Moorabool River (Moorabull-Yuluk) Vegetation Monitoring – Environmental Water

Phase 1: Planning and program design

C. Jones and A. Backstrom

March 2023

Arthur Rylah Institute for Environmental Research
Unpublished Client Report

Arthur Rylah Institute for environmental research

CORANGAMITE CMA

Wadawurrung Traditional Owners Aboriginal Corporation

VICTORIA State Government | Energy, Environment and Climate Action

Acknowledgment

We acknowledge and respect Victorian Traditional Owners as the original custodians of Victoria's land and waters, their unique ability to care for Country and deep spiritual connection to it. We honour Elders past and present whose knowledge and wisdom has ensured the continuation of culture and traditional practices.

We are committed to genuinely partner, and meaningfully engage, with Victoria's Traditional Owners and Aboriginal communities to support the protection of Country, the maintenance of spiritual and cultural practices and their broader aspirations in the 21st century and beyond.

Arthur Rylah Institute for Environmental Research
Department of Environment, Energy and Climate Action
PO Box 137
Heidelberg, Victoria 3084
Phone (03) 9450 8600
Website: www.ari.vic.gov.au

Citation: Jones, C., and Backstrom A. (2023). Moorabool River (Moorabull Yuluk) Vegetation Monitoring – Environmental Water. Phase 1: Planning and program design. Unpublished Client Report for the Corangamite Catchment Management Authority. Arthur Rylah Institute for Environmental Research, Department of Environment, Energy and Climate Action, Heidelberg, Victoria.

Front cover photo: Vegetation along the Moorabool River (Moorabull Yuluk) in 2022 (C. Jones).

Moorabool River (Moorabull Yuluk) Vegetation Monitoring – Environmental Water

Phase 1: Planning and program design

Chris Jones[1] and Ana Backstrom[2]

[1]Arthur Rylah Institute for Environmental Research
123 Brown Street, Heidelberg, Victoria 3084

[2]Fractal Ambergris, Sunshine, Victoria.

Arthur Rylah Institute for Environmental Research
Unpublished Client Report for the Corangamite Catchment Management Authority, Department of Environment, Energy and Climate Action

Arthur Rylah Institute for Environmental Research
Department of Environment, Energy and Climate Action
Heidelberg, Victoria

Acknowledgement of Country

The Corangamite Catchment Management Authority (Corangamite CMA) and the Arthur Rylah Institute (ARI) wish to acknowledge the Wadawurrung, Traditional Owners of the land of the Moorabool River. We pay our respects to their Elders past and present. We commit to continuing to work with all Traditional Owners to ensure their knowledge and culture is included and valued in Corangamite CMA planning and delivery.

Acknowledgements

This project was funded by the Corangamite CMA (CCMA) and managed by Rhiannon Glover. The project involved a group of personnel from the CCMA: Rhiannon Glover, Sharon Blum-Caon, David Windle and Leigh Dennis; the Wadawurrung Traditional Owners Aboriginal Corporation (WTOAC): Greg Robinson, Claire Mennen and Michael Cook; the Arthur Rylah Institute (ARI) Chris Jones and ecologist Ana Backstrom. This project team collaboratively defined the scope of the project, participated in a workshop, provided resources, and provided feedback on draft. Thanks also to Paul Reich, Philip Mitchell, Fiona Warry and Peter Vollebergh (DEECA) for comments on the draft.

Contents

Tables

Figures

Summary

Context: The Corangamite Catchment Management Authority (CCMA) and Wadawurrung Traditional Owners Aboriginal Corporation (WTOAC) require vegetation monitoring data on the Moorabool River (Moorabull Yuluk) to assess the effectiveness of current environmental water releases on key vegetation species and habitats. This need was identified in the Moorabool River Environmental Watering Management Plan (EWMP) (2016) and is important for informing annual watering decisions through the seasonal watering proposals. No current vegetation monitoring programs collect the data required, nor are their methods suitable for the specific needs of the Moorabool River water managers. Therefore, a new monitoring program is being designed to monitor the status of the Moorabool River's flow-dependent and flow-assisted vegetation communities in order to provide a line of evidence as to the effectiveness of the current and future environmental watering program. The program is focused on environmental watering responses only, so does not include specific monitoring on other riparian management actions such as livestock grazing or weed control. However, the influence of any interacting factors will be accounted for as part of evaluations and recommendations.

Methods: This document describes the process and outcomes of a vegetation monitoring program design to directly meet the needs of the Moorabool River water managers. The design was developed cooperatively by a large project team of representatives particularly from CCMA, WTOAC and the Arthur Rylah Institute (ARI). The process followed a series of steps, as follows:

1. Monitoring program scope defined by CCMA and WTOAC.
2. Inception meeting and refinement of scope with ARI.
3. Development of design process and proposal of method options by ARI.
4. Workshop to address knowledge gaps, determine needs and preferences, and prioritise options with project team.
5. Development of a full draft program design by ARI.
6. Review of draft by project team and DEECA staff.
7. Finalisation of program design by ARI.

Results: This process resulted in a monitoring design based on replicate quadrat samples to survey vegetation cover within river channel zones (aquatic, marginal, damp). Cover estimates are targeted at plant species with particular ecological or Aboriginal cultural significance. Surveys will be conducted annually if possible at priority sites to indicate environmental flow responses and vegetation trends.

To finalise the approach, the following processes need to be completed by the project team:

1. Finalise the specific wording of targets relating to vegetation objectives from environmental water management. The wording is important because it will determine how and when evaluation will be undertaken and set the bar for management outcomes.
2. Finalise the list of target significant species. Many species have been indicated as either ecologically or culturally significant but few are both (as yet). Site inspections, pilot data and prioritisation will be required to determine the most valuable set of target species.
3. Confirm selection of priority monitoring sites to provide the most valuable sampling pool within constraints.

Conclusions: The proposed monitoring program design represents a successful cooperative project that has enabled all project team members' views and requirements to be acknowledged. The design is a fast, simple and repeatable process that should provide water managers with the information they require to evaluate and inform environmental water management. Once the approach is tested and finalised, a strategic implementation plan can be developed to commence baseline surveys and an ongoing monitoring program. Detailed sampling and data management protocols will be implemented to ensure consistent and accurate implementation of the method, data curation and evaluation.

1 Context

Vegetation monitoring was one of the four equal highest priority knowledge gaps identified within the Moorabool River Environmental Watering Management Plan (EWMP) (2016), developed in collaboration with community stakeholders. The aim of this proposed vegetation monitoring program is to allow the Corangamite Catchment Management Authority (CCMA) to track ecological change in vegetation communities and to assess the effectiveness of current environmental water releases on key vegetation species and habitats, in the context of increases in the volume of environmental entitlement in Lal Lal reservoir and creation of an environmental entitlement in Bostock reservoir by 2025 as set out in the Central and Gippsland Region Sustainable Water Strategy. Therefore, this monitoring program is designed to monitor the status of the Moorabool River's flow-dependent and flow-assisted vegetation communities in order to provide a line of evidence as to the effectiveness of the current and future environmental watering program. While the program is focused on environmental watering responses only, the influence of interacting factors, such as grazing, weed invasion and historical disturbances will be accounted for as part of evaluations and recommendations. The monitoring program will sit alongside previous and potential future research and monitoring approaches that do not currently meet all the monitoring needs for the river. The design of this program allows for the establishment of a baseline against which progress towards vegetation objectives and targets can be tracked.

1.1 The Moorabool River (Moorabull Yuluk)

1.1.1 Overview of the Moorabool River

Moorabool River (Moorabull Yuluk) is approximately 88 kilometres long with the upper reaches beginning between Ballan and Ballarat in the Central Victorian Uplands Bioregion and the lower reaches travelling through the Victorian Volcanic Plain Bioregion, joining the Barwon River at Fyansford. The Moorabool is a tightly meandering perennial river flowing within a dendritic drainage pattern, whereby the river follows a branched pattern with tributaries such as Dolly Creek, Eclipse Creek, Woolshed Gully Creek and many unnamed intermittent creeks and streams draining into the main stem.

The Wadawurrung Traditional Owners have a strong connection to the river and place a high cultural value on Moorabull Yuluk. Looking after waterways is a key component of the Wadawurrung Country Plan – *Paleert Tjaara Dja – let's make Country good together 2020-2030* (WTOAC 2020) and the Wadawurrung people will work with partners to shape the future of the river and it's cultural, ecological, and social values.

