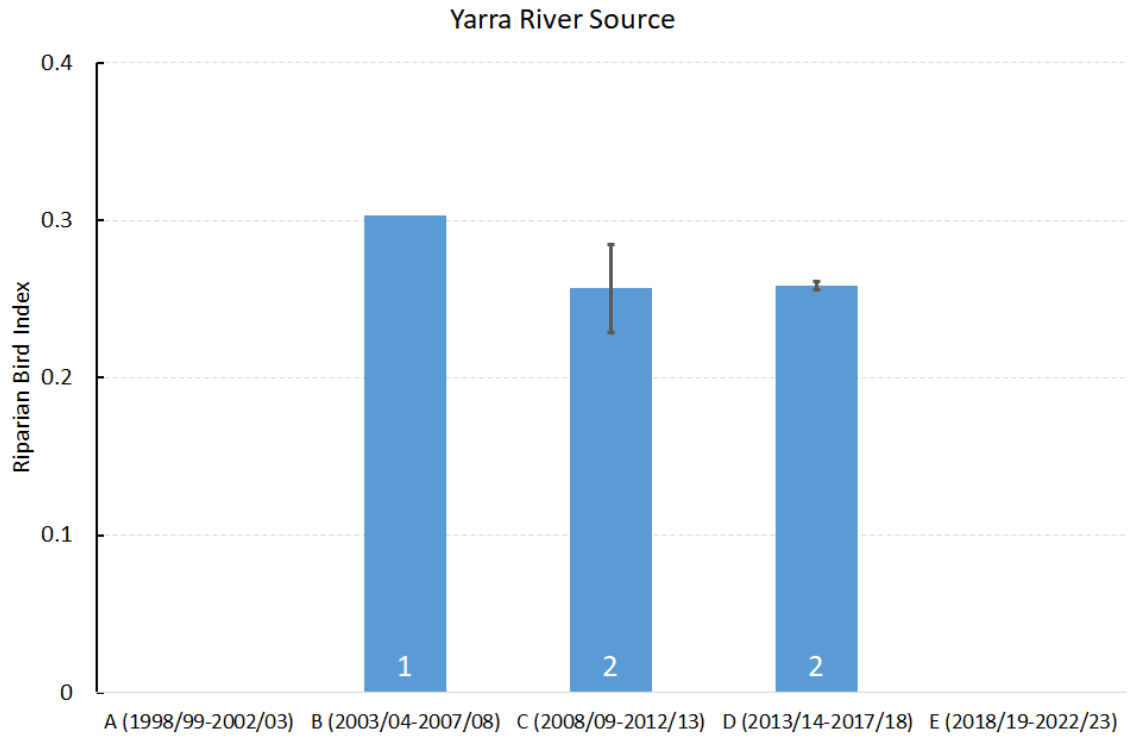


Figure 2 (cont.) *Mean annual Riparian Index scores (and standard deviation) for sub-catchments over a 25-year period.*

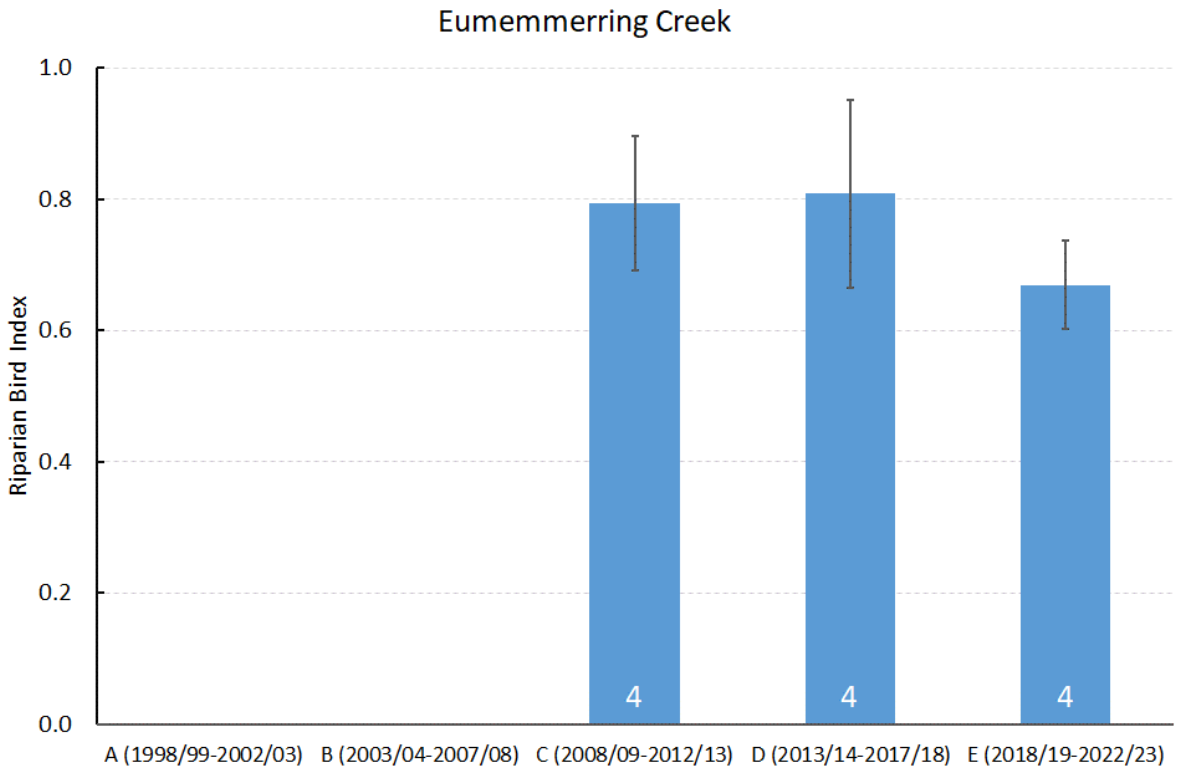


Figure 2 (cont.) *Mean annual Riparian Bird Index scores (and standard deviation) for sub-catchments over a 25-year period.*

Target setting against "current" benchmarking

The revised Riparian Bird Index was used to describe 'current' condition of our riparian bird communities in 2017, as the benchmark for the *2018 Healthy Waterways Strategy* (HWS, Melbourne Water 2018). Expert elicitation was employed to test the Riparian Bird Index results, and to estimate possible future condition scores for the 2018 HWS. The development of the 2017 version of the Index and how HWS performance objectives were set are described in detail in Steele (2019) and Melbourne Water (2020b).

As a Habitat Suitability Model used for other key values such as Platypus and fish was not available for birds at the time of the Strategy development, a hybrid data and expert elicitation approach was used to forecast future bird condition. Riparian bird scores were calculated using our metric and presented in a January 2018 survey sent to ~85 people identified as having expert knowledge of birds in the Port Phillip region. Experts were asked whether the scores presented were a reasonably accurate depiction of the heath of riparian bird communities. To determine the most likely future trajectory of riparian communities, this survey then asked experts for their forecast for riparian bird condition ~20 years ahead, when planned urban growth is in place and climate change effects will be apparent, assuming current policies and levels of investment in the management of our waterways. The spatial scale used in this survey was the 'system', a coarse subdivision of the Port Phillip and Westernport catchment developed for the 2013 Healthy Waterways Strategy and used in initial preparation for the 2018 HWS. Systems are smaller than Catchments but larger than the sub-catchments used in the present Strategy. The forecast trajectory was downwards for most Systems

although, surprisingly, the expert elicitation suggested some areas might improve under current investment futures with better targeted works.

The expert survey was not intended, or designed, to determine achievable long-term scores for riparian birds. Such targets are difficult to quantify when we do not have a set timeframe to work within, or know the budgets and investment likely to be invested. Estimating long-term targets is especially difficult when climate change effects are occurring faster than all modelled predictions, and the population growth of Melbourne is outstripping all planning estimates. At the time of the expert elicitation process, we could only ask for their best guess of what was achievable.

Nevertheless, when long-term "targets" (estimates) were required for riparian bird value, at some point in the future after indeterminate investment, results from our survey were considered the best available guide. Forecast scores for Systems were used as the possible long-term outcome for sub-catchments within the system. The 'best possible' scores for systems was used. Thus the higher of the two predicted scores generated through expert elicitation (likely under business as usual, and possible) was taken as the best possible outcome.

2. Summary of current management actions and progress

A conceptual model for birds as a key value was developed representing our scientific understanding at the time of the Strategy development (Alluvium 2017). The model documents and describes the relationships between environmental conditions and bird communities, including relevance to rivers, estuaries and wetlands, and with reference to landscape context, land use, urban growth and climate change (***Figure 3***).

This suggests that riparian birds will benefit particularly from revegetation and improved riparian vegetation quality and extent; improved water quality; and pest animal control. Hydrology is critically important for wetland birds but probably less so for riparian birds, although cease-to-flow events will be detrimental (through food chain effects) and brief overbank flows likely beneficial.

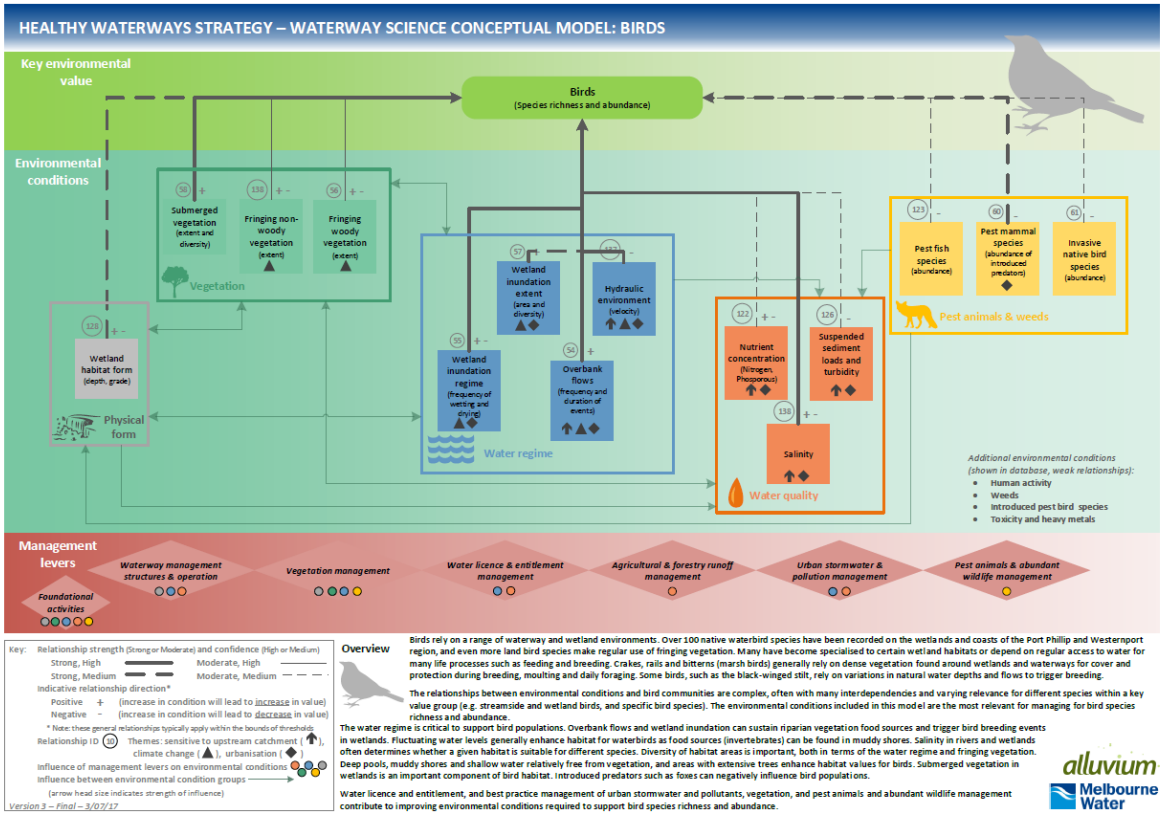


Figure 3. *A conceptual model for bird key values (Alluvium 2017).*

The overarching strategy in the HWS was to manage and improve the conditions that support riparian bird values through several performance objectives that also support other environmental and social values (Table 3).

Table 3. *Performance objectives (sub-catchment and regional) which influence riparian bird outcomes.*

Supporting condition	Sub-catchment Performance Objectives	Regional Performance Objectives
Vegetation	Establish a continuous riparian vegetated buffer (XX km, XX ha) and maintain existing vegetation (XX km, XXX ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality) (indicator: Ha vegetation established) Maintain or achieve high and very high quality vegetation (Vegetation Quality level 4 and 5 - currently XX km) through effective monitoring and management of threats including protection of endangered EVCs in these reaches. Fill data gaps and ensure additional high quality reaches are also protected. (indicator ha vegetation managed)	RPO-30 Climate change resilient revegetation management practices are understood and implemented by selecting plant species, provenances and vegetation communities that are suited to projected future climatic conditions. (indicator: qualitative assessment in annual progress report)
Management of predators and weeds	N/a	RPO-31 A risk-based approach is adopted to prevent, eradicate and contain pest plants and animals (including deer) and protect waterway assets. RPO – 32 Programs are in place to protect and enhance sites of biodiversity significance associated with the region's waterways, such as through Melbourne Water's Sites of Biodiversity Significance Strategy. (indicator: qualitative assessment in annual progress report)
Overbank Flows	Investigate options to increase environmental water reserve for the catchment is increased by xx GL /year by 2028 to meet ecological watering objectives and cover projected shortfalls. (indicator: GL water recovered)	RPO 12 Water for the Environment continues to be managed and delivered to the region's rivers and wetlands and recovery options continue to be investigated.
Water Quality	Improve water quality for environmental values and receiving waters (eg Port Phillip Bay and Westernport) by reducing turbidity and nutrient run-off from rural land. This may include establishment of vegetated buffers in headwater streams. (indicator: ha rural land managed to best practice)	RPO 25. Programs, standards, tools and guidelines are in place to manage nutrients, sediments and other pollutants from rural land in priority areas. (indicator: qualitative assessment in annual progress report)

The progress of implementing these performance objectives are outlined in the Vegetation Technical report (Melbourne Water 2022) and in the Annual Report online (https://healthywaterways.com.au/report-card). Very few of the performance objectives refer to

progress made towards supporting riparian birds as a value due to the expectation that actions undertaken for other values will support riparian birds.

