Healthy Waterways Strategy

Wetlands Monitoring and Evaluation Plan

Working together for healthy waterways

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Acknowledgements

This Monitoring and Evaluation Plan draws upon the information, experience and thought of many people, all of who's contributions are gratefully acknowledged. Should their expert recommendations not be adopted here it will only be because our resources are insufficient to implement the ideal monitoring and evaluation program.

The Healthy Waterway Strategy Science Panel provided critical advice throughout the development of this plan. This expert panel comprised Michelle Dickson (Chair), Professor Ian Rutherford, Dr Rhys Coleman, Dr Belinda Hatt, Dr David Jones, Dr Randall Lee, Dr Kay Morris, Professor Vin Pettigrove, Dr Simon Treadwell, Associate Professor Chris Walsh, Dr Yung En Chee, Dr Fiona Warry and Dr Paul Reich.

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While this Monitoring and Evaluation Plan has been prepared in consultation with many people within Melbourne Water and other agencies, the team responsible for drafting this plan comprised Bronwyn Gywther and Simon Treadwell (Jacobs), Dylan Osler (Ecological Perspective), Paul Boon (Dodo Environment) and Doug Frood (Pathways Bushland).

We acknowledge and respect Traditional Owners and Aboriginal communities and organisations. We recognise the diversity of their cultures and the deep connections they have with the region's lands and waters. We value partnerships with them for the health of people and Country.

Abbreviations and Acronyms

ARI	Arthur Rylah Institute for Environmental Research, DELWP
AVIRA	Aquatic Values Identification and Risk Assessment
CMA	Catchment Management Authority
DELWP	Victorian Department of Environment, Land, Water and Planning
DIWA	Directory of Important Wetlands in Australia
EPA	Environmental Protection Authority Victoria
ETP	Melbourne Water's Eastern Treatment Plan, Carrum
GDE	Groundwater-dependent ecosystem
HSM	Habitat Suitability Models
HWS	2018 Healthy Waterways Strategy
IBBA	Important Bird and Biodiversity Area
IWC	Index of Wetland Condition assessment/ methodology
KEQ	Key Evaluation Question (from the 2019 MERI Framework)
MEP	Monitoring and Evaluation Plan
MERI Framework	Monitoring, Evaluation, Reporting and Improvement Framework (Melbourne Water 2019)
MWRPP	Melbourne Water Research-Practice Partnership; a research partnership between Melbourne Water and the Waterway Ecosystem Research Group of the University of Melbourne
PPW	Port Phillip and Westernport catchment region
PPWCMA	Port Phillip and Westernport Catchment Management Authority
PV	Parks Victoria
RB	Retarding basin; which often hold a wetland
RLG	Regional Leadership Group – the decision-making body overseeing implementation of the HWS
RPO	Regional Performance Objective
SoBS	Melbourne Water Site of Biodiversity Significance
SSN	Shorebird Site Network
WGR	DELWP's Western Grassland Reserve
WPO	Wetland Performance Objective
WSUD	Water sensitive urban design
WTP	Melbourne Water's Western Treatment Plant, Werribee

Introduction

This Wetlands Monitoring and Evaluation Plan describes indicators and the monitoring and reporting requirements needed to track effectively progress towards targets and objectives set in the *Healthy Waterways Strategy*. It describes how to evaluate the success of the strategy for wetlands in the region.

1 Background context

1.1 The 2018 Healthy Waterways Strategy

The 2018 *Healthy Waterways Strategy* (HWS) (Melbourne Water 2018) is the overarching planning document for the management of rivers, wetlands and estuaries in the Port Phillip and Westernport region. It is a 10-year plan that takes a 50-year perspective, and aims to ensure that the values of waterways in our region are protected and improved. The 2018 HWS follows previous regional river health strategies (Melbourne Water 2007a, 2007b, 2013) but is the first to have a strong focus on wetlands and estuaries in addition to rivers and creeks.

The development of the HWS was led by Melbourne Water, with a stakeholder co-design approach used to determine collaboratively the goals and management actions to be undertaken in each major catchment (Yarra, Maribyrnong, Werribee, Westernport and Dandenong).

1.2 The HWS Monitoring, Evaluation, Reporting and Improvement Framework

The HWS commits Melbourne Water to developing and implementing a Monitoring, Evaluation, Reporting and Improvement (MERI) plan to support the strategy through adaptive management. To address this, Melbourne Water prepared a MERI Framework (Melbourne Water 2019), under which there are three Monitoring and Evaluation Plans (MEPs), one for each waterway "asset class": rivers/streams, estuaries and wetlands. In addition, there will be a fourth, separate, MEP for regional performance objectives.

Key Evaluation Questions

Under the MERI Framework, key evaluation questions (KEQs) were developed to ensure we measure the effectiveness, impact, efficiency, appropriateness, and legacy of the HWS (see Table 1). Accordingly, these KEQs include both *bona fide* monitoring questions regarding environmental change but also administrative and environmental survey-type

questions. Monitoring requirements outlined in this MEP will contribute directly to addressing KEQs 1, 2 and 3 in the MERI Framework. KEQs 4 and 5 are not focused on wetland environmental conditions or values and these are addressed in the MERI Framework (Melbourne Water 2019) rather than in this Wetlands MEP.

Table 1. Healthy Waterways Strategy key evaluation questions (from Melbourne Water 2019).

Evaluation question	When it is asked
KEQ No. 1 - To what extent have the performance objectives of the Strategy been achieved?	Annual Event-based (as needed) Mid-term (i.e. 2022)
KEQ No. 2 - To what extent has progress been made towards the longer term environmental condition targets for rivers, wetlands and estuaries?	Mid-term (i.e. 2022) End of Strategy (i.e. 2026)
KEQ No. 3 – What is the state of waterway values?	Mid-term (i.e. 2022) End of Strategy (i.e. 2026)
KEQ No. 4 -To what extent have the delivery methods of the Strategy been cost effective and efficient?	Mid-term (i.e. 2022) End of Strategy (i.e. 2026)
KEQ No. 5 – To what extent have legacy items been identified and managed for?	End of Strategy (i.e. 2026)

Reporting timeframes

Although the HWS has a temporal scope of ten years, 2018/19 – 2027/28 (inclusive), data will be needed to inform reporting annually, midway (in 2022), and again in 2026 (before the formal end of the Strategy to allow time for evaluation and for findings to be adopted in the preparation of a new strategy) (see Figure 1). Although reporting on wetland condition and key values will occur at mid-term and towards the end of the HWS most significant improvements – especially for wetland values – are expected to take longer than this to become evident. Therefore, reporting during the HWS will involve a mix of annual **output** reporting (the measurable result of management activity, such as hectares of revegetation) and less frequent **outcome** reporting (the resulting impact of these activities, such as increased area of native vegetation).

Years 1-2 of strategy implementation (i.e. 2018/19 and 2019/20) are foundation years and involve: "*finalising MEPs, refining indicators, improving systems and data management, collecting phase 1 data, testing evaluation methods and developing report templates and conducting the first annual review* (Melbourne Water 2019)." The three MEPs will be reviewed periodically, and no later than mid-term (2022) to ensure that new techniques and any safety issues are addressed.

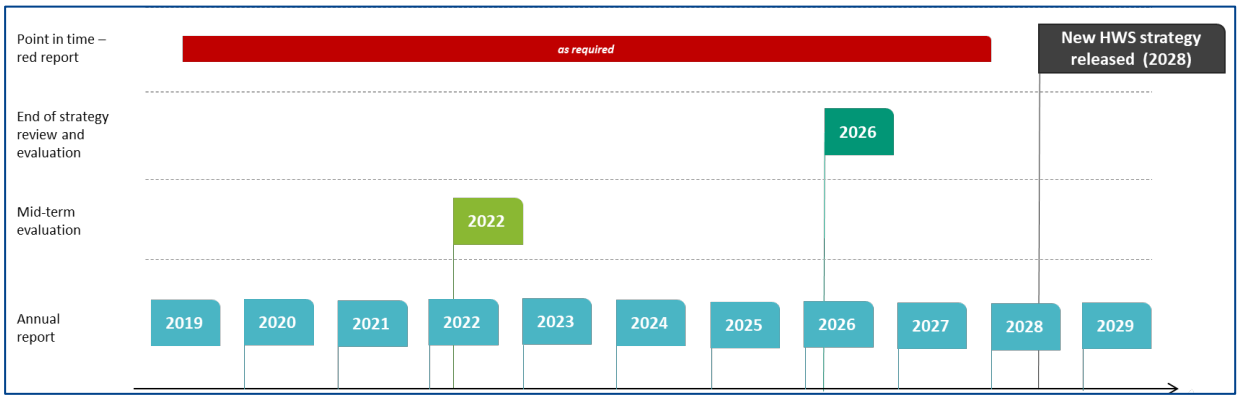

Figure 1. Reporting timeline for the 2018 Healthy Waterways Strategy (Melbourne Water 2019).

1.3 Our Wetlands Monitoring and Evaluation Plan

This plan fulfils the requirement for a Wetland MEP and describes the requirements for key wetland values and conditions to be measured consistently for the duration of the HWS. The document will be updated over time, but particularly at the mid-point of the HWS, to adopt learnings and efficiencies, such as developments in monitoring methods and analytical techniques.

This MEP presents a summary of planned wetland monitoring for the HWS. It adopts and builds upon many existing monitoring programs. So, where comprehensive or contextual information is available in existing documents these are referred to, rather than repeating detailed information here. The monitoring program described is realistic and prudent, trying to balance reporting needs – and ability to detect meaningful changes in condition or values – with resources required to deliver the MERI program.

The following is an overview of the contents of this MEP so that the reader can identify the part (or type of target) that is most relevant to their work and interest.

Table 2. Structure of this MEP.

MEP section	Title	Purpose and time frames	Key Audience
Part A	**Monitoring Implementation** *How are the wetland performance objectives tracking?*	Determining how Performance Objectives will be tracked and evaluated. How the strategy is being implemented locally *Guide on-ground works* *To inform annual planning and prioritisation* *Wetland, sub-catchment, catchment and regional scale* *For wetlands much of this reporting can only be **mid-term***	Implementers of the Strategy (e.g. MW, DELWP, PV, CMAs, local councils, IWM forums) Interested community groups/ members Regional Leadership Group
Part B	**Key Values** Surveillance Monitoring *How wetland key values will be monitored*	Determining if the Values are on track to achieve long term targets. State of Environmental and Social Values *Catchment scale* *Focus is on **end of strategy***	Long-term planners Policy-makers Researchers Regional Leadership Group (end of Strategy) Community
Part C	**Waterway Conditions** Monitoring *How wetland environmental conditions will be monitored*	Determining if waterway conditions are being maintained and improved to support the key Values *Catchment and regional scale focus* *Focus is **mid-term** and **end of strategy***	Medium-term planners Researchers Regional Leadership Group (end of Strategy) Community
Part D	**Research and Intervention Monitoring**	Focussing effort on filling knowledge gaps to drive continuous improvement *Catchment and regional scale focus* *Focus is on **end of strategy***	Researchers Policy makers Planners MW Communities of Practice Other natural resource managers?

2 About this Wetlands MEP

The 2018 HWS is the first regional strategy for the Port Philip and Westernport region to include wetlands in any detail. Our current knowledge about the wetlands across the region is limited. There has been no established monitoring program for the region's wetland conditions or values (other than Ramsar wetlands). Another factor complicating wetland monitoring is that – unlike rivers – there is no single agency with clear designated oversight for all wetlands. Regional wetland management and monitoring must of necessity be a collaborative exercise involving DELWP, PV, Melbourne Water, Councils, community groups, Representative Aboriginal Parties, developers and private land owners.

2.1 Waterbodies vs wetlands

Waterbodies

To support detailed Habitat Suitability Modelling (HSM) of frog, fishes, wetland birds and other wetland values, some 69,000 'waterbodies' were identified and mapped across the Port Phillip and Westernport (PPW) region after combining information from a number of sources including LiDAR analyses (see Appendix A). These include around 55,000 constructed wetlands (farm dams, salt recovery pans, aquaculture ponds, sewage treatment lagoons, stormwater treatment wetlands, industrial storages, reservoirs, bioretention systems, quarry pits, golf course ponds and urban lakes) and around 14,000 "natural" (or modified natural) wetlands; including swamps and billabongs but also minor, previously unmapped depressions detected through LiDAR analysis that are likely to hold water for extended periods (e.g. weeks to months) at particular times of the year and therefore, also potential habitat for some wetland values.

Wetlands

It is important to distinguish between the mapped 'waterbodies' described above (which are features useful for habitat modelling) and recognised 'wetlands', which are assets that might be managed and monitored. The *Water Act* 1989, Section 3, defines waterways as, among other things: "*(d) a lake, lagoon, swamp or marsh, being—*

> *(i) a natural collection of water (other than water collected and contained in a private dam or a natural depression on private land) into or through or out of which a current that forms the whole or part of the flow of a river, creek, stream or watercourse passes, whether or not the flow is continuous;*

Wetlands, as a class of waterway asset, are defined in the 2018 HWS as: "*areas, whether natural, modified or artificial, subject to permanent or temporary inundation, that hold static or very slow-moving water and develop, or have the potential to develop, biota adapted to inundation and the aquatic environment. They may be fresh or saline. Examples of wetlands include swamps and billabongs.*" (Melbourne Water 2018, p. 173)

This definition of a wetland matches that of the *Victorian Waterways Management Strategy* (DEPI 2013d) but is a broad description open to some interpretation. Therefore, to provide a robust definition of a natural wetland (such as might be defensible in a VCAT hearing) we recommend using the hydrogeomorphic wetland classification developed by Brinson (1993) and Smith *et al*. (1995), adopted by the U.S. Army Corps of Engineers, as our detailed definition of a natural wetland.

> Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Diagnostic environmental characteristics include:
>
> (a) *Vegetation*. The vegetation consists of macrophytes that are typically adapted to areas having these hydrologic and soil conditions that are expressed during the drawdown phase – which may occur episodically, at intervals of years, in some Australian wetlands.
>
> (b) *Soils*. Soils that are classified as hydric, or possess characteristics associated with reducing soil conditions.
>
> (c) *Hydrology*. The area is inundated either permanently or periodically, or the soil is saturated to the surface at some time during the growing season of the prevalent vegetation.
>
> Evidence of a minimum of one positive wetland indicator from each parameter (hydrology, soil and vegetation) must be found in order to make a positive wetland determination (Environmental Laboratory 1987).

The HWS categorised wetlands in the PPW region into four broad "types", expected to be impacted by the long-term pressures of climate change and urbanisation in different ways due to the primary sources of their water and their location in the landscape:

- Constructed stormwater treatment wetlands (Figure 2).
- Natural wetlands of the western volcanic (basalt) plains (Figure 3)
- Natural coastal wetlands
- Other natural wetlands of the alluvial plains (Figure 4)

Melbourne Water has well-defined assessment and monitoring procedures for constructed stormwater treatment wetlands (e.g. GHD 2018) and billabongs (e.g. GHD 2019). These programs will continue to be used to monitor performance objectives and wetland conditions, to address knowledge gaps around constructed wetland design, management and function, and are likely to evolve in response to ongoing research into more efficient and effective monitoring approaches. Thus, monitoring of wetland conditions and values in this Wetland MEP focusses on the three 'natural' wetland types highlighted by the 2018 HWS (plus billabongs, which are an existing program with the Environmental Flows Team of Melbourne Water). The performance objectives around constructed wetlands are

included. But Melbourne Water has longstanding and well organised planning and assessment procedures for these constructed wetlands, in contrast to natural wetlands which require the establishment of a monitoring program.

Information on the state of the many thousand natural wetlands occurring across the PPW region is sparse. We are unable to assess the majority of these wetlands until we have developed remote-sensed data collection and appropriate analytical tools.

Surveying, identifying and collating information on current values of natural wetlands are challenging. Ecological surveys provide only a single snap-shot in time of any wetland conditions and values. This is particularly limiting in the case of ephemeral wetlands, where some species may have periods of absence or dormancy. But most natural wetlands experience cyclical expression of certain flora and fauna values as hydrology shifts in response to long-term rainfall and weather patterns. Thus, traditional ecological assessment techniques used to inform planning and urban development processes have the potential to miss, or underestimate, natural values of wetlands.

The HWS Regional Leadership Group (RLG) have recognised that improved data on wetland condition across the region will be required to inform and improve future wetland prioritisation for their protection. Given the large number of wetlands across a large area, the only practical way to collect data on the condition of these regional wetlands is with remote sensing. The reason this approach is suggested is because of the numbers of wetlands and enormous spatial extent of our region, and also because of the proportion of natural wetlands on private property, which are difficult to access for assessment. So, for example, Melbourne Water's waterway research-practice partnership with the Waterways Ecosystem Research Group of the University of Melbourne is working to develop wetland characterisation models for hydroperiod and vegetation using satellite imagery (Bond et al. 2020; and see Section 22).

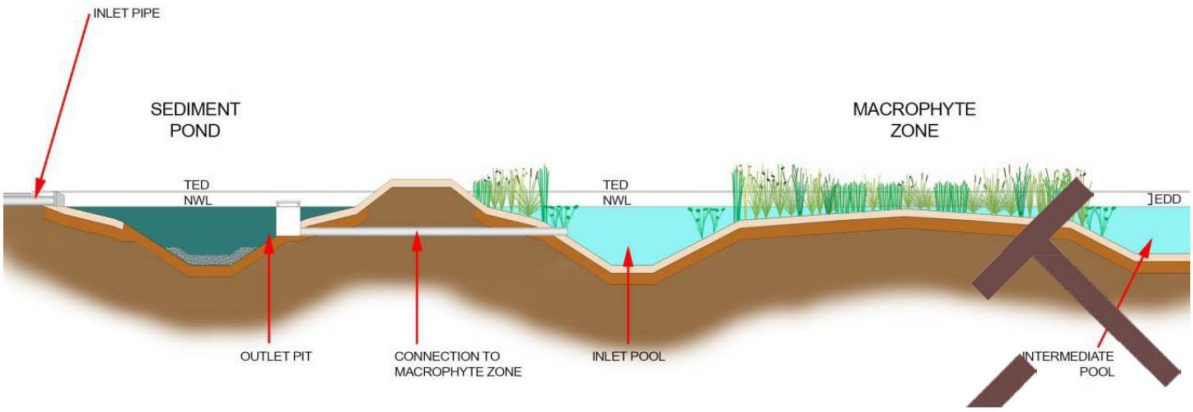

Figure 2. Indicative section of a typical stormwater wetland layout (Melbourne Water undated).

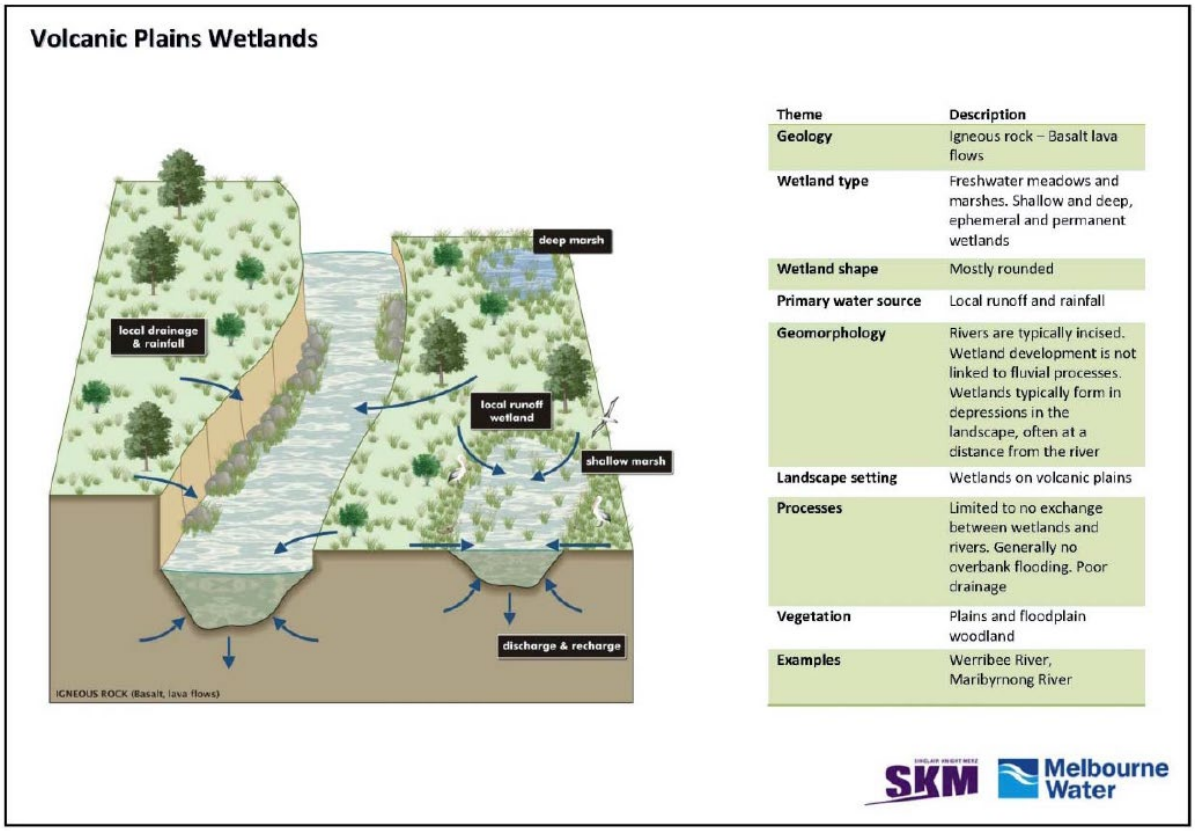

Figure 3. Conceptual model of general wetland occurrence and function on the Victorian volcanic plains.

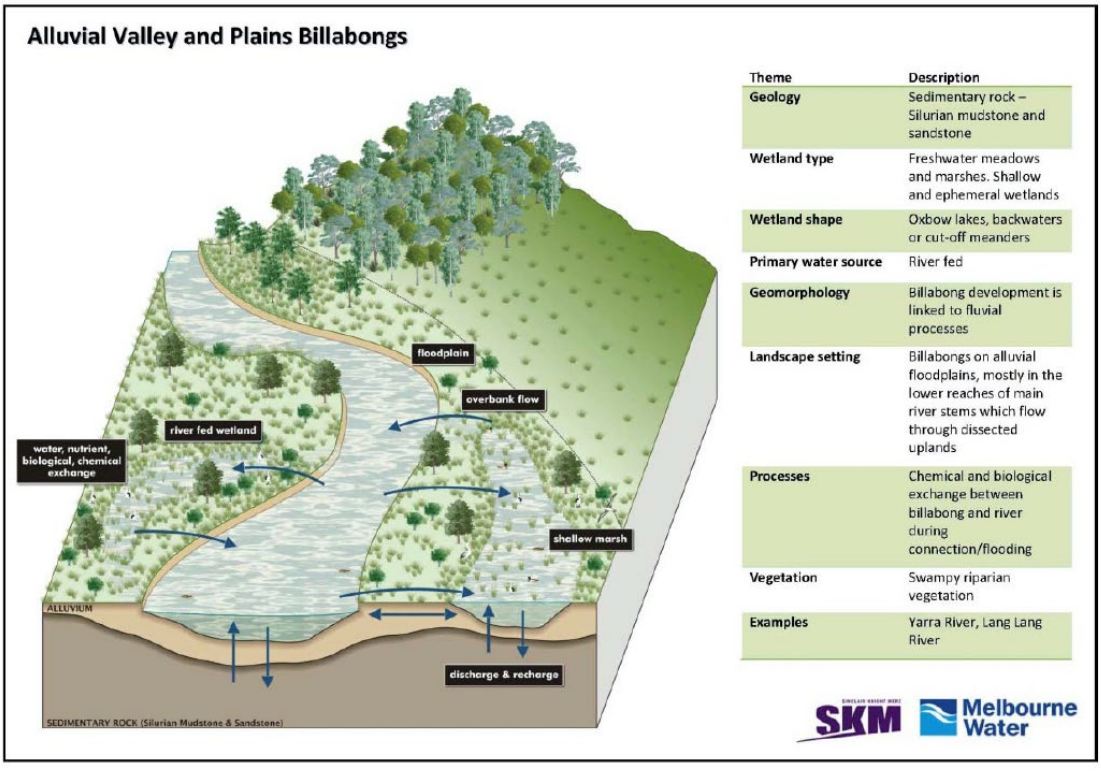

Figure 4. Conceptual model of general billabong occurrence and function on alluvial valleys and plains.

2.2 Regional wetland prioritisation

Initial prioritisation, 2018

A preliminary regional prioritisation process by Melbourne Water in 2017 identified 155 wetlands of potential value, either for natural values and conservation of biodiversity or for their social values. The Aquatic Values Identification and Risk Assessment (AVIRA, DELWP 2015) process was run for 133 of these wetlands, others being found to be inaccessible, or not wetlands. In the absence of Index of Wetland Condition (IWC) information for these wetlands the AVIRA process had to use estimates of some conditions.

During the writing of the HWS additional wetlands were prioritised in light of community engagement. These priority wetlands were then grouped, purely for mapping purposes, into only 82 "wetlands" in the HWS. Unfortunately, this includes one 'grouping' of two sites that do not have wetlands: Andersons Creek East RB and Cardigan Creek RB.

The preparation of the 2018 HWS highlighted the large gaps in our information on wetlands (and estuaries). This reflected the lack of focus on these waterway types in previous regional strategies and the very limited number of IWC assessments undertaken in our region. In addition, it was expected that habitat suitability models (HSM) would be available for wetlands, similar to those used to describe the distribution of our Values in rivers and to model the responses of Values to management interventions. As such models were not available, we recognise our wetland planning in the HWS is quite basic. HSMs are being developed for several wetland key values and will be available to inform the next regional strategy.

Moreover, time constraints meant that a rapid data collation and prioritisation process was required for the region's wetlands. The 2018 HWS acknowledges the lack of data and limited number of wetlands assessed and does not preclude consideration of other wetlands through the implementation period.

Second prioritisation, 2019/20

Following the release of the 2018 HWS, the wetland priority list was expanded to 250 wetlands based on a more comprehensive prioritisation process, including formally recognised significance. A full list of priority wetlands and their significance is provided in Appendix B.

In this process, wetlands of our region were prioritised, initially, on the basis of their ecological values. The conservation status of wetlands was the first consideration and wetlands selected were those lying within Ramsar sites, SSN (Shorebird Site Network) sites, IBBA (Important Bird and Biodiversity Area, now known as Key Biodiversity Areas), DIWA (Directory of Important Wetlands in Australia), Melbourne Water's SoBS (Sites of Biodiversity Significance), etc. Next, reports were reviewed and all wetlands noted for significant ecological values were added (e.g. Schulz et al. 1991; Beardsell 1991, 1997;

Larwill & Costello 1992; Moore 1994; Environment Australia 2001; DNRE 2002; SKM 2012; DEPI 2013a). Finally, wetland experts were asked to name any significant wetlands they knew of that we may have missed in searching the published literature.

Important 'social' value wetlands were identified from publicly available material, such as Stevens (1996) and Cowling (undated). Additional priority 'social value' wetlands had been added during the HWS co-design process and community engagement.

Cultural values of wetlands remain a significant knowledge gap. Other than limited information on the importance of Bolin Bolin billabong, the Edithvale-Seaford Wetlands and other natural wetlands to Traditional Owners we have little understanding of the relative importance, culturally, of our region's wetlands. This knowledge gap must be addressed as a priority over the life of the strategy through:

- Partnership projects with traditional owners,
- Cultural heritage surveys,
- Naming of wetlands in consultation with traditional owners, and
- Knowledge sharing.

Priority wetlands include examples of each of the four broad wetland types mentioned above. A simplified summary of the relationship between priority wetlands and the wetland types described above is provided in Figure 5.

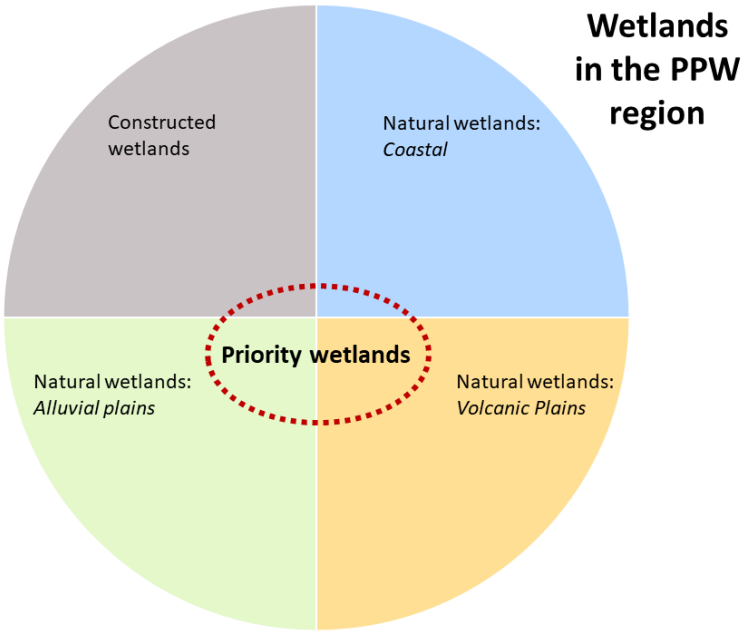

Figure 5. Schematic representation of the wetland types in the PPW region and how these relate to our regional priority wetlands. Please note, this figure is purely schematic and does not represent the proportion of each type of wetland in the PPW region.

2.3 Waterway Targets (for values and conditions) and Performance Objectives

This Wetlands MEP communicates the approach to monitor, evaluate, report and adopt learnings for HWS targets and objectives. The targets and objectives provide quantitative measures of progress towards the goals and vision within the HWS. There are three different types of targets in the HWS:

- Performance objectives
- Condition targets
- Key values targets

These each have different timescales associated with them related to the length of time it may take for a measurable change to occur and be detected (Figure 6**Error! Reference source not found.**).

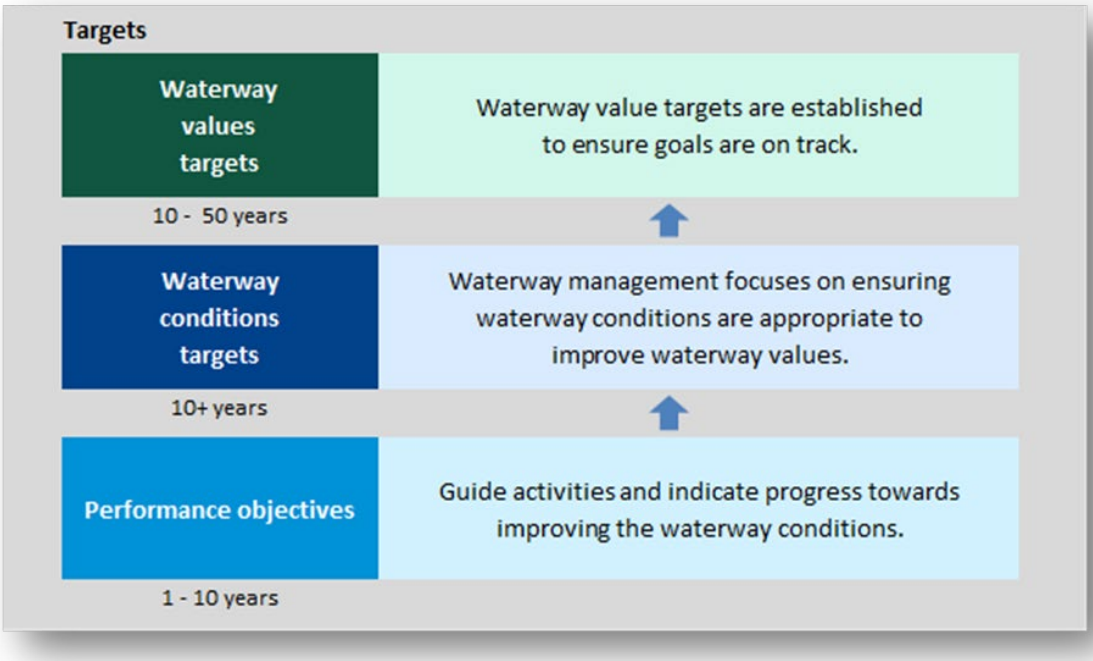

Figure 6. Hierarchy of targets and objectives in HWS.