The riparian zone of the Moorabool River has been subject to landscape modification from land-clearing, livestock grazing, agricultural cultivation and urbanisation since European occupation. This anthropogenic land use change, including river regulation, has resulted in a considerable contraction and modification of remnant vegetation communities (Figure 1 and Figure 2). In general, the upper reaches support more intact remnant vegetation communities while the lower reaches commonly maintain a narrow band of highly modified remnant vegetation immediately adjacent to the riverbed. The dominant vegetation community within the upper and middle reaches is Streambank Shrubland, that has a Bioregional Conservation Status of 'endangered' in the Victorian Volcanic Plain Bioregion and 'vulnerable' in the Central Victorian Uplands Bioregion (DECCA, 2023). Fringing the Streambank Shrubland are various vegetation types including, the endangered Grassy Woodland, Escarpment Shrubland, Plains Grassy Woodland and Riparian Woodland. In the lower reach, the endangered Floodplain Riparian Woodland is the dominant vegetation type.

Figure 1. Mature and uncleared vegetation at upstream sites provide a relatively stable vegetation community that is being supported by flow regimes. Improved pasture and sheep grazing has increased weed cover and reduced natives at Bakers Bridge Road.

Figure 2. Flow has been disconnected at the upper east branch below the Bostock reservoir wall (left) but pooled water is supporting a diverse and abundant 'wetland' aquatic vegetation community (right).

The river is partitioned into four hydrologically distinct reaches (Figure 3). These reaches have different social, cultural and ecological values, hydrology, geomorphology and historical disturbances. Each reach, and locations within reaches, will require different actions to support or enhance values – including watering and complimentary measures not involving water. The selection of reference sites will be done in a way that maximises the capacity to understand and evaluate environmental water releases only, but the presence and potential influence of other factors will be noted in evaluations and recommendations so that responses are not misunderstood.

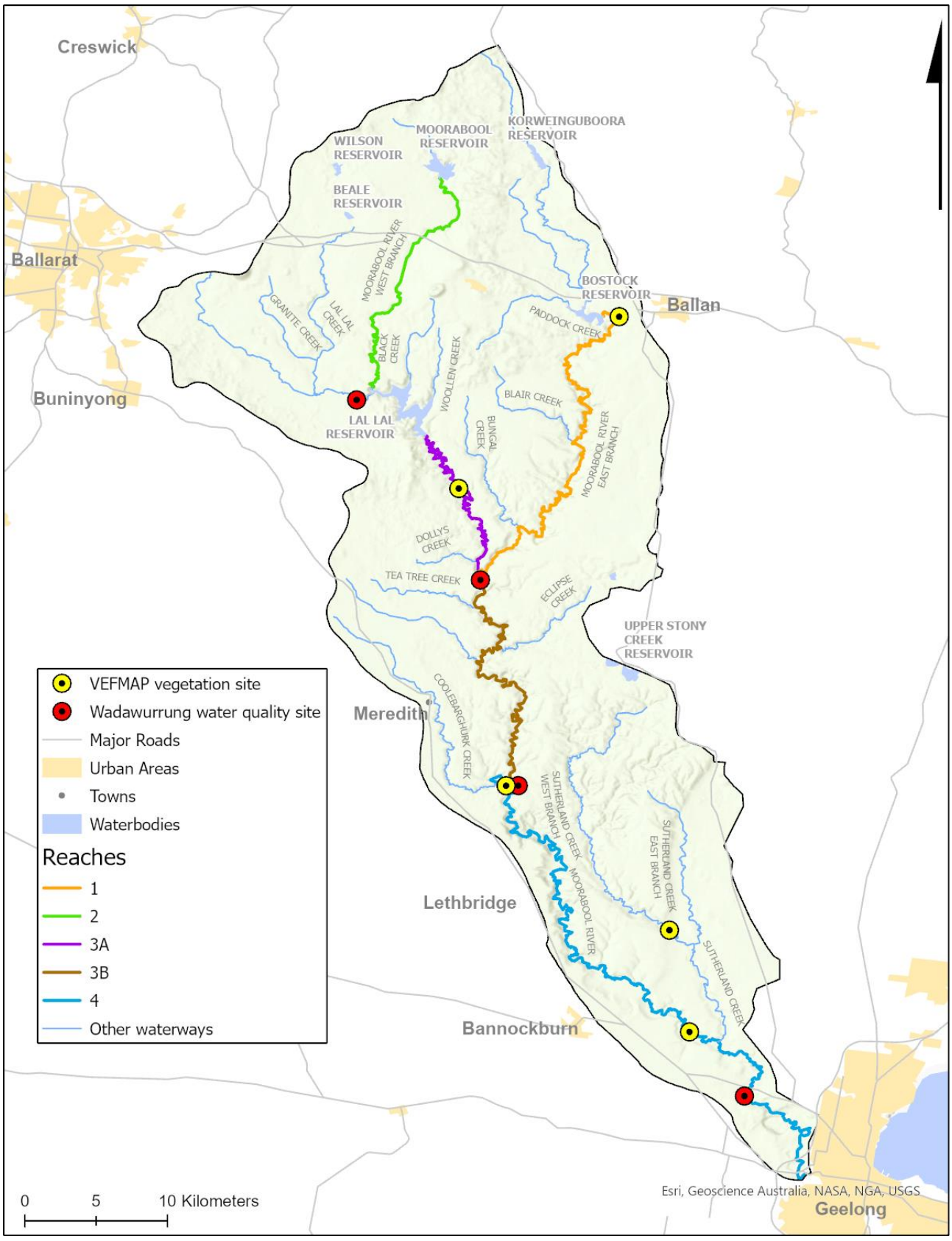

Figure 3. Map of the Moorabool River catchment including four distinct reaches relating to major river infrastructure, e.g. reservoirs. Historical VEFMAP vegetation sites and Wadawurrung water quality site monitoring locations are indicated. New monitoring locations will need to be selected via a selection process indicated below.

1.2 Environmental watering in the Moorabool River

The Moorabool River occurs within a relatively dry part of southern Victoria with a catchment area that supports a relatively low flow volume compared to southern Victorian waterways with upper catchments in high rainfall regions. However, the current flow regimes are well below the naturally occurring flow volumes and levels that fall below the flow recommendations required to meet ecological and cultural objectives (Jacobs, 2015). This means that achieving current objectives with the current flow allocations is difficult. This does not mean that the current environmental flow allocation is not beneficial, nor does it mean that careful management of the current allocation will not improve the outcomes. However, the magnitude of the expected outcomes is dependent on the volume of flows delivered (Jacobs, 2015) such that the ability to achieve objectives will increase with proposed increases in allocations in Lal Lal reservoir and creation of an environmental entitlement in Bostock reservoir by 2025.

There are three flow components that are delivered to support the various river objectives (CCMA 2022):

1. Low flows in warm seasons and cool seasons to maintain stream flow and connectivity.
2. Summer/autumn freshes.
3. Winter/spring freshes.

Each of these flow components is targeted at achieving different objectives and each of them is important for supporting vegetation communities within and adjacent to the river. High and bankfull flows are not included in the environmental watering program as they exceed both the entitlement volume and the outlet pipe at Lal Lal reservoir.

1.3 Vegetation objectives in response to environmental watering

The overall goal (**fundamental or end objective**) for this vegetation monitoring program, as specified by the CCMA (2016), is:

To improve the Moorabool River's flow-dependent ecological values and services through the provision of environmental water. The delivery of environmental water will also provide for social and cultural values for future generations.

Specific to vegetation, the purpose of the monitoring program is two-fold:

- to assess the status of flow dependant vegetation communities along the Moorabool River; and
- to assess effectiveness of current environmental releases on key vegetation species and habitats that have a strong link to flows and/or have a particularly high value (social, cultural, environmental).

The proposed overall **means objective** – way of achieving a fundamental objective – in relation to the Moorabull / Moorabool's vegetation is:

To maximise (maintain, or increase) the abundance and richness of ecologically and culturally significant flora species and habitats.

This means objective is centred around specific significant species, rather than species groups that can be represented by any species. This significant species approach reflects the values of the river's major stakeholders, which is indicated in the FLOWS study (Jacobs 2015). Furthermore, this monitoring program will allow progress to be assessed towards achieving The Living Moorabool Flagship strategic objectives and outcomes linked to environmental water delivery (Table 1), the vegetation objectives outlined in the Moorabool River FLOWS Study Update (Jacobs, 2015) (Table 2), and the cultural objectives detailed in the Moorabool River Seasonal Watering Proposal 2022-23 (CCMA, 2022) (Table 3).