The Regional Performance Objective 32 which supports Melbourne Water's Sites of Biodiversity Significance program is one of the few performance objectives that involves direct management for riparian birds. An example of this is an assessment of nocturnal avifauna populations at four sites of Biodiversity Significance that was undertaken in 2019/20 (McNabb 2020). The assessment detected two threatened bird species, the vulnerable Powerful Owl on each of the four sites surveyed (Cardinia Reservoir, Silvan Reservoir, Sugarloaf Reservoir and Yan Yean Reservoir) and the vulnerable Sooty Owl at Silvan Reservoir. The assessment identified that these four Sites of Biodiversity Significance provide foraging habitat for large forest owls and may support breeding activity.

The implications of prescribed planned burns in the vicinity of these regions for these species was highlighted and included the potential loss of hollow den and nest trees and impacts on prey such as possums and gliders. The assessment recommended that land managers should consider such impacts if planning to burn, and adopt strategies to protect sensitive owl nesting habitat. The report and its recommendations have been communicated to site managers, and will be taken into account when site management plans are revised (which happens every seven years).

3. Key Evaluation Questions and approach

KEQ 3a To what extent are key values on the target trajectory?

Evaluation methodology

The Riparian Bird Index was re-calculated, including recent minor improvements (see above), for all sub-catchments for which we have at least 40 robust surveys for the five-year period preceding the 2018 HWS (our 2018 benchmark) and the period July 2018 to December 2021.

The 2022 ("current") scores were to be compared with the 2018 ("benchmark") to assess if we are on-track to meet HWS objectives. This follows the rubric presented in the HWS *Rivers Monitoring and Evaluation Plan v1.0* (Table 4; Melbourne Water 2020b). However, following advice of the HWS Evaluation Panel the rubric was changed to compare current condition against the HWS target (rather than the 2018 benchmark).

Table 4. *Performance tracking rubric for riparian bird communities (Melbourne Water 2020b). Note: the rubric has been modified since to compare against HWS* ***target****, not benchmark. Thus 'slightly off-track' is when current score is one below HWS target.*

Performance rating	Performance criteria / evidence
On track to achieving long term target	Bird value score (2018 – 2022) has increased or is maintained at the HWS baseline (2013 – 2017)
Slightly off-track to achieving the long term target	Bird value score (2018 – 2022) has decreased by one category relative to the HWS baseline (2013 – 2017)
High chance that long term targets will not be met	Bird value score (2018 – 2022) has decreased by two categories or more relative to the HWS baseline (2013 – 2017)

Limitations and uncertainties

The Riparian Bird Index is a coarse measure of riparian bird community structure that is based on presence/absence only data collected from an uncontrolled range of disparate streamside sites. The Index is intended solely as a high level reporting tool for comparing scores aggregated across large areas (sub-catchments) over long time scales (multiple years).

Data are vetted by Birdlife Australia and we select only a small proportion of the available community-collected data. But the data collection is still somewhat ad hoc and there is no rigour around standardising the timing or seasonality of surveys. Birdlife Australia are asked to advertise sub-catchments requiring additional survey effort, but sites surveyed are decided by individual birdwatchers.

The Riparian Bird Index has not been tested to ascertain the influence of environmental (non-management) factors, such as annual rainfall, drought years, bushfires, etc. Therefore, we cannot, yet, distinguish between changes in score and management interventions/ investment versus environmental factors at the very large spatial scale of sub-catchments.

The Riparian Bird Index cannot be used to explain causes of changes in score. It was never intended for this purpose, but only to indicate changes in riparian community elements over time, which might then be investigated.

Evaluation results and discussion

Results are presented and discussed by catchment but, overall, there are several observable improvements (Figure 4).

First, the number of sub-catchments with insufficient robust surveys to calculate a Riparian Bird Index falls from 32 out of 69 to 24. Furthermore, many of these 24 sub-catchments now without 40 robust bird surveys will have the required data by the end of the five-year reporting period, 30 June 2023. Our data collection has improved over time and provides us with improved data, to support condition monitoring and reporting.

Second, the number of sub-catchments scoring 'Very low' has declined from 1 to zero. The number of sub-catchments scoring as 'Moderate' and 'High' have increased since 2013/14-2017/18, as many sub-catchments move up in condition (Figure 4).

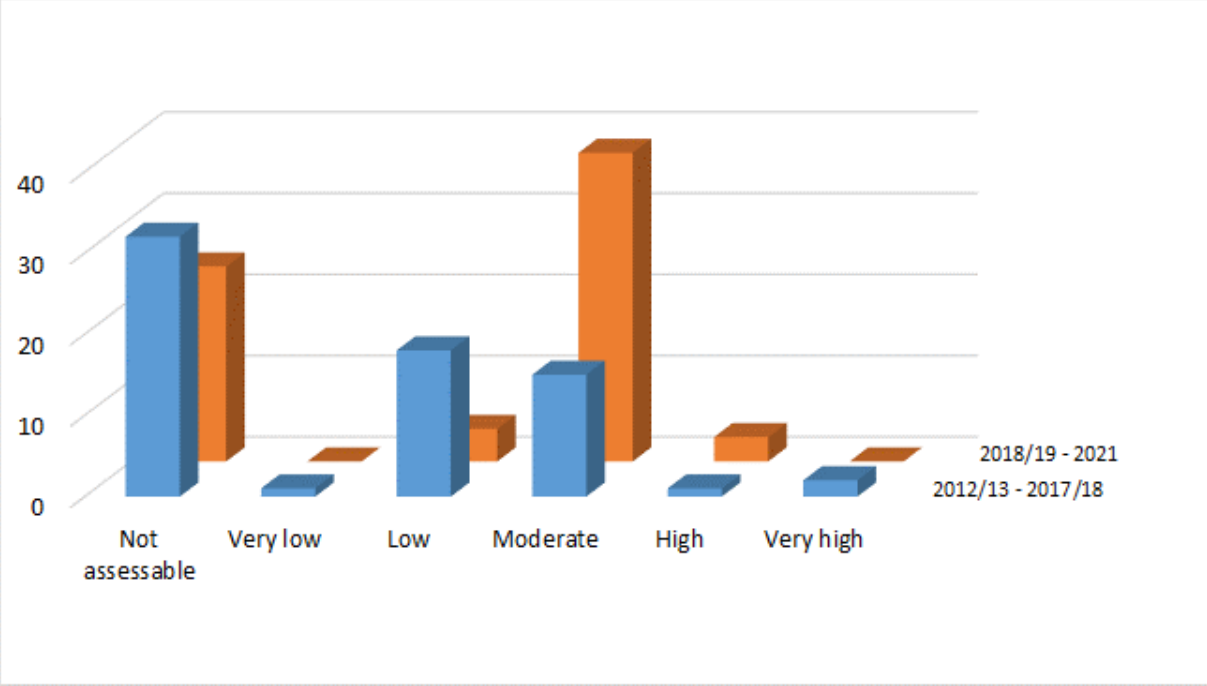


Figure 4. *Changes in coarse reporting category for riparian bird communities, comparing the 2013/14-2017/18 and 2018/19-2021 periods.*

However, it is not possible to attribute these improved community scores solely to our on-ground works. There is annual variability in Riparian Bird Index scores (see above) which possibly relates to annual rainfall, and other environmental factors, and we cannot tell to what extent the improved categorical reporting is a result of these, rather than our management. Given that revegetation is known to require some years before providing good quality bird habitat, the observed improvements could be attributable to on-ground works dating back to before the current HWS.

While 24 of 69 sub-catchments currently have insufficient data to permit an assessment, the majority of sub-catchments assessed (n = 37) are 'on track' according to the agreed rubrics. Two sub-catchments are 'off-track' (Watts River Source and Watsons Creek) and six sub-catchments are 'slightly off-track' (Eumemmerring Creek, Gardiners Creek, French and Phillip Islands, Bunyip Middle and Upper, Bayside and Mornington Peninsula SE Creeks).

Dandenong Catchment

We are mostly "on track" to meet the HWS 2018 objectives for riparian bird communities in the Dandenong Catchment. Seven of eight sub-catchments scored the target 'moderate' condition for the recent, 2018/19 to 2021, period (Table 5).
Dandenong Creek Upper is scoring above expectations: as 'high' when expectations were for a 'moderate' score. During the preparation of the HWS 2018 we had insufficient data to assess the riparian bird community condition for this sub-catchment and it appears likely we underestimated its riparian bird value.

Blind Creek and Dandenong Middle have seen the greatest increase in Index score. It is not clear why Blind Creek should have increased from 0.37 (2013/14 – 2017/18) to 0.66 (2018/19 – 2021/22). Further investigation is required.

Table 5. *Comparison of index and categorical scores of the riparian bird communities of Dandenong sub-catchments, 2018 and 2022.*

Sub-catchment	2018 Index	2018 Category	HWS target	2022 Index	2022 Category	Tracking
Bayside	0.92	Very high	High	0.39	Moderate	Slightly off-track
Blind Creek	0.37	Moderate	Moderate	0.66	Moderate	On track
Corhanwarrabul, Monbulk & Ferny Creeks	0.62	Moderate	Moderate	0.59	Moderate	On track
Dandenong Creek Lower	0.54	Moderate	Moderate	0.61	Moderate	On track
Dandenong Creek Middle	0.50	Moderate	Moderate	0.68	Moderate	On track
Dandenong Creek Upper		Insufficient data	Moderate	0.76	High	On track
Eumemmerring Creek	0.74	High	High	0.67	Moderate	Slightly off-track
Kananook Creek	0.62	Moderate	Moderate	0.59	Moderate	On track

In contrast, Bayside and Eumemmerring Creek are scoring below target. Eumemmerring is 'slightly off-track' since the simplified, categorical Riparian Bird Index score is one below the HWS target condition of 'high'. But the Riparian Bird Index score has only dropped from 0.74 to 0.67 and, although resulting in a categorical drop, this is not a large change in index score.

It has been suggested that the riparian bird value for the Eumemmerring sub-catchment may have been affected adversely by:

> "*There is a huge amount of development occurring in this catchment. There are 10 active precinct structure plans (new suburbs) which have taken over what was largely rural farmland. As such there have been considerable changes in land use in the last decade from rural/peri-urban to suburban.*
>
> *"Like some of the other catchments, this area is experiencing a lot of subdivision as the density of housing increases. Subdivision usually creates smaller blocks with less room for large trees and other vegetation and so this may be contributing to the slow decline overall in this area.*
>
> *"Covid may also have had an impact as more people were crammed into using the open space in the areas (largely waterways) increasing the level and frequency of disturbance for birds*." (Paul Rees, pers. comm.)

But similar factors would be at play across other sub-catchments that have not seen declines, and we cannot be certain of any specific cause of the decline in this area. As noted above, the decline is relatively small in terms of the Index and our coarse reporting categories perhaps exaggerate the actual change.

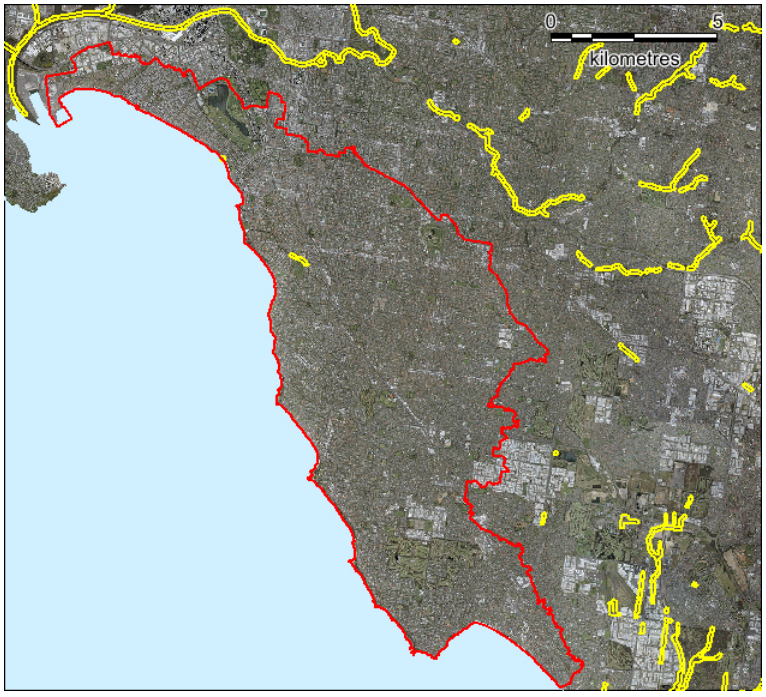


Figure 5. *Bayside sub-catchment, showing the limited area of 'riparian habitat' (yellow polygon) when selecting bird surveys to calculate the Riparian Bird Index.*

The score for Bayside has declined and is now 'moderate' compared to the HWS target of 'high'. There has been a significant decline in index score for this sub-catchment. But the sub-catchment is unusual in that the only 'streamside' considered relevant for the Riparian Bird Index is a very short stretch of the Elster Creek, where this runs through the Elsternwick Public Golf Course (Figure 5). This small area could be influenced by relatively minor vegetation clearance, or increased human disturbance or chemical use.

Maribyrnong Catchment

Unfortunately, we still have insufficient data of adequate quality to calculate riparian bird community condition scores for most of the Maribyrnong sub-catchments (Table 6). The four sub-catchments for which we can calculate our riparian bird metric for the period since mid-2018 are all on track.