Nine **Key values** were selected as representative of waterways' broad range of social and environmental values (Figure 7; Melbourne Water 2018).

The HWS defines waterway (and hence) wetland **condition** as the overall state of the waterway and the key processes that underpin a well-functioning ecosystem (Melbourne Water 2018). It is assumed that improvements in wetland conditions will improve the wetland key values.

Figure 7. The nine 'key values' identified in the HWS.

It should be noted that aquatic macroinvertebrates were considered a key wetland value by conceptual models prepared for the HWS (Alluvium 2017) but were not included as a key wetland value in the 2018 HWS due to a lack of available data and the absence of an agreed metric for aquatic macroinvertebrate status in wetlands. We consider the state of the aquatic macroinvertebrate community in a waterbody to be more appropriately represented as a measure of ecosystem condition for strategic planning purposes rather than being included in the suite of Key Values.

Our understanding of the critical environmental conditions of wetlands that influence our key wetland values were developed from the HWS Conceptual Models (refer to the HWS Resource Document, Melbourne Water 2020) and largely follow the IWC approach. Five environmental conditions are seen as key influencers of wetland values (Figure 8).

Current state and targets

The current state (as at 2017) of key wetland values and conditions at some priority wetlands was set as a baseline against which progress will be measured over the life of the HWS. The metrics used to assess this baseline are described in the HWS Resource Document (Melbourne Water 2020). The findings are reported at a high level in the HWS and more detail is provided in each of the Co-designed Catchment Programs that outline the wetland-specific values, conditions and performance objectives.

It became evident during the preparation of the HWS that there were significant information gaps for both wetland conditions and values across our region. This MEP will ensure we gather better data to inform both the continuous improvement of the current HWS and to better inform the development of future strategies.

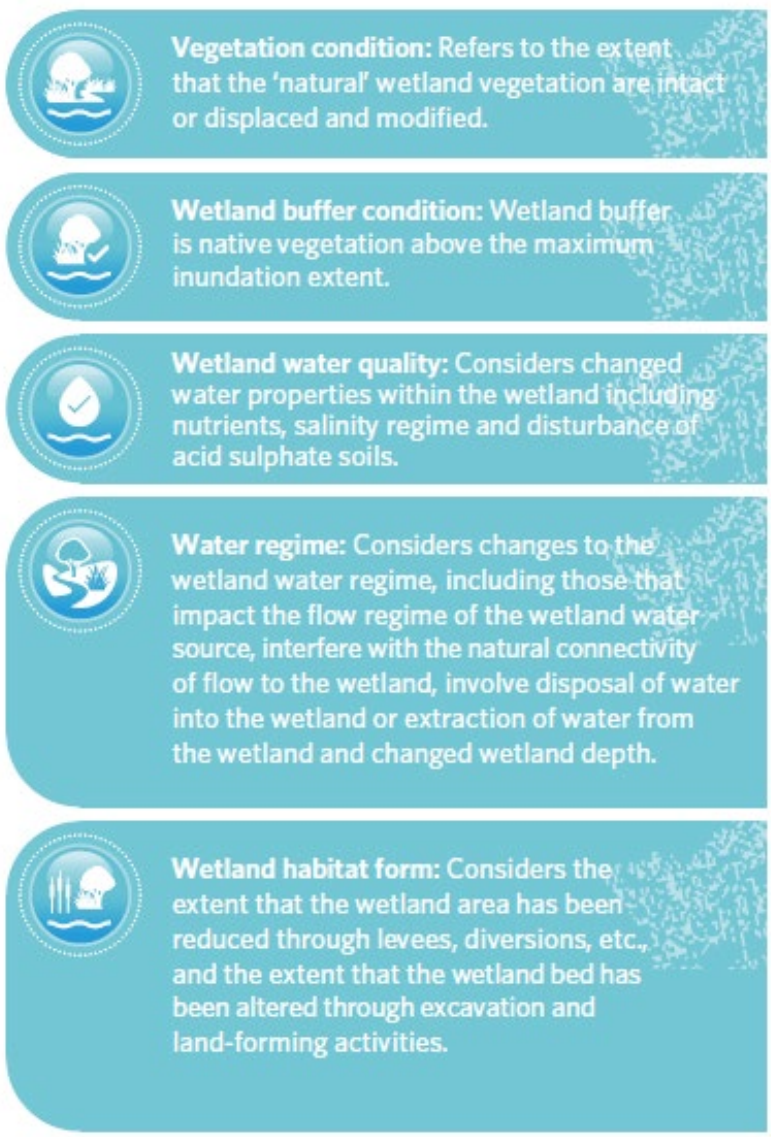

Figure 8. The critical environmental conditions of wetlands which determine key value status (Melbourne Water 2018)

Because of the lack of data on the condition of many natural wetlands within the Port Phillip and Westernport region, Melbourne Water commissioned an assessment of wetland values and conditions using the AVIRA method as our benchmark for the HWS. This method was not a comprehensive description of conditions and values since IWC information was missing but was the best available means to collate available information

within the required timeframes. Assessment methods have since been updated for this MEP and will be based on data collected over the period of the HWS. For example, IWC assessments will be used in preference to AVIRA. Bird data will be used to describe wetland bird value (for example, see Birdlife Australia 2020) rather than assuming wetland buffer condition determined bird value, as was done for the HWS. Where the method of monitoring changes in wetland condition and key value status differs from that of the HWS, those differences are outlined in this document.

Performance objectives

The short term (one to ten-year quantitative steps) by which targets can be achieved are described in the HWS by **Performance Objectives**. Performance objectives provide short-term, tangible outcomes which indicate progress towards longer-term outcomes (i.e. change in condition or in key value).

Performance objectives may, for example, define an area of land that must be revegetated, or a number of fish barriers that need to be removed. The terminology 'performance objectives' is aligned with the requirements of the *State of Victoria Yarra River Protection (Wilip-gin Birrarung Murron) Act* (2017).

According to the HWS, performance objectives should have the following attributes:

- are outcome-based, and not based merely on actions undertaken
- enable a partnership approach with other parties that undertake waterway management actions
- are quantitative, measureable and achievable in 10 years
- inform short-term management aims through annual planning processes
- describe where they link to environmental conditions
- are underpinned by transparent and best available information and knowledge
- are able to be assessed without needing to measure waterway values and condition outcomes on every asset.

Program Logic

The Program Logic for wetlands (Figure 9) shows the relationship between the performance objectives and expected changes in environmental conditions and values. It indicates the time frames across which change is expected to be detectable and maps the relationship between the program logic and the sections of this Wetland MEP.

Our program logic for wetlands recognises that management activities and outcomes occur over a range of timeframes. It considers:

- Aspirational long-term regional vision and catchment goals: (50+ years)
- Longer term outcomes - key values targets (~ 20+ years - addressed in this document in Part B)
- Intermediate outcomes - waterway condition targets (~10+ years – addressed in this document in Part C)

- Immediate outcomes– performance objectives (1-10 years – addressed in this document in Part A)
- Activities – on-ground actions, partnerships, governance, tracking performance (annual – in this document addressed in Part A)

This Wetland MEP is, for present, focussed on only the environmental conditions and values of wetlands. Environmental conditions no doubt underpin social, cultural and economic values of wetlands as much as they do the environmental values of fishes, frogs, birds and vegetation. But our development of suitable measures of social, cultural and, to a lesser extent, economic values of wetlands is not yet at the point where the monitoring and reporting of these values can be finalised.

Work is continuing on measures, or metrics, of the social and cultural values of wetlands. Once defined these measures will be included in future reviews of this Wetland MEP.

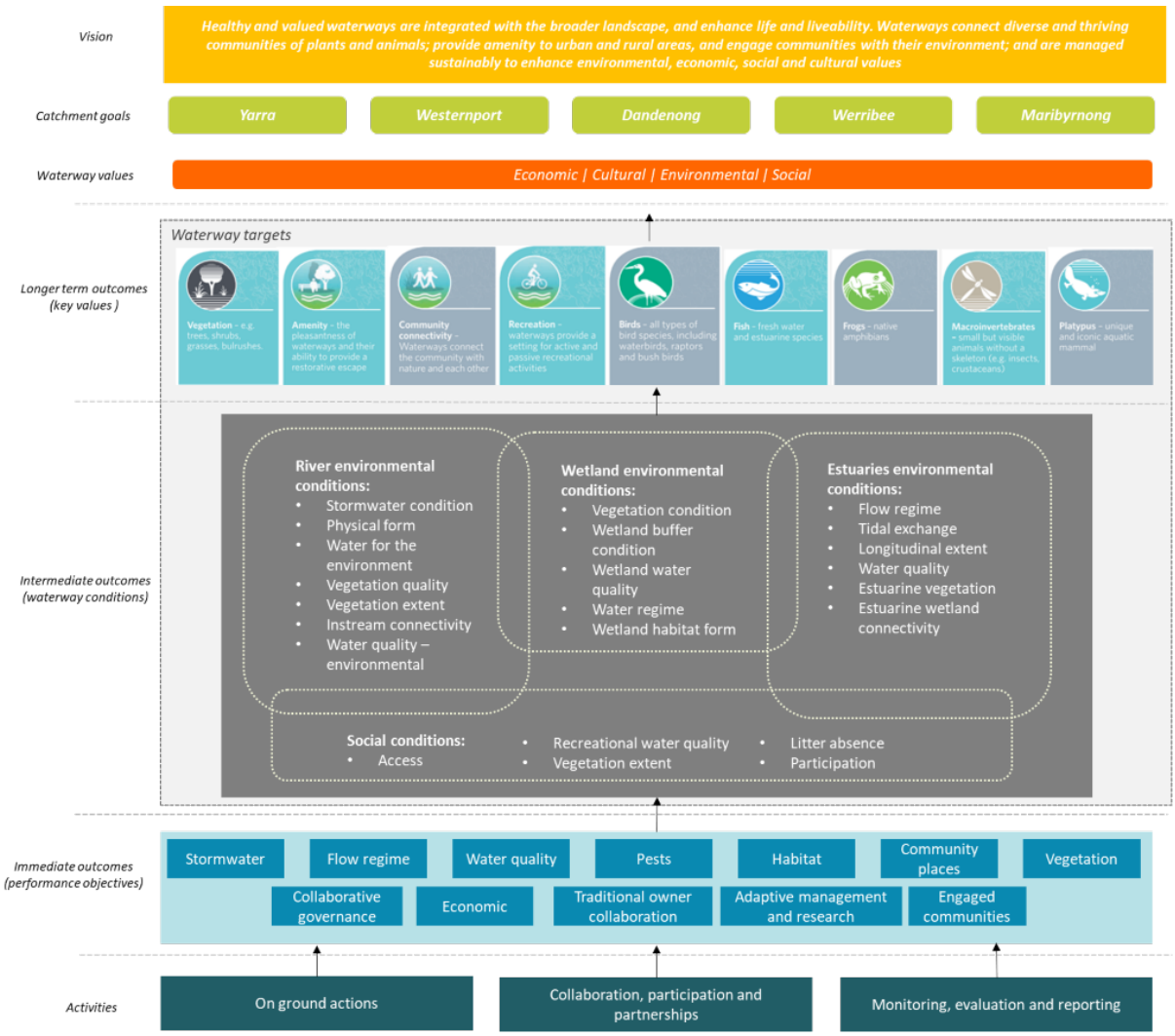

Figure 9. Healthy Waterways Strategy program logic (Melbourne Water 2018)

2.4 Evaluation and reporting

Tracking progress towards meeting the three different types of performance objectives allows us to know if our actions are creating the change that is outlined in the HWS vision and goals. But tracking progress is not enough, we also need to evaluate our efforts to understand if the actions we are doing are the best ones to create the change. It is through evaluation that we are able to learn and adapt to ensure the HWS remains effective over the 10-year period. It this reason that the Wetland MEP will be updated over time, but particularly at mid-point of the HWS period (end of 2022), to adopt learnings and efficiencies, such as developments in monitoring methods and analytical techniques.

A web-based reporting system will be used, with annual, mid-term (i.e. end of 2022) and end of strategy (i.e. end of 2026) reporting. Delivery Partners, community groups and the RLG will all utilise the evaluation results (annual, mid-term and final) to understand progress, guide annual planning and drive continuous improvement. The HWS

governance processes will involve the RLG where significant findings require further deliberation and direction. These processes are in development with the RLG and will be documented in the MERF. The Science will also provide expert advice on evaluation and communicate recommendations to the RLG.

Our approach to evaluation and reporting is detailed below.

Annual Evaluation and Reporting

The focus of annual evaluation and reporting will be on the short-term indicators

Performance Objectives

KEQ No. 1 - To what extent have the performance objectives of the Strategy been achieved?	Annual Event-based (as needed) Mid-term (2022)

Progress towards the 10-year Performance Objectives may be tracked annually using quantitative output indicators (e.g. area revegetated). But some POs will only be reported on at mid-term and end of strategy. Reporting will be through the Healthy Waterways website https://healthywaterways.com.au/.

Where appropriate reporting will align with the nine PO groupings outlined in the MERI framework (e.g. vegetation, stormwater, community places).

Whilst each PO theme and group will be tracked at the individual wetland or sub-catchment level, a traffic light approach will be used to determine whether a PO theme or group is on track or off track at the **catchment scale** (i.e. Werribee, Maribyrnong, Yarra, Dandenong and Westernport). For example, we might report the PO theme 'increase vegetation extent' is on-track for the Yarra Catchment. The main reason for this reporting by catchment is to acknowledge works may be implemented at different times in different sub-catchments because of local constraints and opportunities. Presenting a synthesis of how the strategy is performing at a catchment scale is thought likely to be valuable to managers and the RLG.

The different types of PO tracking are:

Quantitative targets Where Performance Objectives have 10-year quantitative targets, the measureable indicator will be used to track progress with a rubric that defines *On-track, Slightly off-track and Significantly off-track* each year. This will help to ensure that POs that are falling behind in reaching their target are identified early enough that appropriate actions can be taken to ensure the PO is achieved.

Status updates will be used where quantitative indicators or targets are not available. For example, POs may be assigned an annual status of 'not started', 'in-progress', or

'complete'. Rubrics can then be used to evaluate performance for PO groups or themes across each major catchment (i.e. on-track, or not).

Progress reports may be used, as an alternative to status updates, where quantitative targets are not available or appropriate. These will provide a brief update (one or two sentences only) on progress made each year. An on-track/ off-track assessment will not be made for this form of reporting. Progress reports will be used at mid-term to inform decisions about whether an evaluation is required. For example, if circumstances have changed, or new facts come to light, that change the viability of an action this will be reported as a progress report and a review suggested.

Case studies will highlight stories of success, or challenge, and focus on the achievements of a range of strategy partners or collaborations. These will typically be four to five paragraphs in length, and be more story-based. An on-track/ off track assessment will not be made for this form of reporting. Case studies can be used either as the main form of tracking or in addition to the approaches outlined above. If it is the only form of tracking like Progress Reports a decision will need to be made at mid-term whether an evaluation is required.

Values and Conditions

While most values and conditions will only be evaluated at mid-term information on the key values and conditions can be reported annually as new data is available. This approach provides useful context both spatially and temporally on relevant indicators and metrics related to the HWS values and conditions.

Mid-term review evaluation process

A summary of the approach to the mid-term evaluation for both Performance Objectives and Values and Conditions is summarised below. More detail can be found within each of the relevant sections. The RLG will play a key role in deciding what gets evaluated and decisions resulting from evaluation outcomes. The science panel will also provide expert advice on the design of evaluations and critique of the findings.

Performance Objectives

Mid-term evaluation of the POs will focus on POs or groups which are significantly off-track rather than evaluating all POs. If a deeper mid-term evaluation is deemed necessary, potential lines of enquiry which would be worth pursuing are outlined within each PO Group. The RLG decide which areas are evaluated and evaluation methods will then need to be developed.

Under this Wetlands MEP, the mid-term evaluation will consider the following:

- identifying PO groups that are significantly off track
- reviewing performance objectives if better data is available.

- identification on new performance objectives that have arisen from strategy partners or community
- flagging any major threats to wetland condition that have not been previously identified.
- re-prioritising management if required (based on this updated information) for the second half of the strategy.
- re-prioritising monitoring if required

The outcome of the mid-term evaluation of particular performance objective groups will need to be reported to the internal MW governance group with options of how to address the PO in the future. If a performance objective target needs to be altered, or is reliant on actions from partner organisations, this will need to brought to the attention of RLG to resolve and decide the way forward.

Values and conditions

The mid-term review phase (2022) will focus on an assessment of progress towards the long term sub-catchment scale targets. The relevant KEQs are:

KEQ No. 2 - To what extent has progress been made towards the longer term environmental condition targets for rivers, wetlands and estuaries?	Mid-term (2022) End of Strategy (2026)
KEQ No. 3 – What is the state of waterway values?	Mid-term (2022) End of Strategy (2026)

Where possible analysis will combine multiple lines of evidence (including different indicators and quantitative models such as the HSMs, if these are available) to help draw conclusions about whether long term targets for values and conditions are on-track or not. A similar three-point traffic light evaluation to POs will also be made for the values and conditions i.e.

- On-track to meet long term targets
- Slightly off-track to achieving long term targets
- High chance that long term targets will not be met

If long term targets appear to be off-track then a deeper analysis to understand why will be undertaken. This process also looks at multiple lines of evidence – integrating PO performance, relevant values and conditions and other contextual data. Each section outlines possible lines of enquiry to assist in the evaluation process.

While the MERI framework outlines the governance arrangements for how decisions will be made regarding evaluation outcomes, the following are examples of potential changes which made need to be made:

- Re-prioritise efforts to fast track works into priority locations
- Modify existing performance objectives or create new ones and secure funding
- Undertake further investigation into underlying causes

- Modify the monitoring program
- Change the long term targets

End of strategy review

The end of strategy review has not been detailed in this MEP but will be developed after the mid-term review. The end of strategy review will refer back to the KEQ in the MERI, particularly those relating to efficiency, legacy and appropriateness.

Part A Monitoring performance objectives

3 Overview

Tracking progress against the performance objectives allows us to understand if the effort being assigned to different investment programs is adequate, whether there are differences between the major catchments, or whether different approaches are more applicable in different areas. Some performance objectives have readily trackable specific indicators (e.g. hectares of vegetation established). Others are described more qualitatively, and indicators and evaluation approaches developed accordingly. Wetland objectives are largely, but not entirely, non-quantitative.

Progress towards achievement of HWS performance objectives will be tracked and reported to address KEQ 1 in the HWS MERI Framework: "To what extent have the performance objectives of the Strategy been achieved?" (Melbourne Water 2019).

The timeframe for reporting on performance objectives will depend on the nature of each performance objective, whether these require annual, mid-term or event-based reporting.

The Healthy Waterways Strategy website (https://healthywaterways.com.au/) will be used to share information on progress toward performance objectives. This reporting will include annual tracking of outputs (e.g. hectares of land being managed for weeds) and a mid-term assessment of performance (i.e. on-track/off-track for each performance objective group at the wetland and catchment scale).

A mid-term evaluation of any WPO theme will be required should:

- the performance objective be *significantly* off track
- it be unlikely the performance objective will be met by end of strategy
- there is *significant* uncertainty about appropriateness, effectiveness or efficiency of the actions proposed to achieve the performance objective.

The outcome of mid-term evaluations of particular performance objective themes will be reported to the RLG (the internal MW governance group), with recommendations on how to address the issue. It is likely some performance objectives will be found to be impractical, e.g. works requiring approval and support of private landowners. The RLG is the decision-making body to determine if and how any performance objective may be modified.

3.1 Regional Performance Objectives

There are 45 Regional Performance Objectives (abbreviated to RPO) in the 2018 HWS, covering all waterway asset types. Many are particularly relevant to wetlands (Table 2). Monitoring of these, and all other RPOs is described in the Regional Performance Objectives MEP (Melbourne Water in prep.).

Table 2. Regional performance objectives with special relevance to wetlands.

PO #	Performance Objective
RPO-10	An adaptive pathways approach is adopted to understand and manage the risks of climate change on waterways.
RPO-11	Understanding of groundwater dependent ecosystems is improved and opportunities to maintain or improve these continue to be investigated.
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.
RPO-13	Industry capacity for whole of water cycle and stormwater management is increased to enable collaboration, improved access to information and knowledge, and a skilful and capable industry with strong established networks.
RPO-14	Standards, tools and guidelines are in place and implemented to enable re-use and infiltration of excess stormwater, and protect and/or restore urban waterways.
RPO-15	Victoria's planning system is used effectively to protect and enhance waterway values.
RPO-17	Water quality in waterways and bays is improved by reducing inputs of sediment and other pollutants from urban construction and development.
RPO-18	Critical waterway health assets including stormwater treatment systems, fishways and erosion control structures, are maintained for their designed purpose or the same outcomes are delivered by alternative means.
RPO-20	The amenity, community connection and recreation values of wetlands are better understood and performance objectives are developed to enhance these values.
RPO-28	Seasonal Herbaceous Wetland vegetation communities are identified and a management program is in place to protect them on public and private land.
RPO-29	Programs, standards, tools and guidelines are in place to protect wetland vegetation communities from urban and rural threats, including adequate planning controls.
RPO-32	Programs are in place to protect and enhance sites of biodiversity significance associated with the regions waterways, such as through Melbourne Water's Sites of Biodiversity Significance Plan)
RPO-34	Waterway Labs are established as needed to tackle complex or region-wide priorities.

RPO-37	Participation rates in education, capacity building, incentive programs and citizen science activities have increased and enable greater levels of environmental stewardship for our waterways.
RPO-42	Wetland condition information and prioritisation with a focus on vulnerable wetlands is understood and informs collaborative planning.

3.2 Wetland-specific Performance Objectives

The 2018 HWS includes another 293 performance objectives that are specific to wetlands. These are called Wetland Performance Objectives (abbreviated to WPO). Where there is significant overlap between a RPO and a WPO tracking of the performance objective falls under the Regional Performance Objectives MEP (Melbourne Water in prep.).

Table 3. Summary of the HWS Performance Objective groups and themes for wetlands.

Group	Themes
Stormwater	Build and maintain stormwater treatment systems Maintain stormwater treatment systems Stormwater foundational actions
Water quality	Address urban diffuse sources of water quality impact Improve water quality from agricultural land practices
Water for environment	Maintain or improve flow regimes in unregulated systems
Habitat	Mitigate threats to physical form Protect specific values and habitat Pest management Re-engage floodplains
Vegetation	Increase native vegetation condition or extent (i.e. buffers)
Community places	Increase access to and along waterways, wetlands and estuaries by filling gaps and improving connections to existing path networks.

While many of the WPOs are unique, there are common themes of activities to achieve objectives (see Table 3). To simplify how we report progress with several hundred WPOs these were grouped into eight themes under the MERI Framework (Melbourne Water 2019): stormwater management, water quality, flow regimes, habitat, pest plants and animals, vegetation, community places and governance. Each of these eight WPO themes are discussed below, with rubrics suggested for how to report progress towards achievement of these objectives.

4 Stormwater

Stormwater performance objectives seek to ensure stormwater is adequately managed to protect wetland conditions and key values. The stormwater performance objectives align closely with water quality performance objectives but focus on the urban environment and the need to protect wetlands' natural hydrological regimes from the effects of increased run-off from impervious surfaces, or altered seasonality of inflows.

WPOs within the stormwater management group are summarised in Table 4. Our approach to monitoring and scoring these is presented in Table 5, and the requirements for data management in

Table 6.

Table 4. WPOs within the Stormwater group.

WPO theme	No. of WPOs	PO wording	Possible management actions	Relevant wetlands
Build and maintain stormwater treatment systems	6	Implement urban stormwater treatment measures in the catchment/upstream to reduce water quality threat.	• Investigations • WSUD • Management of directly connected imperviousness in the catchment • Street and end-of-pipe systems (e.g. street trees and stormwater treatment wetlands) • Stormwater harvesting schemes • Distributed on-lot systems (e.g. raingardens, rainwater tanks, green roofs and living walls)	• Growling Grass Frog Reserve wetlands • Ringwood Lake • Lillydale Lake • Domain Chandon Billabongs • Westgate Park Wetlands • Willsmere Billabong Other wetlands may be identified over the course of the HWS

WPO theme	No. of WPOs	PO wording	Possible management actions	Relevant wetlands
			• Community engagement and education	
Maintain stormwater treatment systems	6	Maintain the flood retention/stormwater treatment design capacity and function of constructed wetlands, with consideration/management of the biodiversity values	• Ongoing maintenance of existing stormwater assets, such as desilting and infrastructure maintenance • Engaging with asset manager to elevate environmental priorities where appropriate • Aquatic revegetation where needed	• Barnbam Swamp • Dandenong Catchment stormwater treatment wetlands • Boggy Creek wetland • Jacana Wetlands • Wannarkladdin Wetlands • Yarra Catchment stormwater treatment wetlands
Build and maintain stormwater treatment systems OR improve WQ from agricultural land practices	2	Implement urban stormwater and rural land management improvements upstream to reduce water quality threat to wetland.	• Stormwater quality wetlands • Installing and maintaining water sensitive urban design (WSUD) infrastructure. • Stock-exclusion fencing • Reducing fertiliser and other chemical run-off • Protecting or revegetating wetland buffers • Education and community engagement • Grants to landowners (e.g. for alternative water points, such as troughs, away from wetlands)	• Spadonis Billabong • Yarra Bridge Streamside Reserve
Stormwater management foundational actions	4	Ensure appropriate planning controls are in place (e.g. Environmental Significance Overlay) to	• Legislative controls/ improvements e.g. planning overlays	• Rockbank No. 1 Wetland • Rockbank Railway Swamp • Wyndham Vale Swamp

WPO theme	No. of WPOs	PO wording	Possible management actions	Relevant wetlands
		protect EPBC-listed Seasonally Herbaceous Wetland vegetation (identified in the HWS)	• Engaging in non-regulatory controls e.g. working with developers and Councils	• Cunningham's Swamp
	1	Ensure that use of Cunningham's Swamp as a stormwater retarding basin is not at the expense of the natural wetland form.	• Planning controls • Management of stormwater through a wetland protection plan	• Cunningham's Swamp
	1	Implement opportunities to enhance social and environmental values of Stormwater wetland sites through the Living Links program.	• Living Link program activities	• Dandenong catchment stormwater treatment wetlands

Table 5. Summary of monitoring approach and scoring criteria for Stormwater.

Performance objective	Indicators	Reporting	Requirements	Scoring			
				Annual or mid term			Final term
				On-track	Slightly off-track	Significantly off-track	
Implement urban stormwater treatment measures in the catchment/upstream to	(1) Stormwater improvement projects (WSUD)	(1) annual status update	• Stormwater projects, or maintenance, must be undertaken within	(1) One or more of the seven target wetlands is	(1) No new action in any year	(1) No action taken in any two-year period	>90% of objective achieved

Performance objective	Indicators	Reporting	Requirements	Scoring			
				Annual or mid term			Final term
				On-track	Slightly off-track	Significantly off-track	
reduce water quality threat.	implemented since 30 June 2018 (2) Modelled ML/yr run-off for precinct required to be prevented to achieve objective	(2) Mid-term quantitative target	the wetland's catchment. • Targets for ML/yr interception, and number of new developments in the seven wetland catchments will be developed on a case by case basis following detailed studies.	progressed each year (2) On track to achieving ML/yr target	(2) 20-50% below ML/yr target	(2) >50% below ML/yr target	
Implement urban stormwater and rural land management improvements upstream to reduce water quality threat to wetland.	See below, under Water Quality.						
Maintain the flood retention/stormwater treatment design capacity and function of constructed wetlands, with consideration/management of the biodiversity values	To be tracked as per RPO#18 (Critical waterway health assets including stormwater treatment systems, fishways and erosion control structures, are maintained for their designed purpose or the same outcomes are delivered by alternative means).						
Ensure appropriate planning controls are in place (e.g. Environmental Significance Overlay) to	As per RPO#15 and RPO#29 (Programs, standards, tools and guidelines are in place to protect wetland vegetation communities from urban and rural threats, including adequate planning controls).						

Performance objective	Indicators	Reporting	Requirements	Scoring			
				Annual or mid term			Final term
				On-track	Slightly off-track	Significantly off-track	
protect Seasonally Herbaceous Wetland vegetation.							
Ensure that use of Cunningham's Swamp as a stormwater retarding basin is not at the expense of the natural wetland form.	Investigation and follow up undertaken	Mid-term status update		Completed	Not completed	N/A	Completed
Implement opportunities to enhance social and environmental values of Stormwater wetland sites through the Living Links program.	To be tracked as RPO#20.						

Table 6. Summary of data collection, processing, storage and website reporting for each indicator.

Performance objective	Indicators	Data collection responsibility	Processing and reporting responsibility	Data storage system	Data provided on HWS website
Implement urban stormwater treatment measures in the catchment/upstream to	(1) Stormwater improvement projects (WSUD) implemented since 30 June 2018	MW Developer Services Team Local Councils MW Community Engagement	MW Water Services Planning	Mapbox?	• Annual - Whether POs, grouped by catchment, are on track

reduce water quality threat.	(2) Modelled ML/yr intercepted per precinct	MW Water Services Planning Research-Practice Partnerships			• Mid-term – modelled ML/yr intercepted
Ensure that use of Cunningham's Swamp as a stormwater retarding basin is not at the expense of the natural wetland form and Obligations of managing a Seasonally Herbaceous Wetland.	Investigation and follow up undertaken	MW Developer Services Team	MW Developer Services Team	Mapbox	

5 Water quality

Water quality performance objectives ensure that water quality is managed to protect priority wetlands and the values they support. Reducing the impacts of land use adjacent to wetlands in rural areas is important to prevent excess nutrients and/or sediments from entering the wetland. There also are a range of pollutants in urban catchments that contaminate wetlands; many of these threats can be reduced through appropriate stormwater management.

WPOs within the Water Quality Group are summarised in Table 7 and the approach to monitoring and scoring these is summarised in Table 8.

Table 7. Summary of Wetland performance objectives within the Water Quality Group.