Table 1. The Living Moorabool Flagship relevant strategic objectives and outcomes linked to environmental water delivery.

Policy or Strategy	Specific action(s), outcome(s), or objective(s)	Specific relevance to this project/ environmental water delivery
Water for Victoria (2016)	Action 3.4 – Provide long-term investment to improve waterway health	Management of waterways, wetlands and estuaries improves water quality; secures water for the environment, irrigation and consumption; provides habitat and refuges; store carbon; and contributes to significant cultural, economic, primary production, recreation and tourism benefits.
Corangamite Waterway Strategy (2013)	Goal ENV3: Manage water for the environment to improve waterway condition	Delivery will be monitored to determine if vegetation is responding

Table 2. Overview of the vegetation objectives specified in the Moorabool River FLOWS Study Update (Jacobs, 2015).

Objective	Example species	Method pathway	Flow
V1 Maintain aquatic zone	Varied Watermilfoil, Water-ribbons	Sufficient water habitat, scour periphyton, drown terrestrials	Low flow/Freshes
V2 Maintain marginal zone	Tall Sedge, Narrow-leaf Cumbungi	Flow variability	Freshes/High flow
V3 Maintain damp zone	Blackwood, River bottlebrush, Tussock grass	Soil moisture, recruitment	Freshes/High flow
V4 Maintain inset benches/floodplain/ floodplain wetlands *[not a focus of monitoring because not influences by environmental watering]*		Soil moisture, recruitment	High flows *[not possible through current environmental water allocation]*

Table 3. Summary of the objectives for culturally significant species specified by the Wadawurrung Traditional Owner Aboriginal Corporation (WTOAC) (CCMA, 2022)

Objectives and opportunities	Values and uses	Specific relevance to this project/ environmental water delivery
Maintain or improve abundance, breeding and recruitment of *Wad-dirring/ Perridak* (platypus).	Meat and pelt	Environmental watering will aim to provide pool habitat and connectivity between reaches where possible.
Maintain or improve abundance of *Buniya* (Eels).	Meat, important food source sometimes smoked. Large gatherings during Eel run at *Benia Wulla* (Buckley's Falls).	Environmental watering aims to provide water where possible for pools, habitat and food sources, as well as providing water over riffles to allow eels to migrate.
Maintain or improve abundance of *Turrpurt* (Native trout *galaxias spp*.)	Meat	Environmental watering aims to provide water where possible for pools, habitat and food sources; and provide water over riffles to allow fish to move between pools and breed, feed and find new habitats.
Maintain or improve abundance of *Ware-rap* (Blackfish).	Meat	
Maintain or improve abundance of *Polango/ Warngare* (Water ribbons *Triglochin procera*).	Plant food. Finger shaped tubers are crisp and sweet. Cooked in ground oven.	Environmental watering aims to maintain adequate depth of water in channels where possible.
Maintain or improve condition, extent and abundance of *Tark* (common reed *Phragmites australis*), *Toolim* (Pale Rush *Juncus pallidus*), and Bal-yan (Cumbungi *Typha latifolia*)	*Tark*: Weapon-stems used for spear shafts for fishing. Reed cut while still green to make necklaces, weaving-bags and baskets. Also, a food plant. *Toolim*: Weaving baskets.	Environmental watering aims where possible to maintain adequate depth of water to limit terrestrial encroachment into aquatic habitats and lower banks. This will also support growth of target species on terraces, channel edges and lower banks.

2 Current monitoring methods

There is relatively little existing or historical vegetation monitoring data available for the Moorabool River. Of these, there are three main levels of data, ranging from very large spatial scales at low resolution to relatively small spatial scale where there are a limited number of sites that give high resolution data. Supplementary to vegetation monitoring, there are several fauna monitoring sites, e.g., fish and macroinvertebrates, some of which align with extant vegetation monitoring sites (e.g., Figure 3). Additionally, there have been previous comprehensive investigations, such as the FLOWS assessment (Jacobs, 2015), that provide information to guide management actions but no quantitative data for monitoring vegetation change over time. Below is a summary of some existing survey methods currently applied to the Moorabool River riparian system. This summary was used to help determine what data gaps exist and how existing and new data collection can be complimentary, for example, none of the current programs conducts annual or near annual monitoring and none of the existing methods can be easily done by CMA and/or WTOAC staff. The summary also indicates the current status of vegetation in the river, as indicated by that method.

2.1 Index of Stream Condition (ISC)

The ISC surveys are conducted at large temporal intervals (e.g., 10 years) and over large spatial scales. They provide continuous data (with no gaps) along river reaches, as opposed to restricted site based assessments that sample a small number of locations with large gaps between. The current ISC approach relies entirely on remotely sensed data (aerially sourced images and LiDAR), with no on-ground data, to assess vegetation. These remote-sensed data are used to generate scores for several indicators of vegetation and stream condition including physical form and streamside zones that combine with other scores to give an overall ISC score and condition category. Of these sub-indexes, the streamside zone is most relevant to the scope of the proposed monitoring program because it focuses on woody vegetation from the bank toe outwards (cover, extent and high threat woody weeds). However, many of the significant species that need to be monitored are not woody species (Tables 2 and 3) so there is only partial alignment of this index to monitoring needs.

The most recent ISC assessment was completed in 2010 (ISC3) and in 2018-19 a reduced LiDAR survey was completed as part of a new Stream Change Assessment (DELWP 2019). Overall, the Moorabool River reaches in Figure 3 had ISC scores ranging from moderate (upstream) to Very Poor (downstream), with reaches 3a and 3b indicating the best condition (ISC3, 2010): Reach 1 (22, 24 and 29), Reach 2 (24), Reach 3a (33), Reach 3b (32 and 33), and Reach 4 (18). The streamside zone component of the overall score was moderate to good (5-8 out of 10), with the highest scores in Reaches 1 and 3. Updated ISC scores in 2019 showed little change within the CCMA from 2010 (DELWP 2019).

2.2 Victorian Environmental Flow Monitoring and Assessment Program (VEFMAP) vegetation monitoring

2.2.1 Event-based monitoring

Within Stage 6 and again in Stage 7 of VEFMAP, event based vegetation monitoring was conducted at four sites in the Moorabool River catchment. In 2017/18 this included three sites on the Moorabool River and one on the Sutherland Creek. In 2022/23 this included three of the same sites, but the Sutherland Creek site was substituted for a site on the Moorabool River east branch, immediately below Bostock Reservoir, within WTOAC owned land. These survey methods are described in the VEFMAP Stage 6 monitoring design (DELWP 2017) with outcomes summarised in Tonkin et al. (2020). Broadly, the VEFMAP monitoring have demonstrated several important vegetation responses to environmental water releases:

- Inundation of vegetation on the bank can cause disproportionate negative effects on terrestrial species that reduce terrestrial vegetation encroachment. Environmental water achieves this response through small annual increments (Tonkin et al. 2020) and occasionally in dramatic responses on the Moorabool River (Jones and Thomas 2018) when the physical tolerances of a species is exceeded. These physical tolerances to inundation vary between species and throughout the season, with impacts greater in warmer seasons (Vivian et al. 2020, Main et al. 2022).
- Additionally, elevated flows at times that correspond with the natural flow regime (winter/spring) can support the recruitment of riparian plants by stimulating germination of some seed, increasing water

resources available to growing plants, and reducing the competitive influence of terrestrial species (Tonkin et al. 2020).

- Consequently to the above, riparian species (including many of the significant species of the Moorabool River) in regulated streams commonly have distributions indicating positing associations with elevated flow deliveries, e.g., spring freshes (Tonkin et al. 2020).

The VEFMAP event-based method requires three surveys within a watering year (financial year) and high intensity objective methods. This means that the methods are relatively slow and require a high level of botanical expertise. This approach is not recommended for widespread use as a general and long-term annual monitoring tool due to the relatively high cost.

2.2.2 Annual regime sampling

VEFMAP program managers have indicated a likely shift in preference for vegetation monitoring from event-based surveys to annual surveys for the bulk of sampling. If this is to occur, the event-based surveys may be discontinued from 2023 and they could be replaced by annual surveys. The annual surveys would employ a more rapid survey method that will be less detailed and less objective due to the likely need to use subjective visual estimates, but will allow more sites to be surveyed more often. It is yet unknown how many sites could be monitored and if the surveys would be annual or near-annual. This sampling approach is currently under development and is hoped to align with the methods provided within this plan.