Table 6. *Comparison of index and categorical scores of the riparian bird communities of Maribyrnong sub-catchments, 2018 and 2022.*

Sub-catchment	2018 Index	2018 Category	HWS target	2022 Index	2022 Category	Tracking
Deep Creek upper		Insufficient data	Moderate	0.32	Moderate	On track
Maribyrnong River		Insufficient data	Moderate	0.63	Moderate	On track
Jacksons Creek	0.54	Moderate	Moderate	0.90	High	On track
Moonee Ponds Creek	0.58	Moderate	Moderate	0.56	Moderate	On track
Boyd Creek		Insufficient data	Moderate		Insufficient data	Not assessable
Deep Creek lower		Insufficient data	Moderate		Insufficient data	Not assessable
Emu Creek		Insufficient data	Moderate		Insufficient data	Not assessable
Steele Creek		Insufficient data	Moderate		Insufficient data	Not assessable
Stony Creek		Insufficient data	Moderate		Insufficient data	Not assessable
Taylors Creek		Insufficient data	Moderate		Insufficient data	Not assessable

Maribyrnong River, Deep Creek Upper and Moonee Ponds Creek are on-track, with a score of 'moderate', and Jacksons Creek is exceeding the HWS target and scoring as 'high' (Table 6). Interestingly, Jacksons Creek has seen targeted vegetation management for birds and other stream values in recent years.

Werribee Catchment

In the Werribee Catchment, four of 14 sub-catchments have insufficient data to permit an estimate of current condition (Table 7). The other 12 sub-catchments are on track.

Werribee River Middle is above target, which is surprising given the extent of urban development occurring in this area. Little River Lower has increased in score, which possibly reflects a capital works program initiated there in 2014 to improve bird habitat.

Table 7. *Comparison of index and categorical scores of the riparian bird communities of Werribee sub-catchments, 2018 and 2022.*

Sub-catchment	2018 Index	2018 Category	HWS target	2022 Index	2022 Category	Tracking
Cherry Creek		Insufficient data	Moderate		Insufficient data	Not assessable
Kororoit Creek Lower	0.29	Low	Moderate	0.47	Moderate	On track
Kororoit Creek Upper		Insufficient data	Moderate		Insufficient data	Not assessable
Laverton Creek	0.34	Moderate	Moderate	0.41	Moderate	On track
Lerderderg River		Insufficient data	Moderate		Insufficient data	Not assessable
Little River Lower	0.23	Low	Low	0.36	Moderate	On track
Little River Upper	0.22	Low	Moderate	0.35	Moderate	On track
Lollypop Creek	0.17	Low	Low	0.30	Low	On track
Parwan Creek		Insufficient data	Moderate	0.32	Moderate	On track
Skeleton Creek	0.21	Low	Moderate	0.43	Moderate	On track
Toolern Creek		Insufficient data	Moderate	0.48	Moderate	On track
Werribee River Lower	0.25	Low	Moderate	0.37	Moderate	On track
Werribee River Middle		Insufficient data	Moderate	0.75	High	On track
Werribee River Upper		Insufficient data	Moderate		Insufficient data	Not assessable

Westernport Catchment

We have sufficient data to assess only six of the 12 sub-catchments in this area. Of these, half are on track to meet HSW targets (Table 8***Table 8***).

The Mornington Peninsula Western Creeks sub-catchment has a HWS target of 'moderate', and scored 'moderate' in this 2022 assessment. However, the Riparian Bird Index has dropped from 0.64 to 0.38 in this sub-catchment, and it currently rates as only 'low'. This illustrates the wide band categorized as 'moderate' (and why it was suggested categorical scoring be adjusted to reduce this large central category). Further investigation is needed to identify the causes of this decline in Index.

Bunyip Middle and Upper sub-catchment and Mornington Peninsula South-eastern Creeks sub-catchment both have a target of 'high' but are currently rated as 'moderate'.

Table 8. *Comparison of index and categorical scores of the riparian bird communities of Westernport sub-catchments, 2018 and 2022.*

Sub-catchment	2018 Index	2018 Category	HWS target	2022 Index	2022 Category	Tracking
Bass River		Insufficient data	Low		Insufficient data	Not assessable
Bunyip Lower		Insufficient data	Low		Insufficient data	Not assessable
Bunyip Middle and Upper		Insufficient data	High	0.39	Moderate	Slightly off-track
Cardinia, Toomuc, Deep & Ararat Creeks	0.41	Moderate	Moderate	0.51	Moderate	On track
Dalmore Outfalls	0.30	Low	Moderate	0.34	Moderate	On track
French and Phillip Islands	0.35	Moderate	High	0.42	Moderate	Slightly off-track
King Parrot and Musk Creeks		Insufficient data	Low		Insufficient data	Not assessable
Lang Lang River		Insufficient data	Low		Insufficient data	Not assessable
Mornington Pen. NE Creeks		Insufficient data	Moderate		Insufficient data	Not assessable
Mornington Pen. SE Creeks	0.49	Moderate	High	0.42	Moderate	Slightly off-track
Mornington Pen. W Creeks	0.64	Moderate	Moderate	0.38	Moderate	On track
Tarago River		Insufficient data	High		Insufficient data	Not assessable

Yarra Catchment

Of the 25 Yarra sub-catchments we have sufficient bird data between 2018/19 and 2021 to assess 17 for progress towards HWS targets. Of these, the majority, 14, are on track to meet HWS targets but three are not (***Table 9***).

Watsons Creek and Watts River (Source) are off-track (i.e. two or more categorical ranks below HWS target condition). Part of this area was burnt in the 2009 'Black Saturday Fires', which may have contributed to the lower score although, in the absence of data, this is only supposition. In fact, the RBI score for Watts River (Source) is very similar for both 2018 and 2022. The score for Watsons Creek has declined between periods.

Gardiners Creek is 'slightly off-track', being rated as one categorical rank below the HWS target. But the score for this sub-catchment has improved over time.

Table 9. *Comparison of index and categorical scores of the riparian bird communities of Yarra sub-catchments, 2018 and 2022.*

Sub-catchment	2018 Index	2018 Category	HWS target	2022 Index	2022 Category	Tracking
Brushy Creek		Insufficient data	Moderate		Insufficient data	Not assessable
Darebin Creek	0.10	Very low	Moderate	0.58	Moderate	On track
Diamond Creek (Rural)	0.21	Low	Moderate	0.37	Moderate	On track
Diamond Creek (Source)		Insufficient data	Moderate		Insufficient data	Not assessable
Gardiners Creek	0.19	Low	Moderate	0.27	Low	Slightly off-track
Koonung Creek	0.49	Moderate	Moderate	0.45	Moderate	On track
Little Yarra River and Hoddles Creek		Insufficient data	High		Insufficient data	Not assessable
Merri Creek Lower	0.29	Low	Moderate	0.43	Moderate	On track
Merri Creek Upper		Insufficient data	Moderate	0.31	Moderate	On track
Mullum Mullum Creek	0.27	Low	Moderate	0.37	Moderate	On track
Olinda Creek	0.26	Low	Moderate	0.43	Moderate	On track
Plenty River (Source)		Insufficient data	Moderate		Insufficient data	Not assessable
Plenty River Lower	0.15	Low	Moderate	0.42	Moderate	On track
Plenty River Upper	0.29	Low	Low	0.26	Low	On track
Steels and Pauls Creek (Rural)		Insufficient data	Moderate		Insufficient data	Not assessable
Steels and Pauls Creek (Source)		Insufficient data	Moderate		Insufficient data	Not assessable
Stringybark Creek		Insufficient data	Moderate		Insufficient data	Not assessable
Watsons Creek	1.03	Very high	Very high	0.67	Moderate	Off-track
Watts River (Rural)		Insufficient data	Moderate	0.31	Moderate	On track
Watts River (Source)	0.29	Low	High	0.28	Low	Off-track
Woori Yallock Creek	0.36	Moderate	Moderate	0.42	Moderate	On track
Yarra River Lower	0.19	Low	Moderate	0.43	Moderate	On track
Yarra River Middle	0.52	Moderate	Moderate	0.56	Moderate	On track
Yarra River Upper (Rural)	0.12	Low	Moderate	0.38	Moderate	On track
Yarra River Upper (Source)	0.26	Low	High		Insufficient data	Not assessable

KEQ 3b What other spatial and temporal trends and patterns for key values are of significance for implementation?

Evaluation methodology

Riparian Bird Index

The long-term trends in Riparian Bird Index were analysed with a focus on annual rainfall and other environmental factors that may play an important role in determining riparian bird community structure. This is because bird abundance, species richness and functional guild representation will respond to varying resources within a habitat and these are not set solely by our management.

Two approaches were tried. Where possible – i.e. when 40 or more robust scores were available for three or more time periods for a sub-catchment – we plotted these 5-year measures to track riparian bird community health at a coarse level. In addition, the annual Riparian Bird Index was calculated for those sub-catchments with sufficient data. The annual Index score provides a more detailed view of trends over time.

The Riparian Bird Index was designed for five-yearly reporting. We have not yet analysed the Index against the nature and scale of our works in any sub-catchments. This assessment is needed, especially in connection with our vegetation management, but was planned only for at least five years after the 2018 HWS was published.

Works evaluation

Given the limited number of targeted works aimed at improving riparian bird habitat, we cannot confirm any clear trends.

However, trends in the annual Riparian Bird Index provide an interesting possibility that capital vegetation works along Little River Lower and Jacksons Creek have positively influenced the riparian bird community. We need to investigate the bird community response at these works sites – using functional guild representation (number of individuals) as a measure and not the coarse Riparian Bird Index (refer to Section 5).

Evaluation results and discussion

Riparian Bird Index – Five-year periods

Figures 6 to 10 show the changes in five-year Riparian Bird Index scores.

The riparian bird communities of Dandenong sub-catchments – as measured by our metric – show varying trends over time. Figure 6 shows calculated condition scores for four 5-year periods, when we have 40 or more acceptable bird surveys for the period.

Results suggest Bayside has seen a significant decline in riparian bird communities over recent years. Eumemmerring Creek has seen a less pronounced decline since the mid-2008 to mid-2013 period, and is now rated as only ‘moderate’ condition. As noted above, this sub-catchment index score has not declined by much, but this was sufficient to change its reporting category.

Dandenong Creek Lower and Middle have seen some improvement in scores for the most recent period. Blind Creek – for which we have few data prior to mid-2013, when our Regional Bird Monitoring program was initiated as part of the 2013 *Healthy Waterways Strategy* – shows significant improvement over time, although remaining in our 'moderate' category.

The only clear trend in the Maribyrnong catchment is an improvement in riparian bird score in the Jacksons Creek sub-catchment (**Figure 7**). Moonee Ponds Creek shows a consistent score over nearly 20 years.

Yarra sub-catchments, for which we can plot some kind of trend line, show a similar pattern to the Werribee: a decline from Period C to Period D, and then a recovery in Period E (**Figure 8** and Figure 9).

The clearest trend among Westernport sub-catchments is a steady decline in Mornington Peninsula Western Creeks (Figure 10).

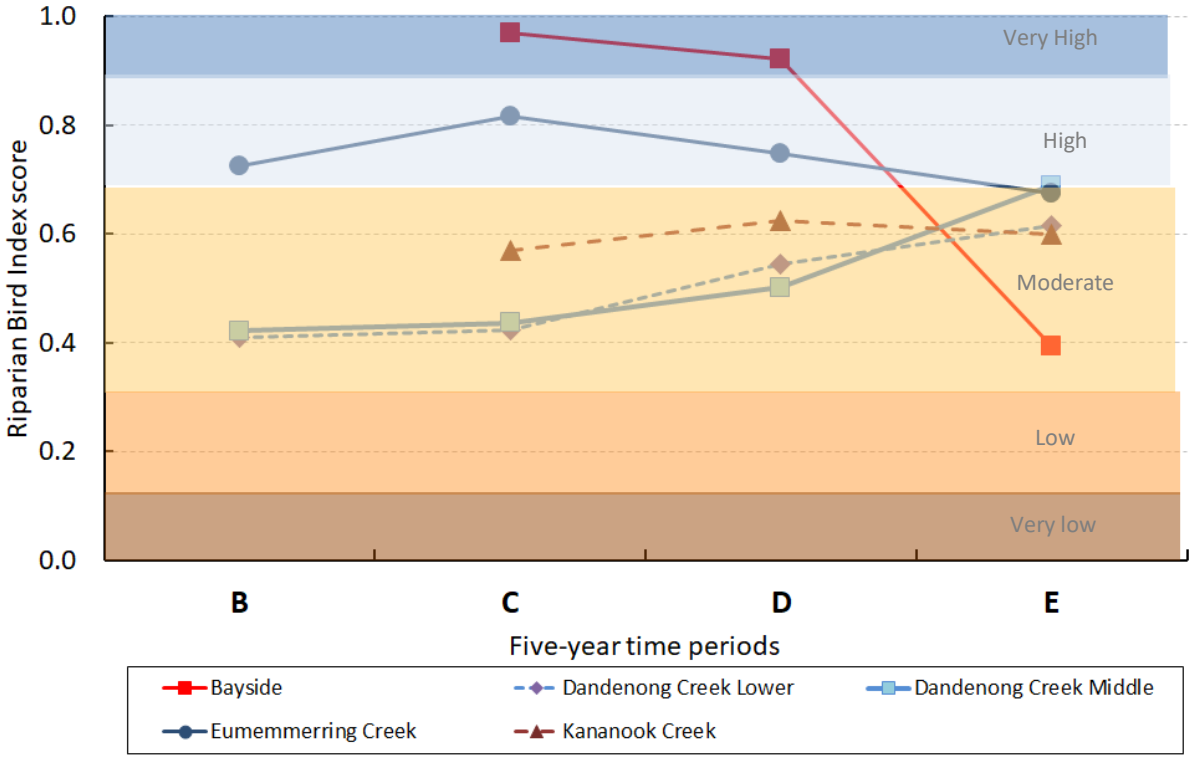


Figure 6. *Riparian Bird Index scores for Dandenong sub-catchments over four 5-year periods. Only index scores based on 40+ surveys are given, and only sub-catchments with three or more period scores shown.*