WPO theme	No. of POs	Example PO wording	Possible management actions	Relevant wetlands
Improve water quality from agricultural land practices	2	Implement urban stormwater and rural land management improvements upstream to reduce water quality threat to wetland.	• Stormwater quality wetlands • Installing and maintaining water sensitive urban design (WSUD) infrastructure. • Stock-exclusion fencing • Reducing fertiliser and other chemical run-off • Protecting or revegetating wetland buffers • Education and community engagement • Grants to landowners (e.g. for alternative water points, such as troughs, away from wetlands)	• Spadonis Billabong • Yarra Bridge Streamside Reserve
	3	Implement rural land management program to reduce	• Stock exclusion fencing	• Western Port coastal wetlands • Tootgarook Swamp

		nutrient and sediment inflow to the wetlands	• Reducing fertiliser and other chemical run-off • Protecting or revegetating wetland buffers • Education and community engagement • Grants to landowners (e.g. for alternative water points, such as troughs, away from wetlands)	• Cockatoo Creek Swamp

Table 8. Summary of monitoring approach and scoring criteria for Water Quality.

Performance objective	Monitoring			Scoring			
	Indicators	Reporting	Requirements	Mid term			Final term
				On-track	Slightly off-track	Significantly off-track	
Implement urban stormwater and rural land management improvements upstream to reduce water quality threat to wetlands.	To be tracked as per RPO #29 (Programs, standards, tools and guidelines are in place to protect wetland vegetation communities from urban and rural threats, including adequate planning controls.)						
Implement rural land management program to reduce nutrient and sediment inflow to the wetlands	To be tracked as per RPO #29 (Programs, standards, tools and guidelines are in place to protect wetland vegetation communities from urban and rural threats, including adequate planning controls.)						

6 Water for the Environment

The management of flow regimes (under "water for the environment") differs between regulated and unregulated systems. In regulated rivers (those with dams), the environmental water reserve is made up of the entitlement held by the Victorian Environmental Water Holder (VEWH). This includes the Yarra, Tarago and Werribee river catchments. Not all regulated rivers have an environmental entitlement. Where environmental entitlements exist, water for the environment may be delivered to wetlands (e.g. Yarra billabongs). Diversions from unregulated rivers (those without dams) are managed through Stream Flow Management Plans or other local management plans.

It is critical, especially in the face of climate change threats, that Water for the Environment continues to be managed and delivered to the region's rivers and wetlands. Environmental water supply and delivery options are under active investigation.

WPOs within the Flow Regimes Group are summarised in Table 9, the approach to monitoring and scoring these is summarised in **Error! R eference source not found.**, and the requirements for data management are summarised in **Error! Reference source not found.**.

Table 9. Summary of Wetland performance objectives within the water for the environment Group.

WPO theme	Number of POs	Example PO wording	Possible management actions	Relevant wetlands
Maintain or improve flow regimes in regulated or unregulated systems	28	Investigate opportunities to further re-engage the natural wetlands in this area and to improve wetland water regime to meet ecological watering objectives, improve ecosystem	• Investigate hydrological requirements of wetland values. • Deliver required hydrology through an	Hearnes Swamp, Kalkallo Creek Wetlands, Ringwood Lake, Gisborne Marshlands, Deanside Marsh, Rockbank, Holden Road Wetlands, Balls Wetland Complex (Western Grassland Reserve), Greens Rd E Wetland No. 2 (Western Grassland Reserve), Kirks bridge Rd W Wetland (Western Grassland Reserve), Rabbitters Lake and Swamp (Western Grassland Reserve), Target Range Swamp (Western Grassland Reserve), West Quandong Swamp (Western Grassland Reserve), Cardinia Creek Retarding Basin Wetlands, Paynes Rd Swamp, Yallock Creek floodplain wetlands, Barnbam Swamp, Donnybrook Road Lake, Wyndham Vale Swamp, Braeside Park, Point Cook Wetlands - RAAF Lake, The Briars Wetlands, WTP - Paul & Belfrages Wetland, Annulus Billabong,

WPO theme	Number of POs	Example PO wording	Possible management actions	Relevant wetlands
		services, cultural and social value.	appropriate method • Consider Scada technology and passive retrofit options for less labour-intensive data collection at MW assets	Hays Paddock Billabong, Black Swamp, Winton Wetlands, Dandenong Creek, Eastern Treatment Plant, Tootgarook Swamp
	12	Maintain or implement water regime to meet ecological watering objectives (where an environmental entitlement exists)	• Deliver environmental water • Modify hydrology through works	Tootgarook Swamp, Cockatoo Swamp, Lang Lang floodplain wetlands, Truganina Swamp, Yarra Bridge Streamside Reserve, Banyule Flats Billabong, Bolin Bolin Billabong, Burke Road Billabong, Spadonis Billabong, Willsmere Billabong, Domain Chandon Billabongs, Yering Backswamp
	10	Maintain/implement water regime to meet ecological watering objectives (where no environmental entitlement exists)	• Modify hydrology through works • Manage catchment stormwater	Cherry Lake, Tirhatuan Wetland, Edithvale Wetland, Seaford Wetland, EODC Dwarf Galaxias habitat ponds, Dwarf Galaxias Conservation Wetland, Narre Warren, Deanside Marsh, Rockbank, Hallam Valley Floodplain wetlands, Winton Wetlands, Dandenong Creek, Tamarisk Waterway Reserve
	2	Prepare adaption pathway for climate change impacts, including opportunities to maintain water regime in light of	• Investigations • Preparation of suitable management plan • Implementation and reporting	Laverton RAAF Swamp, Westernport coastal wetlands

WPO theme	Number of POs	Example PO wording	Possible management actions	Relevant wetlands
		climate change and stormwater impacts.	against management plan	
	3	Continue to implement water regime management to meet ecological objectives in artificial habitats within the Ramsar site.	Deliver appropriate environmental, or other, flows	• Cheetham Wetlands, WTP - Ryans Swamp, WTP – operational ponds

Table 10. Summary of monitoring approach and scoring criteria for Flow Regimes.

Performance objective	Monitoring			Scoring			
	Indicators	Reporting	Requirements	Mid-term*			Final term
				On-track	Slightly off-track	Significantly off-track	
Investigate opportunities to further re-engage the natural wetlands in this area and to improve wetland water regime to meet ecological watering objectives, improve ecosystem services, cultural and social value. Maintain/implement water regime to meet ecological watering objectives.	No. of Environmental Water Action Management Plan (EWAP), or equivalent, investigated and/or prepared	Mid-term status update	Implement approved management plans: e.g. Ramsar site management plan at the WTP; SoBS management plans; billabong watering	>80% of plans are in progress or completed	60 - 80% of plans are in progress or complete.	Less than 60% of plans are in progress or completed.	>90% of the target achieved

			program or Western Grassland Reserve management plan				
Prepare adaption pathway for climate change impacts, including opportunities to maintain water regime in light of climate change and stormwater impacts.	As per: RPO#29 (Programs, standards, tools and guidelines are in place to protect wetland vegetation communities from urban and rural threats, including adequate planning controls). RPO#10 (An adaptive pathways approach is adopted to understand and manage the risks of climate change on waterways).						
Continue to implement water regime management to meet ecological objectives in artificial habitats within the Ramsar site.	(1) Relevant Limits of Acceptable Change (LACs) for the Port Phillip Bay Ramsar site (DELWP 2018b) (2) Implementation of actions in the WTP site management plan (Ecology Australia 2020)	(1) Annual reporting to DELWP through the Ramsar Management System (2) Status update of actions implemented		(1) No LAC exceeded. (2) ≥90% of scheduled management actions are being addressed or have been completed	(1) Results show any LAC is being approached. (2) 70 – 90% of scheduled management actions are being addressed or are completed.	(1) Any LAC is exceeded. (2) <70% of scheduled management actions are being addressed or are completed.	(1) No LAC exceeded. (2) All priority actions completed

*Definitions for scoring criteria:

- Complete: Evidence that issue has been resolved (or a process in place to actively manage any ongoing issues that cannot be eliminated) or objective achieved.
- In progress: Investigation commissioned, or investigation completed and follow-up management underway
- Not started: No evidence of any action.

Table 11. Summary of data collection, processing, storage and website reporting for each indicator.

Performance objective	Indicators	Data collection responsibility	Processing and reporting responsibility	Data storage system	Data provided on HWS website
Investigate opportunities to further re-engage the natural wetlands in this area and to improve wetland water regime to meet ecological watering objectives, improve ecosystem services, cultural and social value.	Environmental water action management plan (EWAP) or equivalent investigated or implemented	WTP Ops Team (for WTP) ETP Management Team MW Catchment Asset Management (for SoBS) MW Developer Services Team (for urban growth area wetlands) Parks Victoria (Braeside Park, RAAF Lake) DELWP (Western Grassland Reserve wetlands) Mornington Peninsula Shire Council (for Tootgarook) EWR (Annulus and Yarra Flats)	MW Waterways & Biodiversity Team	Mapbox	Whether collection of POs at catchment scale is on-track, slightly off-track or significantly off-track at mid term
Maintain/implement water regime to meet ecological watering objectives where environmental entitlement exists		MW Environmental Water Management Team and Regional Services	MW Environmental Water Management Team	TBC	
Prepare adaption pathway for climate change impacts, including opportunities to maintain water regime in	Please refer to Regional MEP, RPOs 10 and 29.				

Performance objective	Indicators	Data collection responsibility	Processing and reporting responsibility	Data storage system	Data provided on HWS website
light of climate change and stormwater impacts.					
Continue to implement water regime management to meet ecological objectives in artificial habitats within the Ramsar site.	(1) Relevant Limits of Acceptable Change (LACs) for the Port Phillip Bay Ramsar site (DELWP 2018b) (2) Implementation of actions in the WTP site management plan (Ecology Australia 2020)	(1) MW WTP Ops PV (2) MW WTP Ops	(1) Corangamite CMA (2) MW WTP Ops	(1) DELWP's Ramsar management System (2) Bespoke datasheet	

7 Habitat

Habitat performance objectives relate to protecting specific values or conditions. This includes a wide range of actions but notably excludes the vegetation management element of habitat. (Please refer to the Vegetation WPO section below for details on that theme). Habitat POs include the management of physical habitat form (e.g. reducing soil disturbance and preventing the disruption of Potential Acid Sulphate Soils, PASS), and actions to reduce the threat presented by pest plants and animals to native fauna and flora values at priority wetlands.

WPOs within the Habitat Group are summarised in Table 12, the approach to monitoring and scoring these is summarised in

Table , and the requirements for data management are summarised in

Undertake IWC assessment and identify performance objectives after assessment.	No. of IWC assessments completed with management objectives developed	Progress report of actions undertaken (mid-term)	• An IWC assessment is undertaken for the wetland as per the DELWP methodology (DELWP 2018). • A performance objective is developed to address any issues raised, and then managed as per the relevant specifications in this MEP, or that specifications are added to the MEP subsequently.	4 out of 5 POs are in progress or completed	2 - 4 POs are in progress or completed.	< 2 POs are in progress or completed.	All POs complete
Incorporate wetland into the WGR boundary.	No. targeted wetlands incorporated into WGR boundary	Progress report of actions undertaken (mid-term)	• That the wetland boundary as defined by the Melbourne Water waterbodies GIS layer is added to the WGR.	8 out of 10 POs are in progress or completed	4-7 POs are progress or completed	< 4 POs are in progress or completed	All POs complete

			• That land management planning and implementation arrangements are updated accordingly • That publicly available spatial mapping is updated accordingly.				
Implement the Western Grassland Reserves adaptive management regime.	Proportion of management/ monitoring plan actions undertaken	Progress report of actions undertaken (mid-term)	• TBC (DELWP)	7 out of 9 POs are in progress or completed	4 – 6 POs are in progress or completed	<4 POs are in progress or completed	All POs complete
Identify opportunities for habitat creation and migration to mitigate habitat loss due to climate change risks/ identify options for addressing risk to coastal habitat.	No. of investigations completed; no. with implementation plans prepared; no. with plans being implemented.	Progress report of actions undertaken (mid-term)	Assessment of the achievement of each of these will be undertaken against each individual performance objective on a case by case basis.	8 out of 11 POs are in progress or completed	5 - 8 POs are progress or completed	< 5 POs are in progress or completed	All POs complete
Undertake monitoring to ensure that site stays within the limits of acceptable change as identified in the Ramsar	As per RPO#32 (programs are in place to protect and enhance sites of biodiversity significance associated with the regions waterways, such as through Melbourne Water's Sites of Biodiversity Significance Plan)						

Management Plan and in accordance with new requirements for monitoring, evaluation and reporting at Ramsar sites.					
Implement priority actions from relevant plans	As per RPO#32 (programs are in place to protect and enhance sites of biodiversity significance associated with the regions waterways, such as through Melbourne Water's Sites of Biodiversity Significance Plan)				
Reduce/ ensure invasive wetland flora threat is low/ moderate	Hectares of land actively managed for weeds	Annual quantitative report	• Target hectares set by the wetland extent, from normal full water out to 50 m from the water's edge (i.e. the wetland 'buffer zone'). • A "low weed threat" level is defined as: (a) <5% cover abundance with high-threat species of weed present, or (b) <25% cover abundance with no high-threat species of weed present. • High-threat weed species are those listed in the Ecological Vegetation Class benchmark and other species that have the ability to displace native	Refer to Section 7.1	Refer to Table 13.

			vegetation (see IWC, DELWP 2018). • Other weed species which have the ability to 'displace native vegetation' can be defined as those that are "highly invasive" or "moderately invasive" under the category 'potential for invasion' in White et al. (2018).		
Monitor/reduce threat of invasive fauna to moderate/low.	Hectares of land actively managed for target pest animals	Annual quantitative target	• Target hectares set by wetland and surrounds (which is considered – at a minimum – to be the property/reserve boundary, or to 500 m from normal full water level for very large properties such as national parks). • The AVIRA definition of 'moderate' or 'low' threat from introduced fauna is too coarse for meaningful evaluation. We assume that an approved pest animal management plan, if resourced and implemented, will reduce the threat at the site to an acceptable level. • "Active Management" is defined as the planning,	Annual tracking, see Section 7.1.	Annual tracking, see Table 13.

			surveillance and/or on-ground works required to manage pest animal threats to key values as defined in the WPO. Therefore, preparation of an approved pest animal plan contributes to 'active management' even before on-ground works are undertaken. • Pest management plan must meet MW's Local Pest Animal Plan Template (Melbourne Water 2010) pest animal strategy standards and include monitoring of effectiveness, appropriate timing, collaboration with neighbours, adequate effort, multiple control methods, (as appropriate for each site). • Only those pest species control programs specifically required in the HWS will be reported. So, for example, if rabbit control is not stipulated this is not reported even should rabbit control programs be instituted		

			• Pest management plans may encompass more than one site for efficiency and effectiveness.		
Ensure flood mitigation design intent of lake is retained, whilst considering site biodiversity values including significant vegetation communities identified in site management plan	No impact on values	Mid-term status update	• Evidence of planning that incorporates biodiversity values	No adverse impacts on vegetation values around these wetlands	

*Definitions for scoring criteria:

- Complete: Evidence that issue has been resolved (or a process in place to actively manage any ongoing issues that cannot be eliminated) or target achieved.
- In progress: Investigation commissioned, or completed and follow-up management underway
- Not started: No evidence of any action.

Table 12. Guidance for determining severity of soil disturbance
(*source*: DELWP 2018a; refer to this publication for illustrated examples).

Severity rating	Soil disturbance examples
High	• High density of pug marks (page 31, Plate 4) • Severe soil disturbance by livestock (aside from pugging, e.g. erosion or uprooted vegetation) • High density of deer or feral pig wallow (page 31, Plate 5) • High density of carp mumbling (page 31, Plate 6) • High density of rabbit diggings • Rabbit warrens present • High density of human trampling • High density of vehicle tracks • Cultivation
Medium	• Medium density of pug marks (page 31 , Plates 2 and 3) • Medium level of soil disturbance by livestock (aside from pugging, e.g. erosion or uprooted vegetation) • Medium density of deer or feral pig wallow • Medium density of carp mumbling • Medium density of rabbit diggings • Medium density of human trampling • Medium density of vehicle tracks
Low	• Low density of pug marks • Slight soil disturbance by livestock (aside from pugging, e.g. erosion or uprooted vegetation) • Low density of deer or feral pig wallow • Low density of carp mumbling • Low density of rabbit diggings • Low density of human trampling • Low density of vehicle tracks (page 31, Plate 1)

7.1 Annual targets for spatial indicators (pest plant and animal)

- "On track" at each year is the percentage of the overall hectare target for the region (see Table 14). Note hectare targets for wetlands encompass the entire wetland and an adequate buffer (as described above in Table 13). There is little point in pest animal control over only a portion of a site.
- Slightly off-track – is up to 20% below on-track
- Significantly off-track – is more than 20% below on-track

Table 13. Annual progress target for hectare indicators.

2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28
2% of hectare target under active management	5% of hectare target under active management	10% of hectare target under active management	25% of hectare target under active management	35% of hectare target under active management	45% of hectare target under active management	60% of hectare target under active management	80% of hectare target under active management	90% of hectare target under active management	100% of hectare target under active management

Table 14.

Table 12. Summary of Wetland performance objectives within the Habitat Group.

WPO theme	Number of POs	Example PO wording	Possible management actions	Relevant wetlands
Mitigate threat of soil disturbance	5	Confirm threat to wetland from livestock access and reduce threat to low, Or	• Control of stock and human traffic (both pedestrian and vehicle) through exclusion fencing, or installing gates, pathways and signs.	Paynes Rd Swamp, Troups Rd Swamp, Live Bomb Wetland,

WPO theme	Number of POs	Example PO wording	Possible management actions	Relevant wetlands
		Reduce soil disturbance threat to low.	• Controlling works near wetlands to prevent erosion and transport of sediments into the wetland. • Preparation and implementation of appropriate site management plans.	Rabbitters Lake and Swamp, Wyndham Vale Swamp[1]
	4	Minimise threat of acidification through appropriate works practices in acid sulphate soils.	• Assess and document potential acid sulphate soils (PASS) risk. • Avoid exposure of PASS. • Control of stock and human traffic (both pedestrian and vehicle) through exclusion fencing, or installing gates, pathways and signs. • Preparation and implementation of appropriate site management plans.	Edithvale Wetlands, Seaford Wetland, Cherry Lake, Altona Treatment Plant
Re-engage floodplains	4	Investigate opportunities to further re-engage the natural wetlands in this area and to improve wetland water regime to meet ecological watering objectives, improve ecosystem services, cultural and social value.	• Investigate hydrological requirements of wetland values. • Investigate feasibility of achieving wetland improvement	Winton Wetlands Dandenong Creek, Hallam Valley floodplain wetland, Yallock Creek floodplain wetlands, Lang Lang floodplain wetlands
Protect specific values and habitat	5	Undertake IWC assessment at wetlands identified in the HWS, and prepare wetland specific performance objectives after assessment.	• Field assessment • Planning	Kororoit Creek No. 3 Wetland, Rockbank No. 1 Wetland, Rockbank Railway Swamp, Black Forest Rd Wetland, Cobbledicks Ford Streamside Reserve

[1] Note that the natural wetland of Wyndham Vale Swamp has been lost as a result of urban development. This WPO will need to be reviewed.

WPO theme	Number of POs	Example PO wording	Possible management actions	Relevant wetlands
	9	Incorporate wetland into the Western Grassland Reserve with management.	• Land acquisition • Management plan • Management implementation	Baths Swamp, Richmonds Grass Swamp, Greens Rd E Wetland No. 2, West Quandong Swamp, Balls Wetland Complex, Live Bomb Wetland, Rabbitters Lake and Swamp, Target Range Swamp
	9	Implement the WGR adaptive management regime.	• Management plan preparation and implementation	
	11	Identify opportunities for habitat creation and migration to mitigate habitat loss resulting from climate change. Identify options for addressing risk to coastal habitat.	• Assessment and planning	Cheetham Wetlands, The Spit Lagoon, WTP - Ryans Swamp, WTP - Paul & Belfrages Swamp, WTP – operational ponds, Western Port coastal wetlands
	8	Undertake monitoring to ensure that site stays within the limits of acceptable change as identified in the Ramsar Management Plan and in accordance with new requirements for monitoring, evaluation and reporting at Ramsar sites. This is done through DELWP's Ramsar Management System, which is effectively an online, real time MERI plan.	• Monitoring • Reporting	Cheetham Wetlands, The Spit Nature Conservation Reserve, WTP - Ryans Swamp, WTP - Paul & Belfrages Swamp, WTP – operational ponds, Western Port coastal wetlands, Edithvale Wetlands, Seaford Wetland
	3	Implement priority actions from relevant plans	• Consultation • Research/ investigations	Edithvale Wetlands, Seaford Wetland, Westernport Coastal wetlands

WPO theme	Number of POs	Example PO wording	Possible management actions	Relevant wetlands
			• On-ground works • Monitoring	
	25	Reduce/ ensure invasive wetland flora threat is low/moderate	• Weed control • Monitoring	Gisborne Marshlands; Cherry Lake; Cheetham Wetlands; The Spit Nature Conservation Reserve; Ryans Swamp; Paul & Belfrages Wetland; WTP operational ponds; RAAF Lake; Western Port coastal wetlands; Coolart Wetlands; Tootgarook Swamp; Domain Chandon Billabongs; Annulus Billabong, Yarra Flats Billabong; Banyule Flats Billabong; Burke Road Billabong; Hays Paddock Billabong; Westgate Park Wetlands; Willsmere Billabong; Spadonis Billabong; Yarra Bridge Streamside Reserve; Yering Backswamp; Barnbam Swamp; Edithvale Wetlands, Seaford Wetlands Winton Wetlands Dandenong Creek wetlands.
	41	Monitor/ reduce threat of invasive fauna to moderate/low.	• Monitoring – for Smooth Newt, Red-necked Slider and other potential invasive species (e.g. detected through eDNA surveillance as part of this MEP) • Fox/cat control • Rabbit control • Deer control • Education and restrictions regarding domestic animal access	Jacana Wetlands; Cherry Lake; Deanside Marsh, Rockbank; Jawbone Reserve; Paynes Rd Swamp; Troups Rd Swamp; Holden Road Wetlands; Altona Treatment Plant; Cheetham Wetlands; Truganina Swamp; Baths Swamp; Richmonds Grass Swamp; The Spit Nature Conservation Reserve; Ryans Swamp; Greens Rd E Wetland No. 2 (Western Grassland Reserve); Balls Wetland Complex;

WPO theme	Number of POs	Example PO wording	Possible management actions	Relevant wetlands
				Black Swamp; Rabbitters Lake and Swamp; Paul & Belfrages Wetland; Western Treatment Plant Ponds; Jenz Swamp; Bingham's Swamp; Laverton RAAF Swamp; Cunningham's Swamp; RAAF Lake; Spectacle Lake; Yallock Creek floodplain wetlands; Lang Lang floodplain wetlands; Western Port coastal wetlands; Coolart Wetlands; Tootgarook Swamp; Donnybrook Rd Lake; Cockatoo Swamp; Banyan Waterhole; Barnbam Swamp; Braeside Park; Eastern Treatment Plant; Edithvale Wetlands; Seaford Wetland; Tamarisk Waterway Reserve; Tirhatuan Wetlands, Dandenong Creek wetlands
	3	Ensure flood mitigation design intent of lake is retained, whilst considering site biodiversity values including significant vegetation communities identified in site management plan	• Appropriate planning and co-ordination	Cardinia Creek RB wetlands, Anderson Creek RB, Lillydale Lake

Table 13. Summary of monitoring approach and scoring criteria for Habitat.

Performance objective	Monitoring			Scoring			
	Indicators	Reporting	Requirements	Mid term*			Final term
				On-track	Slightly off-track	Significantly off-track	
Confirm threat to wetland from livestock access and reduce threat to low/ Reduce soil disturbance threat to low.	No. investigations undertaken (with effective follow-up action implemented when required)	Mid-term status update	• "Low threat" is described using the IWC soil sub-index terminology (see Table 14).	3 out of 5 POs are in progress or completed	2 POs are in progress or completed.	<2 POs are in progress or completed.	All POs complete
Minimise threat of acidification through appropriate works practices in acid sulphate soils (ASS).	No. target wetlands addressed through (i) completed investigation and avoidance protocols prepared, or (ii) monitoring in place	Mid-term status update	• Assessment of the threat by the HWS mid-term review. • Adequate notifications at relevant wetlands, not to disturb PASS. • All works will be done according to best practise standards for managing ASS (EPA 2000).	Both POs are in progress or completed	One POs is in progress or completed.	Neither PO is in progress	Both POs complete
Minimise threat of acidification through appropriate works practices in acid sulphate soils.	Management at Ramsar sites to be monitored as per RPO#32 (programs are in place to protect and enhance sites of biodiversity significance associated with the regions waterways, such as through Melbourne Water's Sites of Biodiversity Significance Plan)						

Performance objective	Monitoring			Scoring			
	Indicators	Reporting	Requirements	Mid term*			Final term
				On-track	Slightly off-track	Significantly off-track	
Investigate opportunities to further re-engage the natural wetlands in this area and to improve wetland water regime to meet ecological watering objectives, improve ecosystem services, cultural and social value.	No. of investigations completed	Mid-term status update	• Feasibility, cost and community support are important factors to consider	>80% of investigations are in progress or completed	60 - 80% of investigations are in progress or complete.	Less than 60% of investigations are in progress or completed.	>90% of the target achieved
Undertake IWC assessment and identify performance objectives after assessment.	No. of IWC assessments completed with management objectives developed	Progress report of actions undertaken (mid-term)	• An IWC assessment is undertaken for the wetland as per the DELWP methodology (DELWP 2018). • A performance objective is developed to address any issues raised, and then managed as per the relevant specifications in this MEP, or that specifications are added to the MEP subsequently.	4 out of 5 POs are in progress or completed	2 - 4 POs are in progress or completed.	< 2 POs are in progress or completed.	All POs complete

Performance objective	Monitoring			Scoring			
	Indicators	Reporting	Requirements	Mid term*			Final term
				On-track	Slightly off-track	Significantly off-track	
Incorporate wetland into the WGR boundary.	No. targeted wetlands incorporated into WGR boundary	Progress report of actions undertaken (mid-term)	• That the wetland boundary as defined by the Melbourne Water waterbodies GIS layer is added to the WGR. • That land management planning and implementation arrangements are updated accordingly • That publicly available spatial mapping is updated accordingly.	8 out of 10 POs are in progress or completed	4-7 POs are progress or completed	< 4 POs are in progress or completed	All POs complete
Implement the Western Grassland Reserves adaptive management regime[2].	Proportion of management/ monitoring plan actions undertaken	Progress report of actions undertaken (mid-term)	• TBC (DELWP)	7 out of 9 POs are in progress or completed	4 – 6 POs are in progress or completed	<4 POs are in progress or completed	All POs complete
Identify opportunities for habitat creation	No. of investigations completed; no.	Progress report of actions	Assessment of the achievement of each of these will be undertaken	8 out of 11 POs are in progress or completed	5 - 8 POs are progress or completed	< 5 POs are in progress or completed	All POs complete

[2] DELWP (2014) Melbourne Strategic Assessment: Land Protection under the Biodiversity Conservation Strategy. Department of Environment, Land, Water and Planning, Victoria. https://www.msa.vic.gov.au/__data/assets/pdf_file/0030/64794/Land-Protection-under-the-Biodiversity-Conservation-Strategy-May-2014.pdf
DELWP (2013) Biodiversity Conservation Strategy for Melbourne's Growth Corridors. Department of Environment, Land, Water and Planning, Victoria. https://www.msa.vic.gov.au/__data/assets/pdf_file/0032/64787/Biodiversity-Conservation-Strategy-Jun-2013.pdf

Performance objective	Monitoring			Scoring			
	Indicators	Reporting	Requirements	Mid term*			Final term
				On-track	Slightly off-track	Significantly off-track	
and migration to mitigate habitat loss due to climate change risks/ identify options for addressing risk to coastal habitat.	with implementation plans prepared; no. with plans being implemented.	undertaken (mid-term)	against each individual performance objective on a case by case basis.				
Undertake monitoring to ensure that site stays within the limits of acceptable change as identified in the Ramsar Management Plan and in accordance with new requirements for monitoring, evaluation and reporting at Ramsar sites.	As per RPO#32 (programs are in place to protect and enhance sites of biodiversity significance associated with the regions waterways, such as through Melbourne Water's Sites of Biodiversity Significance Plan)						
Implement priority actions from relevant plans	As per RPO#32 (programs are in place to protect and enhance sites of biodiversity significance associated with the regions waterways, such as through Melbourne Water's Sites of Biodiversity Significance Plan)						

Performance objective	Monitoring			Scoring			
	Indicators	Reporting	Requirements	Mid term*			Final term
				On-track	Slightly off-track	Significantly off-track	
Reduce/ ensure invasive wetland flora threat is low/ moderate	Hectares of land actively managed for weeds	Annual quantitative report	• Target hectares set by the wetland extent, from normal full water out to 50 m from the water's edge (i.e. the wetland 'buffer zone'). • A "low weed threat" level is defined as: (a) <5% cover abundance with high-threat species of weed present, or (b) <25% cover abundance with no high-threat species of weed present. • High-threat weed species are those listed in the Ecological Vegetation Class benchmark and other species that have the ability to displace native vegetation (see IWC, DELWP 2018). • Other weed species which have the ability to 'displace native vegetation' can be defined as those that	Refer to Section 7.1			Refer to Table 13.

Performance objective	Monitoring			Scoring			
	Indicators	Reporting	Requirements	Mid term*			Final term
				On-track	Slightly off-track	Significantly off-track	
			are "highly invasive" or "moderately invasive" under the category 'potential for invasion' in White et al. (2018).				
Monitor/reduce threat of invasive fauna to moderate/low.	Hectares of land actively managed for target pest animals	Annual quantitative target	• Target hectares set by wetland and surrounds (which is considered – at a minimum – to be the property/reserve boundary, or to 500 m from normal full water level for very large properties such as national parks). • The AVIRA definition of 'moderate' or 'low' threat from introduced fauna is too coarse for meaningful evaluation. We assume that an approved pest animal management plan, if resourced and implemented, will reduce the threat at the site to an acceptable level. • "Active Management" is defined as the planning, surveillance and/or on-	Annual tracking, see Section 7.1.			Annual tracking, see Table 13.

Performance objective	Monitoring			Scoring			
	Indicators	Reporting	Requirements	Mid term*			Final term
				On-track	Slightly off-track	Significantly off-track	
			ground works required to manage pest animal threats to key values as defined in the WPO. Therefore, preparation of an approved pest animal plan contributes to 'active management' even before on-ground works are undertaken. • Pest management plan must meet MW's Local Pest Animal Plan Template (Melbourne Water 2010) pest animal strategy standards and include monitoring of effectiveness, appropriate timing, collaboration with neighbours, adequate effort, multiple control methods, (as appropriate for each site). • Only those pest species control programs specifically required in the HWS will be reported. So, for example, if rabbit			

Performance objective	Monitoring			Scoring			
	Indicators	Reporting	Requirements	Mid term*			Final term
				On-track	Slightly off-track	Significantly off-track	
			control is not stipulated this is not reported even should rabbit control programs be instituted • Pest management plans may encompass more than one site for efficiency and effectiveness.				
Ensure flood mitigation design intent of lake is retained, whilst considering site biodiversity values including significant vegetation communities identified in site management plan	No impact on values	Mid-term status update	• Evidence of planning that incorporates biodiversity values	No adverse impacts on vegetation values around these wetlands			

*Definitions for scoring criteria:

- Complete: Evidence that issue has been resolved (or a process in place to actively manage any ongoing issues that cannot be eliminated) or target achieved.
- In progress: Investigation commissioned, or completed and follow-up management underway
- Not started: No evidence of any action.