The early stages of VEFMAP employed a sampling approach designed to broadly track change over time, which involved quadrat samples at different bank elevations. Elements of this approach may be useful for meeting the sampling needs in future monitoring, where sampling needs to be rapid and will occur once annually.

3 Developing new monitoring methods

The above methods (ISC and VEFMAP) represent two extremes of the monitoring scale from low-frequency/ low resolution to high frequency/ high resolution. A new method is required to meet the CCMA and WTOAC needs for capturing broadscale changes in specific vegetation communities and key significant species populations.

3.1 Monitoring requirements

This new monitoring program will need to meet many requirements to ensure that the methods are relevant, cost-effective, and acknowledge the multiple needs of users. This new method has been developed in consideration of the following:

- Objectives and program scope outlined in the conceptual model below.
- Existing monitoring sites (vegetation, fish, Waterwatch, gauging, etc.)
- Ecological indicator species for each zone in each reach (see section 3.4)
- Culturally significant species (see section 3.4)
- The annual evaluation and reporting requirements for the CCMA (e.g., Seasonal Watering Plan)
- Level of detail required e.g., site specific versus whole system
- Available resources, including pre-existing and ongoing monitoring programs, equipment, expertise of people expected to complete the monitoring surveys, analysis and reporting, financial costs
- Site accessibility.

3.2 Conceptual model of the vegetation monitoring program design

This conceptual model, below, visually shows the relationship between the objective hierarchy underpinning the vegetation monitoring program and the framework that will be developed to monitor how these objectives will potentially be achieved. The following sections of this document provide further details and examples of the objectives, monitoring targets and quantifiable questions.

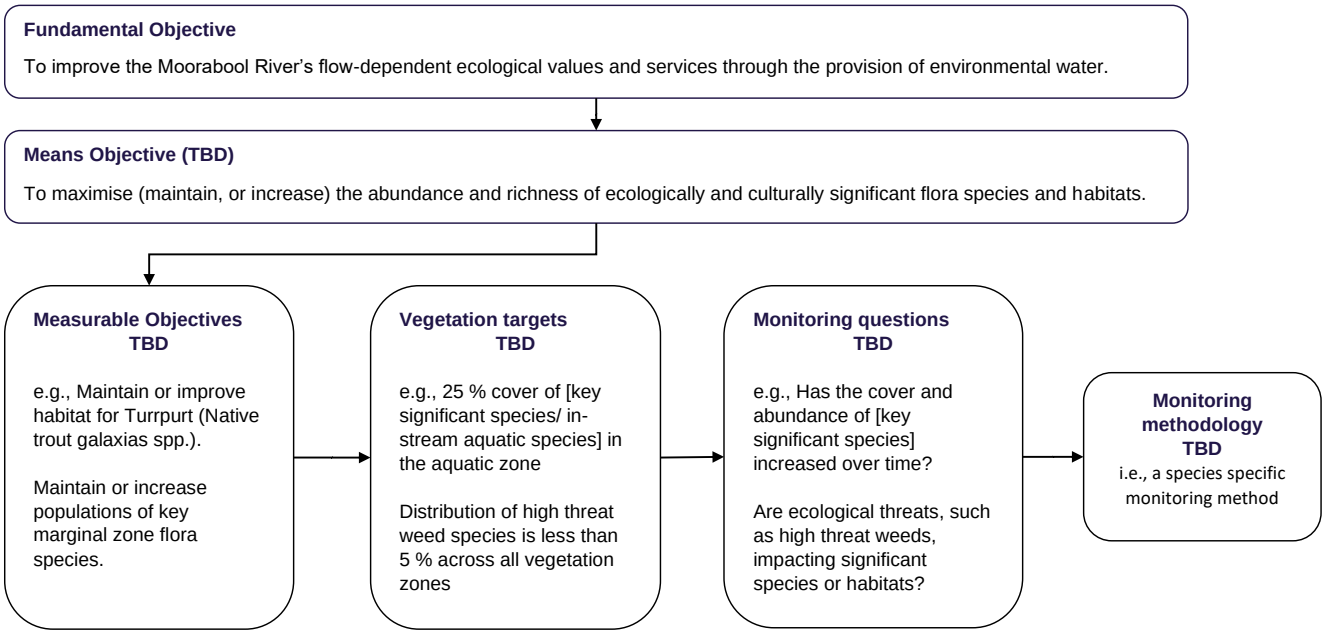

Figure 4. Conceptual model of the monitoring program design process

3.3 Vegetation objectives to targets

To achieve the means objective of *maximising (maintaining or increasing) the abundance and richness of ecologically and culturally significant flora species and habitats*, measurable objectives have been proposed. A detailed summary of the WTOAC vegetation objectives adapted from Table 3 in the Moorabool Seasonal Watering Proposal 2022-23 and the CCMA's vegetation objectives from the Moorabool River FLOWS Study Update (Jacobs, 2015) is provided in Appendix 1. A summary of the proposed measurable objectives is provided below (Figure 5).

Monitoring targets shall be extrapolated from the final set of measurable objectives (see Section 3.4)

Figure 5. Summary of measurable objectives and associated vegetation zones

3.4 Monitoring targets

Monitoring targets need to be SMART: Specific, Measurable, Achievable, Realistic, and Timely. If not, then there is a high risk that the monitoring program will not be able to address the targets; that is, it will not be possible to use monitoring data to know if a target is met or not. Monitoring targets are yet to be determined. Input is required from the project steering committee (CCMA and WOTAC) and the Moorabool Stakeholder Advisory Committee.

Currently, the temporal preference for the targets is to establish an ongoing annual target relative to historical baselines, rather than setting a point to achieve by a specific date. Examples of each are as follows.

> *'all 5 target species present in the aquatic zone on Reach 2 by 2030'*,
>
> *'maintain occurrence of all target species present in XXX[baseline year] in all future years'*.

The project team have indicated a preference for the latter type of temporal specification of targets, so this has been used to suggest target examples below that link to the significant species objectives:

1. Maintain or increase populations of significant flora species in applicable zones and reaches:
    a. E.g. maintain/increase **occurrence** of all target species present *in 2023 [baseline year]* in each applicable zone and reach, *in all future managed years*.
    b. E.g. maintain/increase **occurrence** of all target species present *in the previous year* in each applicable zone and reach.
    c. E.g. maintain/increase **cover** of all target species present *in 2023 [baseline year]* in each applicable zone and reach, *in all future managed years*.
    d. E.g. maintain/increase **extent** of all target species present *in 2023 [baseline year]* in each applicable zone and reach, *in all future managed years*.
2. High threat weed cover less than 10 %
    a. E.g. decrease high threat weed cover across the three water zones in all reaches from 2023 baseline levels.

Note: Tree condition and canopy assessments are not included in this new monitoring approach. Overstorey tree assessments and monitoring are captured through the ISC monitoring (approximately once every 10 years), but this does not discriminate between native species so it would provide a high-level evaluation only. Evaluation of species-specific would need to be evaluated using a separate approach that takes into consideration the life-history of the trees, spatial scale, environmental water connections and objectives.

3.5 Quantifiable monitoring questions

Monitoring questions are designed to relate directly to the targets and objectives. Therefore, the questions are essentially just rewording of the targets, but they clearly indicate the priority questions so that focus of the monitoring is clear.

Examples of potential monitoring questions connected to the monitoring objectives and targets:

1. Has the baseline level [insert significant flora species] been maintained/exceeded since the previous year/baseline year? Are all target flora species present at the respective monitoring sites?

2. Are the populations of [insert significant flora species] present in the baseline/previous year still present?

3. Is high threat weed cover below the baseline level? Is it declining?

4. Are other management actions required to meet targets/objectives? [requires knowing the change in abundance of threat and target native species and capacity to evaluate multiple drivers].

4 New monitoring approach – species specific monitoring

From the above objectives and workshop discussions it is clear that the CCMA and WTOAC desire a significant species approach to setting objectives, monitoring, and evaluation. This means that a selection of significant species is targeted rather than the whole plant community. The methods are similar to a community-level evaluation, but sampling is constrained to focus on priority components only.

4.1 Determining significant species

The FLOWS study (Jacobs, 2015) indicated a suite of ecologically significant species allocated to river bank zones, while the WTOAC objectives indicated culturally significant species, independent of zones (see the full list in Appendix 2). Of the four bank zones defined in the Jacobs (2015) study, only three are included in this new program design because the vegetation of the more terrestrial zone – inset benches and floodplain – is likely not to be as responsive to environmental watering events and no key significant species were identified for this upper bank zone.