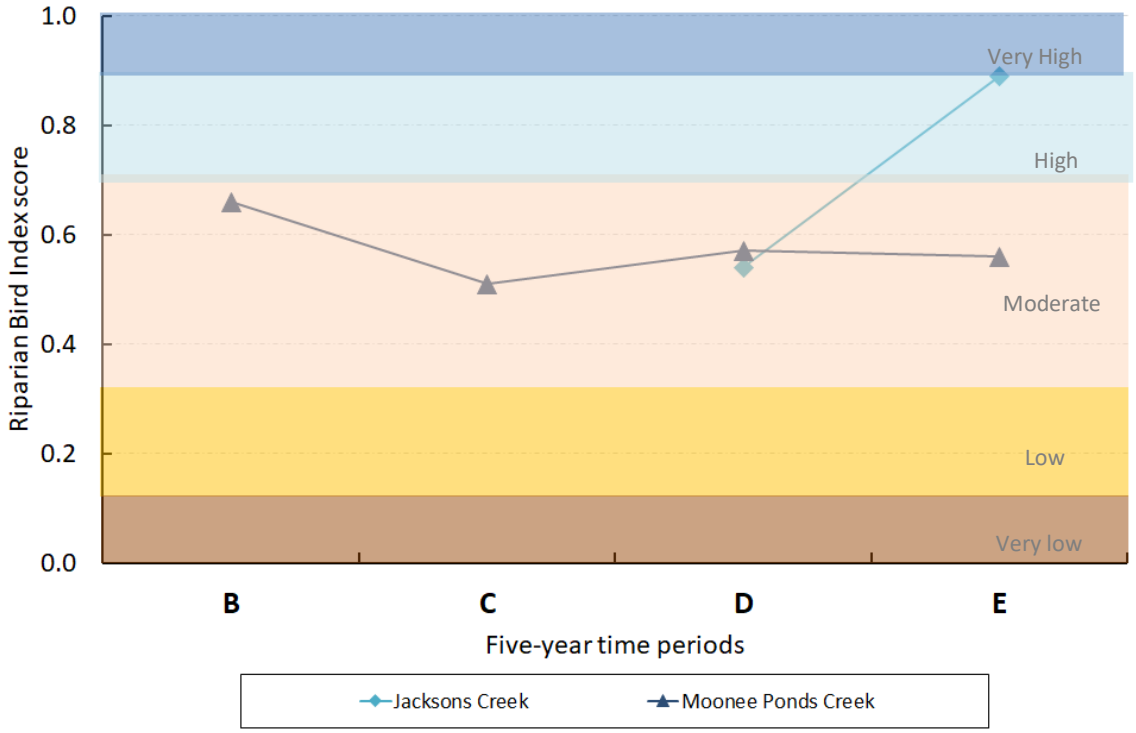


Figure 7. *Riparian Bird Index scores for Maribyrnong sub-catchments over four 5-year periods. Only index scores based on 40+ surveys are given, and only sub-catchments with two or more period scores shown.*

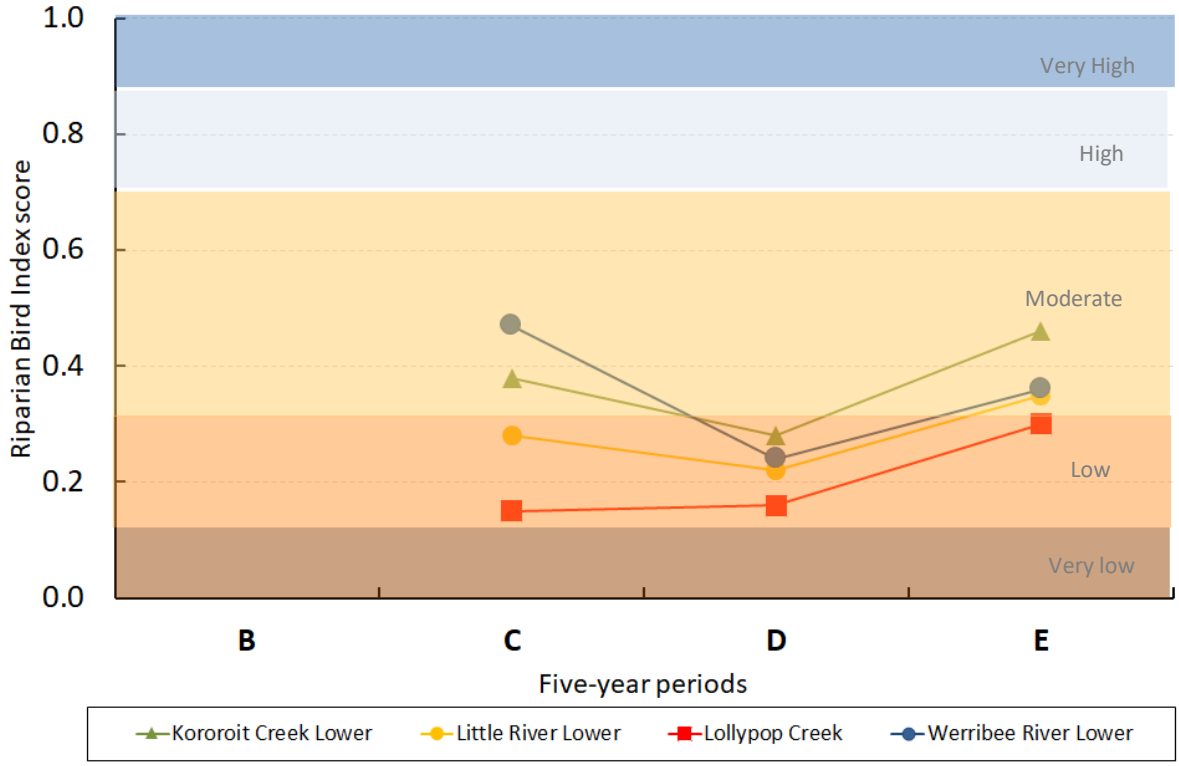


Figure 8. *Riparian Bird Index scores for Werribee sub-catchments over four 5-year periods. Only index scores based on 40+ surveys are given and only sub-catchments with three or more period scores shown.*

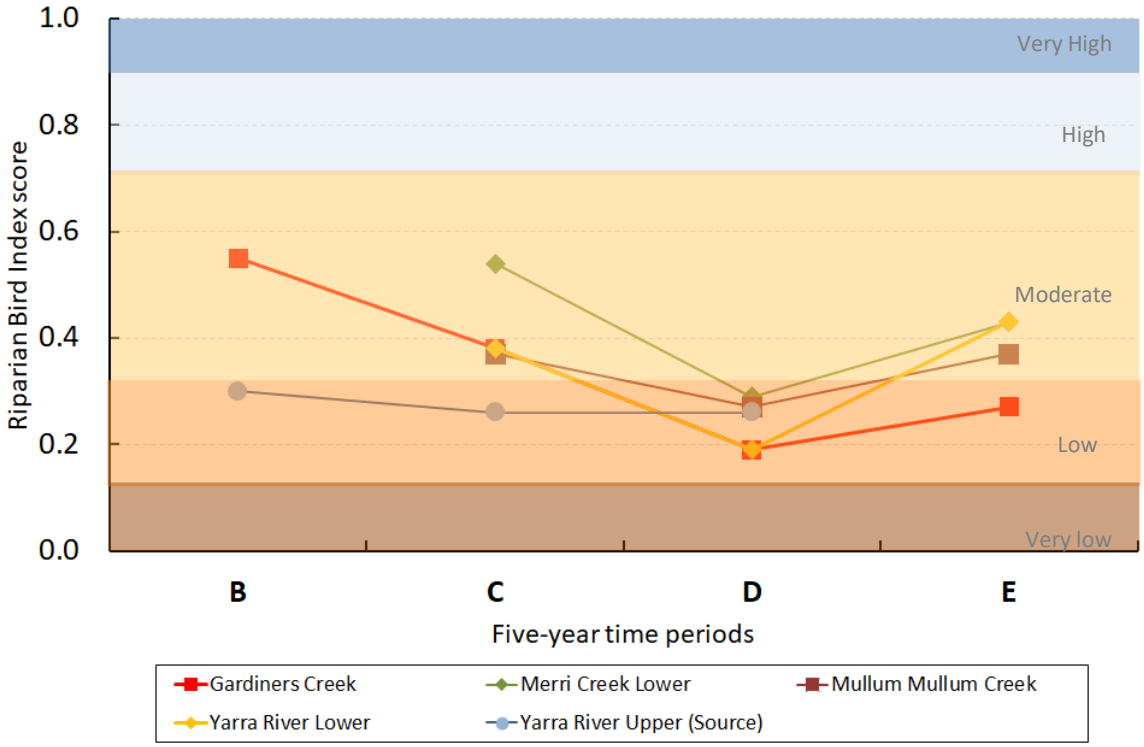


Figure 9. *Riparian Bird Index scores for Yarra sub-catchments over four 5-year periods. Note only robust scores based on 40+ surveys are included, and only those sub-catchments with at least three period scores graphed.*

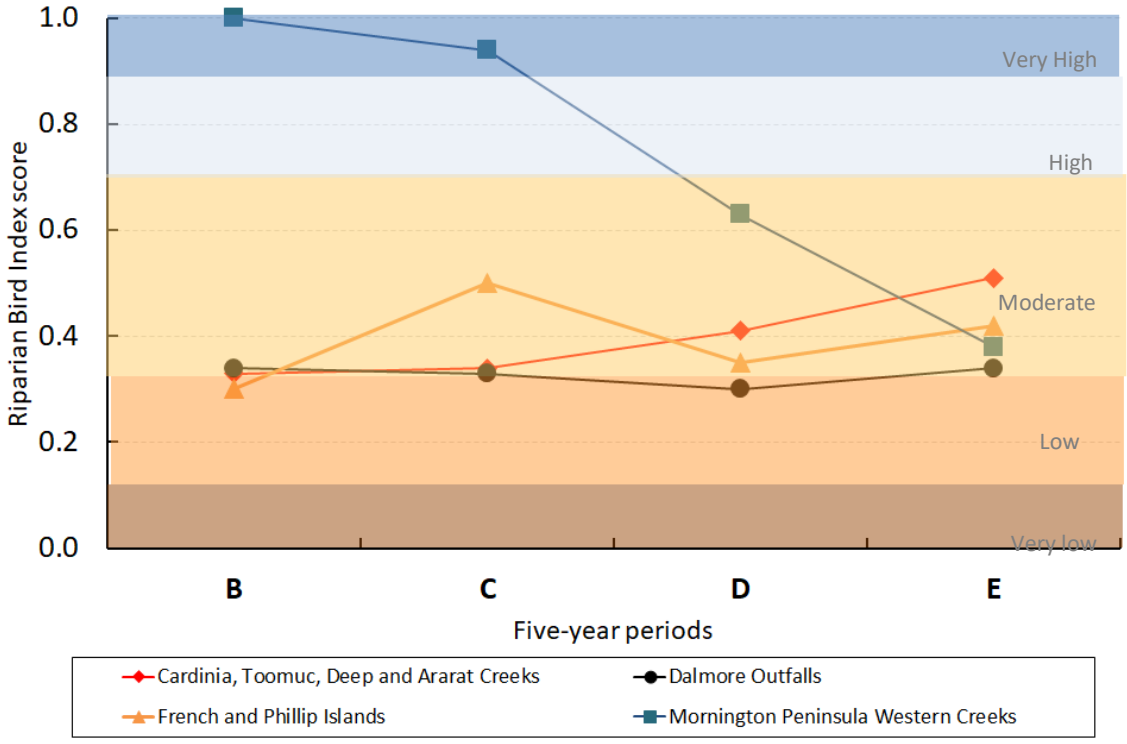


Figure 10. *Riparian Bird Index scores for Westernport sub-catchments over four 5-year periods. Only index scores based on 40+ surveys are given and only sub-catchments with three or more period scores shown.*

Riparian Bird Index – annual changes

Sub-catchments for which we can calculate annual indices are plotted below. The Riparian Bird Index shows a reassuring 'smoothness' in pattern over time with clear trends shown and few extreme variations between data points. But further analysis is required.