Table 12. Guidance for determining severity of soil disturbance
(*source*: DELWP 2018a; refer to this publication for illustrated examples).

Severity rating	Soil disturbance examples
High	• High density of pug marks (page 31, Plate 4) • Severe soil disturbance by livestock (aside from pugging, e.g. erosion or uprooted vegetation) • High density of deer or feral pig wallow (page 31, Plate 5) • High density of carp mumbling (page 31, Plate 6) • High density of rabbit diggings • Rabbit warrens present • High density of human trampling • High density of vehicle tracks • Cultivation
Medium	• Medium density of pug marks (page 31 , Plates 2 and 3) • Medium level of soil disturbance by livestock (aside from pugging, e.g. erosion or uprooted vegetation) • Medium density of deer or feral pig wallow • Medium density of carp mumbling • Medium density of rabbit diggings • Medium density of human trampling • Medium density of vehicle tracks
Low	• Low density of pug marks • Slight soil disturbance by livestock (aside from pugging, e.g. erosion or uprooted vegetation) • Low density of deer or feral pig wallow • Low density of carp mumbling • Low density of rabbit diggings • Low density of human trampling • Low density of vehicle tracks (page 31, Plate 1)

7.1 Annual targets for spatial indicators (pest plant and animal)

- "On track" at each year is the percentage of the overall hectare target for the region (see Table 14). Note hectare targets for wetlands encompass the entire wetland and an adequate buffer (as described above in Table 13). There is little point in pest animal control over only a portion of a site.
- Slightly off-track – is up to 20% below on-track
- Significantly off-track – is more than 20% below on-track

Table 13. Annual progress target for hectare indicators.

2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28
2% of hectare target under active management	5% of hectare target under active management	10% of hectare target under active management	25% of hectare target under active management	35% of hectare target under active management	45% of hectare target under active management	60% of hectare target under active management	80% of hectare target under active management	90% of hectare target under active management	100% of hectare target under active management

Table 14. Summary of data collection, processing, storage and website reporting for each indicator.

Performance objective	Indicators	Data collection responsibility	Processing and reporting responsibility	Data storage system	Data provided on HWS website
Confirm threat to wetland from livestock access and reduce threat to low/ Reduce soil disturbance threat to low.	No. investigations with follow-up action undertaken	MW Regional Services team	MW Catchment Asset Management Team	Mapbox	• Investigations and follow-up works (e.g. kilometres of fencing installed for the purpose of protecting wetland

Performance objective	Indicators	Data collection responsibility	Processing and reporting responsibility	Data storage system	Data provided on HWS website
Minimise threat of acidification through appropriate works practices in acid sulphate soils (ASS).	No. target wetlands addressed	MW Regional Services team	MW Catchment Asset Management Team	Mapbox	habitat form) (mid-term). • Whether each PO (or collection of POs) is on track/ slightly off track/ significantly off track at mid-term
Investigate opportunities to further re-engage the natural wetlands in this area and to improve wetland water regime to meet ecological watering objectives, improve ecosystem services, cultural and social value.	Investigation completed	MW Regional Services	MW Catchment Asset Management Team	Mapbox	Whether each PO (or collection of POs) is on track/ slightly off track/ significantly off track at mid term
Undertake Index of wetland condition assessment and identify performance objectives after assessment.	No. of IWC assessments completed and management objectives developed	DELWP MW Waterways and Biodiversity team	DELWP MW Waterways and Biodiversity team	Index of Wetland Data Management System https://iwc.vic.gov.au/home	Whether each PO (or collection of POs) is on track/ slightly off track/ significantly off track at mid term
Incorporate wetland into the Western Grassland	No. targeted wetlands incorporated into Ramsar/ or WGR boundary	DELWP or Frankston City Council	DELWP or Frankston City Council	DELWP	

Performance objective	Indicators	Data collection responsibility	Processing and reporting responsibility	Data storage system	Data provided on HWS website
Reserve/Ramsar boundary.					
Implement the Western Grassland Reserve's adaptive management regime.	Proportion of management/ monitoring plan actions undertaken	DELWP	DELWP	DELWP	
Identify opportunities for habitat creation and migration with the mitigate habitat loss due to climate change risks / identify options for addressing risk to coastal habitat.	No. of investigations completed; no. with implementation plans prepared; no. with plans being implemented.	Parks Victoria MW WTP Operations Team	MW Parks Victoria MW WTP Operations Team	Parks Victoria MW - Bespoke tracking spreadsheets	
Reduce/Ensure invasive wetland flora threat is low/moderate	Hectares of land actively managed for invasive flora	MW Regional Services team Parks Victoria DELWP Local Councils	MW Catchment Asset Management Team	Maximo (AMIS)/ Mapbox	• Annual tracking of hectares of land under active management to control high-risk pest plants and animals (at the regional scale) • Whether each PO (or collection of POs) is on track/ slightly off track/ significantly off track at mid term
Monitor/Reduce threat of invasive fauna to moderate/low.	Hectares of land actively managed for invasive fauna	MW Regional Services team Parks Victoria DELWP Local Councils	MW Catchment Asset Management Team	As above	

8 Vegetation

The vegetation performance objectives set out in the strategy are aimed at establishing and maintaining vegetation in priority wetlands to benefit key values. WPOs within the Vegetation Group are summarised in Table 17, the approach to monitoring and scoring these is summarised in Table 18, and the requirements for data management are summarised in Table 16.

Table 17. Summary of Wetland performance objectives within the Vegetation Group.

WPO theme	Number of POs	Example PO wording	Possible management actions	Relevant wetlands
Protect, maintain or improve vegetation quality	8	Ensure appropriate aquatic macrophyte habitat is established/protected in the habitat ponds.	Revegetation Wetland plant protection Weed control Water management Signage Fencing	Lang Lang floodplain wetlands, Cherry Lake, Dwarf Galaxias Conservation Pond, EODC Dwarf Galaxias habitat ponds, Tamarisk Wetland, Tirhatuan Wetlands, Winton Wetlands Dandenong Creek, Hallam Valley floodplain wetlands Also, future Growling Grass Frog reserve wetlands
Increase Vegetation Extent	61	Improve/increase wetland buffer to 25/50 per cent of the wetland perimeter. Improve wetland buffer width and fill gaps in wetland buffer length.	Revegetation of sites with fencing Maintenance works – weed management, maintenance of supporting infrastructure (e.g. fencing, off-stream watering) Monitoring and investigations	Those priority wetlands with this WPO as listed in the HWS.
	1	Protect specific values	• Environmental watering to control terrestrial weeds	Burke Rd Billabong

Table 18. Summary of monitoring approach and scoring criteria for Vegetation.

Performance objective	Monitoring			Scoring	
	Indicators	Reporting	Requirements /assumptions	Annual	Final term
Ensure appropriate aquatic macrophyte habitat is protected in the wetlands.	Proportion of conservation ponds (for Growling Grass Frog or Dwarf Galaxias) with appropriate macrophyte habitat	Annual quantitative target (no. ponds with appropriate macrophyte habitat as a proportion of total no. of species' ponds)	Determining what is appropriate aquatic macrophyte habitat, will need to be determined on a site by site basis. 'Habitat' in the context of this performance objective is for Dwarf Galaxias or Growling Grass Frogs. General advice for providing habitat for these species is provided in Sections 8.1 to 8.2.	*Lang Lang floodplain wetlands* – 'significantly off-track' from 1 July 2026 if aquatic habitat is not appropriate by that date. 'Off-track' from 1 July 2023 if no action yet taken to establish appropriate aquatic habitat.* *Cherry Lake* - 'significantly off-track' from 1 July 2022 if high value saltmarsh and grassland habitat is not protected by that date (fencing, signage, etc.). 'Off-track' from 1 July 2019 if no action yet taken to establish appropriate protections and management.* *Dwarf Galaxias habitat wetlands* (n = 6) – 'significantly off-track' if aquatic habitat is not appropriate in three of the specified wetlands. 'Off-track' if aquatic habitat is not appropriate in two of the specified wetlands. (Please note the inclusion of Tamarisk Wetland will need to be reviewed. This rubric will still apply if the number of specified wetlands is reduced to five.) *Growling Grass Frog habitat wetlands* - ' 'significantly off-track' if aquatic habitat is not appropriate in a majority of ponds within three years of their construction. 'Off-track' if aquatic	All specified wetlands meet aquatic habitat standards

				habitat is not appropriate in any pond within two years of construction.			
Improve/Increase wetland buffer to 25/50 per cent of the wetland perimeter. Improve wetland buffer width and fill gaps in wetland buffer length.	Proportion of wetland edge with adequate vegetated buffer	End strategy quantitative (based on IWC assessment)	• Specifications are outlined in Section 8.3.	Ideally we would measure achievement of this performance objective through IWC scoring of buffer condition when such an assessment is carried out (once or twice over the course of the HWS). But annual reporting has been demanded. While annual quantitative reporting may, eventually, be possible through remote-sensed vegetation extent this is not likely to be available for some years yet. Therefore, although of somewhat dubious value, and only semi-quantitative, we will initially report each year on the proportion of wetlands with this target that have seen work on revegetation or vegetation management within 50 m of the wetland edge. To determine 'on-track' and 'off-track' refer to table 20 for the minimum proportion of specified wetlands to be addressed by the end of each year of the Strategy.			IWC scoring of wetland buffers shows improvement in >90% of specified wetlands
Protect specific values	Improvement in aquatic vegetation cover and condition	Mid-term status update	Effective watering of billabong will play a key role in switching vegetation from terrestrial (weed) dominated to aquatic vegetation	Wetland vegetation improved	Wetland vegetation remains the same as at start of the strategy	Wetland vegetation deteriorates	Objective achieved at Burke Rd Billabong

*Definitions for scoring criteria:

- Complete: Evidence that the target has been met.
- In progress: Investigation commissioned, or completed and follow-up management underway
- Not started: No evidence of any action.

8.1 Growling Grass Frog habitat specifications

The Growling Grass Frog relies heavily on aquatic vegetation, particularly floating and submerged lifeforms and the cover of this vegetation is a strong predictor of wetland occupancy.

- Dense (target 50%) cover of submerged/ floating vegetation in the deep water zone and patches of emergent vegetation (MSA GGF design guidelines)
- A diversity of vegetation (MSA GGF design guidelines[3])
- Stock exclusion (Clemann & Gillespie 2012).
- Patches of fringing and floating vegetation are present (Clemann & Gillespie 2012).

8.2 Dwarf Galaxias habitat specifications

- This species occurs in locations with dense aquatic macrophyte cover and emergent plants. In larger pools, the fringing macrophytes become particularly important, as this is where the fish often shelter. Having a diversity of plant species on site, is useful to provide a diversity of habitats (DG Recovery Plan)
- Stock excluded (Saddlier et al. 2010).

8.3 Wetland buffer specifications

Buffers must be[4]:

- Native vegetation adjacent to the wetland (from the maximum inundation level outwards; or EDD - Extended detention depth - for constructed wetlands).
- Where native vegetation is defined as vegetation where native species make up more than 25% of the total understorey cover. Total understory vegetation cover (both native and exotic) must be more than 25% by area (Figure 10).
- Overstorey species if present *must* be native.
- Revegetated areas are classed as native vegetation if they restore the natural Ecological Vegetation Class and meet the above criteria. Allowance should be made for climate change adaptation modification to accepted EVC.
- At least 80% plant survival is required in revegetation areas.
- The buffer only includes native vegetation contiguous with the wetland, i.e. where there is no break between the wetland boundary and native vegetation.
- We take 20 m from the maximum inundation level as the minimum width for a wetland buffer. Thus any pathway within 20 m of the water's normal full level negates the effect of a vegetation buffer and makes the creation of an effective wetland buffer impossible in the vicinity of the path.

[3] DELWP (2017b) Growling Grass Frog Habitat Design Standards, Melbourne Strategic Assessment. Department of Environment, Land, Water and Planning, Melbourne. https://www.msa.vic.gov.au/__data/assets/pdf_file/0019/73414/Growling-Grass-Frog-Habitat-Design-Standards_March2017.pdf. Melbourne Water is also developing technical standards for GGF habitat ponds.

[4] Victoria has devised the Index of Wetland Condition (IWC) to assess and describe natural wetland condition (DEPI 2013b), and Melbourne Water will use the IWC method to track wetland condition. The IWC Manual uses the term "wetland buffer" in a very specific sense (described above).

- If there are paths or other breaks in the wetland 'buffer zone' (maximum inundation to 50 m from edge) these do not void the buffer providing the bare area is <10% of the total buffer area. Thus, a 3 m wide shared path requires an otherwise intact native vegetation belt at least 33 m deep that is contiguous with the 'normal full' wetland inundation level. As noted above, the pathway cannot be <20 m from the water's edge.

Table 19. Level of service required to achieve the following POs: "Increase wetland buffer to 25 percent (or 50 percent or 100%) of wetland perimeter"

Element	Specifications		
	25% Wetland Buffer	50% Wetland Buffer	100% Wetland Buffer
A - Vegetation Structure	Restore Natural Ecological Vegetation Class structure or other suitable Vegetation Community Structure.		
B - Species Diversity	Use Ecological Vegetation Class species, with allowance for climate change adaptation modifications to the EVC.		
C – Vegetation Composition	Vegetation where native species make up more than 25% of the total understorey cover. Overstorey species if present must be native.		
D – Patch Shape and Fragmentation	At least 25% of the area surrounding the wetland is covered with native vegetation from the maximum inundation level to 20 m from that.	At least 50% of the area surrounding the wetland is covered with native vegetation from the maximum inundation level to 20 m from that, or, A suitable buffer over less than 50% of the perimeter but extending farther than 20 m to achieve half of the total possible IWC score for buffer.	At least 90% of the area surrounding the wetland is covered with native vegetation from the maximum inundation level to a minimum of 20 m from that line.
E – Approaches	The wetland buffer performance objectives can be met through vegetation management to extend the area of native vegetation bordering natural wetlands by: (1) Extending the width of area meeting the 'native vegetation' criteria to at least 20 m (or more to accommodate walking paths or cycle tracks), or (2) Increasing the length of wetland edge that is contiguous with 'native vegetation', or (3) Extending the depth of native vegetation adjacent to a wetland out to 50 m where possible. (4) The buffer should be protected by fencing or other suitable means from domestic stock and other pest animals		

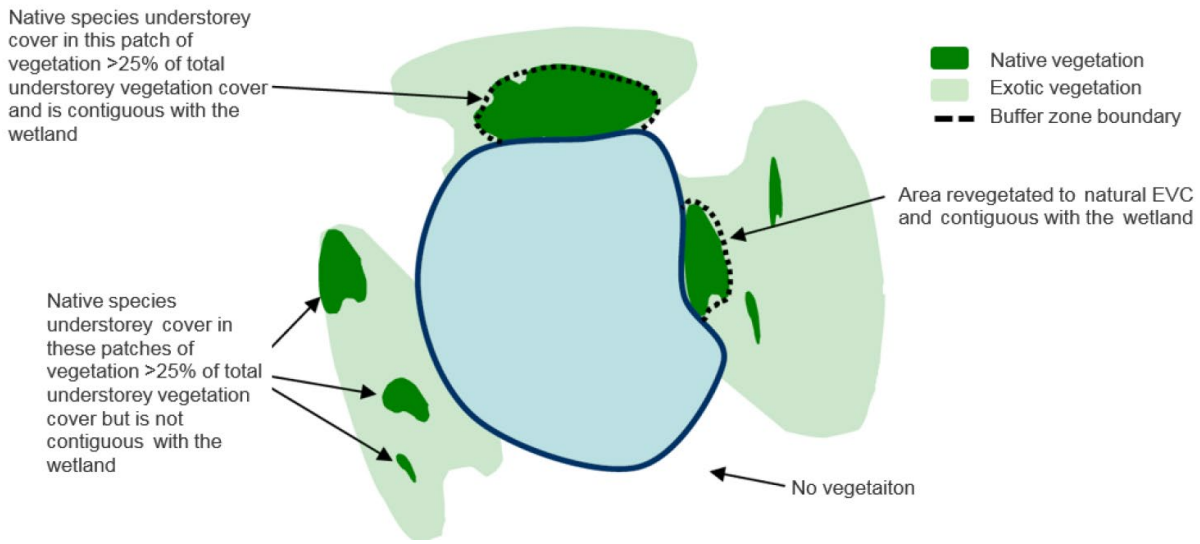

Figure 10. Conceptual diagram depicting native vegetation criteria required for the buffer zone (DEPI 2013b).

8.4 Annual targets for buffers

Buffer extent and condition will be assessed using the IWC methodology by the end of the Strategy. But annual reporting has been demanded. Until we can report annually in a quantitative manner using remote-sensed data annual buffer targets are defined as a percentage of specified wetlands with works undertaken within the buffer area. There is an increasing proportion expected to be addressed with each year of the Strategy implementation (see Table 15Table 13).

Table 15. Annual progress target for hectare indicators.

18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28
2%	5%	10%	25%	35%	45%	60%	80%	90%	100%

Tracking of progress will be described as:

- On-track will be if we have met 100% of the annual target (as described in Table 20).
- Slightly off-track means we have achieved ≥80% of the target figure.
- Significantly off-track means we have achieved <80% of the target figure.

Table 16. Summary of data collection, processing, storage and website reporting for each indicator.

Performance objective	Indicators	Data collection responsibility	Processing and reporting responsibility	Data storage system	Data provided on HWS website
Ensure appropriate aquatic macrophyte habitat is protected in the habitat ponds.	No. conservation ponds meeting threatened species habitat requirement	MW Applied Research Team (waterways) MW GGF team Service Delivery	MW Catchment Asset Management Team	Mapbox?	• Annual tracking of proportion of specified wetlands having vegetation improvement works within 50 m of water's edge (at the region and catchment scale). • Whether each PO (or collection of POs) is on track/ slightly off track/ significantly off track at mid term
Improve/Increase wetland buffer to 25/50 per cent of the wetland perimeter. Improve wetland buffer width and fill gaps in wetland buffer length.	Proportion of wetland edge with buffer	MW Regional Services team	MW Catchment Asset Management Team	Mapbox?	

9 Pests

This theme considers WPOs to reduce the threat to native fauna and flora values at priority wetlands. Specifically, this Group focusses on addressing pest species of fish. Other pest plants and animals are addressed in the Habitat Group (above).

Table 22. Summary of Wetland performance objectives within the Pest Plants and Animals Group.

WPO theme	Number of POs	Example PO wording	Possible management actions	Relevant wetlands
Protect specific values and habitat	7	Maintain threat from carp at low following watering events.	• Monitoring of pest fish following environmental flow delivery • Installing carp exclusion screens to incoming flows. • Drying wetlands, removal of pest fish.	Domain Chandon Billabongs, Banyule Flats Billabong, Bolin Bolin Billabong, Burke Rd Billabong, Hays Paddock Billabong, Willsmere Billabong, Yarra Bridge Streamside Reserve
	8	Monitor threat levels from invasive fish species, and mitigate risks if required.	• Monitoring for presence and impact of pest species of fish • Management of water levels and aquatic habitat to mitigate impacts	Dwarf Galaxias Conservation Pond, Hallam Valley Floodplain wetlands, Tamarisk Waterway Reserve, Tirhatuan Wetlands, Winton Wetlands and other EODC native fish habitat ponds along Dandenong Creek

Table 17. Summary of monitoring approach and scoring criteria for Pest Plants and Animals.

Performance objective	Monitoring			Scoring			
	Indicators	Reporting	Requirements	Annual			Final term
				On-track	Slightly off-track	Significantly off-track	
Maintain threat from carp at low following watering events.	No. events meeting standard	Progress report of actions undertaken (reporting period will be event-based)	• Watering events are defined as active delivery of environmental flows to a wetland. • The period of time for management is the period of inundation of the wetland. • Carp threat score: ○ 0 or "N/A" = Carp not present ○ 1 or "Low"= Carp presence uncertain. ○ 2 or "Moderate" = Carp known to be present but no observable impacts to wetland water quality or key values. ○ 3 or "High" = Carp present and observable impacts on water quality, or wetland values.	Carp threat score of 0, 1 or 2 at >80% of watering events	Carp threat score of 0, 1 or 2 at 50-80% of watering events	Carp threat score of 0, 1 or 2 at <50% of watering events	Carp threat score of 0, 1 or 2 at >80% of watering events

Performance objective	Monitoring			Scoring			
	Indicators	Reporting	Requirements	Annual			Final term
				On-track	Slightly off-track	Significantly off-track	
Monitor threat levels from invasive fish species on Dwarf Galaxias and Yarra Pygmy Perch and mitigate risks if required.	No. target wetlands with monitoring	Mid-term status update	Monitoring includes eDNA sampling as well as dip netting surveys. Dip netting will occur once or twice between 2020 and 2022. Invasive fish species are defined as: non-native species that may compete with native species for food or habitat resources. Key pest species include Mosquitofish and Carp, as well as potentially Redfin Perch and Weatherloach. • Mitigation is required when: pest species are detected as present. • Mitigation actions include: drawing down/drying the wetland (for Yarra Pygmy Perch, this would require a partial salvage of the fish present) or intensive netting.	>80% of POs are in progress or completed	50 - 80% of POs are in progress or complete.	Less than 50% of POs are in progress or completed.	>90% of the target achieved

*Definitions for scoring criteria:

- Complete: Evidence that issue has been resolved (or a process in place to actively manage any ongoing issues that cannot be eliminated) or target achieved.
- In progress: Investigation commissioned, or completed and follow-up management underway
- Not started: No evidence of any action.

Table 24. Summary of data collection, processing, storage and website reporting for each indicator.

Performance objectives	Indicators	Data collection responsibility	Processing and reporting responsibility	Data storage system	Data provided on HWS website
Maintain threat from carp at low following watering events.	(3) Monitoring and follow-up undertaken (maintenance inspections plus assessment during watering event)	MW Environmental Water Management Team	MW Environmental Water Management Team Service Delivery	TBC	Whether each PO (or collection of POs) is on track/ slightly off track/ significantly off track at mid term
Monitor threat levels from invasive fish species on Dwarf Galaxias and Yarra Pygmy Perch and mitigate risks if required.	(4) Monitoring and follow-up mitigation completed when necessary	MW Applied Research MW EODC project team	MW EODC project team	TBC	

10 Community places

Community Places performance objectives are aimed at enhancing the connection between people and wetlands. The social values that wetlands support (such as amenity, recreation and community connection) are not well understood. Building our knowledge of how wetlands support these values is the first step in building this connection. Follow up actions may include enabling access along wetlands via pathways, interpretive signage and education, among others.

WPOs within the Community Places Group are summarised in Table 20, and the approach to monitoring and scoring these is summarised in Table 21.

Table 18. Summary of Wetland performance objectives within the Community Places Group.

WPO theme	Number of POs	Example PO wording	Possible management actions	Relevant wetlands
Increase access to and along waterways, wetlands and estuaries by filling gaps and improving connections to existing path networks	3	Develop understanding of the amenity, community connection and recreation values of wetlands and develop performance objectives to enhance the values.	• Social studies • Literature reviews • Surveying visitors • Building infrastructure and assessing how it is used • Developing performance objectives to drive on-ground actions.	Pipemakers Park Wetlands, Greenvale Reservoir Park Wetlands, Queens Park Wetlands

Table 19. Summary of monitoring approach and scoring criteria for Community Places.

Performance objective	Monitoring			Scoring			
					Mid term		Final term
	Indicators	Reporting	Requirements	On-track	Slightly off-track	Significantly off-track	
Develop understanding of the amenity, community connection and recreation values of wetlands and develop performance objectives to enhance the values.	To be tracked as per RPO #20 (The amenity, community connection and recreation values of wetlands are better understood and performance objectives are developed to enhance these values).						

11 Collaborative governance

The governance group of performance objectives include administrative, planning and evaluation actions that support wetland health by ensuring that sites are protected and effectively managed. Several of these performance objectives link HWS actions to parallel wetland management programs at larger scales, such as the international Ramsar Convention on Wetlands of International Importance and the Victorian Western Grasslands Reserve initiative through implementation of actions under these programs and evaluation.

Planning and policy responses are also a key mechanism for addressing threats; in particular, using Environmental Significance Overlays in local planning schemes to protect wetlands from the impacts of development.

There are a number of RPOs which are relevant to Governance. Tracking and evaluation of these performance objectives will be done through the Regional MEP. The relevant RPOs are listed below:

- **RPO-10.** An adaptive pathways approach is adopted to understand and manage the risks of climate change on waterways
- **RPO-29.** Programs, standards, tools and guidelines are in place to protect wetland vegetation communities from urban and rural threats, including adequate planning controls.

Table 20. Summary of Wetland performance objectives within the Collaborative Governance Group.

WPO theme	Number of POs	Example PO wording	Possible management actions	Relevant wetlands
Supporting governance framework	1	Incorporate the Downs Estate in the Ramsar Site Boundary.	Ramsar listing is a DELWP and Commonwealth Government decision and would need to be discussed with these authorities	Seaford Wetland

Table 21. Summary of monitoring approach and scoring criteria for Collaborative Governance.

Performance objective	Monitoring			Scoring			
					Mid term		Final term
	Indicators	Reporting	Requirements	On-track	Slightly off-track	Significantly off-track	
Incorporate the Downs Estate in the Ramsar Site.	Decision on this matter.	Mid-term Status update	This performance objective is dependent on agreement by DELWP and the Commonwealth	Decision agreed	No decision agreed	N/A	Decision agreed

Part B Key values surveillance monitoring

12 Overview

12.1 Audience and needs

The target audience for this part of the Wetland MEP is those people tasked with tracking the trajectories of key wetland values and reporting whether these are in line with our expected/desired goals. Melbourne Water's Waterways and Biodiversity Team within Integrated Planning has a primary role in this. Their information needs include:

- How the current state of key values is being measured
- How key value monitoring results are compared to expectations.

12.2 Key evaluation questions

The current state (as at 2017) and target trajectory of each of the four key wetland values (birds, fish, frogs and vegetation) are described in the 2018 HWS for each of the, then, priority wetland in the region. Monitoring of these key values must address key questions prescribed by the MERI Framework (Melbourne Water 2019):

- KEQ 3: What is the state of waterway values?
- KEQ 3a: To what extent are key values on the predicted trajectory?

Reporting against these questions is expected towards the end of the HWS – at the end of 2026 (to allow data from 2025/26 to be assessed while allowing time for results to be incorporated into the preparation of the next regional strategy) – and also at the halfway point, in 2022 (to include 2021/22 data). The evaluation approach and method are summarised in **Error! Reference source not found.**.

KEQs addressed	Evaluation approach and method	Data required to inform evaluation	Who judges progress and success?
KEQ No. 3 – What is the state of waterway values?			
Sub question 3a. To what extent are key values on the predicted trajectory?	Comparative methods – the status of key values will be compared to predicted target trajectory in the HWS. Evaluation will be undertaken based on the methods described for each key value below.	Specific to each key value (see below).	Regional Leadership Group

As we have little benchmark data on most wetlands it is likely that current and predicted future trajectory will need to be reviewed as data on conditions and values are collected (for the first time in many instances), and also when HSMs are built to predict outcomes under urban growth and climate change.

12.3 Summary

Table 29. Summary of key value monitoring methods and evaluation.

Key Value	Monitoring method (any change from HWS 2018)	Indicators	Other information to support evaluation	Monitoring frequency	Monitoring locations	Monitoring responsibility	Baseline data	Evaluation/ reporting
 Birds	Field surveys of wetlands through Birdlife Australia volunteers (Data-based metrics)	Native waterbird species richness and reporting rate, weighted by threatened species and observations of breeding	Abundance/ density of wetland birds Habitat use by birds (e.g. foraging vs roosting) eDNA may be trialled, using vertebrate primers to screen for waterbirds and provide complementary data to the primary Birdlife Australia program.	Monthly at key wetlands (e.g. Edithvale-Seaford Ramsar wetlands) Ideally at least quarterly at other wetlands.	Selected priority wetlands (locations dependent on Birdlife Australia citizen science volunteer teams)	MW Waterways and Biodiversity team to commission BirdLife to collect data PV and CMA to facilitate targeted surveys at Ramsar wetlands and other critical sites	September 2017 – as reported in the HWS	Review of trends at mid-term (end of 2022, to include 2021/22 data) and evaluation towards the end of strategy (end of 2026, to include 2025/26 data)

Key Value	Monitoring method (any change from HWS 2018)	Indicators	Other information to support evaluation	Monitoring frequency	Monitoring locations	Monitoring responsibility	Baseline data	Evaluation/ reporting
 Fish	eDNA (This is a new survey technique not available when the HWS was prepared.)	Species' presence (observed/ expected ratios may be calculable following habitat suitability modelling)	Safety considerations are likely to limit broad-scale surveillance to eDNA method. But traditional field surveys will be required to validate eDNA results and obtain information not available through DNA analysis.	Two sampling sessions per year (autumn and spring), with each of the priority wetland sampled during at least once autumn and once spring prior to the mid-review, and the same effort repeated between the mid and final review.	Subset of priority wetlands (locations to be confirmed following trials) Refer Appendix B	MW Waterways and Biodiversity team/ MW Applied Research team to commission consultants to collect data	To be established from autumn 2021	
 Frogs	eDNA (New survey technique)	Species' presence/ absence (observed/ expected)	Frog Census records. Targeted field surveys for threatened species, e.g. call-playback, acoustic monitoring,	Two sampling sessions per year (autumn and spring)	Subset of priority wetlands (locations to be confirmed following trials)	MW Waterways and Biodiversity team/ MW Applied Research team to commission consultants to collect data	Expected species to be derived from MW's current frog records database	

Key Value	Monitoring method (any change from HWS 2018)	Indicators	Other information to support evaluation	Monitoring frequency	Monitoring locations	Monitoring responsibility	Baseline data	Evaluation/ reporting
			dip-netting and spotlighting					
Vegetation 	IWC, plus field surveys to include a more detailed vegetation assessment (e.g. IWC-GDE[5] and IWC with added veg quadrats[6]) (Improved field data rather than desk top assessment of the HWS)	Vegetation condition and extent	Presence of rare species/ communities Wetland vegetation uniqueness	Every five years (Note, every three years at SoBS and some WTP wetlands)	Selected priority wetlands with notable native vegetation values, e.g. Seasonal Herbaceous wetlands	MW Waterways and Biodiversity team/ MW Catchment Asset Management team to commission consultants to collect data	To be established from 2020 onwards	

**Please note that these metrics are different to those used in the 2018 HWS.*

[5] Papas, P. & Frood, D. (2016a) Index of Wetland Condition for Groundwater Dependent Wetlands – assessment methods and data entry sheets V1.1. Unpublished report prepared for Melbourne Water by the Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning, Heidelberg, Victoria.
[6] Ecology Australia (2020e) Index of Wetland Condition and Monitoring Round 2 Report. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Fairfield, Victoria.