Currently, there is a small overlap between the ecologically and culturally significant species across all reaches; therefore, the selection of species that should be used to define objectives, targets and focus monitoring should be carefully interrogated and reviewed before finalised. The current set of the most-aligned species is provided in Table 4, these are the only species that were listed as significant in the FLOWS study and by WTOAC to date. There are many species listed in the FLOWS study that are not indicated as culturally significant species, and a small number in the reverse.

Table 4. Species that are indicated as both ecologically and culturally significant for the Moorabool River.

Zone	Scientific name	Waddawurrung name	Common name	Cultural values and uses
Aquatic	*Cycnogeton procerum*	Polango/Warngare	Water ribbons	Food
Marginal	*Phragmites australis*	Tark	Common reed	Weapon-stems/spears for fishing, weaving, food
	Juncus palidus	Toolim	Pale rush	Weaving baskets, healing
	Typha latifolia	Bal-yan	Cumbungi	Healing
	Amphibromus nervosus	Kokibainang	Swamp wallaby grass	Rope for nets
	Rumex brownii	Kadthek	Slender dock	Food, medicine
Damp	*Eucalyptus camaldulensis*	Biyal	River red gum	Canoe, tarnuk (bowl, nectar drink, healing, steam bath leaves
	Eucalyptus viminalis	Larrap	Manna gum	Shields, lerps, healing
	Eucalyptus ovata	Yarrabil/ we-in-kalk	Swamp gum	Food, sap used for tool making, branches used
	Acacia dealbata	Ngelitj	Silver wattle	Food, healing, timber used for tool making
	Acacia mearnsii	Ngelitj	Black Wattle	Healing, food, timber used for tool making, sap used as resource

4.2 Survey sites

Survey sites will occur at monitoring locations determined in consideration of multiple criteria and priorities. Following is a suggested decision process for the site selection:

1. Determine financial resources available for monitoring surveys.
2. Undertake a pilot survey of a preliminary set of sites (e.g., three sites) to determine a realistic approximation of what resources are required per site i.e., time and expertise.
3. Determine the feasible number of sites that can be included in this monitoring program with the available resources.
4. Develop a list of site selection criteria based on the monitoring program's aims and objectives.
5. Develop a comprehensive list of desired monitoring site locations.
6. Use decision analytic tools to refine the final set of monitoring sites. For example, compare site alternatives using a consequences table (Table 5) and eliminate alternatives using trade-off techniques (e.g. Hammond et al. 1999).

Initial site selection criteria to be considered:

- Sites that support, or provide conditions for, multiple key significant flora species
- Sites with appropriate hydrogeomorphology that allow for Wad-dirring/ Perridak (Platypus), Buniya (Eels), Ware-rap (Blackfish), and Turrpurt (Native trout galaxias spp.) habitat
- Sites that represent typical Moorabool River habitats, including pools, riffles, benches, and billabongs
- Sites of cultural significance
- Pre-existing monitoring sites e.g., Water Watch sites that collect macroinvertebrate data (food source for culturally significant fauna species)
- Sites with a range of benchmark ecological conditions – from high quality to low quality sites – that can be used to track vegetation trajectories from improving to maintaining or declining conditions.

Table 5. Example consequences table for comparing alternative potential monitoring site locations for the Moorabool River.

		Alternatives		
Criteria derived from aims and objectives	**Site attributes**	**Site 1**	**Site 2**	**Site 3 etc**
Key significant flora species present	Bal-yan (Cumbungi) Polango/Warngare (Water ribbons) Toolim (Pale rush) etc			
In-stream habitat features for significant fauna species	Overhanging vegetation In-stream logs In-stream boulders etc			
Culturally significant site	Yes/ No			
Representative Moorabool River habitat type	Pools Riffles Benches etc			
Remnant vegetation condition	Streambank shrubland vegetation condition (good, moderate, poor) Floodplain riparian woodland condition (good, moderate, poor)			

		Alternatives		
Criteria derived from aims and objectives	**Site attributes**	**Site 1**	**Site 2**	**Site 3 etc**
In-stream submerged aquatic vegetation present	Absent, low, moderate, high richness and abundance			
Presence of high threat environmental weeds	Absent, low, moderate, high abundance			
Pre-existing monitoring site	Yes/ No (If yes, which program)			
Site access	Public, Private etc			
Reach location within the Moorabool system	Reach 1 Reach 2 Reach 3a Reach 3b Reach 4			

Suggested site locations provided by the CCMA:

- Representative sections of reaches 3a, 3b (West Moorabool) and 4, as defined in the Moorabool River FLOWS study update (Jacobs 2015).
- Reach 1 (East Moorabool) could also be included to provide a basis for comparison to stream with environmental releases (West Moorabool) to one without (East Moorabool, possibly below the spillway or the disconnected section above the reservoir) and to allow future comparisons with the East Moorabool itself following allocation of an environmental entitlement in Bostock Reservoir.
- WTOAC Water Watch sampling sites
- FLOWS sites from FLOWS Study (Jacobs 2015) originally selected as examples of major geomorphic and ecological features typical of each FLOWS reach
- Refuge pools identified in Habitat Refuge Pools and Flow-dependent Vegetation of the Moorabool River, Victoria (Jacobs 2017). Sites currently being used by ARI for long term fish population monitoring program within VEFMAP
- Sites assessed in the past by ARI in relation to research questions associated with vegetation
- General community Water Watch sampling sites
- Complimentary work that may or may not be undertaken as part of ARI's VEFMAP program in relation to vegetation

4.3 Frequency of sampling

This monitoring design is aimed at tracking evidence of vegetation responses to flow regimes (not flow events) and change in vegetation attributes over time to inform flow management. Sampling multiple times within a year would be useful but is cost prohibitive. Sampling every few years would not enable regular and up-to-date data to inform annual seasonal watering proposals. Sampling once annually aligns most directly with the monitoring needs and resources.

4.4 Survey timing

Currently, all significant species listed are perennial and are therefore present all year. This means that survey timing does not need to consider seasonal presence. However, the growth and flowering of each species does vary between seasons, so that cover and identification will be improved by conducting surveys in summer when the cover is high and flowers are more likely to be present. Alterations to the listed significant species may mean a different or more constrained survey timing is required.

4.5 Vegetation data collection method

The objectives and draft targets relate to the presence and abundance of significant species, which means that monitoring will also focus on these variables. Abundance can be indicated by multiple attributes, e.g., vegetation cover, number of plants, frequency plots, etc. The most commonly used measure of abundance for vegetation surveys in Australia is foliage projective cover (hereafter 'cover') and it is recommended that this is used for the Moorabool River vegetation monitoring. Given the program objectives relating to significant species, rather than all species, assessing species richness is out of scope of this study – but it is likely to be useful to assess in initial baseline surveys to determine broader site richness and occurrence of significant species beyond sample locations.

Vegetation cover can be surveyed in many ways, with each approach having different strengths and weaknesses relating to needs. Point quadrat surveys and visual cover estimates are two commonly used options for assessing vegetation cover and both are currently used in waterway and wetland monitoring programs across Victoria. There have been many published research studies on the use of, and comparisons between, visual cover estimates and point quadrats. Additionally, the project team for this project has extensive experience implementing both methods.

Visual estimates are by far the most commonly used method for vegetation cover estimates in monitoring programs. However, visual estimates have often been criticised due to inaccuracies (when cover is not very low or high) and high subjectivity causing large variation in estimates between observers (Gorrod and Keith 2009; Vittoz and Guisan 2007), but this variation differs with the detectability of a species influenced by its traits, as well as community composition and observer experience (Garrard et al. 2013). These issues can be mitigated to various extents by reducing the size of plot areas (e.g. from 10 x 10 m to 1 x 1 m quadrats) (e.g. Klimes 2003) or through training/feedback of observers (Wintle et al. 2013) to reduce the variation in cover estimates between observers.

In comparison, point quadrat methods are generally considered more objective and more accurate, but their objectivity and accuracy can often be lower than visual estimates for plants with low cover (Dethier et al 1993, Floyd and Anderson 1987; Godínez-Alvarez et al. 2009; Vittoz and Guisan 2007). In situations where the two methods have largely equivalent accuracy overall, other considerations may be used to determine the more suitable option (Ónodi et al. 2017). Other considerations include the survey speed (point quadrats are typically slower than visual estimates), survey impacts to site (setting up and sampling point quadrats will typically cause more trampling damage), and surveyor fatigue (visual estimates may be more likely to vary with observer fatigue).