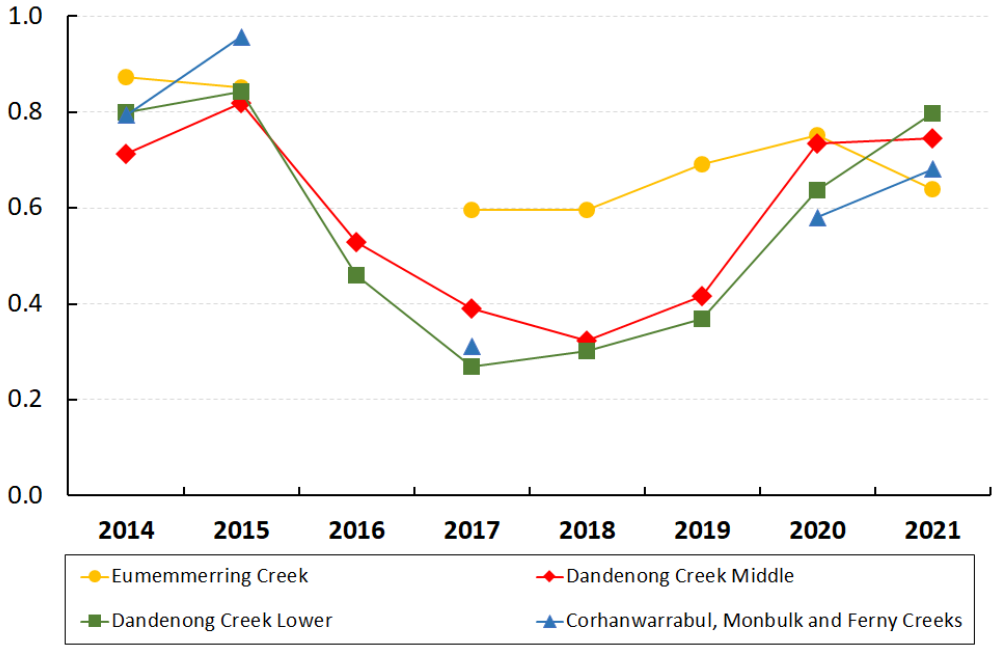


Figure 11. *Annual Riparian Bird Index scores showing trends over time for those Dandenong sub-catchments with sufficient data.*

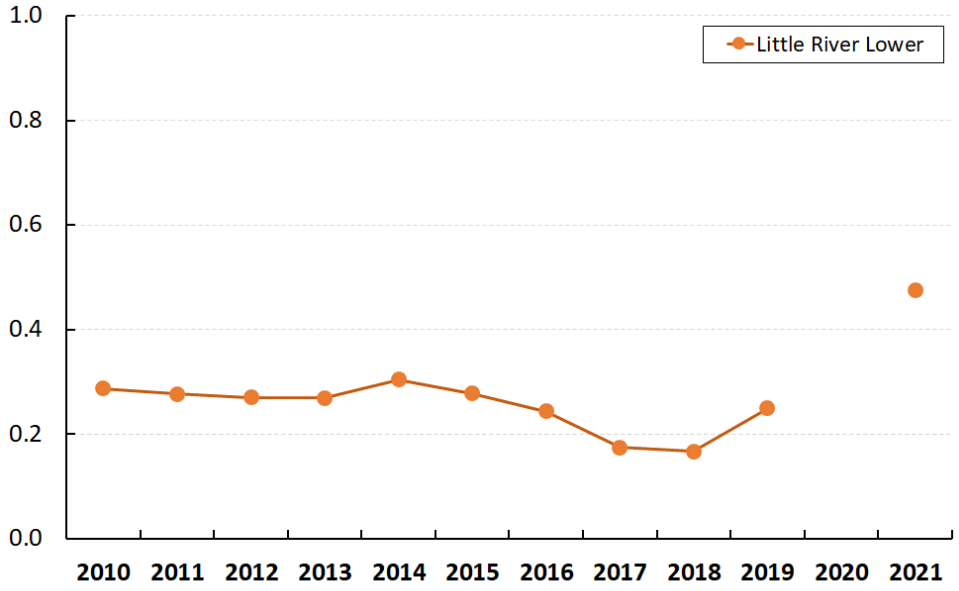


Figure 12. *Annual Riparian Bird Index trend over time for the Little River Lower sub-catchment of the Werribee Catchment.*

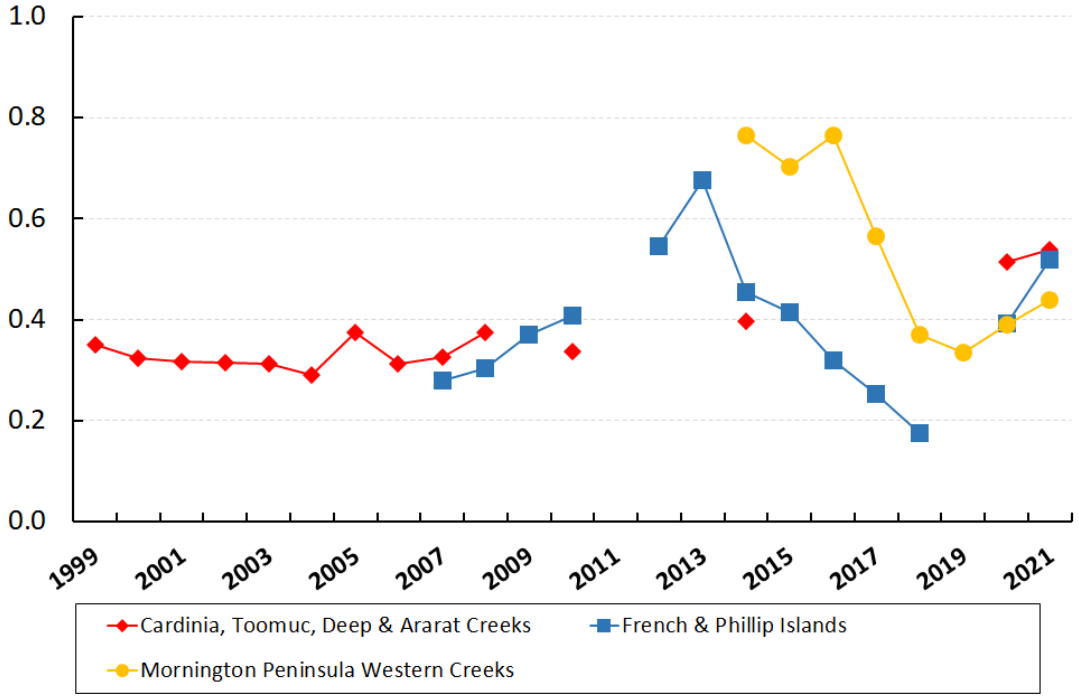


Figure 13. *Annual Riparian Bird Index scores showing trends over time for those Westernport sub-catchments with sufficient data.*

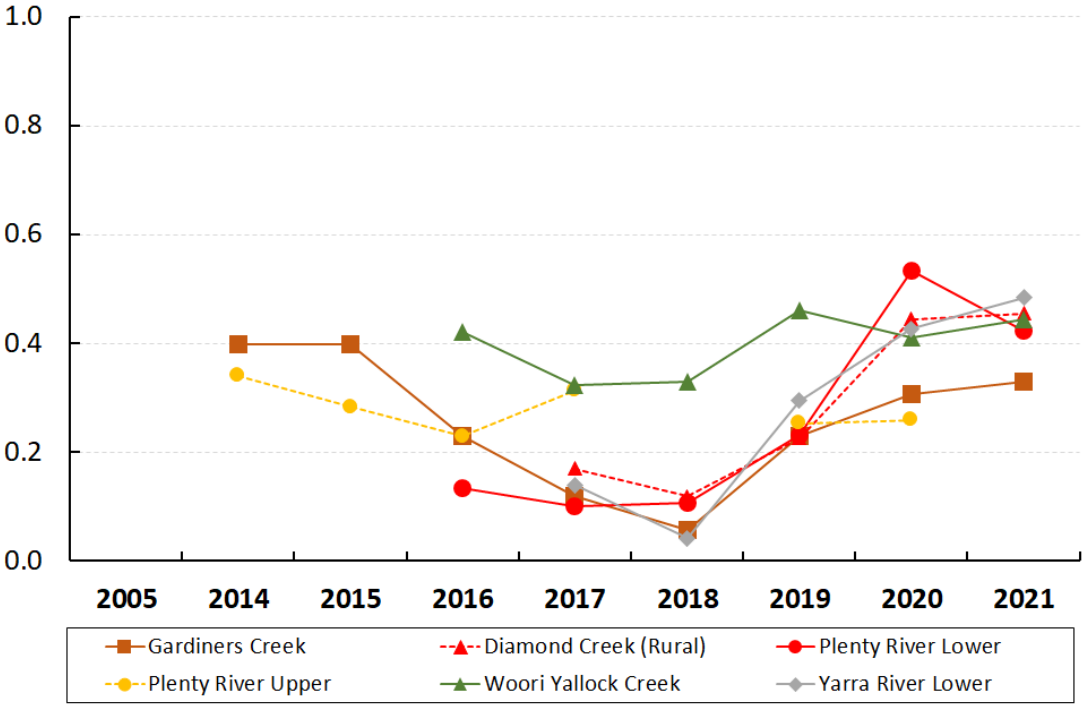


Figure 14. *Annual Riparian Bird Index scores showing trends over time for those Yarra sub-catchments with sufficient data.*

4. Information relevant to remaining KEQs

KEQ 2b. To what extent have projected known and emerging future threats changed from 2018? Have any assumptions about impacts to key values changed?

A project has been initiated to look at 'what's changed' since the HWS was released. The results of this project will feed into KEQ2b and be presented in the Science Inquiry. The project will also provide useful data for the Implementation Inquiry which will evaluate the extent to which performance objectives have been achieved along with the effectiveness of collaboration.

The project will focus on:

1. What has changed in the external environment in the past few years to now, that may impact our effectiveness?
2. What is happening in our waterways and drainage operating environment and strategy implementation, that may impact our effectiveness, now and to the final strategy review?
3. How have our assumptions around threats to waterways changed since the strategy was developed? Have they increased, remained the same or decreased?

The project will look at Melbourne Water's annual environment operating scan to identify external conditions relevant to the implementation of the HWS. It will consider new information (e.g. how threats have changed as well policy and institutional arrangements) and will also draw on practitioners observations and experience.

The project will consider the impacts of these changes through a SWOT analysis to identify what's significant for future implementation of the HWS. A complete list of threats for environmental values is currently being compiled and is being refined as each Key Value paper is prepared and is also being compiled in the Threats technical paper (Melbourne Water 2023b).

Further work is underway to determine datasets and information which will provide evidence for how threats and assumptions have changed since the HWS was developed. There are a number of Waterways Research Projects which will provide important information for this KEQ in terms of birds, including:

- Climate change (vegetation D5, temperature & flow A1)
- Chemicals of concern (B1.1)
- Urban development (A1 – HSM)
- Construction sediment/pollution (B2)

The *Flora and Fauna Guarantee Act* has been revised and new threatened species status assigned to several species of bird. Most affected species have increased in risk status. These changes will need to be taken into account in future works evaluation studies, and should a conservation status weighting be incorporated into our Riparian Bird Index. The Gang-gang Cockatoo has recently been listed as Endangered under the EPBC Act.

KEQ 4a. To what extent are interventions appropriate and effective for achieving outcomes?

In the context of the HWS mid-term evaluation, an intervention is defined as:
an action taken to protect or improve the condition (i.e. vegetation extent) or reduce a threat to an asset (i.e. river) to support a key value.

Interventions are typically undertaken in the effort to ultimately support a key value (e.g. platypus) to meet the expectations of stakeholders and the community to achieve the targets outlined in the HWS. Interventions typically fall into two categories;

1. On ground – for example physical or structural actions such as revegetation, weed management
2. Administrative – for example non – structural programs, projects, planning and policy

Interventions have been included in the HWS mid-term evaluation to understand:

1. If interventions are having an impact
2. If investment is being spent on the right interventions
3. If certain interventions are more appropriate in locations than others

This section includes a summary of interventions which directly protect or improve riparian birds. A full evaluation of broader interventions is outlined in the Interventions stocktake report (Melbourne Water, 2023d). This section provides some insights into the information which will feed into this evaluation.

Overview of Riparian Bird Interventions

During preparation of the 2018 HWS, expert elicitation was employed and 85 knowledgeable local ornithologists/birdwatchers were questioned about the best interventions or management actions for riparian birds (Steele 2019). Of 33 responses received vegetation management was viewed as the most important management action (**Table 10**).

Table 10. *Response of experts to the question "Considering what management interventions are possible to improve riparian bird richness and resilience in our region, please let us know your top three (in terms of overall effectiveness and practicality)". Maximum score possible was 33 (n = 30 respondents to this question; Steele 2019).*

Management action	Score
Revegetation of corridors to link habitat patches.	20.04
Planning controls to preserve set-backs and areas of native vegetation.	19.73
Revegetation to increase depth of riparian zone.	19.38
Cat and/or fox control.	19.35
Stock exclusion fencing.	18.27
Controlling human (and dog) access or disturbance.	17.40
Promoting natural regeneration of vegetation (as opposed to revegetation).	16.42
Woody weed removal.	16.40
Further research (e.g. riparian bird responses to management and climate change).	16.33
Reinstating meanders or billabongs.	16.21

A review by AECOM found support for vegetation management and predator control benefits to birds (AECOM 2012b, Box 1).

Thus, most stream management activities will potentially benefit riparian birds over time. Riparian vegetation has been shown to be of near critical importance to bird communities, especially in largely cleared agricultural and urban landscapes (Bishop & Myers 2005; Palmer & Bennett 2006; Price et al. 2006; Bennett et al. 2006, 2014, 2022; Berges et al. 2010; Perry et al. 2011). But no works have been initiated under the 2018 HWS solely to benefit riparian birds.

During 2013 to 2018, under the previous HWS, a number of capital projects were initiated to improve our riparian bird value. Bird surveys have continued at these sites:

- Revegetation along Balcombe Creek tributaries at The Briars to connect remnant patches of vegetation (2014),
- Revegetation along Salt Creek in the Rosanna Parklands (a community request)
- Revegetation works along Jacksons Creek (2014),
- Revegetation along Monbulk Creek (2014), and
- Staged removal of willows on Olinda Creek (2013)

However, sample sizes are small, and the duration of these works may not be sufficient to assess bird response. Revegetation takes many years to become high quality bird habitat (e.g. Vesk & Mac Nally 2006; Mac Nally 2008; Vesk et al. 2008; Munro et al. 2011; Radford et al. undated a, b).

Doeg (2011) summarised the time lag as: 5-10 years following revegetation for ground-dwelling birds, 10-20 years for tree-dwelling birds, and 100+ years for those species that nest in large tree hollows, such as Powerful Owl. In addition, there are also complications caused by loss of access to sites, control sites being worked on, or works sites not receiving the anticipated treatment.

Our largest and longest running works evaluation study was set up in 2012 at 16 sites along the Yarra tributaries. Four sites were willow (or poplar) infested, four native vegetation remnants, four with willows removed prior to 2002, and four with willows removed between 2002 and 2012 (AECOM 2012b, 2013). Subsequently further sites were added, but difficulties in finding adequate control sites has limited the value of these studies. Sites added include:

- Olinda Creek (2013 to present) – three sites: one willow-infested, one willows removed and one planned for staged removal of willows.
- Monbulk Creek (2013 to present) – two sites: one willow-infested and one control site.

This study of bird community use of riparian sites that are willow-infested vs native vegetation, revegetation >10 years of age, and revegetation <10 years of age (at the commencement of the study) initially showed a positive response to willow removal, although a decline as revegetation aged (AECOM 2012a, 2013).