12.4 Environmental DNA (eDNA)

Environmental DNA (eDNA) involves sampling DNA that organisms have shed into the environment. It provides a new, relatively cheap, quick and non-invasive method for detecting species in aquatic environmental. Environmental DNA sampling is also safer than many traditional survey techniques because it does not require operators to enter the water and also avoids stress to animals that would otherwise be trapped and/or handled. It is intended to have eDNA sampling at suitable priority wetlands during both autumn and spring every 2-3 years to ascertain the presence native and pest species of fish, frogs, and selected waterbirds – and so allow us to mid-term review requirements.

Priority wetlands will be sampled at least once in autumn and once in spring, prior to the mid-term review and at least once in autumn and once in spring between the mid-term review and final review of the HWS. It is anticipated that three sub-samples will be taken at each wetland. However this may need to be adjusted to suit wetland size and form. Initial testing of eDNA sampling requirements for wetlands according to size and complexity is to be conducted during the spring of 2020. These trials were delayed from autumn 2020 because of the coronavirus pandemic.

Sampling will be timed to maximise the chances of detecting species that are only intermittently present (e.g. when frogs are breeding and active), so during autumn and spring.

This program is aimed at (i) providing a status update on key values at priority wetlands, and (ii) determining whether a change in distribution (or site occupancy) has occurred between the two 5-year reporting periods. Metrics that could be reported on in a 5-year period include: presence/absence of key values across the region, native/invasive species richness overall and for each group (fish, frogs, waterbirds) and wetland (EnviroDNA 2020).

13 Birds

Wetlands in our region provide critical foraging, roosting or breeding habitat for many species of bird, and support many rare and threatened endemic bird species including the Brolga, Australasian Bittern and Freckled Duck. Thousands of migratory birds travel annually to Port Phillip Bay and Western Port wetlands from as far away as Alaska, Siberia, China and Japan, and our wetlands provide these birds with the essential resting and feeding places they need to survive. More than 310 bird species have been recorded at Melbourne Water's WTP alone (Melbourne Water unpubl data).

The management of water levels and vegetation, with control of pest and domestic predatory species all contribute to improving environmental conditions to support wetland bird communities.

This section describes our approach to broad-scale, regional surveillance monitoring for birds at wetlands. Knowledge gaps, research and intervention monitoring activities associated with birds are outlined in Part D.

Monitoring objectives

- Regularly assess/report the status (or "health") of bird communities at priority wetlands.
- Track changes likely in response to external factors, e.g. drought, climate change and urbanisation.
- Assess changes in response to large-scale management interventions.

13.1 Indicators

Past

Timeframes during strategy development prevented a thorough assessment of bird communities, and little of the available bird were referenced. Instead, results of a simple AVIRA process were used to estimate the status of wetland bird communities at the, then, listed priority wetlands. This meant that AVIRA measures such as formally recognized significance (i.e. Ramsar wetlands, East Asian-Australasian Flyway Sites, or Directory of Important Wetlands in Australia); VBA records of rare or threatened species; and the desktop assessment of wetland vegetation condition, were used to infer the status of wetland birds[7]. In order to ensure our investment in activities to protect bird values is directed towards the most beneficial actions as the most important locations, it is important that we undertake a more thorough analysis of the bird data to test our original assumptions.

[7] For further detail, please see the HWS Technical Resource Document (Melbourne Water 2020).

Proposed

Since the HWS, an index of wetland bird community status based on the comprehensive datasets held by Birdlife Australia has been developed and tested (see Birdlife Australia 2020). The indicators and scoring are presented in Table 30).

Table 30. Indicators for the wetland bird community value at regional surveillance scale.

Indicator	What it's useful for
Summed reporting rates of specified wetland bird species over the time period in question (minimum of 20 standardised surveys required)	A simple aggregate score that includes elements of both appropriate species richness and frequency of occurrence, thus measuring changes in overall species richness and increased (or decreased) frequency of use.
No. of wetland bird species recorded breeding over period	Wetlands are critical waterbird breeding habitat and breeding is essential for the persistence of these species.
No. of listed species of wetland bird (both threatened and migratory) recorded over the period	Threatened or migratory species have particular importance for conservation management. This is used as a modifier to weight wetland bird communities by the number of these important species found at a site, to ensure that wetlands with otherwise low numbers and variety of waterbirds but which support listed or migratory species are not under scored.

13.2 Data collection

How –

From 2002/03 onwards Melbourne Water has worked with Birdlife Australia to develop a comprehensive regional, community-based bird monitoring program. This sees teams of volunteers recruited to conduct standardised surveys at a large number of selected sites. For regional surveillance monitoring we will continue to use community-based 'citizen scientist' surveys, combined with professional bird counts where available, to collect field data. The advantages obtained through community engagement and participation (e.g. see community engagement performance objectives in the HWS) outweigh limitations, such as not recording nocturnal or cryptic species of bird.

However, quantitative count data collected by community volunteers will vary with observer skills (in addition to other sources of variation: weather conditions, time of day, etc.). Therefore, while count data will be useful when explaining results, for regional surveillance we have developed indicators of wetland bird community that do not require accurate count data.

Survey protocol:
(1) During surveys a minimum of 20 minutes should be spent observing each wetland.

(2) Surveys must take place, and be completed, within three hours of sunrise.

(3) Surveys should include both scanning of the wetland and surrounding vegetation from vantage points, and active searches along as much of the wetland margin as possible. Telescopes should be used for larger wetlands.

(4) All birds within the wetland depression and a 'logical wetland' margin are to be recorded. This area will vary from wetland to wetland but should normally include at least 25 m from the maximum inundation level. For our purposes, wetland margins generally would not extend more than 50 m beyond a wetland's edge. Essentially the logical margin would be to a major change in land use (i.e. to the edge of neighbouring housing or croplands) or vegetation type (i.e. to the edge of dry woodland).

(5) Interesting species seen outside the 'logical margin' and birds passing-by in flight overhead can be noted, but are not included in the wetland survey analysis.

(6) Breeding behaviours are to be recorded, using the terms below (modified from Mac Nally 2007):

Rank	Behaviour
1	Feeding of young out of the nest
2	Young birds seen or heard
3	Feeding of young in the nest
4	Presence of juveniles
5	Adults carrying food
6	Adults on the nest
7	Courtship/ mating

(7) Habitat conditions at the time of the survey are to be recorded, such as water depth, extent of water, extent of mudflats, nature of fringing vegetation and so on. The recording of habitat variables is still under discussion with Birdlife Australia but methods should be finalised during 2020.

(8) Surveys results will be submitted to Birdlife Australia for vetting and then inclusion in their Birdata database.

Where –

Regional surveillance monitoring of wetland birds will be conducted at suitable wetlands among our 255 'priority' wetlands. Some priority wetlands, where birds are not considered to be a community value, will not be targeted for surveys (see Appendix B). Also, it is recognised that some priority wetlands are small, ephemeral or on private land and unlikely to be accessible to bird survey teams.

When –

It may take years to develop a regional program that adequately surveys all priority wetlands. But we are building on a solid foundation of wetland bird surveys (Birdlife Australia 2020).

Monthly surveys will continue at Ramsar wetlands and other wetlands of particular importance to wetland birds. The goal is to have adequate, standard bird surveys at *c.* 160 priority natural wetlands every quarter.

Table 31. Summary of regional wetland bird monitoring.

Method	Where monitoring is required	Monitoring frequency (when)	Monitoring responsibility	Baseline data
BirdLife Australia bird surveys Types 2 (<500 m active search) and 3 (fixed route)	~160 of the 250 priority wetlands	Quarterly surveys. Monthly surveys at important wetlands (e.g. Ramsar listed wetlands)	MW Waterways & Biodiversity team (to commission BirdLife Australia)	Birdlife Australia database at September 2019; using only selected survey types and centred within 100 m of a priority wetland polygon (see Birdlife Australia 2020)

Table 32. Summary of data storing processing and access requirements for wetland bird values.

Method	Data storage	Data access requirements	Data processing requirements	Data processing responsibility
BirdLife Australia bird surveys (combined with professional surveys where possible)	Stored in the BirdLife Australia database. Melbourne Water is provided with a data update approximately every 9 to 12 months. MS Access database at: I:\MEL\1. SHARED FOLDERS (Waterways Group) Inflo Migration\Cross Team Information\Investigations Programs\Birds\1 Data Management\11 Data MapInfo GIS layer Currently not in compliance with the DataVic access policy - Only accessible by MW	Annual submission of updated Birdlife Australia database in MS Access format	Data selection and extraction through MS Access and GIS. Metric calculations through MS Excel at each priority wetland	Melbourne Water IT (spatial selection) then Melbourne Water/ Integrated Planning (score calculation)

13.3 Data storage, processing and access

Table 32 presents a summary of where data are to be stored, how this can be accessed and processing requirements.

13.4 Data analysis

From the Birdlife Australia database we will use data from only selected surveys that are:

- centred within 100 m of the wetland polygon,
- Type 2 or 5 surveys[8],
- Have no limitations (i.e. all species of bird were recorded and there were no restrictions on access or through adverse weather).

Table 33. Wetland Bird Community Index scoring.

Indicator	Score	Description
Basic score Sum of reporting rate of wetland species	<5	Very low condition
	5 to 10	Low condition
	10 to 15	Moderate condition
	15 to 20	High
	>20	Very high condition
Modifier 1 No. spp. breeding	<5	No change to basic score
	5 to 10	If basic score is less than Moderate, increase score to this category
	11 to 15	If basic score is less than High, increase score to this category
	>15	If basic score is less than Very High, increase score to this category
Modifier 2 No. listed spp. recorded	<10	No change to basic score
	10 to 15	If basic score is less than Moderate, increase score to this category
	16 to 20	If basic score is less than High, increase score to this category
	>20	If basic score is less than Very High, increase score to this category

[8] BirdLife Type 2 (<500m active search) and Type 5 (fixed route) surveys will be undertaken.

There are three wetland bird community indicators: (1) the sum of the reporting rate of all wetland species; (2) the number of wetland species recorded breeding; and (3) the number of listed species of wetland bird recorded. Wetland species of bird are defined in Appendix C and listed species (i.e. threatened or migratory) identified.

The following metric will be used to determine wetland bird value (Table 33). This has been tested with Birdlife Australia data (Birdlife Australia 2020) and wetland bird community scores re-calculated for regional wetlands (Appendix D).

13.5 Evaluation and reporting

Mid-term

The mid-term review (2022) will focus on an assessment of progress towards the long term priority wetland scale targets. The relevant KEQ is:

- KEQ No. 3 – What is the state of waterway values?
  - 3a. To what extent are key values on the predicted trajectory?

Table 32 describes the rubric which will be used to review trends toward long term targets. The assessment will be made at the wetlands scale, for wetlands where there are data available. The targets for all key values are expected to be achieved over a 20-50 year scale. As such major changes may not be observed after only four years of strategy implementation.

The potential value of other measures, such as eDNA sampling, or including a waterbird density element will be explored at mid-term.

The mid-term review assessment will be reported on the HWS website.

Table 34. Rubric for value for assessing performance against long term HWS targets at each priority wetland at the mid-term evaluation.

Performance rating	Performance criteria / evidence
On-track to achieving long term target	Bird value score is maintained at, or above, the 2017 score.
Slightly off-track to achieving long term target	Bird value score has decreased by one category relative to the 2017 benchmark.
High chance that long-term targets will not be met	Bird value score has decreased by two categories or more relative to the 2017 benchmark.

Final evaluation

The form of the final evaluation is to be determined following the mid-term review but might include an assessment of climate change impacts. Results of works intervention studies will inform our understandings of bird responses and likely adjust our practical objectives.

Results will be reported through the HWS website and a final strategy report.

13.6 Emerging/ complementary monitoring methods

eDNA Sampling

The ability of eDNA to collect data on bird presence at priority wetlands is to be explored at a subset of priority wetlands. While eDNA techniques may be fully developed within the timeframe of the Strategy there will be a continued need for field visual observation-based data to provide information of population abundances and health (e.g. recruitment, sex ratios) as well as aiding in the interpretation of eDNA results.

Waterbird density

Over the life of the Strategy, we will explore whether additional indicators of waterbird value should be incorporated into the metric. The density of waterbirds at a wetland is one measure to be explored, pending the availability of sufficient robust count data. Species richness can be a poor indicator if used alone as population declines will not be detected sufficiently early to effect appropriate management responses.

Guilds and 'evenness'

We will investigate whether estimation of the 'evenness' of waterbird populations, such as a balanced distribution of various foraging guilds, is a useful indicator of wetland bird community health. As we are doubtful of the accuracy of quantitative count data we would use appropriate indices based on presence/absence data such as the Jacard Co-efficient or Sorensen Co-efficient.

14 Fish

Wetlands in the region are used by native fish species such as pygmy perch (*Nannoperca* spp.), Galaxiids (e.g. *Galaxiella pusilla and Neochanna cleaveri*) and shortfinned eels (*Anguilla australis*). Wetlands may also be important for feeding, breeding and refuge to some species of threatened native fish including the Dwarf Galaxias (*Galaxiella pusilla*).

The provision of environmental water, management of stormwater, control of pest fish species, establishing aquatic vegetation and reducing litter and pollutants will all contribute to improving environmental conditions to support wetland fish communities.

This section describes our approach to broad-scale, regional surveillance monitoring for fish – not site specific, works effectiveness monitoring. Knowledge gaps, research and intervention monitoring activities are described in Part D.

Monitoring objectives

To address HWS MERI Framework requirements we must regularly assess, and report on, the status of native fish assemblages at selected priority wetlands (i.e. those with identified or suspected fish values).

14.1 Indicators

Past

For the 2018 HWS, a desk-top assessment was used to determine the status of native fish at certain priority wetlands and then set long-term targets. This assessment was restricted to available VBA records of threatened species of fish and the potential for a wetland to act as a drought refuge. There was very little information upon which to base this assessment (Melbourne Water 2020).

Proposed

Work is currently underway at La Trobe University to develop improved indictors for native fish communities across all three waterway asset types: streams, wetlands and estuaries (King et al. 2020). Our wetland fish monitoring will be determined by this work and so, what is presented here, should be seen as a reduced monitoring plan.

Initially we will use eDNA sampling of wetlands to gain a better idea of the presence and distribution of native fish (and pest species of fish) in our wetlands. We will use the basic native species richness as our indicator for the fish value.

While eDNA techniques may be fully developed within the timeframe of the Strategy there will be a continued need for traditional field sampling – especially for wetland-specific species of fish that are threatened, such as the Dwarf Galaxias – to provide

information on size class distribution, population abundances and health (e.g. breeding and recruitment, sex ratios) as well as aiding in the interpretation of eDNA results.

Table 22. Summary of indicators for fish and how they can be used.

Indicator	What it's useful for
No. of species present (both native and exotic, determined through eDNA)	It is useful to know the distribution of native fish species across priority wetlands within the region.
Evidence of breeding and general health among threatened Dwarf Galaxias and Yarra Pygmy Perch populations (through traditional trapping)	Understanding the persistence, general health and breeding success among populations of a threatened species. (Note, this would be applied at only few wetlands where these species are known to occur or could potentially occur)

14.2 Data collection

How –

Water samples will be collected for eDNA analysis. The number of samples, or sub-samples, required for each wetland size and morphology is still to be determined (EnvironDNA 2020) with field collection to start in spring 2020, after a delay necessitated by the coronavirus pandemic.

Observation and dip-netting will be undertaken at wetlands managed specifically for the endangered Dwarf Galaxias and Yarra pygmy perch. Basic measures of continued presence, general health and size classes (to confirm breeding) will be collected.

Where –

Wetlands where fish are not considered to be a community value (e.g. stormwater treatment wetlands) will not be targeted for eDNA sampling. The number and identity of wetlands to be surveyed for native fish (and frogs) through eDNA analysis is still to be determined. This will be limited by factors such as cost, accessibility and suitability. Priority wetlands where, ideally, eDNA sampling would take place are identified in Appendix B.

Observation and dip netting will be undertaken at Dwarf Galaxias and Yarra Pygmy Perch habitat ponds (currently three priority wetlands comprising ~23 ponds).

When –

eDNA sampling for fish will be undertaken once in spring and once in autumn for each priority wetland prior to the mid-term review and then repeated between the mid-term review and the end of strategy review? Sampling over multiple seasons is recommended

because detectability for some species will be highest in spring, while other species will be highest in autumn; many fish species are more likely to be detected after breeding, when juveniles are present in waterways, or during particular migratory phases (EnviroDNA 2020).

Observation and dip netting will be undertaken annually at Dwarf Galaxias and Yarra pygmy perch wetlands following reintroduction – which will take some years to achieve.

Table 36. Summary of fish monitoring methods.

Method	Frequency	Responsibility	Where required	Baseline data
eDNA analysis	Once or twice per selected wetland between 2022 and 2027	MW Waterways & Biodiversity team	Selected priority wetlands (see Appendix B)	2020 eDNA results
Observation and dip netting (for Dwarf Galaxias)	Annually	MW Applied Research Team – waterways	Dwarf Galaxias Conservation pond Dwarf Galaxias EODC habitat ponds Hallam Valley Floodplain, O'Grady Road	Existing information

14.3 Data storage, processing and access

Table 37. Summary of fish monitoring data collation.

Indicator	Data storage	Data access requirements	Data processing requirements	Data processing responsibility
No. of native species present (determined through eDNA)	MW fish database (still to be finalised)	MW	Mid-term compilation and comparison of results	MW Waterways & Biodiversity Team
Evidence of breeding and general health among Dwarf Galaxias populations (through dip-netting)	MW internal files	MW	Annual compilation of results	MW Applied Research Team - waterways

14.4 Data analysis

Compilation of results will be required for each wetland surveyed. Wetland scores (species richness) will be averaged to present a catchment score.

14.5 Evaluation and reporting

Mid-term

The mid-term review (2022) will assess progress towards the long term sub-catchment scale targets. The relevant KEQs are:

KEQ No. 3 – What is the state of waterway values?

- 3a. To what extent are key values on the predicted trajectory?

As the data underpinning the 2018 assessments for the wetland fish value was extremely limited, the monitoring method is still to be tested, a new baseline will need to be set. Evaluation will only be possible at the end of the HWS period. But habitat suitability modelling for some species of wetland fish is underway and this may be available to inform baselines at the mid-term review.

Table 38. Means of scoring progress towards HWS objectives at priority wetlands for the mid-term evaluation for the Fish value.

Performance rating	Performance criteria / evidence
On-track to achieving long term target	To be determined
Slightly off-track to achieving long term target	To be determined
Significantly off-track	To be determined

Final evaluation

This is to be determined following the mid-term assessment and review. Some assessment of the trajectory of fish communities should be possible then as we will have at least two species richness scores over ten years. These results will be analysed in light of pest fish presence, climate change effects, drought and results of detailed works effectiveness studies.

15 Frogs

The still or slow-flowing waters of wetlands provide shelter, feeding grounds and breeding habitat for frogs. Around 20 species of frog have been recorded in the Port Phillip and Westernport region since 1839, including the Commonwealth Environment Protection and Biodiversity Conservation Act - listed Growling Grass Frog (*Litoria raniformis*) (see Appendix D).

The management of water (both water quality and hydrology) and vegetation with control of pest species, stock and vehicle access can contribute to improving environmental conditions to support wetland frog communities.

This section describes the approach to broad-scale, or regional, surveillance monitoring for frogs. Knowledge gaps, research and intervention monitoring activities associated with frogs are outlined in Part D.

Monitoring objectives

To address HWS MERI Framework requirements we need to regularly assess and report on the status of frog populations at priority wetlands, using observed/ expected frog species ratios.

Monitoring significant frog populations at wetlands - challenges

Twenty species of frog have been recorded in the Port Phillip and Westernport region since 1839, although some of these are probably erroneous records (Appendix D). Of these species, only three are both listed as significant (i.e. listed) and 'wetland-dependent' in the AVIRA manual (DELWP 2015). However, the *Pseudophryne* species have also been categorized as 'terrestrial breeders' (Thompson et al. 2018). One species has been classified as an obligate stream breeder (Rocky River, or Lesueur's Frog; Gillespie & Hines 1999) and will not be considered as an 'expected' species in wetlands.

Some species of frog utilise for breeding very shallow swales and drains, or temporarily flooded depressions that are too small to be mapped as 'wetlands'. These include the threatened taxa *Pseudophryne bibroni* and *Ps. semimarmorata*. Such species are unlikely to be detected in surveys at larger wetlands and will be difficult to detect through eDNA collection without targeted habitat survey efforts.

We have limited data on our Region's frog populations and what data we have are limited to species' distribution and breeding period. It is difficult to determine breeding success without detailed field surveys – which are inappropriate for regional surveillance. Determining abundance data for frogs at any site is similarly difficult and, other than standardized spotlight transects, dip-netting or light-traps (which are suitable only for a few sites in a works evaluation type study), reliant on subjective estimates of observers.

Simple observed/expected species occurrence metrics provide limited opportunities to demonstrate improvements in the frog community. Attracting new species to any wetland may be difficult, and likely dependent on connectivity issues extending well beyond the individual wetland. Local extinctions of species would be detected but only after the fact. Thus, there are very few options for measuring wetland frog communities and their relative health. Hamer *et al*. (2010) recommended a 'proportion of area occupied' approach). However, it has proved impractical to collect data at the scale and frequency required to evaluate using this approach for such a large number of wetlands.

Indicators

For the 2018 HWS, a modified observed/ expected species method was developed using data-driven 'predicted Species Richness Models' (Ecology & Heritage Partners 2017) to determine frog values status within sub-catchments – rather than for individual wetlands. This high-level assessment was supplemented by assumptions based on information collected during the 2017 AVIRA, desk-top, assessment of some wetlands (Jacobs 2017). But the AVIRA measures were constrained to only the presence of threatened species records in the VBA database[9].

A simple observed/ expected species richness index will be used as the indictor for wetland frog community health. Frog data will be analysed to determine an expected list of species per catchment (or sub-catchment), potentially using the Ecology and Heritage Partners' 2017 method. We will exclude one stream-dependent species: the Rocky River Frog (Lesueur's Frog).

15.1 Data Collection

How –

Sampling and analysis for eDNA will be undertaken at selected wetlands in a rolling program of monitoring (see EnviroDNA 2020). Sub-samples will be collected from large wetlands. The number of sub-samples needed, and the best method for collection (discrete sub-samples or combined) are being tested during spring 2020.

Indications of successful breeding (tadpoles and/or metamorphs) will be a secondary condition measure, potentially integrated as a modifier that shows improvement (in water quality, habitat connectivity, etc.).

It is important to note that this section relates to ***regional surveillance*** of frogs, ***not*** site-specific, works effectiveness, evaluation projects. Frog Census and targeted fog surveys are important sources of data for works effectiveness studies. For example, Frog Census is being used to assess frog responses to watering of the lower Yarra billabongs (Dr T. Preston, Melbourne Water, pers. comm.). Evaluating works focused on protecting and improving *Pseudophryne* habitat will not rely on eDNA but will include

[9] For further detail, please see the HWS Technical Resource Document (Melbourne Water 2020).

targeted monitoring using call-playback and active search. In addition, frog surveys are carried out at constructed wetland prior to capital works.

Where –

eDNA monitoring will be undertaken at a selection of the 250 priority wetlands. Wetlands where frogs are not considered to be a value (e.g. stormwater treatment wetlands) will not be targeted for eDNA surveys. A list of the wetlands that will, ideally, be targeted for eDNA sampling is provided in Appendix B.

When –

Sampling will be conducted during spring and autumn since that is when many frog species are breeding and likely to be active, and when eggs and tadpoles may be present in the water (EnviroDNA 2020). Sampling for eDNA will be undertaken once in autumn and once in spring at each of the selected priority wetlands before the mid-term review and then repeated between the mid-term review and end of strategy review.

Table 39. Summary of frog monitoring methods.

Method	Where required	Frequency	Responsibility	Baseline data
eDNA detection	A subset of priority wetlands	Twice before the mid-term review and twice after the mid-term review	MW CLAW Team	To be established from 2020
Observation and dip-netting to ascertain breeding	A subset of priority wetlands – focussing on threatened species of frog	Twice before the mid-term review and twice after the mid-term review	MW CLAW team	To be established from 2020

15.2 Data storage, processing and access

Table 35. Summary of data storing processing and access requirements for wetland frog values.

Indicator / monitoring method	Data storage	Data access requirements	Data processing requirements	Data processing responsibility
Observed (wetland)/ Expected (catchment) species ratio	MW MERI data systems	MW	Mid-term compilation and comparison of results	MW Waterways & Biodiversity Team

Successful breeding (tadpoles or metamorphs observed)	MW internal files	MW	Mid-term compilation of results	MW Waterways & Biodiversity Team

15.3 Data analysis

The following table outlines the criteria which will be used to assess frog value status at mid-term and final term of the Strategy at the wetland scale. As data collection methods have been updated since the development of the Strategy in 2018, baseline data will be collected in 2020 and categories may be refined based on a review of the data collected.

The following metric will be used to interpret/assign frog value score (Table 40).

Table 40. Frog value scoring.

Indicator	Score	Description
observed/ expected index	>0.9	Very High
	0.7 to 0.9	High
	0.3 to 0.7	Moderate
	0.1 to 0.3	Low
	<0.1	Very Low

15.4 Evaluation and reporting

Mid-term evaluation

The mid-term review (2022) will focus on an assessment of progress towards the long term sub-catchment scale targets. The relevant KEQs are:

KEQ No. 3 – What is the state of waterway values?

- 3a. To what extent are key values on the predicted trajectory?

Table 41, below, explains the rubric which will be used to assess trends in relation to the long term targets. The assessment will be made at the wetlands scale, for wetlands where there is data available. The targets for all key values are expected to be achieved over a 20--50 year scale. As such major changes are not expected following only four years of strategy implementation.

Final evaluation

The form of the final evaluation is to be determined following the mid-term review but might include an assessment of climate change impacts if HSMs are available. Results of works intervention studies will inform our understandings of frog responses and likely adjust our practical objectives.

A final report will be prepared that describes observed changes in frog community scores and presents possible explanations for these changes. The usefulness, or otherwise, of our approach will then be need to be judged and improvements recommended for the next regional strategy.

Table 41. Rubric for value for assessing performance against long-term HWS targets for frogs at each wetland.

Performance rating	Performance criteria / evidence
On-track to achieving long term target	Frog value score is maintained at or above baseline.
Slightly off-track to achieving long term target	Frog value score has decreased by one level from the 2020 baseline
Significantly off-track	Frog value score has decreased by two or more levels from 2020 baseline.

16 Vegetation

Several wetlands in our region support rare and threatened species of flora and/or vegetation communities. This includes Commonwealth EPBC Act-listed vegetation communities such as Seasonal Herbaceous Wetland vegetation and Coastal Saltmarsh as well as a range of vegetation communities and species of State or bioregional significance.

Vegetation as a value (in contrast to vegetation as a supporting environmental condition – see Section 0) has been defined for our purposes as comprising several elements: (1) the *condition* of the native vegetation, (2) the *extent* of wetland vegetation, (3) the presence of significant (listed rare or threatened) species and communities, and (4) the rarity of the wetland type in the region.

For the purposes of the Wetland MEP, monitoring of wetland vegetation will be limited to vascular plants, and will not include groups such as cyanobacteria, forms of eukaryotic unicellular algae, multicellular algae such as charophytes, or bryophytes (mosses). Only inundation-dependent species and communities are considered in this wetland vegetation value.

This section describes our proposed broad-scale, regional, surveillance monitoring for vegetation values. Knowledge gaps, research and intervention monitoring activities associated with vegetation are described in Part D.

Monitoring objectives

The primary objectives are to assess and report vegetation condition at appropriate regional priority wetlands (i.e. those where wetland vegetation is considered a value, such as seasonal herbaceous wetlands, coastal saltmarsh wetlands, etc.).

16.1 Indicators

Past

For the 2018 HWS, a very rough assessment was carried out for a proportion of the priority wetlands using the AVIRA method. Due to data and time constraints, this was based on desk-top measures of wetland vegetation condition, formal significance (such as listed/threatened species under Victorian and/or Commonwealth legislation) and the presence of significant wetland vegetation classes (EVCs).

Proposed

In developing this Wetland MEP the need for more robust wetland vegetation assessment and scoring became apparent. Work to develop riparian vegetation scoring (Dell in prep.); trialing of an IWC assessment with enhanced vegetation assessments at wetlands (Ecology Australia 2019d, in prep.) similar to the modified IWC for groundwater-dependent wetlands (Papas 2014); and four years of vegetation

assessments at Melbourne Water SoBS (Ecology Australia 2017, 2018a, b, 2019e, 2020e) informed our thinking. Improved indicators have been identified (Table 42) and the need for regular field assessments confirmed.

Table 42. Summary of various indicators for vegetation and how they can be used.

Indicator	What it's useful for
Wetland vegetation condition (or 'health')	An assessment of vegetation that integrates the condition of key vegetation attributes including structure and health, life forms group, weediness, etc. This signals if vegetation attributes are able to support values expected of that vegetation community.
Wetland vegetation extent	Extent of vegetation is important for resilience and is one characteristic we can influence through on-ground management. This inform habitat availability for some biota and extent can also signal changes in abiotic conditions.
Presence of rare vegetation communities	A measure of importance for rarity and representativeness.
Presence of rare species of flora	
Wetland type rarity	

Vegetation condition ("health")

The Index of Wetland Condition (IWC) Biota sub-index score (assessed in the field as part of vegetation condition monitoring – see Part C) will be used as the measure of vegetation condition. The Biota sub-index provides a score based on the condition of the vegetation expected in each EVC, and is comprised of assessments of critical lifeforms; presence of weeds; indicators of altered processes; and vegetation structure and health. Biota scores and condition categories are provided in Table 43 below.

Table 43. IWC Biota sub-index score range and condition category.

Biota sub-index score range	Condition category
0–8	Very poor
>8–13	Poor
>13–16	Moderate
>16–18	Good
>18–20	Excellent

Presence of rare vegetation communities

National

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides a mechanism for identifying and listing species and ecological communities as threatened, and for protecting these species and communities through legislative controls and the development of conservation advice and recovery plans. Three vegetation communities listed under the EPBC Act are present at priority wetlands in the region:

- Seasonal Herbaceous Wetlands of the Temperate Lowland Plains (SHW) – listed as critically endangered;
- Subtropical and Temperate Coastal Saltmarsh – (Coastal Saltmarsh) – listed as vulnerable, and
- Alpine Sphagnum Bogs and Associated Fens – listed as endangered.

There are 58 priority wetlands with areas of SHW; and a small number with Coastal Saltmarsh (Cherry Lake, Truganina, Western Lagoon WTP, The Spit NCR, Seaford Swamp and Cheetham Saltworks). Only one regional priority wetland is thought to support Alpine Sphagnum Bogs and Associated Fens - Tooronga Plateau wetlands.

Regional

The Bioregional Conservation Status (Endangered, Vulnerable, Depleted, or Rare) of the EVCs at the priority wetlands will be used to indicate rarity of vegetation type. Wetland EVCs are listed in Table A1.1 of DEPI 2013c. The DELWP modelled EVC layer[10] will be used except where more accurate information is available (e.g. on ground mapping by botanists) or updated information from DELWP.

Presence of rare species of flora

Wetland flora can be listed under several conservation programs/legislation:

- Victorian Advisory List of Rare or Threatened Plants in Victoria (VROT)
- Victorian *Flora and Fauna Guarantee Act 1988* (FFG)
- Commonwealth EPBC Act.