For the purposes of the Moorabool River monitoring program, it is expected that using visual estimates to survey plant cover are likely to be the most suitable. This will enable a faster and simpler approach to assessing plant cover. However, it will be important to acknowledge that this approach will mean that small differences between surveys (e.g. between years) will be unreliable indicators of change because of the potential for observer biases to be causing the difference. To mitigate this effect, standardisation of visual estimates through training and visual references will be important to adopt.

Below are some practical suggestions for implementing the monitoring that will be refined and confirmed as the project is developed.

Data recording

Data can be recorded directly into tablets with pre-loaded field survey data collection templates developed in Excel specifically for this method. Paper versions of data sheets should be carried with the field gear and used if tablets fail (e.g. due to heat or rain). Cover should be estimated as best as possible on a continuous scale, i.e. if the best estimate is 35% or 0.5% then those values are recorded, not a categorical or rounded value.

Plot details

Plot metadata will be required for all plots. These include project area, plot code, bank position, date surveyed, observer names, hydrology notes, disturbance notes etc.

4.6 Survey layout

Visual estimates of cover need to be applied to a bounded area (usually a quadrat). Quadrats are typically square or rectangular and may vary greatly in size depending on the monitoring objectives, the terrain and the species being recorded. Smaller species can be effectively sampled within smaller areas (e.g. 1m x 1m), but larger species may require larger areas (e.g. 10m x 10m). River banks contain strong vegetation gradients due to the influence of water, creating the focus zones indicated in the program objectives. On

most river banks, these zones are no more than 1m wide in bank elevation. This means that a quadrat larger than 1m will span multiple zones at the same time, so will be ineffective in meeting the program objectives. Therefore, it is recommended that multiple smaller quadrats of 1m x 1m are used.

Quadrats will need to be positioned within each of the different zones (3 zones – at least initially). Replication will be required to sample the variation in plant cover within sites, i.e. multiple quadrats will need to be sampled within each zone in each site. Five quadrats within each zone within each site (~100m) are recommended. Within a quadrat we would survey:

- Visual estimate of total plant cover
- Visual estimate of cover for all individual 'significant' species (not trees)
- Bank slope (gentle, moderate, steep)

The quadrat position within each zone at each site could be random or structured. Random can be beneficial because it means that exact locations do not need to be relocated each time. However, with small numbers of quadrats (5 per zone), it would be likely that a random approach would lead to a weak ability to compare across years. A structured approach would provide a much more powerful comparison (e.g. Figure 6), with locations specifically selected to capture significant species present.

During initial establishment of new survey methods, it is recommended that a comprehensive species list for each site should be conducted, so that there is a presence/ absence record of what species occur at each monitoring site, even if they are not captured in the quadrat survey. This will indicate if species are locally present but are uncommon, or not present at all and may need reintroduction.

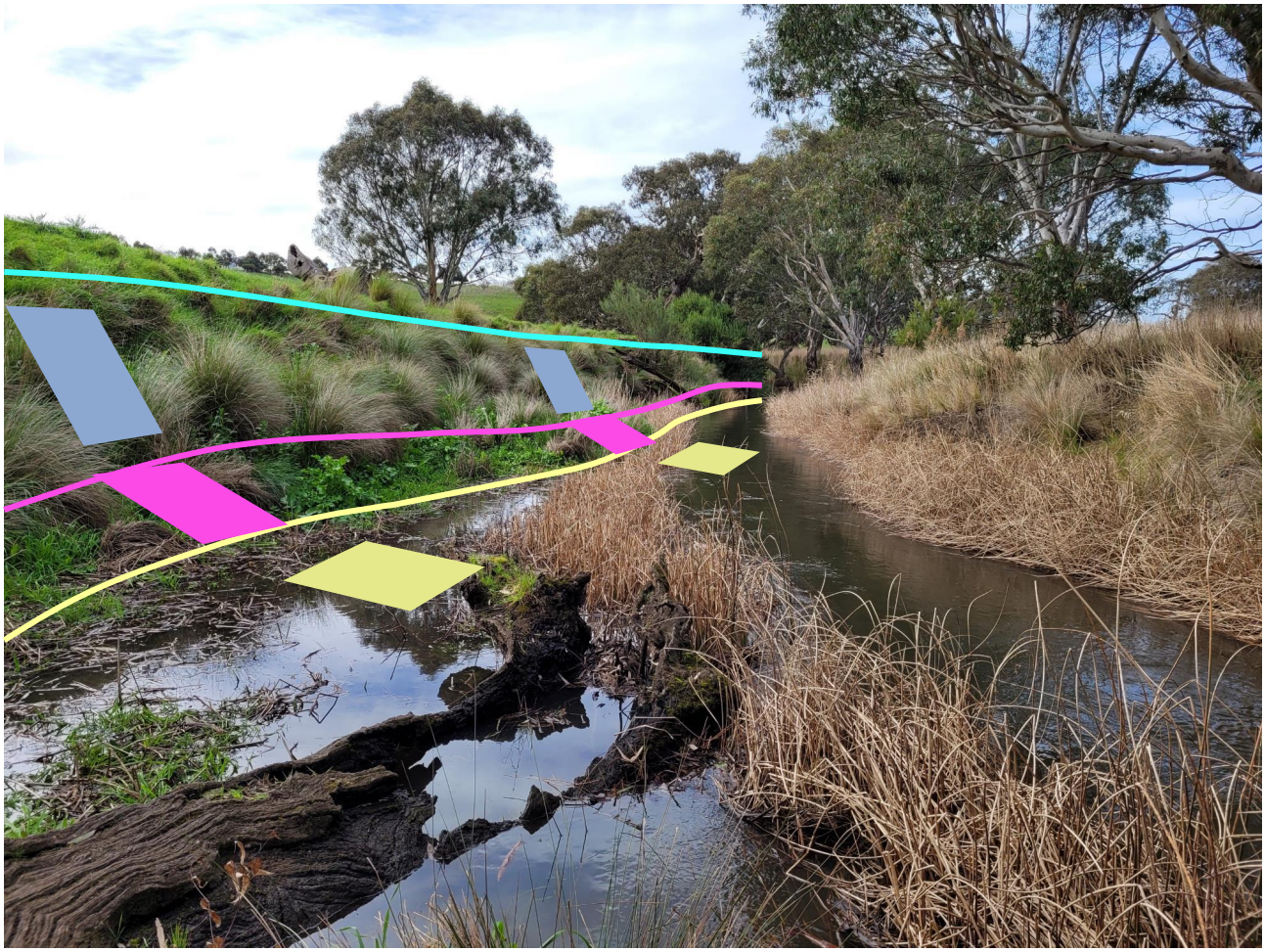

Figure 6. Schematic of proposed quadrat layout within priority channel zones: aquatic (yellow), marginal (pink) and damp (blue).

4.7 Data management and use

Whether or not data are collected electronically (e.g. on tablet spreadsheets, Section 4.5) or on paper, it is critical that the collected data are fully compiled into a single electronic spreadsheet and the data quality controlled to complete a survey. Data quality controls include the following as a start:

- checking that names of sites or species are entered correctly and consistently (not with multiple versions of names),
- ensuring that there are no data gaps, and if so, they are entered as 'NA',
- checking that there are no impossible values that indicate a 'typo'.

Once a single clean dataset is finalised for the sampling period (year), the data should be housed securely with the other related datasets (e.g. metadata and data from previous years) and backed up to a location accessible to multiple data managers.

Misuse or misrepresentation of the data is easily done and common. It is important that data interpretation and use for evaluation is done appropriately and acknowledging the limitations of the data. Even simple calculations of mean values can grossly misrepresent the data if the inappropriate values are used.

It is also very common to use the data in a way that does not directly evaluate against objectives, so it is important to link outcomes and interpretations to the monitoring purpose.

5 Discussion and conclusions

The monitoring program design outlined above represents a successful cooperative project that has enabled all project team views and requirements to be acknowledged. The design is a fast, simple and repeatable process that should provide water managers with the information they require at a high level to evaluate and inform environmental water management. Importantly, this local evidence should be coupled with updated knowledge and insights from the broader water management community and literature to address knowledge gaps, improve understanding of causal pathways, and broaden understanding of environmental drivers and interactions.