Box 1. *Effects of riparian management on birdlife (AECOM 2012b).*

Table 1. Summary of Key Published Literature for Effects of Riparian (and other) Improvement Works on Native Bird Communities and Populations

Actions / Works	Effects on Native Birds	Source
Positive Benefits		
Revegetation	Positive benefits on bird diversity in early stage revegetation	Barrett *et al.* (2008)
Revegetation	Positive benefits on increased revegetation extent on bird diversity	Clarke *et al.* (2010)
Revegetation	Positive benefits on bird diversity, especially in intersection plantings	Lindenmeyer *et al.* (2007)
Revegetation	Positive benefits on bird diversity of woodlot and ecological plantings, especially floristically diverse understorey vegetation	Munro *et al.* (2010)
Revegetation	Beneficial effects for hollow-dependent birds and fauna requiring high fallen timber loads not evident for >60 years	Vesk *et al.* (2008)
Revegetation	Beneficial effects for hollow-dependent birds not evident for >50 years	Shanahan *et al.* (2010)
Weed control	Evidence to indicate willows have detrimental impact on native birds in New Zealand	Gianotti and Stanley (2004)
Weed control	Evidence to indicate willows have detrimental impact on native bird diversity in Victoria	Holland-Clift *et al.* (2011)
Weed control	Evidence to indicate weeds have positive benefit to exotic birds only	Munro *et al.* (2010)
Fox control	Positive effects on fledgling success in Pied Oystercatcher	Wellman *et al.* (2000)
Pest animal control	Positive benefits for native birds	Paton (1991); Dickman (1996); Olsen *et al.* (2006)
No Positive Effects		
Revegetation	No obvious benefits of linear plantings on declining species (Brown Treecreeper) in extensively cleared and degraded landscape	Mac Nally *et al.* (2010)
Weed control	Evidence to indicate that camphor laurels have some beneficial effects on native forest pigeons and other rainforest birds in NSW	Neilan *et al.* (2006)
Weed control	Boxthorn provides habitat and food resources for certain native birds in an extensively cleared landscape; removal of boxthorn is recommended to be staged with associated revegetation works	Peter (2000)
Weed control	Hawthorn and gorse infested areas had higher native bird diversity than nearby cleared areas and recent revegetation in a cleared landscape	Carlo and Gibson (2010)
Weed control	Infestation by exotic plants has little consistent effect on bird communities, although particular foraging guilds were negatively affected; weed removal had a negative effect on birds as displayed by the significantly lower richness of bird species in sites cleared of weeds, discard piles and young revegetation sites	French and Zubovic (1997)

More recent analysis of added years of data did not reveal this decline as revegetation aged and reinforces the expectation that willow removal improves riparian bird community condition. For example, during 2018/19, Birdlife Australia analysed the greater body of data available. Bird

responses to willow removal or absence were generally positive using a range of metrics (Birdlife Australia 2020b):

- Total number of species recorded per site (surveys combined)
- Total number of species recorded per site per survey
- Total Conservation Score for species recorded per site (surveys combined)\
- Total Conservation Score for species recorded per site per survey
- Total number of native birds per site per survey
- Total number of exotic birds per site per survey
- Total number of bird foraging guilds per site (surveys combined)
- Total number of bird foraging guilds per site per survey

Later, we used the study data to 2022 to look at only woodland species of bird and their response to willow removal and age of revegetation. Woodland species richness and abundance were highest in native vegetation remnants and lowest in willow-infested sites. Revegetation sites of both age classes supported a greater number of woodland birds and species than willow-infested sites (Figure 15 a and b).

Looking at woodland species richness and abundance by three time periods shows the initial (Period A: 2012/13) results – where younger age revegetation supported higher richness and abundance than older revegetation – was not reflected in later periods once more data was available (Figure 15 c and d).

Bird surveys during Period A (n = 57) were carried out by a different ornithologist to later periods, and covered a much briefer period (July 2012 to January 2013). Therefore, this first period may not be truly comparable to the later periods. Period B (n = 431 surveys between April 2014 and May 2018) and Period C (n = 276 surveys between September 2018 and March 2021) were all carried out by the same skilled birdwatcher.

A capital improvement project along the banks of the lower Little River saw extensive weed control and revegetation (7500 plants), with riparian birds identified as a key value to benefit from these works, during 2014. Shortly after this, during 2016, the lower ford crossing on the Little River was modified to remove a fish barrier, and extend the estuarine conditions farther inland.

There is very little understanding of the true nature of the relationship between water quality and hydrology, and riparian birds. AECOM (2012b) summarized the literature but practically all of this relates to wetland rather than riparian birds. Some environmental flow assessment studies attempt to understand the flow requirements of riparian and woodland birds (e.g. Lieschke et al. 2000) but water quality in particular remains a major knowledge gap in our conceptual model.

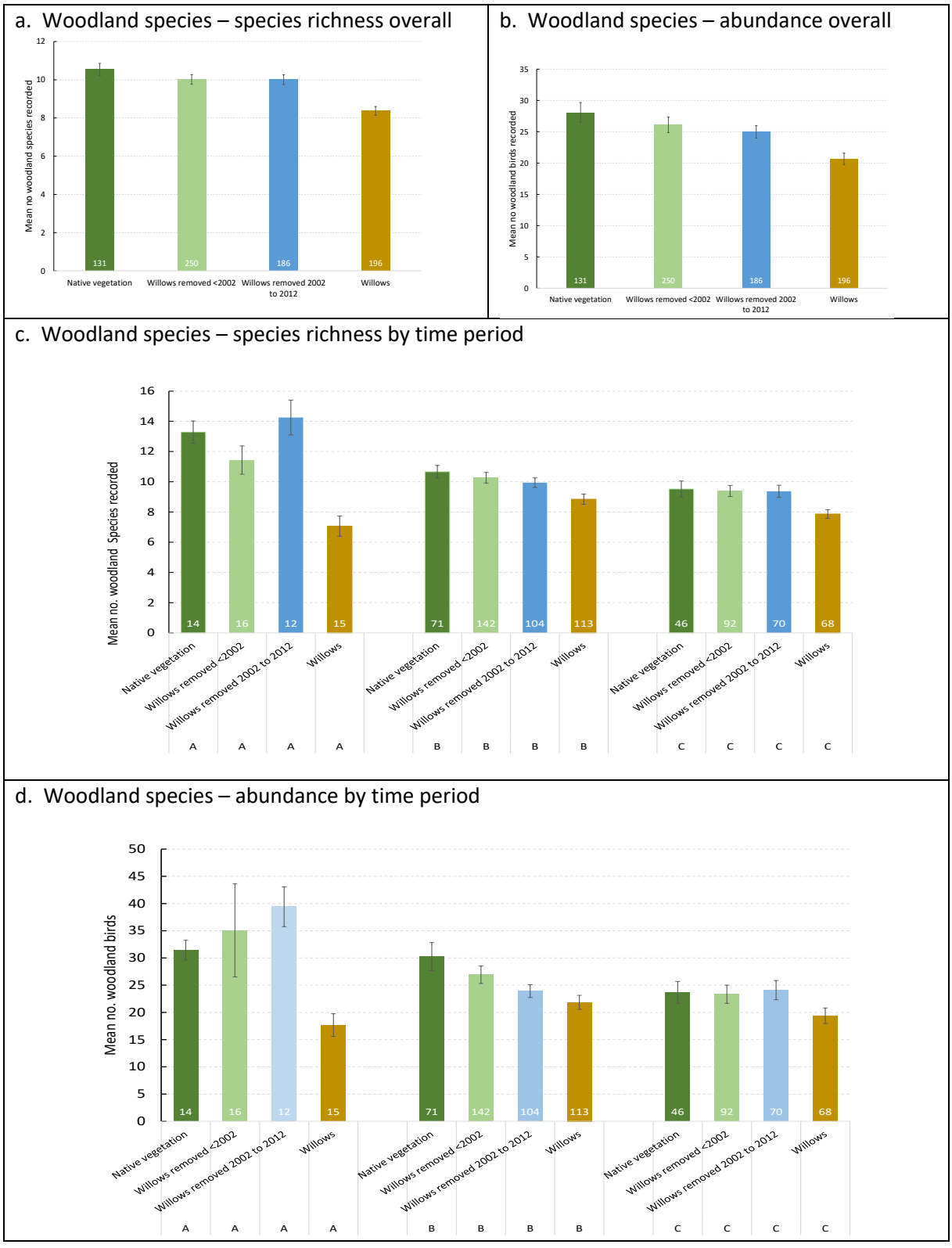


Figure 15. *Results for native woodland species of bird counted at 16 sites over three time periods on Yarra River northern tributaries covering four treatments: native vegetation remnant, willow-infested sites and revegetation sites < or > 12 years.*

Limitations

There is a dearth of detailed studies across the Port Phillip and Westernport Region investigating the effectiveness of streamside management, as practised by Melbourne Water, and riparian bird responses. While there is a large body of research from other regions on bird responses to vegetation structure and patch size, fire, revegetation and other factors, both environmental and management, (e.g. O'Neill 1999; Arnold 2003; Price et al. 2004; Radford et al. 2004, undated a, b; Bishop & Myers 2005; Bennett et al. 2006, 2014, 2022; Palmer & Bennett 2006; Price et al. 2006; Vesk & Mac Nally 2006; Antos et al. 2008; Barrett et al. 2008; Mac Nally 2008; Vesk et al. 2008; Berges et al. 2010; Paton & O'Connor 2010; Perry et al. 2011; Munro et al. 2011), which have been summarised by Doeg (2011) and AECOM (2012b), there is little specific data on bird responses to our management actions in our region, or the success of our management techniques. While we can be confident our management interventions are based on robust science and will ultimately benefit riparian birds we cannot provide specific information on how much management, using what combination of techniques, is benefiting birds in what way, over what time frame.

It has proved difficult to set up works-evaluation studies with proper controls and replicates over a timeframe adequate to provide useful data. This is because of a number of factors. Capital projects are rarely planned with any consideration of replicates and control sites. Intervention works invariably preference spending on actual works rather than the detailed ongoing monitoring of birds required from before works to many years after. Environmental effects such as floods, storms, bushfires and drought frequently change the outcomes or trajectories of works as planned. But it is recommended that more effort be put into setting up detailed works-evaluation studies so that we can explain what effect our works are having on riparian bird communities.

KEQ 4b. What are the key remaining knowledge gaps that need to be addressed in the next 5 years to improve strategy delivery or prepare for the next HWS?

Melbourne Water has made minor investment regarding riparian bird community responses to management – and there seems to be little awareness of the research undertaken by others, i.e. that not commissioned by Melbourne Water. But there is a significant body of work, over many decades, investigating riparian and woodland bird community responses to vegetation management, or post-fire recovery of vegetation (O'Neill 1999; Arnold 2003; Price et al. 2004; Radford et al. 2004, unpublished a, unpublished b; Palmer & Bennett 2006; Antos et al. 2008; Barrett et al. 2008; Bennett et al. 2006, 2014, 2022; Berges et al. 2010; Paton & O'Connor 2010; Munro et al. 2011; Perry et al. 2011). Therefore, we can be confident birds do respond to management that increases the condition and/or extent of native vegetation.

Further research into our revegetation and management practices would be informative but of less urgent priority than other knowledge gaps.

We know much less about other threats identified in the HWS conceptual model of birds (***Figure 3***). For example, introduced predator control, has been shown to benefit ground-nesting or ground-living species of bird. But there is very little knowledge of the true cost-effectiveness of predator control for riparian and woodland species of bird, especially when the background 'natural' level of nest predation among these bird communities can be very high (e.g. Fulton 2019).

This mid-term review of our riparian bird data suggests two emerging and potentially significant threats which require further investigation.

- An increased presence of **persistent insecticides** in the urban environment (Pettigrove 2019; Kellar et al. 2020) could affect riparian bird prey resource availability (e.g. Seress et al. 2020). Without detailed analysis, our data suggest that our urban riparian bird communities may have reduced representation of small canopy- and bark-feeding insectivores (relative to studies conducted in more natural areas).

- The 2018 HWS has ambitious targets for **increased human access to streamsides**, and attracting more visits and use of streamsides for recreation and amenity. With increased human access comes increased dog access. Increased human visitation, with the associated vegetation clearance, noise, movement and odours, introduced into previously undisturbed riparian areas seems likely to have an adverse effect on the bird communities (e.g. Holderness-Roddam & McQuillan 2014). With competing HWS objectives – improve riparian bird community while increasing human utilisation of streamsides – we should investigate the relationship between the two.

5. Recommendations

The following recommendations are presented for consideration during the development of the Science Inquiry report.

Regional Bird Monitoring

(1) The Riparian Bird Index is effective as a high-level, reporting tool to track relative condition of riparian bird communities and should continue to be used for this to build upon the ten years of development. However, further improvements can be made. Specifically:

- Lists of expected riparian species of bird should be based upon bioregion, rather than major catchment. Within the Werribee Catchment the expected species of bird will vary considerably between the Lerderderg and lower Skeleton Creek. Expected species based on bioregion will better reflect the riparian bird community actually likely to be present in high quality habitat.
- Following recommendations from Birdlife Australia (2020a), the index should trial a weighting for threatened species of bird.
- Investigate how to include exotic species and over-abundant natives (e.g. Noisy Miner) in a riparian bird index.
- Consider weighting by species' mass (e.g. Lee & Barnard 2016).
- Consider splitting expected riparian species into those that are 'vegetation dependent' – and most influenced by vegetation management – and those which are 'water-dependent' – and potentially most influenced by flows and water quality (Prof. Andrew Bennett, pers. comm.).

(2) Comprehensive analysis by sub-catchment of riparian bird index score and consolidated management interventions.

(3) Aim to have 40+ robust surveys per sub-catchment per year where possible to permit calculation of an annual Riparian Bird Index, to better track changes.

(4) Annual variation between Riparian Index scores appears to be influenced by annual rainfall, and potentially other environmental factors. A comprehensive analysis is required to assess the influence of annual rainfall on the Riparian Bird Index scores relative to management effects.