A full list of wetland waterway dependent significant flora is provided in Appendix H (Table 12) of the Aquatic Value Identification and Risk Assessment (AVIRA) Manual (DELWP 2015).[11]

Flora records will be obtained from:

- Melbourne Water's long-term monitoring program at Sites of Biodiversity Significance (SoBS) sites (of 44 SoBS at least 27 include priority wetlands; some

[10] Native Vegetation - Modelled 2005 Ecological Vegetation Classes (with Bioregional Conservation Status) (NV2005_EVCBCS). http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803003495&publicId=guest&extractionProviderId=1

[11] Note that as part of 2020 amendments to the FFG Act, a combined VROT and FFG threatened flora species list is due to be released in 2020. The Vegetation Value metric will be updated once this list is available.

SoBS with multiple wetlands, such as the Western Treatment Plant (WTP) with 19 priority wetlands).
- Records from the Victorian Biodiversity Atlas.
- Records from IWC+ assessments.
- Records from additional sources (e.g. requests for data from the Arthur Rylah Institute, PV, Councils or consultants).

Flora data records are unevenly distributed across the region, generally due to sparse and varying survey effort exacerbated by the problems of flora responses to weather patterns and wet/dry phases . IWC assessments undertaken for the Wetland MEP will partially remedy this by collecting on-ground data from many additional wetlands.

Wetland type rarity

Wetland type has been mapped[12] and classified (DELWP 2014) for wetlands in Victoria. The rarity of wetland type has not yet been established by bioregion or hydrological basin. Once this has been determined, rare and threatened wetland types will be included in scoring. Should there be no updated wetland rarity determined we may go back to use the Corrick wetland classification system and measures of relative rarity determined using that system.

Wetland vegetation extent

The spatial extent of native wetland vegetation affects value as larger patches may be more resistant to weeds and other edge effects, and are likely to be more resilient to impacts such as fires and floods.

Table 44. Native wetland vegetation cover scores.

Area of native wetland vegetation cover	Condition category
<0.5 ha	Very poor
0.5 – 1 ha	Poor
1 – 5 ha	Moderate
5 – 10 ha	Good
>10 ha	Excellent

Metric for assessment

The following metric will be used to determine overall wetland vegetation value (Table 45).

Table 33

[12] As per Wetland_Current (2018 DELWP spatial layer and classification).

Table 45. Vegetation value metric.

Indicator	Score	Description
Basic score (Condition)	0--8	Very low
	>8--13	Low
	>13--16	Moderate
	>16--18	High
	>18--20	Very high
Modifier 1 (Rarity)	No listed species or vegetation communities	No change to basic score
	Presence of state listed flora (VROT/FFG) OR EVC BCS	If basic score is less than Moderate, increase score to this category
	Presence of state listed flora AND EVC BCS	If basic score is less than High, increase score to this category
	Federally listed vegetation community AND/OR Federally listed flora records	If basic score is less than Very High, increase score to this category
Modifier 2 (Wetland vegetation Extent)	Native vegetation extent score = very poor, poor or moderate	No change to basic score
	Native vegetation extent score = good or excellent	Increase score by one category

16.2 Data collection

How –

IWC Biota and Physical Form sub-indices will be collected as part of IWC assessments (see Part C below). Data records will be downloaded from DELWP's IWC database, or otherwise collated from other sources, such as the IWC-GDE (see Table 46).

Where –

The vegetation value score will be calculated at wetlands where IWC assessments have been undertaken since 2018. A full list of wetlands to be targeted for vegetation value monitoring is provided in Appendix B.

When –

Data will be collected in a rolling program targeting priority wetlands. Appendix F sets out a possible rotational scheme for priority wetlands. In addition, wetlands at SoBS will be assessed every three years as part of the SoBS monitoring program (Ecology Australia 2017, 2018a, b, 2019e, 2020).

Table 23. Summary of vegetation monitoring methods.

Indicator	Monitoring method	Monitoring frequency (when)	Where monitoring is required	Monitoring responsibility	Baseline data
Biota sub-index Listed species Physical Form	Index of wetland condition – biota sub-index	2018 - 2022	All priority wetlands being assessed as per IWC monitoring program	Waterways and Biodiversity team, Melbourne Water	For most wetlands this will be from 2020 onwards as we will only then have IWC assessments at most priority wetlands
Rare communities	DELWP EVC mapping	Data extraction as required	All priority wetlands being assessed	DELWP	
Listed species	SoBS monitoring method (threatened species and EVC records)	Data extraction as required	SoBS sites with listed wetland flora (data collected from existing programs)	CLaW team, Melbourne Water	
	Victorian Biodiversity Atlas species records	Data extraction as required	All priority wetlands being assessed	DELWP	
Extent – area of wetland vegetation	Aerial photography interpretation following ground inspection.	2018 - 2022	Selected priority wetlands being assessed		

Assessments will be timed appropriately, for example spring is when most wetlands should hold some water and vegetation is best assessed. Although the IWC vegetation assessments are best timed for the drawdown phase (D. Frood, pers. comm.) and it must be remembered that any flora survey is unlikely to record all possible or potential values at any wetland.

16.3 Data storage, processing and access

Table 47. Summary of data storing processing and access requirements for wetland vegetation values.

Monitoring method	Data storage	Data access requirements	Data processing requirements	Data processing responsibility
IWC +	Internal Melbourne Water databases IWC database https://iwc.vic.gov.au/	Melbourne Water internal folder DELWP database (request from DELWP)	(1) Data extract as required of updated records in MS Excel format (2) Data conversion to GIS. (3) Metric calculation	Melbourne Water IT (spatial selection) then Melbourne Water/ Integrated Planning (score calculation)
DELWP EVC mapping	https://www.data.vic.gov.au/	Publicly available database		
Victorian Biodiversity Atlas species records	https://vba.dse.vic.gov.au/vba/	Publicly available database		
SoBS data	Internal Melbourne Water databases	Melbourne Water internal folder		
Wetland_ Current	https://www.data.vic.gov.au/			

16.4 Evaluation - data analysis and reporting

Mid-term

The mid-term review phase (2022) will focus on an assessment of progress towards the long term sub-catchment scale targets. The relevant KEQs are:

KEQ No. 3 – What is the state of waterway values?

- 3a. To what extent are key values on the predicted trajectory?

Table 48 below explains the rubric which will be used to assess trends in relation to the long term targets. The assessment will be made at the wetlands scale, for wetlands where there is data available. The targets for all key values are expected to be achieved over a 20–50 year scale. As such major changes are not expected following only four years of strategy implementation.

The data underpinning the 2017/18 assessments for the wetland vegetation value was very poor desktop information, and the monitoring method has subsequently been improved, so a new baseline will need to be established. This new baseline will be determined in the mid-term review. Evaluation against this baseline will be undertaken at the end of the HWS. As we anticipate our management efforts to be realized in values improvements over a longer period than the HWS this late setting of baseline health is not a critical flaw.

Table 48. Means of scoring progress towards HWS objectives at priority wetlands for the mid-term evaluation for the Vegetation value.

Performance rating	Performance criteria / evidence
On-track to achieving long term target	Vegetation value score equal to or above baseline.
Slightly off-track to achieving long term target	Vegetation value score has declined by one category relative to baseline
Significantly off-track	Vegetation value score has declined by two or more categories relative to baseline.

Final evaluation

To be confirmed post mid-term evaluation but should include an assessment of climate change impacts, reassessment of the indicator and analysis of critical background conditions such as vegetation condition, achievement of pest plant management POs and wetland hydrology.

16.5 Emerging/ complementary monitoring methods

One emerging method for measuring wetland extent and vegetation cover is the use of remote sensing data regarding hydroperiod to measure long term changes in wetland extent due to changed water regimes. This is further discussed in Section 0 and Part D. The possibility of including this in the metric will be assessed at mid-term.

Additionally, the 'IWC+' (Ecology Australia 2020e) is collecting quadrat data on species presence and abundance, with each species classified according to its hydro-ecological group. Over the long-term, these data can be used in conjunction with changes in wetland hydroperiod to examine the long term impacts to wetlands due to climate change.

Part C Wetland condition monitoring

17 Overview

17.1 Audience and needs

This part of the MEP addresses the needs of those tasked with data collection, or commissioning this collection, tracking and reporting on progress towards HWS objectives (Table 49). This will mainly be Melbourne Water's Waterways and Biodiversity Team within Integrated Planning and the Catchment Asset Management Team. Their knowledge needs include:

- How the current state of wetland conditions is being measured
- How wetland condition monitoring results will be compared to target expectations.

Table 49. Audience and needs for wetland waterway condition monitoring data.

Audience	Typical groups / organisations	What this part of MEP provides information on (i.e. needs)
People who collect data	Ecological consultants (to be co-ordinated by the Waterways and Biodiversity team, Melbourne Water)	• Data collection methods • Locations for data collection
People who commission data	Waterways and Biodiversity team, Melbourne Water	• Monitoring objectives • Indicators and methods for data collection • Timing and location of data collection • How data should be stored
People who process the data/ are tracking the progress of the HWS	Waterways and Biodiversity team, Melbourne Water Regional leadership group	• How data should be accessed and processed • The intended outcome for wetland waterway conditions • How wetland waterway conditions will be evaluated.

17.2 Key evaluation questions and monitoring objectives

The current state (as at 2018) and trajectory of each of the five waterway conditions for wetlands was defined in the HWS at the, then, list of priority wetland listed. Wetland conditions are monitored under:

- KEQ 2: To what extent has progress been made towards the longer-term environmental condition targets for rivers, wetlands and estuaries?

- KEQ 2a: To what extent are the conditions on the target trajectory? If not, what are the possible causes?
- Monitoring against these questions is due to be reported on at Strategy mid-term (2022) and final term (2026).

The following primary objectives for broad-scale monitoring to address HWS MERI requirements include:

- Document baseline wetland waterway condition status in priority wetlands
- Assess and report on changes in wetland waterway conditions over the life of the Strategy
- Assess the trajectory of change in wetland waterway condition at the landscape/regional scale over the longer term
- Identify emerging threats to wetland waterway condition at the wetland and regional scale
- Inform the on-going management of individual wetlands, and wetland management programs in the region.

17.3 Summary

An overview of the monitoring methods and indicators for each wetland waterway condition is provided in Table 50. The main method proposed for monitoring these conditions is the Victorian Index of Wetland Condition (IWC), a method different to that used to assess wetland waterway condition in 2018. The rationale for change, and a summary of the IWC method is provided in the subsequent section, alongside a summary of data collection, data storage and evaluation for all wetland waterway conditions.

Table 50. Summary of key value monitoring methods and evaluation for wetland waterway conditions.

Condition	Monitoring method (Change from HWS 2018)	Indicators	Monitoring frequency	Monitoring locations	Monitoring responsibility	Baseline data	Evaluation/reporting method and frequency
Water regime 	IWC: Hydrology (water regime) sub-index (new)	• Severity of change to the water regime expected from activities identified as altering the water regime	Rolling assessments	Sub set of priority wetlands	Ecological consultants (coordinated by Waterways and Biodiversity team, Melbourne Water)	From 2018 onwards (as wetlands assessed)	Review of trends at mid-term (2022) and evaluation at final term (2026) as outlined in condition sections; with associated reporting
Vegetation condition 	IWC +: Biota sub-index (new)	• Native/ weed cover ratio • Floristic diversity (overall and against functional groups) • flora abundance • EVC structure, extent, critical lifeforms					
Wetland buffer condition 	IWC – Wetland Catchment (buffer) sub-index (expanding)	• Width of native buffer • % of wetland perimeter with a buffer					

Condition	Monitoring method (Change from HWS 2018)	Indicators	Monitoring frequency	Monitoring locations	Monitoring responsibility	Baseline data	Evaluation/reporting method and frequency
Wetland water quality 	IWC – Water Properties (modified) (nutrients, salinity, ASS-new) sub-index (expanding)	• Severity of nutrient enrichment • Severity of change in salinity • Activation of acid sulphate soils (additional metric for HWS)					
Wetland habitat form 	IWC – Physical Form (wetland area, wetland form) sub-index (expanding)	• Percentage reduction in wetland area • Percentage of wetland where activities have resulted in a change in bathymetry • Severity and extent of wetland soil disturbance					

17.4 Wetland conditions in the 2018 Healthy Waterways Strategy

As noted in the Introduction, significant time constraints during the development of the 2018 HWS and a lack of data on the condition of the many wetlands in the Port Phillip and Westernport region (many of which are on private land), Melbourne Water commissioned a baseline data collation project on wetland values and threats using the AVIRA method. Assessments made using this method were frequently hampered by a lack of available data from on-ground assessments of particular wetlands, particularly IWC assessments (Jacobs 2018). These data were then used to determine (as at 2018) the current state, current trajectory and target trajectory for wetland conditions and values.

AVIRA is a prioritisation method, not a monitoring one, and is therefore not suitable to be used as the basis of monitoring over the life of the strategy. Instead, the Victorian IWC has been adopted as the basis of wetland waterway conditioning monitoring over the life of the Strategy.

Factors supporting this decision included:

- The 2018 HWS wetland waterway conditions are closely aligned with the IWC sub-indices.
- The IWC is a relatively simple, easy to use, rapid-assessment tool.
- The IWC does not require control sites (a practical challenge of other monitoring methods). Control sites in a region as modified as the PPW would be difficult, if not impossible, to find.
- The AVIRA method was used to establish several IWC sub-indices as the basis for the initial wetland condition assessment in the HWS, supporting some level of consistency of evaluation through time.
- IWC assessments have been used as the basis for the current catchment management authority regional waterway strategies across the state (that are analogous to the HWS), supporting some level of consistency across the state.
- A large database of existing IWC assessments across the State exists that can inform condition comparisons across the State (if desired).

We recognise the IWC method has limitations. Many of the indicators identify risks or threats to wetland condition attributes and are not a direct measure of the attribute itself. This limits a true evaluation of condition, but it does allow the identification of management actions needed to manage threats to condition.

17.5 The Index of Wetland Condition

The IWC was developed in Victoria in 2005, with the first training programs initiated by 2006. It is the State-wide standard assessment for assessing wetland condition and has a focus on threats to site values. IWC assessments are a rapid assessment, undertaken

in the field following a preliminary desktop assessment. They include a site-scale habitat assessment with six weighted sub-indices based on key wetland characteristics: catchment, physical form, hydrology, water properties, soils, and biota. General information about the wetland is also collected.

IWC assessments are undertaken across the State by the Victorian DELWP, CMAs and other land managers. Data from these assessments are managed by DELWP (Index of Wetland Condition Data Management System (available at https://iwc.vic.gov.au/home).

The IWC's purpose is as a tool for the surveillance of wetland extent and condition over a 10−20 year time frame. It was designed to assess the condition of naturally occurring wetlands with static (or very slow-flowing) water, without (or with only a minor) marine hydrological influence (DSE 2005). It is not designed for monitoring of rivers and streams, artificial wetlands, or marine and estuarine habitats. However, wetlands that have a connection with tidal lakes or estuaries can be assessed using the IWC (DELWP 2018).

The IWC is the standard wetland condition assessment tool for Victorian Catchment Management Authorities (CMAs), used to inform site management decisions and planning. The IWC has historically been implemented less widely by Melbourne Water. Between 2009−2018 IWC assessments (of varying standards) had been undertaken for 38 wetlands in the region (Steele 2019).

We have added more detailed vegetation assessment to the IWC with the intent of providing a more sensitive measure of vegetation responses to management (or threats, such as climate change) (Ecology Australia 2020e). Informally known as "IWC+" this has increased focus on floristics to detect change in species composition over time, the addition of quadrats and allocating flora species to eco-hydrological categories (Ecology Australia 2019d, 2020e).

As the IWC is the method to be used across all five waterway conditions, the approach to data collection and storage using this method is presented in a common section below. For each waterway condition, a description of the audience, relevant indicators, monitoring objectives, evaluation and emerging monitoring methods is presented against each waterway condition.

17.6 Data Collection

How -

Data collection will be undertaken in line with the IWC manual (*Index of Wetland Condition assessment procedure February 2018*, DELWP, 2018).

Where modifications to the IWC methodology have been made, these have been identified in the appropriate wetland waterway condition section. The bulk of IWC

assessments in the PPW region are anticipated to be commissioned by Melbourne Water under this Wetland MEP. However, other agencies or individuals may undertake IWC assessments in the region. IWC assessment data are managed centrally by the Victorian DELWP. This database will be interrogated for additional IWC assessments at the time of evaluation.

Where -

Modified IWC assessments will be undertaken at a subset of the priority wetlands. Wetlands with predominantly social values and constructed wetlands will not be assessed through IWC. The full list of priority wetlands – ideally - to be monitored using this method is included in Appendix B.

When -

Sampling of priority wetlands will be undertaken on a rolling basis, as outlined in **Error! Reference source not found.**. Note that: where wetlands have been dry for extended periods (over several years for example), there may be a significant reduction in the abundance and cover of wetland plants. In the event that wetland plants are very scarce or absent due to drought, this should be documented, and the wetland vegetation (Biota sub-index) should not be assessed (DELWP 2018).

17.7 Data storage, processing and access

Table 51 below provides a summary of where IWC data will be stored, how it can be accessed and processing requirements.

Table 51. Summary of data storing processing and access requirements for Water Regime.

Monitoring method	Data storage	Data access requirements	Data processing requirements	Data processing responsibility
IWC +	MS Access database at: I:\MEL\1. SHARED FOLDERS (Waterways Group) Inflo Migration\Cross Team Information\Investigations Programs\....	Melbourne Water internal folder	Metric calculations through MS Excel at each priority wetland	Melbourne Water/ Integrated Planning (score calculation)
IWC	State IWC database: https://iwc.vic.gov.au/home	Annual submission of new IWC assessments		

17.8 Evaluation - data analysis and reporting

Mid-term evaluation

Table 52 describes the rubric which will be used to assess wetland condition in relation to long-term targets. The assessment will be made at the wetland scale, for wetlands where there are data available. The targets for wetland conditions are expected to be achieved over a 20-year scale. Thus major changes are not expected following only four years of strategy implementation.

As the data underpinning the 2018 assessments for wetlands was, in many cases, insufficient, and new monitoring methods have been adopted, it is likely that a new baseline will need to be set (pending a review of how the 2018 and mid-term, 2022, data compare). Full evaluation is likely only at the end of this HWS, in 2026--28. Where possible an assessment of trends will be made at the catchment scale.

Table 52. Rubric for assessing performance against long term HWS targets for wetland waterway conditions at the mid-term review (2026).

Performance rating	Performance criteria / evidence				
	Water regime	Vegetation condition	Wetland buffer	Wetland water quality	Wetland habitat form
On-track to achieving long term target	Condition score equals or has increased by one category relative to baseline at the catchment scale.				
Slightly off-track to achieving long term target	Condition score has decreased by one category relative to baseline at the catchment scale.				
Significantly off-track	Condition score has decreased by two categories or more relative to baseline at the catchment scale.				

Final evaluation

The method for final evaluation will be confirmed post mid-term evaluation but should include an assessment of climate change impacts, a re-assessment of the indicators and analysis of critical background conditions.

18 Water regime

Wetland hydrology is the key driver of many processes in a wetland. Changes in hydrology can be expressed as changes to one or more elements of the water regime (DELWP 2018). A wetland's water regime can be considered as the interaction of four factors - the depth (=extent), duration, frequency and seasonality of inundation.

The water regime condition considers alterations to the natural water regime, including those that impact source flows, interfere with natural connectivity of flows to the wetland, involve disposal of water into the wetland, extraction of water from the wetland and changed wetland depth.

18.1 Indicators

Indicators and metrics in the 2018 Healthy Waterways Strategy

For the 2018 Healthy Waterways Strategy, a metric was developed to assess the Water Regime waterway condition status at each of the, then, priority wetlands and to set long-term targets, using the AVIRA method. Due to data and time constraints, this was based on a desktop assessment of the presence of assets that would impact the water regime (such as dams, channels, levees, etc.). Data sources included the MW SoBS database, MW asset spatial layers (levees, etc.), and seasonal herbaceous wetlands assessments. Data was only available for a subset of wetlands.

An updated metric has subsequently been developed to monitor the status of the Water Regime waterway condition over the life of the strategy, based on on-ground data collection at priority wetlands. The updated metric/rubric and the indicator that underpins it are described below.

Updated indicator: Severity of change to water regime

The IWC Hydrology sub-index, a threat-based measure, will be used as the basis of measuring changes to wetland water regimes for the Strategy. The Hydrology sub-index provides a score based on the severity of the change to the water regime, made up of the extent of change to the timing, duration and frequency of inundation.

The following information is also collected to inform wetland management and interpretation of the score, but is not used to score the sub-index:

- the water source for the wetland (i.e. whether river/stream, surface water runoff, groundwater or artificial discharge), as well as the assessor's confidence in their assessment of water source and the source of information they used to make that assessment;
- activities that change the wetland's water regime;
- the assessor's confidence in their assessment of the severity of change in water regime and the source of information they used to make that assessment.

Data collection will be undertaken as per the IWC methodology (DELWP 2018), with the following additions:

- Addition of stormwater runoff to the list of "Activities that changes the wetland's water regime", as this is a regionally important threat.
- Splitting the *water regime* category into *duration* and *frequency* of inundation and using these measures (as well as timing) to score – as the water regime category is not particularly relevant in the MW region[13].

18.2 Scoring rubric

A scoring rubric was developed for the 2018 HWS to categorise Water Regime into very low to very high condition ratings. Please see the Healthy Waterways Strategy Resource Document (Melbourne Water 2020) for a description of this metric. The scoring rubric has been updated to reflect the new monitoring method and indicator (see Table 53).

Table 53. Scoring rubric for water regime waterway condition.

Category	Description (IWC Hydrology sub-index)
Very High	20
High	15
Moderate	10
Low	5
Very Low	0

Wetland hydrology management

Data underlying this score will be reported to wetland managers to enable proactive management of threats.

Changes in Water Regime score can be used to trigger management such as: provision of environmental flows, diversion/management of stormwater, removal of drains, levees etc., reconnecting wetlands to floodplains, and pumping to lower water levels.

[13] Likely changes to hydrology in many of the wetlands in MW's region are drier (with climate change, mostly in the west of the study area) or more permanently wet (with increased stormwater inflows, mostly in areas subject to urban development).

18.3 Emerging/ complementary monitoring methods

Melbourne Water has a network of surface and groundwater monitoring for high value/high risk wetland GDEs. These data are stored on Hydstra. This information will be utilised in assessing individual GDE changes and responses to management or adjacent changes in land uses.

Remote sensing of hydrology

Note that threats picked up by the IWC for hydrology (activities that change the water source) and reduction in wetland area (physical form) are focused on reduction in wetland area due to management (e.g. installation of drainage or changes to outlets), rather than reduction in wetland extent due to changes to rainfall patterns (as expected under climate change). Several remote sensing projects are in development that collect data on wetland extent and water regime for larger wetlands (see Part D and Section 19). These could be incorporated into this metric as they become available and should enable the establishment of reference conditions/benchmarking for inundation patterns as well as an increased understanding of thresholds as data is available for several decades at an interval of fortnightly/monthly over this time period, depending on conditions.

Improving data

The IWC relies on a state-wide inventory[14] for aspects of the assessment (e.g. water quality and hydrology). The scale is coarse across the state and the resolution could be improved in the PPW region to establish the reference conditions more robustly (e.g. for hydrology and water quality). The attributes will be included in the updated wetlands GIS layer for the region.

[14] Victorian Wetland Inventory (Current)/ Wetland_ Current GIS layer (DELWP)

19 Vegetation condition

Wetland vegetation is characterised by its tolerance and/or dependence on flooding. The types and abundance of vegetation present at a wetland is strongly influenced by their hydrology and physico-chemical environment (DELWP 2018). Vegetation condition refers to the extent that the 'natural' wetland vegetation is intact or displaced and modified.

19.1 Indicators

Indicators and metrics in the 2018 Healthy Waterways Strategy

For the 2018 Healthy Waterways Strategy, a metric was developed to determine the Vegetation waterway condition status at each priority wetland and to set long-term targets, using the AVIRA method. Due to data and time constraints, this was based on a desktop assessment of the condition of the Ecological Vegetation Classes (EVCs). Data sources included the MW SoBS database, aerial imagery, available reports, local knowledge, and IWC Biota sub-index data where available.

Indicators and metrics in the 2018 Healthy Waterways Strategy

An updated metric has subsequently been developed to monitor the status of the Vegetation Condition waterway condition over the life of the strategy, based on on-ground data collection at priority wetlands. The updated metric/rubric and the indicator that underpins it are described below.

Updated indicator: Biota

The IWC Biota sub-index, a threat and component-based measure, will be used as the basis of measuring changes to vegetation condition for the Strategy. The Biota sub-index provides a score based on the condition of the EVC, made up of assessments of critical lifeforms; presence of weeds; indicators of altered processes; and vegetation structure and health.

The following information is also collected to inform wetland management and interpretation of the score, but is not used to score the sub-index:

- the assessor's confidence in their assessment
- the source of information they used to make that assessment
- EVC name
- Critical life forms present
- Species list

Data collection will be undertaken as per the Ecology Australia IWC+ methodology (Ecology Australia 2019d), itself based on the IWC. IWC + additions to the standard IWC (that are not scored, but will be used for long term assessment of site change in response to climate change and/or to inform management) include transects and quadrats for long term monitoring of:

- Plant functional groups (hydro-ecological)
- Weed species (cover/abundance rating)
- Native species (cover/abundance rating)

19.2 Scoring rubric

A scoring rubric was developed for the 2018 HWS to categorise Vegetation Condition into very low to very high condition ratings. Please refer to the Healthy Waterways Strategy Resource Document (Melbourne Water 2020) for a description of this metric/rubric. The scoring rubric has subsequently been updated to reflect the new monitoring method and indicator (see Table 24).

Table 24. Scoring rubric for Vegetation Condition waterway condition.

Category	Description (IWC+ Biota sub-index)
Very High	>18–20
High	>16–18
Moderate	>13–16
Low	>8–13
Very Low	0–8

Wetland vegetation management

Data underlying this score will be reported to wetland managers to enable proactive management of threats.

Changes in Vegetation Condition score can be used to trigger management such as: revegetation, weed control, modifying hydrology, pest animal control, exclusion fencing, development of management plans, prevention of runoff drainage/nutrient management, installing signage regarding site values, increased wetland buffer width.

20 Wetland buffer condition

A wetland buffer is the area of native vegetation adjacent to a wetland, above the maximum inundation extent. Wetland buffers provide habitat and protection for native species and filter water flowing overland. For the purposes of monitoring wetland buffers in the HWS, native vegetation is defined as vegetation where the overstorey (if present) is predominantly native, and native species make up more than 25% of the total understorey cover in line with the IWC. Areas of revegetation are classed as native vegetation if they simulate the natural EVC and meet the above criteria (DELWP 2018).

20.1 Indicators

Indicators and metrics in the 2018 Healthy Waterways Strategy

For the 2018 Healthy Waterways Strategy, a metric/rubric was developed to assess the Wetland Buffer waterway condition status at each priority wetland and to set long-term targets, using the AVIRA method. Due to data and time constraints, this was based on a desktop assessment of buffer presence, average width and percentage perimeter cover. Data sources included EVC mapping and aerial imagery.

An updated metric has subsequently been developed to monitor the status of the Wetland Buffer waterway condition over the life of the strategy, based on on-ground data collection at priority wetlands. The updated metric/rubric and the indicator that underpins it are described below.

Updated indicator: Wetland Catchment (buffer)

The IWC Wetland Catchment sub-index, a component-based measure will be used as the basis of measuring changes to Wetland Buffer Condition for the Strategy. The Wetland Catchment sub-index provides a score based on the wetland buffer width and continuity, made up of the average width of buffer and the percentage of the wetland perimeter with a buffer.

The following information is also collected to inform wetland management and interpretation of the score, but is not used to score the sub-index:

- Land use intensity within 250 m of the wetland.

Data collection will be undertaken as per the IWC methodology (DELWP 2018), with the following additions:

- IWC+ data from quadrats within the buffer will also be used to assesses changes to buffer vegetation over time and to inform management.

20.2 Scoring rubric

A scoring rubric was developed for the 2018 HWS to categorise Wetland Buffer Condition into very low to very high condition ratings. Please refer to the Healthy Waterways Strategy Resource Document (Melbourne Water 2020) for a description of this metric/rubric. The scoring rubric has been updated to reflect the new monitoring method and indicator (see Table 25).

Table 25. Scoring rubric for Wetland Buffer waterway condition.

Category	Description (IWC Wetland Catchment sub-index: wetland buffer width continuity score)
Very High	>8–10
High	>6–8
Moderate	>4–6
Low	>2–4
Very Low	<2

Wetland management

Data underlying this score will be reported to wetland managers to enable proactive management of threats.

Changes in Wetland Buffer score can be used to trigger management such as: revegetation, exclusion fencing, weed control, pest animal control, development of management plans, installing signage regarding site values and increasing wetland buffer width.

20.3 Emerging/ complementary monitoring methods

Improving data

Currently land use is considered within a 250 m buffer. Whether this can be refined for wetland types (e.g. different objectives for buffer if water is from overland flow or groundwater, as well as habitat requirements e.g. grassland vs treed landscape) to create a buffer typology will be investigated over the life of the strategy.

Mapping of individual waterbody catchments is being undertaken by the University of Melbourne research team. This will be useful for mapping land use threats and catchment land cover metrics (such as impervious cover, tree cover, etc.) Other work includes wetland vegetation cover estimates using remote sensing data.

21 Wetland water quality

Wetland water properties, whether chemical (e.g. dissolved oxygen, nutrients, pH, salinity) or physical (e.g. temperature, turbidity), influence many biotic components of wetlands and their processes such as fauna survival, feeding, growth and reproduction, and flora growth. Wetland Water Quality considers changed water properties within the wetland including nutrient concentrations, salinity regime and the disturbance of potential or actual acid sulphate soils (DELWP 2018).

21.1 Indicators

Indicators and metrics in the 2018 Healthy Waterways Strategy

For the 2018 Healthy Waterways Strategy, a metric/rubric was developed to assess the Wetland Water Quality waterway condition status at each priority wetland and to set long-term targets, using the AVIRA method. Due to data and time constraints, this was based on a desktop assessment of altered salinity and the potential for activation of acid sulfate soils (ASS). Data sources included reports, local knowledge, IWC Water Properties sub-index data, the MW SoBS database, adjacent land use and ASS potential mapping. Data was only available for a subset of wetlands.

An updated metric has subsequently been developed to monitor the status of the Wetland Water Quality waterway condition over the life of the strategy, based on on-ground data collection at priority wetlands. The updated metric/rubric and the indicator that underpins it are described below.

Updated indicator: Water properties

The IWC Water Properties sub-index, a threat-based measure, will be used as the basis of measuring changes to water quality for the Strategy. The Water Properties sub-index provides a score based on the

- Severity of nutrient enrichment
- Severity of change in salinity

The following information is also collected to inform wetland management and interpretation of the score, but is not used to score the sub-index:

- Nutrient enrichment/salinity threat
- Confidence in assessment
- Information source
- Evidence of nutrient enrichment/salinity change

Data collection will be undertaken as per the IWC methodology (DELWP, 2018), with the following additions (not used to score the sub-index):

- Activation of acid sulphate soils

- Additional threats added to nutrient enrichment list (wastewater/liquid waste disposal, solid waste disposal/landfill, stormwater runoff and infiltration).