The design is currently outlined at a high level and requires finalisation before outlining at a fully operational level (i.e., detailed sampling protocols). To finalise the approach, the following processes need to be completed by the project team:

1. Finalise the specific wording of targets relating to vegetation objectives from environmental water management. The wording is important because it will determine how and when evaluation will be undertaken and set the bar for management outcomes.
2. Finalise the list of target significant species. Many species have been indicated as either ecologically or culturally significant but few are both (as yet). Site inspections, pilot data and prioritisation will be required to determine the most valuable set of target species. A short list of significant species will be simple to assess but will mean that very few plants are monitored, while important plants are ignored. A large list of significant species is more complex to monitor but captures more species and information to determine responses. If a list cannot be determined effectively for all reaches, the approach may be modified to survey a larger suite of species by appropriately skilled observers.
3. Confirm selection of priority monitoring sites to provide the most valuable sampling pool within constraints.

Each of the steps above is important for the successful completion of the monitoring program design and they should be conducted carefully, methodically and transparently.

Once the approach is tested and finalised, a strategic implementation plan can be developed to commence baseline surveys and an ongoing monitoring program. Detailed sampling and data management protocols will be implemented to ensure consistent and accurate implementation of the method, data curation and evaluation.

It is likely that the program will intersect with other monitoring programs or actions such as future VEFMAP monitoring, but these ongoing monitoring program plans are not yet determined. Establishing a monitoring program now to meet the specific needs of the Moorabool River water managers is a proactive step in the midst of uncertainty.

6 References

CCMA (2022). Moorabool River Seasonal Watering Proposal 2022-23. Report by the Corangamite Catchment Management Authority.

Department of Energy, Environment and Climate Action (DEECA) (2023) Ecological Vegetation Class and Disturbance Mapping – Nature Kit [Online] Available: https://maps2.biodiversity.vic.gov.au/Html5viewer/index.html?viewer=NatureKit [accessed 29/01/2023]. Department of Energy, Environment and Climate Action.

Department of Environment, Land, Water and Planning (DELWP) (2022) Stream Change Assessment: detecting change in riparian woody vegetation using LiDAR derived data. Department of Environment, Land, Water and Planning, East Melbourne, Victoria.

Dethier, M. N., Graham, E. S., Cohen, S., & Tear, L. M. (1993). Visual versus random-point percent cover estimations:'objective'is not always better. Marine ecology progress series, 93-100.

Floyd, D. A., & Anderson, J. E. (1987). A comparison of three methods for estimating plant cover. The Journal of Ecology, 221-228.

Garrard, G.E., McCarthy, M.A., Williams, N.S., Bekessy, S.A. and Wintle, B.A., (2013). A general model of detectability using species traits. Methods in Ecology and Evolution, 4, 45-52.

Godínez-Alvarez, H., Herrick, J. E., Mattocks, M., Toledo, D., and Van Zee, J. (2009). Comparison of three vegetation monitoring methods: their relative utility for ecological assessment and monitoring. Ecological indicators, 9, 1001-1008.

Gorrod, E.J. and Keith, D.A., 2009. Observer variation in field assessments of vegetation condition: implications for biodiversity conservation. Ecological Management and Restoration, 10, 31-40.

Hammond, J.S., Keeney, R.L., and Raiffa, H. (1999) Smart Choices: A Practical Guide to Making Better Decisions. Harvard Business School Press, Boston, Masachusetts, USA

Jones, C. S., and F. M. Thomas. (2018). Regular intervention monitoring providing valuable insights into vegetation responses to environmental flows on rivers. Page in G. J. Vietz and I. D. Rutherford, editors. Proceedings of the 9th Australian Stream Management Conference, 12 – 15 August 2018. Hobart, Tasmania.

Jacobs (2015). Moorabool River FLOWS Study Update. Report for the Corangamite Catchment Management Authority.

Jacobs (2017). Habitat Refuge Pools and Flow-dependent Vegetation of the Moorabool River, Victoria.

Klimeš, L., (2003). Scale-dependent variation in visual estimates of grassland plant cover. Journal of Vegetation Science, 14, 815-821.

Lloyd Environmental (2020). Final Report – Moorabool Groundwater and FLOWS project. Report for the Corangamite Catchment Management Authority.

Main, A. C., Greet, J., Vivian, L. M., & Jones, C. S. (2022). Warmer water temperatures exacerbate the negative impacts of inundation on herbaceous riparian plants. Freshwater Biology, 67(7), 1162-1173.

Ónodi, G., Kröel-Dulay, G., Kovács-Láng, E., Ódor, P., Botta-Dukát, Z., Lhotsky, B., ... & Kertész, M. (2017). Comparing the accuracy of three non-destructive methods in estimating aboveground plant biomass. Community Ecology, 18(1), 56-62.

Tonkin, Z., Jones, C., Clunie, P., Vivian, L., Amtstaetter, F., Jones, M., Koster, W., Mole, B., O'Connor, J., Brooks, J., Caffrey, L., Lyon, J. (2020). Victorian Environmental Flows Monitoring and Assessment Program: Stage 6 Synthesis Report. Technical Report Series No. 316. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Vittoz, P. and Guisan, A., 2007. How reliable is the monitoring of permanent vegetation plots? A test with multiple observers. Journal of Vegetation Science, 18, 413-422.

Vivian, L. M., Greet, J., & Jones, C. S. (2020). Responses of grasses to experimental submergence in summer: implications for the management of unseasonal flows in regulated rivers. Aquatic Ecology, 54(4), 985-999.

Wintle, B. C., Fidler, F., Vesk, P. A., & L. Moore, J. (2013). Improving visual estimation through active feedback. *Methods in Ecology and Evolution*, *4*(1), 53-62.

Appendices

Appendix 1. Vegetation objectives for environmental watering

The following measurable objectives are adapted from the Moorabool River Seasonal Watering Proposal 2022-23 and the Moorabool River FLOWS Study Update (Jacobs, 2015). A target species summary is also provided in Table 1 (page 5).

WTOAC vegetation objectives adapted from Table 3 in the Moorabool Seasonal Watering Proposal 2022-23

1. Maintain or improve habitat for the breeding and recruitment of Wad-dirring/ Perridak (platypus).
2. Maintain or improve habitat for Buniya (Eels).
3. Maintain or improve habitat for Turrpurt (Native trout galaxias spp.)
4. Maintain or improve habitat for Ware-rap (Blackfish).
5. Maintain or improve the abundance of Polango/ Warngare (Water ribbons *Cycnogeton procera*).
6. Maintain or improve the condition, extent and abundance of Tark (common reed *Phragmites australis*), Toolim (Pale Rush *Juncus pallidus*), and Bal-yan (Cumbungi *Typha latifolia*)
7. Maintain or improve the abundance of Biyal (River red gum *Eucalyptus camaldulensis*).
8. Maintain or improve the abundance of Larrap (Manna gum *Eucalyptus viminalis*) and Kokibainang (swamp wallaby grass *Amphibromus reservatus,* more likely *Amphibromus nervosus*).

CCMA's vegetation objectives adapted from Moorabool River FLOWS Study Update, (Jacobs, 2015: p. 37)

Note: No species are presented for Reach 2. Jacobs (2015) stated that "no assessment site was surveyed in FLOWS Reach 2 in the previous study and there was not a sufficient justification to spend additional funds in completing a survey as part of the Moorabool FLOWS update. This reach is in poor condition and lacks habitat features suitable for setting ecological objectives and flow recommendations. Biological health in this reach would benefit from improved land management rather than environmental flows".