(5) Complete the current study into the effectiveness of community-based bird surveys relative to professional counts. For riparian species this should focus on whether birdwatchers are recording the hard to detect, small, insectivorous canopy-feeding species. It is possible the dearth of small, canopy-feeding insectivores in our regional dataset is due to inadequate skills or time on the part of community volunteers. It is important to know if the apparent decline in these small insectivorous species of bird is real – and a cause for concern – or only an artefact of our use of volunteers for data collection and the selection and skills biases this brings.
A preliminary review – focussed on wetland birds – looked at proportional species accumulation curves of four teams of Birdlife Australia counters: two volunteer teams and two teams composed of very experienced birdwatchers and/or Birdlife Australia staff at four different wetland complexes.

While this is an inadequate assessment and there are very obvious differences between the wetland complexes surveyed by each team, it does provide some reassurance that the different teams are not generating wildly different results in terms of the rate at which they are detecting new species. But there are differences. Amateur teams took longer to reach 50% of species detected, and started with only about one-sixth of the species detected in early surveys by more experienced teams (Figure 16).

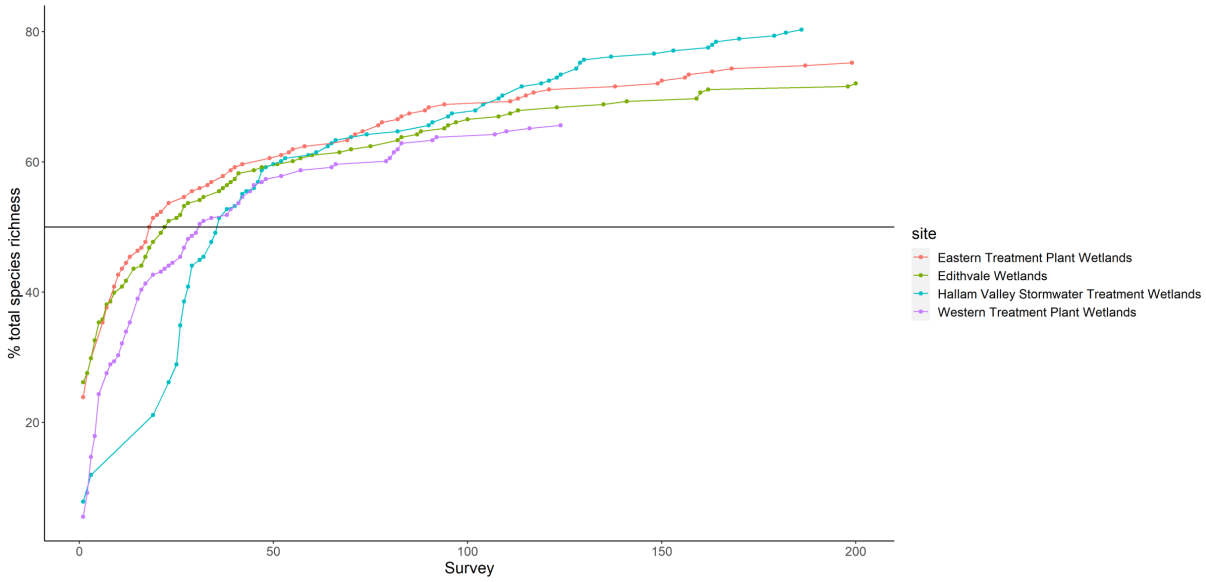


Figure 16. Proportionate species accumulation curves for four teams (two amateur and two semi-professional) at different wetland complexes across our region. Hallam Valley wetlands and WTP ponds were surveyed by volunteer birdwatchers; ETP and Edithvale-Seaford Wetlands were surveyed by qualified Birdlife Australia staff or highly experienced birdwatchers. Source: Birdlife Australia.

(6) Recent declines in Riparian Bird Index have been found in several sub-catchments: Bayside, Phillip and French Islands, and Mornington Peninsula Western Creeks. A detailed investigation into one or more of these sub-catchments is required to understand the reasons behind these results.

(7) Of less urgency, but still useful, would be to analyse those sub-catchments which saw unexpected increases in the Riparian Bird Index, such as Blind Creek and Plenty River Lower.

Works Evaluation studies

(8) The focus now needs to move from high-level regional reporting to detailed works-evaluation studies. Melbourne Water invests significant resources in revegetation of riparian areas and the expectation is that these works will (eventually) provide improvement in riparian habitat condition and extent. Since we know revegetation can take years to become useful bird habitat, we should be planning studies now to effectively test the utility of our on-ground works to riparian birds in future years and take advantage of the bird data record going back at least 20 years.

(9) There are gaps in our understanding of the threats posed to riparian birds (and our HWS targets for this value) by pesticides and increased human visitation/disturbance. Targeted research should be undertaken into these two potential threats to riparian bird communities to ascertain the true nature of the threat, and possible management controls.

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7. Appendices

Table A1. Current list of expected riparian species of bird by major catchment (Source: AECOM 2012a)

Common name	Dandenong Catchment (n = 126 spp.)	Maribyrnong Catchment (n = 95 spp.)	Werribee Catchment (n = 134 spp.)	Westernport Catchment (n = 131 spp.)	Yarra Catchment (n = 153 spp.)
Australasian Darter	TRUE	TRUE	TRUE	TRUE	TRUE
Australian Reed-Warbler	TRUE	TRUE	TRUE	TRUE	TRUE
Australian Wood Duck	TRUE	TRUE	TRUE	TRUE	TRUE
Black-fronted Dotterel	TRUE	TRUE	TRUE	TRUE	TRUE
Flame Robin	TRUE	TRUE	TRUE	TRUE	TRUE
Golden-headed Cisticola	TRUE	TRUE	TRUE	TRUE	TRUE
Latham's Snipe	TRUE	TRUE	TRUE	TRUE	TRUE
Little Grassbird	TRUE	TRUE	TRUE	TRUE	TRUE
Little Pied Cormorant	TRUE	TRUE	TRUE	TRUE	TRUE
Nankeen Night-Heron	TRUE	TRUE	TRUE	TRUE	TRUE
Pacific Black Duck	TRUE	TRUE	TRUE	TRUE	TRUE
Australasian Swamphen	TRUE	TRUE	TRUE	TRUE	TRUE
Welcome Swallow	TRUE	TRUE	TRUE	TRUE	TRUE
Whistling Kite	TRUE	TRUE	TRUE	TRUE	TRUE
White-faced Heron	TRUE	TRUE	TRUE	TRUE	TRUE
Australian Hobby	TRUE	TRUE	TRUE	TRUE	TRUE
Australian Magpie	TRUE	TRUE	TRUE	TRUE	TRUE
Australian Raven	TRUE	TRUE	TRUE	TRUE	TRUE
Black-faced Cuckoo-shrike	TRUE	TRUE	TRUE	TRUE	TRUE
Brown Goshawk	TRUE	TRUE	TRUE	TRUE	TRUE
Brown Thornbill	TRUE	TRUE	TRUE	TRUE	TRUE
Collared Sparrowhawk	TRUE	TRUE	TRUE	TRUE	TRUE
Crested Shrike-tit	TRUE	TRUE	TRUE	TRUE	TRUE
Crimson Rosella	TRUE	TRUE	TRUE	TRUE	TRUE
Dusky Moorhen	TRUE	TRUE	TRUE	TRUE	TRUE

Common name	Dandenong Catchment (n = 126 spp.)	Maribyrnong Catchment (n = 95 spp.)	Werribee Catchment (n = 134 spp.)	Westernport Catchment (n = 131 spp.)	Yarra Catchment (n = 153 spp.)
Dusky Woodswallow	TRUE	TRUE	TRUE	TRUE	TRUE
Eastern Rosella	TRUE	TRUE	TRUE	TRUE	TRUE
Eastern Spinebill	TRUE	TRUE	TRUE	TRUE	TRUE
Eastern Yellow Robin	TRUE	TRUE	TRUE	TRUE	TRUE
Fan-tailed Cuckoo	TRUE	TRUE	TRUE	TRUE	TRUE
Galah	TRUE	TRUE	TRUE	TRUE	TRUE
Golden Whistler	TRUE	TRUE	TRUE	TRUE	TRUE
Grey Butcherbird	TRUE	TRUE	TRUE	TRUE	TRUE
Grey Currawong	TRUE	TRUE	TRUE	TRUE	TRUE
Grey Fantail	TRUE	TRUE	TRUE	TRUE	TRUE
Grey Shrike-thrush	TRUE	TRUE	TRUE	TRUE	TRUE
Laughing Kookaburra	TRUE	TRUE	TRUE	TRUE	TRUE
Little Raven	TRUE	TRUE	TRUE	TRUE	TRUE
Long-billed Corella	TRUE	TRUE	TRUE	TRUE	TRUE
Magpie-lark	TRUE	TRUE	TRUE	TRUE	TRUE
Mistletoebird	TRUE	TRUE	TRUE	TRUE	TRUE
Musk Lorikeet	TRUE	TRUE	TRUE	TRUE	TRUE
Pallid Cuckoo	TRUE	TRUE	TRUE	TRUE	TRUE
Peregrine Falcon	TRUE	TRUE	TRUE	TRUE	TRUE
Rainbow Lorikeet	TRUE	TRUE	TRUE	TRUE	TRUE
Red Wattlebird	TRUE	TRUE	TRUE	TRUE	TRUE
Red-browed Finch	TRUE	TRUE	TRUE	TRUE	TRUE
Rufous Whistler	TRUE	TRUE	TRUE	TRUE	TRUE
Sacred Kingfisher	TRUE	TRUE	TRUE	TRUE	TRUE
Shining Bronze-Cuckoo	TRUE	TRUE	TRUE	TRUE	TRUE
Silvereye	TRUE	TRUE	TRUE	TRUE	TRUE
Spotted Pardalote	TRUE	TRUE	TRUE	TRUE	TRUE
Striated Pardalote	TRUE	TRUE	TRUE	TRUE	TRUE
Striated Thornbill	TRUE	TRUE	TRUE	TRUE	TRUE
Sulphur-crested Cockatoo	TRUE	TRUE	TRUE	TRUE	TRUE
Superb Fairy-wren	TRUE	TRUE	TRUE	TRUE	TRUE
Tree Martin	TRUE	TRUE	TRUE	TRUE	TRUE
Wedge-tailed Eagle	TRUE	TRUE	TRUE	TRUE	TRUE
White-browed Scrubwren	TRUE	TRUE	TRUE	TRUE	TRUE

Common name	Dandenong Catchment (n = 126 spp.)	Maribyrnong Catchment (n = 95 spp.)	Werribee Catchment (n = 134 spp.)	Westernport Catchment (n = 131 spp.)	Yarra Catchment (n = 153 spp.)
White-eared Honeyeater	TRUE	TRUE	TRUE	TRUE	TRUE
White-naped Honeyeater	TRUE	TRUE	TRUE	TRUE	TRUE
White-plumed Honeyeater	TRUE	TRUE	TRUE	TRUE	TRUE
White-throated Treecreeper	TRUE	TRUE	TRUE	TRUE	TRUE
Willie Wagtail	TRUE	TRUE	TRUE	TRUE	TRUE
Yellow Thornbill	TRUE	TRUE	TRUE	TRUE	TRUE
Yellow-faced Honeyeater	TRUE	TRUE	TRUE	TRUE	TRUE
Yellow-tailed Black-Cockatoo	TRUE	TRUE	TRUE	TRUE	TRUE
Australian White Ibis	TRUE	TRUE	TRUE	TRUE	TRUE
Black Swan	TRUE	TRUE	TRUE	TRUE	TRUE
Chestnut Teal	TRUE	TRUE	TRUE	TRUE	TRUE
Eastern Great Egret	TRUE	TRUE	TRUE	TRUE	TRUE
Eurasian Coot	TRUE	TRUE	TRUE	TRUE	TRUE
Great Cormorant	TRUE	TRUE	TRUE	TRUE	TRUE
Grey Teal	TRUE	TRUE	TRUE	TRUE	TRUE
Horsfield's Bronze-Cuckoo	TRUE	TRUE	TRUE	TRUE	TRUE
Little Black Cormorant	TRUE	TRUE	TRUE	TRUE	TRUE
Masked Lapwing	TRUE	TRUE	TRUE	TRUE	TRUE
Pied Cormorant	TRUE	TRUE	TRUE	TRUE	TRUE
Straw-necked Ibis	TRUE	TRUE	TRUE	TRUE	TRUE
Australian Pipit	TRUE	TRUE	TRUE	TRUE	TRUE
Black-shouldered Kite	TRUE	TRUE	TRUE	TRUE	TRUE
Brown Falcon	TRUE	TRUE	TRUE	TRUE	TRUE
Crested Pigeon	TRUE	TRUE	TRUE	TRUE	TRUE
Fairy Martin	TRUE	TRUE	TRUE	TRUE	TRUE
Little Wattlebird	TRUE	TRUE	TRUE	TRUE	TRUE
Nankeen Kestrel	TRUE	TRUE	TRUE	TRUE	TRUE
New Holland Honeyeater	TRUE	TRUE	TRUE	TRUE	TRUE
Noisy Miner	TRUE	TRUE	TRUE	TRUE	TRUE
Yellow-rumped Thornbill	TRUE	TRUE	TRUE	TRUE	TRUE