21.2 Scoring rubric

A scoring rubric was developed for the 2018 HWS to categorise Water Quality into very low to very high condition ratings. Please refer to the Healthy Waterways Strategy Resource Document (Melbourne Water 2020) for a description of this metric/rubric. The scoring rubric has been updated to reflect the new monitoring method and indicator (see Table).

Table 56. Scoring rubric for Water Quality waterway condition.

Category	Description
Very High	>17–20
High	>13–17
Moderate	>9–13
Low	>5–9
Very Low	0–5

Wetland management

Data underlying this score will be reported to wetland managers as frequently as possible to facilitate management of threats.

Changes in Wetland Water Quality score can be used to trigger management such as: implementing stormwater management (e.g. disconnecting stormwater, water sensitive urban design), pest animal control (i.e. of animals that stir up sediment - carp, deer etc.), exclusion fencing, development of management plans, prevention of runoff drainage/ nutrient management from farmland/gardens, modifying hydrology to flush wetland or dilute water, increased wetland buffer width or increase vegetative groundcover for filtration.

Management trigger– Acid Sulphate Soils

While onsite and during desktop preparation, the wetland assessor could look for evidence of the following:

1. The presence of changes that could lead to activation of ASS (at a mapped high-risk area), such as drainage of a given wetland.

2. Evidence of ASS activation, such as changes in the condition or floristics of the vegetation.

The indicators or variables include simple measures of presence/absence of a threat/sign or a high/medium/low rating to be combined to trigger a management response. For example, an altered water regime in a high risk (e.g. coastal) environment would trigger further investigations/management interventions to prevent the realization of the ASS threat at the site.

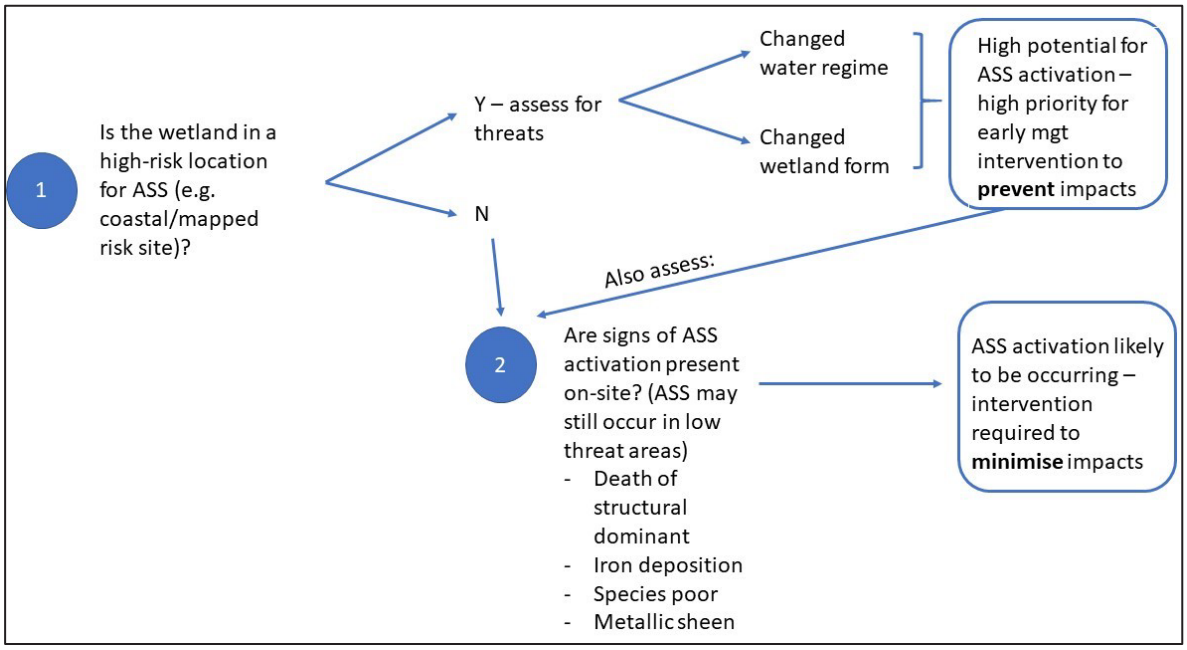

Figure 11. Potential management trigger during onsite assessment: threats leading to the activation of ASS.

21.3 Emerging/ complementary monitoring methods

Water quality sampling

Over the life of the strategy, the cost and impact of testing water quality (e.g. nutrients and salinity when the wetland is in a wet phase), rather than relying on a risk assessment will be investigated. As this would be relevant at only a small carefully selected subset of wetlands – where water quality issues threatened values – this approach is more akin to site-specific works evaluation than regional surveillance monitoring.

Further work will be decided by outcomes from the current Melbourne Water/ A3P research project investigating links between land use and wetland pollutants ("Developing methods to increase the efficiency and effectiveness of aquatic pollution assessment within rivers, wetlands and estuaries" see Part D below). Remote sensing of turbidity, chlorophyll, etc. will be investigated to improve our water quality assessments..

22 Wetland habitat form

The physical form of a wetland influences the depth and duration of inundation as well as the amount and form of available habitat. Wetland Habitat Form considers the extent that the wetland area has been reduced through levees, diversions, etc., and the extent that the wetland bed has been altered through excavation and land-forming activities. The impacts on the wetland include loss of habitat, changes in habitat, and changes in depth (DELWP 2018).

22.1 Indicators

Indicators and metrics in the 2018 Healthy Waterways Strategy

For the 2018 Healthy Waterways Strategy, a metric/rubric was developed to assess the Wetland Habitat Form waterway condition status at each priority wetland and to set long-term targets, using the AVIRA method. Due to data and time constraints, this was based on a desktop assessment of change in wetland area. Data sources included historical (1788) and current (2014) Victorian wetland GIS layers as well as the MW SoBS database, IWC Physical Form sub-index data and aerial imagery. Data were available only for a subset of wetlands.

An updated metric has subsequently been developed to monitor the status of the Wetland Habitat Form waterway condition over the life of the strategy, based on on-ground data collection at priority wetlands. The updated metric/rubric and the indicator that underpins it are described below.

Updated indicator: Soils and Physical Form

The IWC Physical Form and Soils sub-indices, impact and threat-based measures, will be used as the basis of measuring changes to Wetland Habitat Form for the Strategy. The Physical Form sub-index provides a score based on the percentage reduction in wetland area and percentage of wetland where activities have resulted in a change in bathymetry. The Soils sub-index assesses the severity and extent of wetland soil disturbance.

The following information is also collected to inform wetland management and interpretation of the score, but is not used to score the sub-index:

- Reason for reduction in wetland area
- Timing of reduction in wetland area
- Activities that change the wetland bathymetry
- Activity that causes soil disturbance

Data collection will be undertaken as per the IWC methodology (DELWP, 2018), with the following alteration:

- Combining scoring for the two sub-indices.

22.2 Scoring rubric

A metric was developed for the 2018 HWS to categorise Wetland Physical Form into very low to very high condition ratings. Please refer to the Healthy Waterways Strategy Resource Document (Melbourne Water 2020) for a description of this metric. The scoring rubric has been updated to reflect the new monitoring method and indicator (see Table 26).

Table 26. Scoring rubric for Wetland Physical Form waterway condition.

	Category	Description (IWC sub-indices)
Basic score: Physical Form	Very High	>8–10
	High	>6–8
	Moderate	>4–6
	Low	>2–4
	Very Low	<2
Modifier: Soils	Increase basic score by one category (if not already very high)	>8–10
	No change to basic score	>6–8
	No change to basic score	>4–6
	No change to basic score	>2–4
	Reduce basic score by one category (if not already very low)	<2

Wetland management

Data underlying this score will be reported to wetland managers to enable proactive management of threats.

Changes in Wetland Habitat form score can be used to trigger management such as: pest animal control (i.e. of animals that stir-up sediment - carp, deer, etc.), exclusion-fencing, development of management plans, increased wetland buffer width, blocking of drainage channels, removal of levees.

22.3 Emerging /complementary monitoring methods

Threats picked up by the IWC reduction in wetland area are focused on reduction due to management (e.g. installation of drainage or changes to outlets), rather than reduction in wetland extent due to changes to rainfall patterns (as expected under climate change). Over the life of the strategy, we will investigate whether reduction in wetland area due to changes in hydrology can be measured using emerging remote sensing approaches (see Part D and Section 19).

23 Emerging/ complementary methods for wetland monitoring

Given the sheer number of regional wetlands and the challenges associated with accessing many of them (e.g. those on private land), it is not practical to monitor all regional wetlands using an on-ground method with the anticipated budget. In any case, on-ground monitoring of ~12,000 wetlands over the timeframe implicit in the HWS is simply impossible. On the other hand, monitoring only the 250 priority wetlands means that fewer than 2% of all the wetlands in the Melbourne Water region would be subject to monitoring under this program. There are distinct weaknesses in basing region-wide assessments of wetland condition and trend on such a limited scope.

A practical option for monitoring these regional wetlands in order to resolve these questions is outlined below, for further development over the life of the strategy:

- Employing a remote-sensing approach (to be developed based on existing research/practice) that includes assessments of:
  - Wetland presence / absence (e.g. has the area since been developed and the wetland lost?)
  - Wetland extent (i.e. maximum inundation area)
  - Wetland hydroperiod (e.g. is the wetland in a wet, dry or drawing-down phase)
  - Vegetation cover and health.
  - Aspects of water quality e.g. turbidity
  - Improved capacity for temporal assessments of changes in wetted area, vegetation cover and water quality at wetlands
- Combined with the on-ground monitoring method (IWC) applied to a limited number of regional wetlands to validate the findings of the remote-sensing method.

24 Other wetlands surveillance monitoring programs

Melbourne Water and other Government agencies responsible for managing wetlands and their values also undertake monitoring programs of the region's wetlands. These are described briefly below. Data and findings from these projects will be used to inform reporting, prioritisation and future iterations of the HWS where applicable.

24.1 Melbourne Water monitoring programs

Groundwater dependent ecosystems

In 2014, Melbourne Water commissioned Arthur Rylah Institute (ARI) to develop a modified IWC for Groundwater Dependent Wetlands (IWC-GDW). This method includes an additional Groundwater Catchment sub-index and new measures of groundwater height and groundwater quality impacts, change in wetland buffer vegetation, change in wetland vegetation and risk of toxicants in wetland. As well as altered measures of severity of change in wetland water regime, nutrient enrichment and salinity. These measures include additional quadrats of vegetation to assess change in wetland vegetation floristics (Papas 2014). The IWC-GDW was used to assess high priority / high threat wetlands (Yering Backswamp, Truganina Swamp, Edithvale) in 2016, with repeat runs scheduled for 2020.

Melbourne Water undertake monitoring using the IWC-GDE, use the resulting information to assign a condition, repeat the survey in a defined period and then reassign a condition. Where a decline in condition becomes evident, Melbourne Water increases their management focus and investment.

Ramsar monitoring

Three wetland complexes within the PPW region are listed under the Ramsar Convention on Wetlands of international importance especially as waterfowl habitat: Edithvale-Seaford Wetlands, Port Phillip Bay (Western Shoreline) and Bellarine Peninsula (of which Melbourne Water's Western Treatment Plant is a key part) and Westernport. Each of these Ramsar sites has its own management plan and associated Ecological Character Description (ECD) and MERI plan, which includes various value and condition monitoring programs (water quality, bird abundance and diversity, etc.). These sites' management is summarised in Table 27.

Site management plans must be reviewed every seven years. Annual reporting against Limits of Acceptable Change (LACs) of critical Components, Processes and Services (CPS) identified in each Ramsar site's ECD is submitted to DELWP and collated in their Ramsar Management System (RMS) as part of each MERI plan.

Table 27. Ramsar wetland management in the PPW region.

Ramsar site	Site Co-ordinator	Site Manager(s)	Current Management Plan
Edithvale-Seaford Wetlands	Melbourne Water	Melbourne Water Frankston City Council	Ecology Australia (2016)
Port Phillip Bay (Western Shoreline) and Bellarine Peninsula	Corangamite CMA	Melbourne Water Parks Victoria	DELWP (2018b)
Westernport	Port Phillip and Westernport CMA	Parks Victoria	DELWP (2017)

Stormwater wetland monitoring

Within the PPW region there are more than 370 stormwater wetlands, constructed to filter stormwater using physical and biological processes prior to it entering stormwater. Melbourne Water has well-defined assessment and monitoring procedures for these constructed stormwater quality wetland assets. Programs include the monitoring of stormwater quality wetlands (an audit of maintenance needs) and remote sensing of the extent of emergent vegetation as a proxy for filtration performance.

Further information regarding these programs can be found in 'Melbourne Water Corporation Remote Sensing of Constructed Wetlands' (GHD 2018) as well as the (unpublished) wetland audit checklist spreadsheet. Furthermore, the MWRPP/A3P research program is investigating cheap and effective ways of monitoring stormwater wetland performance e.g. low cost sensors and remote sensing.

Sites of biodiversity significance

Melbourne Water's Sites of Biodiversity Significance Program identifies properties we own or manage that support significant populations of listed species or communities, and establishes a higher than usual level of land management for these sites. Sites have comprehensive management plans that are resourced and implemented, and which are to be reviewed every seven years. Sites are monitored regularly (currently a three-yearly vegetation condition and threat assessment) and specific values (i.e. listed species or communities) are regularly surveyed (Melbourne Water 2013, 2014, in prep. B).

The Program recognises 44 sites – some very large, such as the Western Treatment Plant, Eastern Treatment Plant and reservoir reserves. Not unexpectedly, given Melbourne Water's functions, most Sites of Biodiversity Significance are associated with watercourses and/or wetlands. Twenty-seven SoBS include a priority wetland and some

of these sites include multiple wetlands: the WTP (19 priority wetlands), Edithvale-Seaford Wetlands (three priority wetlands) and the ETP (two priority wetlands).

Monitoring techniques employed by the program include: permanent quadrats for flora surveys that record weed species, rare or threatened species, evidence of impacts (pest animals, litter, human disturbance) and a measure of condition against the Melbourne Water Vegetation Vision Templates. Surveillance monitoring of vegetation values is undertaken at the wetland SoBS sites (that are also priority wetlands) listed in Table 28.

Table 28. Sites of Biodiversity Significance wetlands.

Ramsar wetlands	Other SoBS wetlands
Ryans Swamp, WTP	Cardinia Creek Retarding Basin
Paul & Belfrages Wetland, WTP	Cardinia Reservoir
Austen Road Pond 1 (Summer Pond 1), WTP	Cherry Lake
Austen Road Pond 2 (Summer Pond 2), WTP	Galada Tamboore
Paradise Road Pond, WTP	Dunnetts Road Swamp
T-Section Lagoon, WTP (seven ponds)	Liverpool Road Retarding Basin
Western Lagoon, WTP (nine ponds)	Monbulk Creek Retarding Basin
Lake Borrie Ponds 28 and 29, WTP	Police Road Retarding Basin
Walsh's Lagoon Ponds 1 and 6, WTP	Riddell Road Retarding Basin (Lakewood Reserve Lake)
WTP habitat ponds (13 ponds)	Silvan Reservoir
WTP Q4 Wetland	Sugarloaf Reservoir
WTP Cherry Tree Creek pool	Tamarisk Waterway Reserve
WTP The Triangle	Tirhatuan Wetlands
Lake Borrie	Truganina Swamp
WTP operational ponds - Walshes Lagoon	Wannarkladdin Wetlands
WTP operational ponds - 85W Lagoons	Winton Wetlands, Dandenong Creek
WTP operational ponds - 25W Lagoon	Yan Yean Reservoir
WTP operational ponds - 55E Lagoon	Yering Backswamp
WTP operational ponds - 115E Lagoon	
The Spit Nature Conservation Reserve	
Edithvale North Wetland	
Edithvale South Wetland	
Seaford Wetland	

24.2 State monitoring programs

Index of Wetland Condition

As noted in the wetland conditions monitoring section of this report, IWC assessments are undertaken across the State by the Victorian DELWP, CMAs and other land managers. Data from these assessments are managed by DELWP (Index of Wetland Condition Data Management System (available at https://iwc.vic.gov.au/home).

Rolling Ramsar Review

The Ramsar Rolling Review is a national program which sets out to review all Ramsar sites every three years. The review is intended to provide regular information on the status of each Ramsar site's ecological character by comparing the condition of the critical elements against the Limits of Acceptable Change. The status of the key threats is assessed at the same time and the results of the rolling review should inform subsequent management actions to target the highest priority threats (Australian Government 2014).

The Commonwealth Government funded the development and review of Ramsar site Ecological Character Descriptions, and the updating of some Ramsar site Information Sheets between 2008/09 and 2011/12. The Commonwealth Government also funded the first round of rolling review site assessments from 2011. Thereafter, DELWP funded the second round, between 2014/15 and 2015/16 (VAGO 2016).

Remote sensing of wetland extent and water regime

This Method for the Long-term Monitoring of Wetlands in Victoria was developed by Alluvium Consulting Australia in partnership with CSIRO on behalf of DELWP for natural wetlands >1 ha in size and includes the following indicators:

- **Extent index:** maximum inundation, i.e. maximum inundated area over the assessment period, expressed relative to the historical maximum inundation extent.
- **Water regime index:**
  - water regime category/subcategory, which is a function of the frequency of inundation and duration of inundation.
  - frequency of inundation, i.e. number of years in 10 that a wetland 'holds water'
  - duration of inundation, i.e. number of months that a wetland 'holds water' for before drying
  - duration between inundation, i.e. number of months between periods when the wetland 'holds water' and
- **Vegetation index**: vegetation 'cover trends', i.e. assessment of the vegetation cover of wetlands.

The temporal assessment scale recommended by the method developers is annual (or more frequently) with trends to be reported every eight years. The authors also note that the remote sensing measures may be able to complement the IWC by providing more reliable indicators of hydroperiod and vegetation extent over time, particular where the IWC uses indirect threat measures. This facilitation of temporal analyses is an important value derived from remote sensing technologies (DELWP 2016).

Part D Research and Intervention Monitoring

25 Works effectiveness monitoring

Regional surveillance type monitoring, as described in Part B, cannot provide detailed information to explain observed changes in value over time. The results collected will be subject to many uncontrolled variables and, of necessity, will see high-level data collected for simple indicators, only occasionally, over the HWS period. Therefore, detailed works intervention studies are essential for us to understand the effectiveness of our on-ground management. Only through carefully designed studies, with control sites, replicates, and comprehensive data collection over an adequate period of time will we be able to understand and explain the true factors affecting the state of wetland conditions and the health of wetland values.

Our regional surveillance program should seek to have monitoring sites aligned to collect data for several conditions/ values when possible. But past experience shows us that it is unlikely we can get complete alignment of all regional monitoring sites, especially when some programs use citizen scientists to collect data.

Targeted works effectiveness monitoring studies should, as far as possible, focus should on (1) the condition attributes that are expected to be influenced by management, and (2) the values supported by the condition attributes that the management is targeting. Targeted works effectiveness studies, such as DELWP's WIMP and WetMAP programs, are especially required to address knowledge gaps, or points where we have poor understanding or weak associations in our HWS conceptual models (see HWS Resource document, Melbourne Water 2020). We are still learning about the relationship between interventions and the outcomes we may achieve for any given investment. Morris and Papas (2012) summarise our understanding of wetland management through conceptual models. Works intervention monitoring will test major assumptions made in the current strategy and underpin continuous improvement in wetland management strategies. Without this our investments could be severely misguided.

Ideally, 10% of all capital projects which have the stated aim of improving wetland habitat should include a properly designed and resourced works-effectiveness monitoring program. Such monitoring should extend beyond the construction/implementation phase. This presents the problem of ongoing funding for monitoring and evaluation once the capital project is completed. But Melbourne Water should arrange that a proportion of capital projects have appropriate ongoing monitoring and evaluation.

26 Current intervention monitoring projects

There are a number of wetland intervention monitoring projects being run by Melbourne Water or DELWP which will lead to improved understanding of various components of our conceptual models (see HWS Technical Resource Document, Melbourne Water 2020). These are presented in Table 60, with a selection discussed below.

Table 60. Summary of intervention monitoring projects for wetlands related to the HWS wetland conditions and key values.

Project name	Research Questions	Objectives	Study sites	Data collection
Melbourne Water programs				
Ecological monitoring program for Yarra billabongs	(1) Does environmental water delivery enable successful frog reproduction? (2) Are predatory fish species present and potentially impacting frog breeding? (3) How should we monitor frog reproduction?	To improve knowledge about the relationship between environmental water delivery and frog reproduction to support effective delivery of environmental flows.	Eight Yarra billabongs (Willsmere, Wilson Reserve, Burke Road, Bolin Bolin, Annulus, Banyule, Birrarrung, and Montpelier). Initial (2020/21) focus is Annulus Billabong, with control sites: Birrarung and Bolin Bolin. Baseline data are being collected at six other sites.	Frog species presence (songmeter) Frog life stage (field surveys) Presence of predatory fish species Water quality Habitat assessment Time-lapse camera monitoring of water depth
MERI: Birrarung billabong environmental watering sub-project	What is the response of floodplain vegetation (including mature and culturally significant River Red Gums, Floodplain Wetland Aggregate and Floodplain Riparian Woodland) to environmental watering? Secondary Q: What is the relationship between vegetation outcomes and key fauna species?	To improve knowledge about the relationship between environmental water delivery and vegetation response (including for mature trees) to support effective delivery of environmental flows working with the Wurundjeri people.	Montpellier, Burke Rd, Bolin Bolin, Willsmere and a third site TBC (Banksia St, Annulus, Baileys' Billabongs)	Water levels Flora species River Red Gum health

Project name	Research Questions	Objectives	Study sites	Data collection
Rehabilitation of former sewage treatment ponds at the WTP – salt marsh restoration	Rehabilitation of former sewage treatment ponds at the WTP – can we restore coastal saltmarsh, and its ecological functions, in a cost effective manner?	To determine vegetation (salt marsh) response to rehabilitation works.	Former Western Lagoon, WTP.	Permanent quadrats, ~ 3 yearly surveys floristics and cover
WTP shorebird pond management	How do we best manage water levels to support maximum numbers of migratory shorebirds (foraging or roosting) at key periods on their migration cycle?	To improve water management (and achieve potential water savings) at shorebird ponds at the WTP	WTP shorebird ponds	Water levels Some water chemistry parameters Shorebird numbers and activities
WTP sewage ponds as waterfowl habitat	How do we balance sewage treatment operation with the requirements for elevated nutrient levels in lower ponds (for waterfowl) and intertidal mudflat nourishment (for migratory shorebirds)	To reduce discharges to the environment concomitant with meeting Ramsar habitat requirements.	WTP operational lagoons and intertidal mudflats	Effluent flows Water chemistry Waterfowl numbers, distribution and activity Shorebird numbers, distribution and activity
Sites of Biodiversity Significance Monitoring Quadrats	Are MW's sites of Biodiversity Significance being effectively protected?	Monitor changes in values and threats. Determine whether investment in these sites is providing the necessary biodiversity outcomes.	43 Sites of Biodiversity Significance (assessed every 3 years)	Vegetation Community Vegetation Extent and Condition Recruitment Pest / Weeds Human Disturbance
Enhancing Our Dandenong Creek (EODC) native fish project	Can we successfully translocate threatened species of fish into 'constructed' habitat?	To assess the success of translocations of threatened native fish – dwarf galaxias and Yarra pygmy perch		

Project name	Research Questions	Objectives	Study sites	Data collection
Stormwater wetland performance	Testing our assumptions around stormwater wetland design and operations	To assess the validity of assumptions about stormwater wetland performance		
Cockatoo Creek floodplain	What water regime is required to support Mountain Swamp Gum habitat for the Helmeted Honeyeater and Leadbeater's Possum	Improve condition of vegetation in floodplain which is habitat for threatened species of animal.	Cockatoo Creek floodplain in Yellingbo Nature Conservation Reserve	Water levels (including groundwater) Vegetation condition
Controlling over-abundant reeds at a Ramsar Wetland	How do we best limit reed bed extent and retain shorebird foraging areas?	To maintain Ramsar LACS for key listed species at Edithvale Wetlands	Edithvale Wetlands	Red bed extent Shorebird numbers and distribution Australasian Bittern numbers
State programs				
WIMP	Vegetation response to wetland grazing (weeds, native vegetation, community assemblage relative to EVC, vegetation structure, vegetation extent, habitat for significant flora)	(i) Provide rigorous evidence of the responses of wetland attributes to management, (ii) assess if and why responses to management vary among wetlands and (iii) improve conceptual models of expected outcomes of wetland management	A selection of sites across Victoria	Vegetation
WetMAP	Identify short term responses of frogs, birds, vegetation and fish to watering events Identify the water regimes (timing, duration, frequency) needed	To identify the relationship between the delivery of environmental water and ecological responses in Victorian wetlands, and to	A selection of sites across Victoria	Birds Fish Frogs Vegetation

Project name	Research Questions	Objectives	Study sites	Data collection
	to support populations of biota Determine if current water regimes and environmental water practice are meeting these needs. Specific KEQs for fish, vegetation, birds and frogs.	understand the mechanisms that govern the movement of species across the landscape.		

26.1 Melbourne Water intervention monitoring projects

Ecological monitoring program for Yarra Billabongs

Due to the potential to deliver environmental water, billabongs of the middle Yarra have been (and continue to be) managed and monitored more intensively than the majority of other wetlands in the PPW region (with the exception of Ramsar wetlands). Melbourne Water's Environmental Water team is undertaking a multi-year project to inform their Yarra River billabong environmental water delivery program. The focus is the response of frogs to environmental water, particularly whether environmental water delivery enables and supports successful reproduction of frog species. The monitoring program is comprised of field surveys of frog species presence and life stage as well as the use of audio recordings of frog calls (song meters) at sites receiving environmental water. Results should guide future monitoring activities. Conceptual models are also being updated to describe the response of frogs to environmental watering events.

The project design is BACI, with surveys also undertaken at control sites (billabongs not receiving environmental water) and surveys undertaken prior to environmental water delivery as well as while water is present. Initial results are expected in mid-2021. For further detail regarding these monitoring programs refer to GHD (2019).

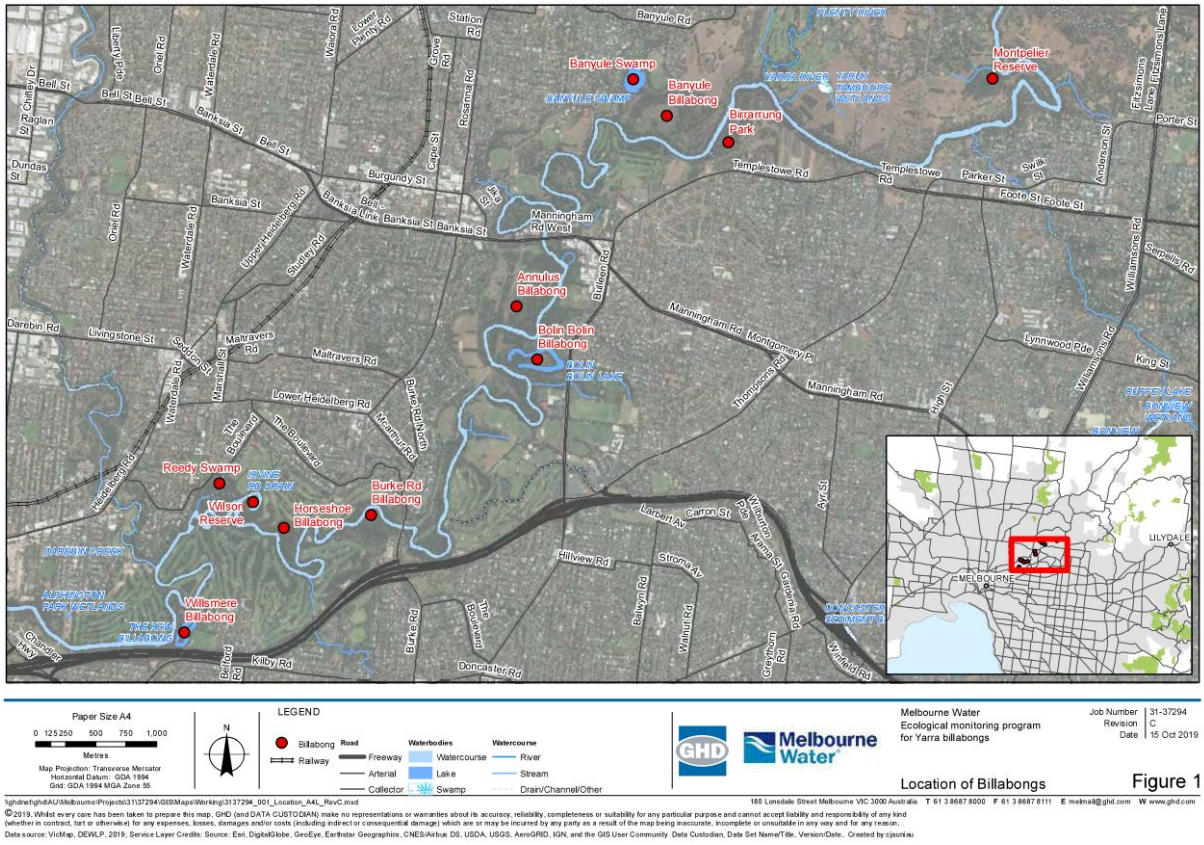

Figure 12: Yarra Billabong locations.

MERI: Birrarung billabong environmental watering sub-project

Melbourne Water's Environmental Water team are currently delivering a four-year coordinated monitoring program to assess the vegetation response to implemented watering events of Yarra's billabongs to inform their adaptive management. This involves permanent quadrats be established at several priority billabongs with varying levels of connectivity (to the Yarra) and sites with and without planned environmental watering events to assess native wetland vegetation responses to natural and implemented watering events and refine recommended water regimes. Large River Red Gums growing along the billabongs will also be monitored for tree condition and flowering (indicated improved resources for riparian biota: insects, birds and bats). It is also envisaged that the monitoring of vegetation responses to environmental watering events will be aligned with concurrent monitoring of other ecological values such as birds and frogs. This project is being continued with collaboration from the Wurrundjeri Woi Wurrung Narrap team.

Wetland bird responses to works

Professional bird surveys will be undertaken to collect quantitative count data and call-playback or other means to detect cryptic marshbirds (crakes, rails and bitterns) for works effectiveness monitoring. The works to be assessed are still to be confirmed but

are likely to include water management and pest animal control at Ramsar wetlands; installation of large woody debris in wetlands; or vegetation management to improve habitat for marsh birds, such as Latham's Snipe, crakes, rails and bitterns. Robust, standardised bird counts will be conducted that focus on the target species of bird, and their use of the site. Surveys will be conducted within a BACI experimental design, with case-appropriate frequency and timing.

Results will be assessed through changes in abundance, frequency of occurrence, or species' use of a site (e.g. observed breeding behaviours of focal species, or foraging, roosting, etc.). Studies will be commissioned by Melbourne Water or other Government agencies as appropriate.