1. Maintain or increase populations of key aquatic zone flora species

Reach 1 species: *Myriophyllum variifollium* Varied Watermilfoil (most likely *M. simulans* for all reaches), *Ranunculus amphitricus* Small River Buttercup, and *Cycnogeton procerum* Common Water-ribbons

Reach 2 species: No species specified

Reach 3a species: *Myriophyllum variifollium* Varied Watermilfoil and *Cycnogeton procerum* Common Water-ribbons

Reach 3b species: *Myriophyllum variifollium* Varied Watermilfoil and *Cycnogeton procerum* Common Water-ribbons

Reach 4 species: Characeae spp. Stonewort, *Lemna triscula* Ivy-leaf Duckweed, and *Cycnogeton procerum* Common Water-ribbons

2. Maintain or increase populations of key marginal zone flora species

Reach 1 species: *Carex appressa* Tall Sedge, *Carex fascicularis* Tassel Sedge, *Schoenoplectus tabernaemontani* River Club-rush, *Typha domingensis* Narrow-leaf Cumbungi

Reach 2 species: No species specified

Reach 3a species: *Carex appressa* Tall Sedge, *Carex fascicularis* Tassel Sedge, *Carex gaudichaudiana* Fen Sedge, *Phragmites australis* Common Reed, *Typha domingensis* Narrow-leaf Cumbungi

Reach 3b species: *Carex appressa* Tall Sedge, *Carex gaudichaudiana* Fen Sedge, *Triglochin striata* Streaked Arrowgrass, *Schoenoplectus tabernaemontani* River Club-rush, *Phragmites australis* Common Reed, *Typha domingensis* Narrow-leaf Cumbungi

Reach 4 species: *Thyridia repens* Creeping Monkey-flower, *Bolboschoenus caldwellii* Marsh Club-rush, *Triglochin striata* Streaked Arrowgrass, *Schoenoplectus tabernaemontani* River Club-rush, *Phragmites australis* Common Reed, and *Rumex bidens* Mud Dock

3. Maintain or increase populations of key damp zone flora species

Reach 1 species: *Acacia melanoxylon* Blackwood, *Callistemon sieberi* River Bottlebrush, *Leptospermum lanigerum* Woolly Teatree, and *Poa labillardierei var. labillardierei* Common Tussock Grass

Reach 2 species: No species specified

Reach 3a species: *Eucalyptus viminalis* Manna Gum, *Pomaderris aspera* Hazel Pomaderris, *Acacia melanoxylon* Blackwood, *Gynatrix pulchella* Hemp Bush, *Leptospermum lanigerum* Woolly Teatree, and *Poa labillardierei var. labillardierei* Common Tussock Grass

Reach 3b species: *Eucalyptus camaldulensis* River Red Gum, *Eucalyptus viminalis* Manna Gum, *Acacia melanoxylon* Blackwood, *Gynatrix pulchella* Hemp Bush, *Leptospermum lanigerum* Woolly Teatree, *Coprosma quadrifida* Prickly Current Bush, *Ficinia nodosa* Knobby Club-rush and *Poa labillardierei var. labillardierei* Common Tussock Grass

Reach 4 species: *Eucalyptus camaldulensis* River Red Gum, *Melicytus dentatus* Broad-leaf Tree-violet, Duma florulenta Tangled Lignum, *Rorippa laciniata* Jagged Bitter-cress, *Poa labillardierei var. labillardierei* Common Tussock Grass

4. Maintain or increase populations of key inset benches (Reaches 1 and 2) or floodplain (Reaches 3, 4 and 5) flora species

Reach 1 species: No species specified

Reach 2 species: No species specified

Reach 3a species: No species specified

Reach 3b species: No species specified

Reach 4 species: No species specified

Appendix 2. Summary of key significant flora species for monitoring (extracted from the FLOWS and Seasonal Watering Proposal documents)

Species	Traditional **name**	Common name	FLOWS/WTOAC Key Sig Species	Additional FLOWS Species	Zone	Reach 1	Reach 3a	Reach 3b	Reach 4
Azolla filiculoides		Pacific Azolla		X	Aquatic				
Characeae spp.		Stonewort	FLOWS		Aquatic				X
Cycnogeton procerum	Polango/ Warngare	Water Ribbons	FLOWS/WTOAC		Aquatic	X	X	X	X
Landoltia punctata		Thin Duckweed		X	Aquatic				
*Lemna triscula **[submerged]***		Ivy-leaf Duckweed	FLOWS		Aquatic				X
Myriophyllum variifollium [simulans]		Amphibious Water-milfoil	FLOWS		Aquatic	X	X	X	
Ranunculus amphitricus		Small River Buttercup	FLOWS		Aquatic	X	X	X	
Acacia dealbata	Ngelitj	Silver Wattle	WTOAC	X	Damp				
Acacia mearnsii	Ngelitj	Black Wattle	WTOAC	X	Damp				
Acacia melanoxylon		Blackwood	FLOWS		Damp	X	X	X	
Acaena novae-zeelandiae		Bidgee Widgee		X	Damp				
Banksia marginata	Wurrak	Silver banksia	WTOAC		Damp				
Bursaria spinosa subsp. spinosa		Sweet Bursaria		X	Damp				
Callistemon sieberi		River Bottlebrush	FLOWS		Damp	X			
Coprosma quadrifida		Prickly Currant-bush	FLOWS		Damp			X	
Dichondra repens		Kidney Weed		X	Damp				
Duma florulenta		Tangled Lignum	FLOWS		Damp				X
Eucalyptus camaldulensis	Biyal	River Red Gum	FLOWS/WTOAC		Damp			X	X
Eucalyptus leucoxylon		Yellow Gum	FLOWS		Damp				
Eucalyptus ovata	Yarrabil/ we-in-kalk	Swamp gum	WTOAC		Damp				
Eucalyptus viminalis	Larrap	Manna Gum	FLOWS/WTOAC		Damp		X	X	
Ficinia nodosa		Knobby Club-sedge	FLOWS		Damp			X	
Geranium sp. 2		Variable Crane's-bill		X	Damp				
Gynatrix pulchella s.s.		Hemp Bush	FLOWS		Damp		X	X	
Hemarthria uncinata		Mat Grass		X	Damp				
Hymenanthera dentata var. dentata		Broad-leaf Tree-violet		X	Damp				
Leptospermum lanigerum		Woolly Tea-tree	FLOWS		Damp	X	X	X	
Lomandra longifolia subsp. longifolia		Spiny-headed Mat-rush		X	Damp				
Melicytus dentatus		Broad-leaf Tree Violet	FLOWS		Damp				X
Poa labillardierei var. labillardierei		Common Tussock-grass	FLOWS		Damp	X	X	X	X
Pomaderris asper		Hazel Pomaderris	FLOWS		Damp		X		
Pteridium esculentum		Bracken		X	Damp				

Species	Traditional **name**	Common name	FLOWS/WTOAC Key Sig Species	Additional FLOWS Species	Zone	Reach 1	Reach 3a	Reach 3b	Reach 4
Rorippa laciniata		Jagged Bitter-cress		X	Damp				
Rumex brownii	Kadthek	Slender Dock	WTOAC	X	Damp				
Senecio minimus		Shrubby Fireweed		X	Damp				
Amphibromus reservatus [nervosus]	Kokibainang	Common Swamp Wallaby-grass	FLOWS/WOTAC		Marginal				
Apium prostratum		Sea Celery		X	Marginal				
Bolboschoenus caldwellii		Marsh Club-rush	FLOWS		Marginal				X
Carex appressa		Tall Sedge	FLOWS		Marginal	X	X	X	
Carex fascicularis		Tassel Sedge	FLOWS		Marginal	X	X		
Carex gaudichaudiana		Fen Sedge	FLOWS		Marginal		X	X	
Crassula helmsii		Swamp Crassula		X	Marginal				
Eleocharis acuta		Common Spike-rush		X	Marginal				
Glyceria australis		Australian Sweet-grass		X	Marginal				
Isolepis cernua		Nodding Club-sedge		X	Marginal				
Isolepis inunudata		Swamp Club-sedge		X	Marginal				
Juncus pallidus	Tooliim	Pale Rush	WTOAC	X	Marginal				
Lileopsis polyantha		Australian Lileopsis		X	Marginal				
Persicaria decipiens		Slender Knotweed		X	Marginal				
Phragmites australis	Tark	Common Reed	FLOWS/WTOAC		Marginal		X	X	X
Rumex bidens		Mud Dock	FLOWS		Marginal				X
Schoenoplectus tabernaemontani		River Club-rush	FLOWS		Marginal	X		X	X
Thyridia repens		Creeping Monkey-flower	FLOWS		Marginal				X
Triglochin striata		Streaked Arrowgrass	FLOWS		Marginal			X	X
Typha domingensis		Narrowleaf Cumbungi	FLOWS/WTOAC		Marginal	X	X	X	
Typha latifolia	Bal-yan	Cumbungi		X	Marginal				
Bulbine bulbosa	Pike	Yellow bulbine-lily	WTOAC		Floodplain				
Caesia calliantha	Bom	Blue grass lily	WTOAC		Floodplain				
Clematis microphylla	Tarook	Small leaved clematis	WTOAC		Floodplain				
Exocarpos cupressiformi	balotj/balout	Cherry Ballart	WTOAC		Damp				

www.delwp.vic.gov.au

www.ari.vic.gov.au