Common name	Dandenong Catchment (n = 126 spp.)	Maribyrnong Catchment (n = 95 spp.)	Werribee Catchment (n = 134 spp.)	Westernport Catchment (n = 131 spp.)	Yarra Catchment (n = 153 spp.)
Little Lorikeet	TRUE	TRUE	TRUE	FALSE	TRUE
Red-rumped Parrot	TRUE	TRUE	TRUE	FALSE	TRUE
Purple-crowned Lorikeet	TRUE	TRUE	TRUE	FALSE	TRUE
Bell Miner	TRUE	TRUE	FALSE	TRUE	TRUE
Little Corella	TRUE	TRUE	FALSE	TRUE	TRUE
Brown-headed Honeyeater	TRUE	FALSE	TRUE	TRUE	TRUE
Common Bronzewing	TRUE	FALSE	TRUE	TRUE	TRUE
Crescent Honeyeater	TRUE	FALSE	TRUE	TRUE	TRUE
Gang-gang Cockatoo	TRUE	FALSE	TRUE	TRUE	TRUE
Pied Currawong	TRUE	FALSE	TRUE	TRUE	TRUE
Pink Robin	TRUE	FALSE	TRUE	TRUE	TRUE
Rose Robin	TRUE	FALSE	TRUE	TRUE	TRUE
Rufous Fantail	TRUE	FALSE	TRUE	TRUE	TRUE
Rufous Songlark	TRUE	FALSE	TRUE	TRUE	TRUE
Satin Flycatcher	TRUE	FALSE	TRUE	TRUE	TRUE
Tawny Frogmouth	TRUE	FALSE	TRUE	TRUE	TRUE
Varied Sittella	TRUE	FALSE	TRUE	TRUE	TRUE
White-winged Triller	TRUE	FALSE	TRUE	TRUE	TRUE
Australian Pelican	TRUE	FALSE	TRUE	TRUE	TRUE
Blue-winged Parrot	TRUE	FALSE	TRUE	TRUE	TRUE
Cattle Egret	TRUE	FALSE	TRUE	TRUE	TRUE
Royal Spoonbill	TRUE	FALSE	TRUE	TRUE	TRUE
Swamp Harrier	TRUE	FALSE	TRUE	TRUE	TRUE
White-necked Heron	TRUE	FALSE	TRUE	TRUE	TRUE
Yellow-billed Spoonbill	TRUE	FALSE	TRUE	TRUE	TRUE
Buff-rumped Thornbill	TRUE	FALSE	TRUE	TRUE	TRUE
Scarlet Robin	TRUE	FALSE	TRUE	TRUE	TRUE
Spiny-cheeked Honeyeater	TRUE	FALSE	TRUE	TRUE	TRUE
Black-tailed Native Hen	TRUE	FALSE	TRUE	FALSE	TRUE
Whiskered Tern	TRUE	FALSE	TRUE	FALSE	FALSE

Common name	Dandenong Catchment (n = 126 spp.)	Maribyrnong Catchment (n = 95 spp.)	Werribee Catchment (n = 134 spp.)	Westernport Catchment (n = 131 spp.)	Yarra Catchment (n = 153 spp.)
Bassian Thrush	TRUE	FALSE	FALSE	TRUE	TRUE
Olive-backed Oriole	TRUE	FALSE	FALSE	TRUE	TRUE
Australian King-Parrot	TRUE	FALSE	FALSE	TRUE	TRUE
Australasian Shoveler	TRUE	FALSE	FALSE	FALSE	FALSE
Blue-billed Duck	TRUE	FALSE	FALSE	FALSE	FALSE
Common Greenshank	TRUE	FALSE	FALSE	FALSE	FALSE
Little Egret	TRUE	FALSE	FALSE	FALSE	FALSE
Little Eagle	FALSE	TRUE	TRUE	FALSE	TRUE
Brush Bronzewing	FALSE	FALSE	TRUE	TRUE	TRUE
White-bellied Sea-Eagle	FALSE	FALSE	TRUE	TRUE	TRUE
Yellow-tufted Honeyeater	FALSE	FALSE	TRUE	TRUE	TRUE
Jacky Winter	FALSE	FALSE	TRUE	TRUE	TRUE
Singing Honeyeater	FALSE	FALSE	TRUE	TRUE	FALSE
Striated Fieldwren	FALSE	FALSE	TRUE	TRUE	FALSE
Brown Treecreeper	FALSE	FALSE	TRUE	FALSE	TRUE
Restless Flycatcher	FALSE	FALSE	TRUE	FALSE	TRUE
White-winged Chough	FALSE	FALSE	TRUE	FALSE	TRUE
Brown Quail	FALSE	FALSE	TRUE	FALSE	TRUE
Stubble Quail	FALSE	FALSE	TRUE	FALSE	TRUE
Weebill	FALSE	FALSE	TRUE	FALSE	TRUE
Fuscous Honeyeater	FALSE	FALSE	TRUE	FALSE	FALSE
Diamond Firetail	FALSE	FALSE	TRUE	FALSE	FALSE
Speckled Warbler	FALSE	FALSE	TRUE	FALSE	FALSE
Zebra Finch	FALSE	FALSE	TRUE	FALSE	FALSE
Brush Cuckoo	FALSE	FALSE	FALSE	TRUE	TRUE
Eastern Whipbird	FALSE	FALSE	FALSE	TRUE	TRUE
Olive Whistler	FALSE	FALSE	FALSE	TRUE	TRUE
Southern Emu-wren	FALSE	FALSE	FALSE	TRUE	TRUE
Beautiful Firetail	FALSE	FALSE	FALSE	TRUE	TRUE
Leaden Flycatcher	FALSE	FALSE	FALSE	TRUE	TRUE
Lewin's Honeyeater	FALSE	FALSE	FALSE	TRUE	TRUE

Common name	Dandenong Catchment (n = 126 spp.)	Maribyrnong Catchment (n = 95 spp.)	Werribee Catchment (n = 134 spp.)	Westernport Catchment (n = 131 spp.)	Yarra Catchment (n = 153 spp.)
White-throated Needletail	FALSE	FALSE	FALSE	TRUE	TRUE
Azure Kingfisher	FALSE	FALSE	FALSE	FALSE	TRUE
Noisy Friarbird	FALSE	FALSE	FALSE	FALSE	TRUE
Painted Button-quail	FALSE	FALSE	FALSE	FALSE	TRUE
Red-browed Treecreeper	FALSE	FALSE	FALSE	FALSE	TRUE
Red-capped Robin	FALSE	FALSE	FALSE	FALSE	TRUE
Satin Bowerbird	FALSE	FALSE	FALSE	FALSE	TRUE
Superb Lyrebird	FALSE	FALSE	FALSE	FALSE	TRUE
Swift Parrot	FALSE	FALSE	FALSE	FALSE	TRUE
Cicadabird	FALSE	FALSE	FALSE	FALSE	TRUE
Fork-tailed Swift	FALSE	FALSE	FALSE	FALSE	TRUE
Masked Woodswallow	FALSE	FALSE	FALSE	FALSE	TRUE
Scarlet Honeyeater	FALSE	FALSE	FALSE	FALSE	TRUE
White-browed Woodswallow	FALSE	FALSE	FALSE	FALSE	TRUE

Table A2. Review of potential metrics for riparian bird communities.

Candidate indicator	How considered in 2013 Healthy Waterways Strategy
1. Breeding success	UNSUITABLE. Lack of robust data on breeding activity amongst riparian species, especially true breeding success (i.e. young raised successfully to adulthood where they join the breeding population).
2. Abundance (density) of individuals	UNSUITABLE. We had limited surveys with quantitative count data, and initially wished to be able to include the previous 'Bird Atlas' data which are almost entirely presence/absence. Also, community surveys could not be guaranteed to follow fixed area searches.
2b. Relative abundance of individuals among species (e.g. proportion of total bird population not of the most abundant species, or proportion of total birds counted that were native species)	UNSUITABLE. While attractive this indicator requires quantitative count data. It is certainly likely to be useful at site scale, where we have quantitative count data, to evaluate works effectiveness.
3. Species richness	SUITABLE. Analysis of bird data by Jamie Mathew (AECOM) shows simple species richness (corrected for survey effort, or number of surveys, affecting the species accumulation curve) was a useful indicator and showed some correlation to ISC scores.[1]
3b. Species richness weighted by reporting rate to include some measure of abundance	SELECTED since reporting rate is a surrogate for abundance or frequency of occurrence and allows managers to increase scores through both attracting new species or increasing frequency of visitation. In addition, one paper suggests we might include a function for species' average size to improve the accuracy of reporting rates[2].
4. Persistence of threatened species	We considered including a weighting for threatened species presence. But, at the time the metric was being developed for the 2013 HWS, this was considered to be taking the bird value beyond Melbourne Water's authorised scope. Including a weighting for threatened species of bird will be investigated.
5. Landscape species	UNSUITABLE. We investigated this option with Andrew Hamer (ARCUE).[3]
6. Keystone species	NOT CONSIDERED. Some work in Perth, using Swamp Harrier as indicator of wetland health, was noted but not pursued for the related wetland bird index development.
7. Indicator species	Briefly considered selecting indicator species, such as Azure Kingfisher and Eastern Yellow Robin but thought to be too restrictive due to (a) survey effort required and (b) limiting on-ground managers' options and opportunities.
8. Functional diversity – foraging guilds	UNSUITABLE. We investigated this option with Kerryn Herman (Birdlife Australia 2015).[4] But this will likely be the approach used for certain works evaluation studies.

9. Functional diversity using 'response guilds' as established in work initiated by Croonquist et al.	Not properly assessed[5]. Another paper recently found tests a range of metrics for riparian birds as indicators of riparian condition – concluding a mix of foraging and nesting guilds plus species richness and defined response guilds to human disturbance[6]. These approaches are tempting – but actually look on riparian birds as indicators of riparian condition and not as a value in and of themselves.
10. Phylogenetic diversity	NOT CONSIDERED.[6]

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Table A3. Riparian Bird Index scores for five-year periods for those sub-catchments for which we have sufficient data, with tentative trend described.

Catchment	Sub-catchment	A	B	C	D	E	Trend
Dandenong	Bayside			0.95	0.92	0.39	Downward
Dandenong	Blind Creek				0.37	0.66	Upward
Dandenong	Corhanwarrabul, Monbulk & Ferny Creeks	0.43			0.62	0.59	Stable
Dandenong	Dandenong Creek Lower	0.63	0.41	0.42	0.54	0.61	Stable
Dandenong	Dandenong Creek Middle	0.40	0.42	0.43	0.50	0.68	Upward
Dandenong	Dandenong Creek Upper					0.76	Not assessable
Dandenong	Eumemmerring Creek		0.72	0.81	0.74	0.67	Stable
Dandenong	Kananook Creek			0.57	0.62	0.59	Stable
Maribyrnong	Boyd Creek						Not assessable
Maribyrnong	Deep Creek lower						Not assessable
Maribyrnong	Deep Creek upper					0.32	Not assessable
Maribyrnong	Emu Creek						Not assessable
Maribyrnong	Jacksons Creek				0.54	0.89	Upward
Maribyrnong	Maribyrnong River					0.63	Not assessable
Maribyrnong	Moonee Ponds Creek		0.66	0.52	0.58	0.56	Stable
Maribyrnong	Steele Creek						Not assessable
Maribyrnong	Stony Creek						Not assessable
Maribyrnong	Taylors Creek						Not assessable
Werribee	Cherry Creek						Not assessable
Werribee	Kororoit Creek Lower			0.38	0.28	0.47	Upward
Werribee	Kororoit Creek Upper		0.31				Not assessable
Werribee	Laverton Creek				0.34	0.40	Stable
Werribee	Lerderderg River						Not assessable
Werribee	Little River Lower			0.28	0.22	0.35	Upward
Werribee	Little River Upper	0.56			0.22	0.35	Stable
Werribee	Lollypop Creek			0.15	0.16	0.30	Upward
Werribee	Parwan Creek					0.32	Not assessable
Werribee	Skeleton Creek				0.21	0.43	Upward
Werribee	Toolern Creek					0.48	Not assessable
Werribee	Werribee River Lower				0.24	0.37	Stable

Catchment	Sub-catchment	A	B	C	D	E	Trend
Werribee	Werribee River Middle	0.68	0.54			0.74	Stable
Werribee	Werribee River Upper						Not assessable
Westernport	Bass River						Not assessable
Westernport	Bunyip Lower						Not assessable
Westernport	Bunyip Middle and Upper			0.38		0.39	Stable
Westernport	Cardinia, Toomuc, Deep and Ararat Creeks	0.32	0.33	0.34	0.41	0.51	Upward
Westernport	Dalmore Outfalls		0.34	0.33	0.30	0.34	Stable
Westernport	French and Phillip Islands		0.31	0.51	0.35	0.42	Stable
Westernport	King Parrot and Musk Creeks						Not assessable
Westernport	Lang Lang River						Not assessable
Westernport	Mornington Peninsula North-Eastern Creeks						Not assessable
Westernport	Mornington Peninsula South-Eastern Creeks				0.49	0.41	Stable
Westernport	Mornington Peninsula Western Creeks	0.65	1.08	0.95	0.64	0.38	Downward
Westernport	Tarago River						Not assessable
Yarra	Brushy Creek						Not assessable
Yarra	Darebin Creek				0.10	0.58	Upward
Yarra	Diamond Creek (Rural)				0.21	0.37	Stable
Yarra	Diamond Creek (Source)	0.38					Not assessable
Yarra	Gardiners Creek	0.40	0.25	0.38	0.19	0.27	Stable
Yarra	Koonung Creek				0.49	0.45	Stable
Yarra	Little Yarra River and Hoddles Creek						Not assessable
Yarra	Merri Creek Lower			0.54	0.29	0.43	Upward
Yarra	Merri Creek Upper					0.31	Not assessable
Yarra	Mullum Mullum Creek			0.37	0.27	0.37	Stable
Yarra	Olinda Creek				0.26	0.43	Upward
Yarra	Plenty River (Source)						Not assessable
Yarra	Plenty River Lower				0.15	0.42	Upward
Yarra	Plenty River Upper				0.29	0.26	Stable
Yarra	Steels and Pauls Creek (Rural)						Not assessable
Yarra	Steels and Pauls Creek (Source)						Not assessable
Yarra	Stringybark Creek						Not assessable
Yarra	Watsons Creek	0.55			1.03	0.67	Downward
Yarra	Watts River (Rural)					0.31	Not assessable
Yarra	Watts River (Source)				0.29	0.28	Stable

Catchment	Sub-catchment	A	B	C	D	E	Trend
Yarra	Woori Yallock Creek				0.36	0.42	Stable
Yarra	Yarra River Lower	0.56		0.38	0.19	0.43	Stable
Yarra	Yarra River Middle				0.52	0.55	Stable
Yarra	Yarra River Upper (Rural)	0.17			0.12	0.38	Upward
Yarra	Yarra River Upper (Source)		0.30	0.26	0.26		Not assessable

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More Information

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