26.2 Victorian Government intervention monitoring programs

Wetland Monitoring and Assessment Program (WetMAP)

WetMAP is a State monitoring program designed to assess the ecological response of vegetation, waterbirds and fish to the delivery of environmental water in Victorian wetlands. Its purpose is to identify the relationship between the delivery of environmental water and ecological responses in Victorian wetlands, and to understand the mechanisms that govern the movement of species across the landscape. It has indicators across four sets of biota: Birds (Rogers 2019); Fish (Cornell & Amtstaetter 2019); Frogs; Vegetation (Papas 2018).

Wetland Intervention Monitoring Program (WIMP)

WIMP is a long-term state wide monitoring program, commencing in 2017, that assesses the effectiveness of management interventions commonly applied in wetlands. The initial (current) phase assesses the impact of grazing management on vegetation. Its purpose is to provide rigorous evidence of the responses of wetland attributes to management, assess if and why responses to management vary among wetlands and improve conceptual models of expected outcomes of wetland management. The WIMP approach is appropriate for increasing confidence in the best means to implement other wetland management work.

While these programs all contribute to our understanding of wetland ecosystem response to management – and hence contribute towards meeting the HWS requirement for intervention monitoring – there is a need for investigation of further management approaches, such as effective control of introduced predators. There are also opportunities to enhance learning through expanding the above research programs into contexts relevant to our urbanised region: if we cannot graze or burn wetland buffers to manage biomass in urban wetlands how best do we manage excessive plant growth and over-abundant species?

27 Current research

27.1 Melbourne Water

A range of research projects currently are being undertaken through the Melbourne Waterway Research-Practice Partnership and the Aquatic Pollution Prevention Partnership (AP3), that were identified based on the Key Research Areas within the Healthy Waterways Strategy 2018, and include:

Melbourne Waterway Research-Practice Partnership

Spatial prioritization of management action for biodiversity outcomes in streams and wetlands (Project A1).

Habitat Suitability Models (HSMs) are spatially-explicit quantitative models that were used to prioritise management actions in the Strategy for rivers based on three key values (macroinvertebrates, fish and platypus). HSMs were used to predict the probability of a family or species presence or absence at a particular location. Environmental characteristics like temperature, streamside vegetation width, mean annual flow, antecedent flow, and Attenuated Imperviousness were important inputs to the model that explain predicted species presence or absence.

HSMs were used to explore the likely outcomes of stream biodiversity responses against different climatic and land-use scenarios resulting from climate change and urbanisation and also mitigating actions such as riparian revegetation, stormwater management and the removal of fish barriers.

The power of HSM lies in the ability to use existing data to extrapolate predictions to un-sampled locations, as well understand the likely benefits of particular management interventions (e.g. revegetation, stormwater management, protection of stream flows, removal of barriers), in isolation and in combination. Habitat Suitability Models are being developed for birds and frogs in wetlands (see Project A1 below) and are planned to be in place approximately halfway through the life of the HWS. Both field-based survey data and eDNA can and will be used to enable habitat suitability modelling of bird and frog presence at wetlands. Condition data may also be required to inform these models, such as estimates of vegetation cover and inundation.

This project will extend existing spatial tools for instream biota and develop new spatial planning tools to develop Habitat Suitability Models (HSM) for wetland-dependant biota. HSMs will be used to: identify where stream- and wetland-dependant taxa occur, assess the effects of impacts like climate and land use change and develop actions to cost-effectively optimise biodiversity outcomes.

Under Project A1 research is being undertaken by the Centre for Freshwater Ecosystems at La Trobe University on behalf of Melbourne Water (with Melbourne Water, University of Melbourne, and Geoscience Australia) to inform predictive modelling for wetlands. In

particular, to understand how land-use and wetland hydrology (cycles of wetting and drying) influence the distribution of wetland biota in the Port Phillip and Westernport region. The aim of the project is to develop species habitat suitability models that reveal biodiversity patterns across the region, thereby helping to guide investment planning in wetland protection and restoration.

The focus of the work is on modelling distributions of frogs and waterbirds, for which extensive datasets have been collected over the last several decades (particularly the period (1990−2009). While it is known that wetland hydroperiod is likely to be a strong driver of the presence/absence patterns of aquatic biota, such as frogs, historical data on the wetting and drying regime of individual wetlands in the region is extremely sparse. To overcome the lack of local hydrologic data, the project is turning its attention to the use of remote sensing to fill this data gap to map waterbodies at large spatial scales.

The project is currently trialling the use of a relatively new product referred to as the Tassled Cap Wetness (TCW) index to characterise wetland hydroperiod. The data is derived from calibrated, ortho-rectified and cloud masked satellite data produced by Geosciences Australia. Geotiffs have been generated to provide the 10th, 50th and 90th percentiles of TCW for each pixel, over the years 1987–2018. Tentative bins of TCW percentile values, representing different degrees of landscape 'wetness' have been proposed, including values that represent open and/or vegetated waterbodies such as wetlands. As part of the project the use of TCW to assess wetland inundation will be validated by comparing wetland inundation maps obtained from high resolution visual aerial photography against individual satellite derived TCW values. The project aims to characterise waterbodies individually as well as across the great Melbourne region, and to link cycles of wetland inundation extent to broader climate drivers (e.g. Bond et al. 2020; Michael Shackleton, LaTrobe Univ., pers. comm.).

Major sources and fate of sediments in streams, wetlands, estuaries and bays to inform management opportunities (Project B2).

This project builds on recent work on sediment budgets in urban headwater settings, refining the urban sediment budget and investigating observations of runoff and sediments in rural and peri-urban areas. In particular, the project will build on the development of the Sednet model of Westernport bay catchment.

Optimizing constructed wetland design, management and performance prediction (Project B3).

This project aims to inform revisions to guidelines and practice for wetland planning, design and construction, modelling and maintenance, and to inform policy regarding investments in wetland constructions and renewals. This includes understanding cheap and effective ways of monitoring stormwater wetland performance e.g. low cost sensors and remote sensing. This study overlaps with project C3, below, but focuses on stormwater wetlands only.

Understanding the interactions between groundwater, surface water and Groundwater Dependent Ecosystems (Project B4).

This project will increase understanding of the interactions between groundwater, surface water and Groundwater Dependent Ecosystems (GDEs). In particular, it will seek to quantify the age and transit time distribution of ground- and surface waters, identifying GDEs that could be at risk of contamination.

Effective, efficient indicators for monitoring Water Sensitive Urban Design asset performance (Project C3).

This project will identify cost effective indicators for WSUD performance monitoring, and incorporate them into a novel new "Expert System" for management of SCM assets. This system will identify (i) processes to involves stakeholders in the design process likely to ensure future maintenance, (ii) critical maintenance points and 'trigger indicators', (ii) required maintenance frequencies and the factors that can predict them, based on validated deterioration models.

Yellingbo hydrology works MERI program (Project D4).

This project aims to support a targeted monitoring, evaluation, reporting and improvement (MERI) program to accompany Melbourne Water hydrology works currently underway at the Cockatoo Swamp, Yellingbo Nature Conservation Reserve. It will continue to implement a comprehensive hydrological and vegetation monitoring program, that will inform adaptive management of this ecologically significant site.

The impacts of 'next generation' citizen science programs (Project E1).

This project will examine the adoption of 'next generation' digitally-mediated citizen science programs (such as the Frog Census app). In particular, it will consider the new forms of 'community' that might be supported by these technologies and the relationship with face-to-face and place-based volunteer experiences.

Long-term effectiveness of WSUD assets on private land (Project E3).

This research project will explore the long-term effectiveness of WSUD assets on private land. Initially, it will systematically review relevant academic and grey literature; eventually identifying factors and challengers that impact the long-term effectiveness of WSUD assets on private land and consider approaches to co-management and governance.

Aquatic Pollution Prevention Partnership (AP3)

Developing efficient and effective indicators and approaches to monitor the performance of stormwater wetlands to inform improved designs, appropriate maintenance regimes and long-term sustainability (Project A1.2).

In collaboration with the Melbourne Waterway Research-Practice Partnership Project B3, this project will identify which toxicants are most problematic in stormwater wetlands in terms of desilting costs and impacts on wetland performance, e.g. denitrification rates. It will also seek to develop cost-effective tools for ongoing monitoring of toxicants and associated impacts on wetland performance.

Identifying and managing emerging contaminants of concern (Project B1.1)

This project aims to keep a watching brief on the international literature for reports of new chemicals of concern, and to initiate programs in Melbourne to detect priority chemicals in the environment and, if necessary, their impacts on human health and the environment. Those chemicals warranting further investigation for their management will be dealt with in specific A3P programs.

Understanding the risk of contaminants in environmentally sensitive areas (Project B2.6)

Will focus on the impacts of pollutants on Ramsar sites and Sites of Biodiversity Significance e.g. Port Phillip (WTP habitats), Edithvale-Seaford, Deep Creek and Western Port. Includes a review of sites in relation to the key environmental values that the sites support and potential contaminant inputs. Sites for detailed field investigations will be selected annually by the project team.

Developing methods to increase the efficiency and effectiveness of waterway health assessment within streams, wetlands and estuaries (Project C3.3)

Through an analysis of current HWS conceptual models this project will identify key gaps in the knowledge of what indicators are needed to reliably predict the relationships between water quality condition and key environmental values, which will be used in developing the HWS Monitoring, Evaluation, Reporting and Improvement (MERI) framework. This project will also identify and develop new indicators (or tools) that can be used to better understand the link between water quality and stream health which ensure appropriate management options are undertaken.

Other research programs include investigating efficacy of eDNA for detecting the presence of native frog and fish species (with EnviroDNA); Smooth Newt detection (Monash University and the Invasive Species Council); and coastal vegetation (mangroves and saltmarshes) mapping in Western Port to identify opportunities where these communities might migrate inland in response to sea level rise.

27.2 Department of Environment, Land, Water and Planning

Wetland Hydrology Monitoring Project

The wetland hydrology monitoring project is a state-wide, long-term project commissioned by DELWP and to quantify the inundation histories of wetlands in Victoria from 1988 to 2017 using Landsat satellite imagery. The primary goal of the project was to improve knowledge of the water regime of wetlands in the *Victorian Wetland Inventory (Current)*. The objectives of the work included:

- characterise and track changes in the inundation patterns of individual wetlands in the Victorian Wetland Inventory (Current) over time
- improve the accuracy of the assigned water regime attributes in the Victorian Wetland Inventory (Current)

An aspatial statistical analysis of the inundation history of mapped wetlands and newly identified polygons enabled the development of two wetland databases, with the following statistics.

Individual wetland inundation statistics:
These statistics documented the proportion of each mapped wetland/newly identified polygon that was inundated for each processed Landsat image. It enables users to track each wetland/polygon's inundation patterns over time. For each mapped wetland/identified polygon, the statistics include Landsat path/row number and acquisition date, number of pixels classified as wet/dry/missing, percentage of wet areas and the first date it was identified as inundated.

Wet area 10-year rolling statistics:
These statistics were summarised from the individual wetland inundation statistics within each 10-year rolling period (i.e. 1988 to 1997, 1989 to 1998… 2008 to 2017) and the entire three decades. For each mapped wetland/identified polygon, the statistics include percentage of valid observations when the wetland/polygon was 'wet' within each season and the full years, number of wet years out of 10, mean inundation duration, and mean/longest gap between inundations.

Water regime categorisation:
The categorisation drew upon the 10-year rolling statistics to identify the appropriate water regime category defined within each 10-year rolling period and the entire period for each mapped wetland/identified polygon. Each mapped wetland in the *Victorian Wetland Inventory (Current)* was categorised as permanent, seasonal, intermittent, episodic or unknown depending on its inundation frequency and duration. In lieu of validating whether all newly identified polygons represent valid wetlands, each polygon was also assigned a water regime category within each rolling period/the entire period. The majority of wetlands (64%) were classified as unknown; smaller percentages of wetlands were classified as seasonal (22%) and intermittent (10%). Very small

percentages of wetlands were classified as permanent (2%) and episodic (1%) (DELWP 2020).

Method for the Long-term Monitoring of Wetlands in Victoria

This method was developed by Alluvium Consulting Australia in partnership with CSIRO for wetlands >1 ha in size and includes the following indicators:

- Extent index: maximum inundation, i.e. maximum inundated area over the assessment period, expressed relative to the historical maximum inundation extent.
- Water regime index:
  - water regime category/subcategory, which is a function of the frequency of inundation and duration of inundation.
  - frequency of inundation, i.e. number of years in 10 that a wetland 'holds water'
  - duration of inundation, i.e. number of months that a wetland 'holds water' for before drying
  - duration between inundation, i.e. number of months between periods when the wetland 'holds water' and
- Vegetation index: vegetation 'cover trends', i.e. assessment of the vegetation cover of wetlands.

The temporal assessment scale recommended by the method developers is annual (or more frequently) with trends to be reported every eight years. The authors also note that the remote sensing measures may be able to complement the IWC by providing more reliable indicators over time, particular where the IWC uses indirect threat measures (DELWP 2016). As part of this project, the potential for a remote sensing salinity index was investigated but abandoned because this had to be undertaken as part of on-ground monitoring (DELWP 2016). Changes in hydrology associated with sea level rise in coastal wetlands may therefore be missed by a remote sensing method such as this unless combined with another assessment method or water sampling program.

27.3 Catchment Management Authority

The Spit Saltmarsh

The PPW CMA has commissioned a study by Glenelg Nature Trust, funded by the Commonwealth Department, to investigate the factors affecting hydrological changes at The Spit Nature Conservation Reserve, and to recommend practical solutions to address these changes and improve vegetation condition.

French Island feral cat and wildlife monitoring project

The PPW CMA is working with the Office of the Threatened Species Commissioner, Parks Victoria, French Island Landcare, Zoos Victoria and expert consultants to monitor the impacts of feral cat's on native wildlife across French Island. Part of a project to eradicate feral cats from the island, this work aims to establish the 'baseline' activity of feral cats and native wildlife populations, particularly ground-nesting birds, prior to

undertaking intensive broad-scale control across the island. Funded through the Australian Government's Office of the Threatened Species Commissioner, the project team has now deployed sixty remote cameras across the island to help determine feral cat distribution and abundance. In addition to this, acoustic recorders have been strategically placed across the island to record and identify bird calls.

28 Priorities for future intervention monitoring or research

28.1 Key research questions

Key Research Areas identified in the HWS and relevant to wetlands are presented in Table 61.

Table 61. Wetland Key Research Areas identified in the HWS.

Topic	Question / need
Wetland and estuary (governance)	Developing strategic decision-making tools and frameworks for the prioritisation of management interventions for wetlands.
	Improving our understanding of management techniques that are most effective to protect and improve the ecological health of wetlands.
	Develop improved monitoring, assessment and reporting methods to understand environmental conditions and values of wetlands.
Port Phillip Bay and Western Port	Undertaking priority research projects identified in the Western Port Environment Science Review and synthesis report.
	Undertaking priority research projects identified in the Port Phillip Environmental Management Plan
	Undertaking priority research projects identified in the Ramsar management plans for the Port Phillip and Westernport region.
Aquatic biodiversity	Understanding areas of high biodiversity significance (for example, Melbourne Water's Sites of Biodiversity Significance, Ramsar) and appropriate management responses to manage key threats to environmental values.
Hydrology and environmental flows	Understanding and mitigating climate change effects on the hydrology of wetlands.
	Improving our understanding of the hydrology of floodplains, wetlands and estuaries, including groundwater-surface water interactions to protect and improve aquatic biodiversity.
	Improving our understanding of the responses of key environmental values to flow regimes to refine our environmental flow objectives
	Developing tools and frameworks to assist improved decision-making in the management of flows to meet environmental flow objectives
Liveability, community engagement and social research	Understanding aboriginal cultural values of waterways and establishing a framework to better integrate these values in waterway management decision making

In the preparation of the HWS and this Wetland MEP a range knowledge gaps have become apparent that are consistent with the identified HWS Key Research Areas.

Projects to fill these gaps may be developed over the life of the HWS to inform its implementation and future iterations of the Strategy. Priorities for future intervention monitoring and research are determined through an annual research review process. The list of priorities developed through the Wetland MEP development process (Table 62) will be considered for funding during this annual process. This table also lists key research areas outlined in the HWS.

Table 62. Summary of priorities for future wetland intervention monitoring or research projects.

Key value / condition / topic	Question / need	Additional information
Wetland trajectory	Wetlands will respond differently to climate change based on location (e.g. Victorian Volcanic Plains, Coastal, Alluvial).	Links to HWS key research theme: Understanding and mitigating climate change effects on the hydrology of wetlands.
	Wetlands have different trajectories based on level of urbanisation in catchment.	
Stormwater Quality wetlands	To what extent are stormwater quality wetlands supporting key (environmental) values or presenting 'ecological traps'?	Links to HWS key research theme: Understanding the costs and benefits of various stormwater management interventions for biodiversity, amenity and recreational outcomes
	Whether stormwater wetlands can be designed to maximise infiltration (feasibility and benefits).?	Links to HWS key research theme: Developing improved technologies and systems to support stormwater harvesting and re-use
Wetland management	Management requirements for seasonal herbaceous wetlands	• Links to HWS key research theme: Improving our understanding of management techniques that are most effective to protect and improve the ecological health of wetlands and estuaries
	Tools for managing wetlands on private land	
	Appropriate width of vegetation buffers.	
	Methods for prioritizing wetland management actions	• Links to HWS key research theme: Developing strategic decision-making tools and frameworks for the prioritisation of management interventions for wetlands and estuaries
	Methods for prioritizing wetlands during strategy development and implementation	
Other	Carbon value of wetlands	• ?
	The impact of climate change wetland flora assemblages	• Links to HWS key research theme: Understanding the potential impacts of climate change on riparian vegetation communities and opportunities to effectively build

Key value / condition / topic	Question / need	Additional information
		resilience or transition vegetation communities
Social / cultural value	Waterway condition that supports cultural values	• Links to HWS key research theme: Understanding aboriginal cultural values of waterways and establishing a framework to better integrate these values in waterway management decision making
	Key communication messages for wetland protection	• Links to HWS key research theme: • Understanding the compatibility between social and environmental values and whether management actions are required to balance potentially competing objectives
Waterway Science Conceptual Models	Are there any threats missing from the conceptual models?	Links to HWS key research theme: Improving our understanding of critical ecological processes and the ecology of key species to improve our conceptual and quantitative models
	Importance of wetlands for Platypus	
	Are the assumptions underpinning conceptual models correct?	
WSCM - fish	The influence of bed composition (diversity of bed habitat and substrate heterogeneity) on fish species richness and abundance.	• Identified as a knowledge gap in the WSCM • Links to HWS key research theme: • Improving our understanding of critical ecological processes and the ecology of key species to improve our conceptual and quantitative models
	The influence of wetland inundation regime (lateral connectivity) on fish species richness and abundance.	
WSCM - frogs	The influence of contaminants (e.g. pesticides, hydrocarbons) and some water quality parameters on frogs.	• May be investigated as part of the AP3 contamination projects (project C3.3, project B1.1, project B2.6). • Links to HWS key research themes: • Understanding the environmental impacts of pollutants, including contaminants of concern, to inform risk-based management of waterways across the region • Improving our understanding of critical ecological processes and the ecology of key species to improve our conceptual and quantitative models
	The influence of wetland habitat form (e.g. depth, gradient) for most frog species.	• Identified as a knowledge gap in the WSCM • Links to HWS key research theme: • Improving our understanding of critical ecological processes and the
	The influence of chytrid fungus on some frog species, including the interactions between the fungus,	

Key value / condition / topic	Question / need	Additional information
	frog species and wetland characteristics.	ecology of key species to improve our conceptual and quantitative models
WSCM - birds	The influence of wetland inundation extent on the species richness and abundance of birds.	• Identified as a knowledge gap in the WSCM • Links to HWS key research theme: • Improving our understanding of critical ecological processes and the ecology of key species to improve our conceptual and quantitative models
	The influence of the abundance of pest mammals (introduced predators) on birds.	
	The influence of wetland habitat form (depth and grade) on the species richness and abundance of birds.	

28.2 Sharing and adopting outcomes from research and intervention monitoring

Based on the Knowledge Exchange and Impact Framework 2018-2023 for the Melbourne Waterway Research-Practice Partnership, outcomes from research and intervention monitoring will be communicated in the following ways:

- Approaches for dissemination of main findings will depend on the target audiences, stages and outcomes of the projects. Formal communication tools (Table 61) will be the dominant approach, but informal dissemination of information (personal communication) will also be used, especially during the initial phases of development of monitoring projects. This is possible due to the relationship between Melbourne Water and Research partnerships that fosters constant communication, through meetings and hot-desk work arrangements between the two.
- Formal communication tools will be used throughout the project, and the choice and complexity of tools will depend on the stage of the project itself. Shorter communication tools (such as eBulletin), will be used at regular intervals for quick updates on the project and to communicate small important outcomes, while web-pages, for example, will be used for the duration of the project and beyond.
- Three of the most important tools (through partnerships) are meetings, presentations and publications, and their use is dictated by the formal agreement between Melbourne Water and partnering universities. In order to facilitate adoption and 'mainstreaming' of research outcomes into Melbourne Water business activities, it also may be necessary for some projects to have a 'development' stage e.g. direct seeding where we are currently refining Melbourne Water processes and procedures for capital delivery to be able to incorporate direct seeding as an alternative revegetation tool and running these as pilot projects. Development projects would be considered as part of annual project planning and would require

the identification of an appropriate Melbourne Water lead with support from researchers and other Melbourne Water staff where necessary.

Table 63. Example learning pathways and key audiences for communication of research.

Learning pathway	Key audience
Annual research summit – combined summit for MWRPP and A3P partnerships, held annually	Researchers, Melbourne Water staff, external stakeholders
Presentations at catchment forums	Catchment forums (agencies and community)
MWRPP/A3P Technical Reports	Technical staff and interested community
Academic papers	Researchers, Technical staff and interested community
Project team meetings	Researchers, Melbourne Water staff
Melbourne Water lunch time seminars (Waterways and Wetlands group seminars)	Melbourne Water staff
External stakeholder presentations	External stakeholders
Email bulletins	Melbourne Water staff, external stakeholders
Conferences (oral and/or poster presentation)	Researchers
Field/Demonstrating days	Melbourne Water staff, external stakeholders
Webpages (MWRPP and A3P)	Melbourne Water staff, public, external stakeholders
Training course on sampling techniques	Melbourne Water staff (professional development)
Newspapers (local or state)	General public
Guideline documents for monitoring	Melbourne Water and external stakeholders (CMAs)
Workshops	Melbourne Water staff, including demonstration of sampling techniques
Case studies	Melbourne Water staff, external stakeholders
Technical notes (one page document with summary of findings)	Any audience at training/workshop/demonstrating days

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Appendix A Waterbody mapping

Melbourne Water, working with the Waterways Ecosystem Research Group at the University of Melbourne, has prepared comprehensive mapping of waterbodies across the region. This mapping drew upon several sources of information:

(a) **WETLAND_CURRENT** a DELWP dataset including all known natural wetlands together with some constructed wetlands (where these are considered sufficiently significant, such as some of the Western Treatment Plant and Cheetham Wetlands ponds) (*n* = 1,239). Limitations to this dataset include (i) that natural wetlands <1 ha in area are generally excluded and (ii) most constructed waterbodies are not mapped.

(b) **DR_waterbodies** a Melbourne Water layer, updated regularly, of (then) 1,533 drainage assets. These include both constructed and modified natural wetlands. Asset types include:

- DUL – urban lakes
- DST – sediment traps/ponds
- DWL – stormwater treatment ponds
- DBS – bioretention systems

(c) **SW_Structure** a Melbourne Water layer updated regularly, of all waterbodies that are sewage treatment assets. This includes both constructed and modified natural wetlands. Asset types include wastewater stabilisation ponds, sludge drying pans, etc.

(d) **Billabong_Location** (version dated 12 November 2014). Mapping of 1,615 billabongs by SKM (2012) to identify potentially significant wetlands of the floodplains too small to have been included in DELWP's wetland mapping.

(e) **Farm_Dam_Boundaries** (version dated 24 June 2014). Mapping of 64,047 farm dams and other small constructed waterbodies, such as golf course ponds.

(f) **Extra by Grace GIS**. The result of a LiDAR-DEM based hill-shade model that identified numerous smaller depressions that would flood at times and which are likely to be important to frog breeding and dispersal. This also provided more accurate mapping of wetland edges than previous mapping.

(g) **Hallam Valley Flora report**. Mapping of Seasonal Herbaceous Wetlands across a small part of the Hallam Valley floodplain by Ecology & Heritage Partners (2018). This ground survey identified and mapped several patches of this nationally listed but difficult to identify wetland vegetation community.

(h) **Wetlands SHW75.** A mapping layer obtained from DELWP which includes potential Seasonal Herbaceous Wetlands across urban growth areas (DEPI 2013).

(i) **Rakali**. Mapping of Seasonal Herbaceous Wetlands across areas of the region by Damien Cook (Cook et al. 2013; Rakali 2018). This entailed two separate surveys:

- Rakali_SHW_Extents_QuandongRockbankStudies_201213 – a 2012 survey of the Rockbank area, and
- Rakali_SHW_Extents_SHW_ExtendedStudy_Autumn2018 – a 2018 survey.

Finally, some wetland polygons were added when known wetlands were not included in any of the above datasets. Grace Detailed-GIS Services was contracted to combine all of the different wetland mapping into a single layer (Grace GIS 2017).

Please note that 'waterbodies' are not the same as 'wetlands'. The term wetland has specific meanings under the *Water Act*.

Appendix B Regional priority wetlands

Regional wetlands were prioritised as described in Section 3 (above). High level prioritisation follows the categories described in Table B1.

Table B1. Wetland significance code.

Code	Category	Significance
A	Ramsar wetlands	International
B	IBBA (Important Bird and Biodiversity Area) - not included in Ramsar sites	International
C	SSN (Shorebird Site Network) wetlands	International
D	DIWA (Directory of Important Wetlands in Australia) - not included in Ramsar sites	National
E	Seasonal Herbaceous Wetlands (Freshwater)	National
F	Growling Grass Frog reserve wetlands	National
G	Dwarf Galaxias habitat ponds	National
H	Significant wetlands listed in previous assessments	State
I	Significant wetlands listed in previous assessments	Regional
J	Priority billabongs	Regional?
K	Melbourne Water's Sites of Biodiversity Significance (SoBS)	Regional
L	Significant wetlands listed in previous assessments	Other/ local
M	"Potential SoBS" - sites raised as potentially significant for natural values	Local
N	Southeast cluster of constructed wetlands (NHT-funded construction)	Local
O	Social value wetlands added by 2018 HWS writing team	Social
P	Other wetlands identified through co-design	Social

This prioritisation identifies 250 wetlands across the Port Phillip and Westernport Region as being of some significance. These are listed below (Table B2), with suggested values and condition monitoring requirements:

- Values: Birds – those wetlands where we would like at least quarterly bird surveys are marked as 'yes'.

- Values: Frogs/Fish – those wetlands requiring targeted surveys for threatened species are marked 'targeted'; other priority wetlands where we would like to see eDNA sampling and analysis are marked 'yes' or 'if practicable'.
- Condition and Values: Vegetation – those wetlands requiring IWC+ assessments are marked 'yes'; those requiring targeted vegetation surveys are so indicated.

It must be noted that the 2018 HWS is the first regional strategy to include wetlands in any detail. Our knowledge of wetlands across the region is limited and no prior budgets have been established for extensive monitoring of wetland conditions or values. A further factor complicating wetland monitoring is that – unlike rivers – there is no single agency with a clear designated oversight of all wetlands. Regional wetland management and monitoring must of necessity be a collaborative exercise involving DELWP, PV, Melbourne Water, Councils, community groups, Representative Aboriginal Parties, developers and even private land owners.

The level of monitoring shown in Table B2 is optimistic and unlikely to be achieved during the HWS. But this sets out our desired monitoring effort to get some data across the relevant subsets of our regional priority wetlands. Any data collection above the 2017 levels will be a useful improvement in our monitoring program.

Table B2. List of priority regional wetlands.

#	Name	Code	Value/ Condition to be monitored		
			Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
1	Ryans Swamp, WTP	A	Yes	Targeted	Yes
2	Paul & Belfrages Wetland, WTP	A	Yes	Targeted	Yes (targeted)
3	Austen Road Pond 1 (Summer Pond 1)	A	Yes	Targeted	Yes
4	Austen Road Pond 2 (Summer Pond 2)	A	Yes	Targeted	Yes
5	Paradise Road Pond	A	Yes	Targeted	Yes
6	T-Section Lagoon (seven ponds)	A	Yes	Targeted	Yes
7	Western Lagoon (nine ponds)	A	Yes	Targeted	Yes (targeted)
8	Lake Borrie Ponds 28 and 29	A	Yes	Targeted	Yes
9	Walsh's Lagoon Ponds 1 and 6	A	Yes	Targeted	Yes
10	WTP habitat ponds (13 ponds)	A	Yes	Yes	No
11	WTP Q4 Wetland	A	Yes	Yes	Yes
12	WTP Cherry Tree Creek pool	A	Yes	Targeted	Yes

#	Name	Code	Value/ Condition to be monitored		
			Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
13	WTP The Triangle	A	Yes	No	No
14	Lake Borrie	A	Yes	No	No
15	WTP operational ponds - Walshes Lagoon	A	Yes	No	No
16	WTP operational ponds - 85W Lagoons	A	Yes	No	No
17	WTP operational ponds - 25W Lagoon	A	Yes	No	No
18	WTP operational ponds - 55E Lagoon	A	Yes	No	No
19	WTP operational ponds - 115E Lagoon	A	Yes	No	No
20	The Spit Nature Conservation Reserve	A	Yes	No	Yes
21	RAAF Lake, Point Cook	A	Yes	Yes	Yes
22	Spectacle Lake, Point Cook	A	Yes	Yes	Yes
23	Edithvale North Wetland	A	Yes	Yes	Yes (targeted)
24	Edithvale South Wetland	A	Yes	Yes	Yes (targeted)
25	Seaford Wetland	A	Yes	Yes	Yes (targeted)
26	Westernport (incl. coastal wetlands)	A	Yes	Yes	Yes (targeted)
27	ETP (incl. Golden Triangle, Serpentine Lagoon, Western Holding Basin, Southern Holding Basin and Effluent Holdings Basins 1 to 6, also Forebays 9A and 9B)	B	Yes	No	No
28	'The Doughnut', ETP	B	Yes	Yes	Yes
29	Banyan Waterhole (Boundary Road Wetland)	B	Yes	Yes	Yes
30	PARCS Wetland	B	Yes	Yes	Yes
31	Boggy Creek stormwater treatment wetland	B	Yes	Yes	No
32	Braeside Park wetlands	B	Yes	Yes	Yes
33	Cheetham Wetlands	D	Yes	Yes	Yes
34	Balls Wetland Complex (no. 28 in DEPI 2013a)/ incl. Balls Swamp	E	Yes	If practicable	Yes (targeted)
35	Barnbam Swamp	E	Yes	If practicable	Yes (targeted)
36	Baths Swamp (no. 31 in DEPI 2013)	E	Yes	If practicable	Yes (targeted)

#	Name	Code	Value/ Condition to be monitored		
			Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
37	Black Forest Road Wetland (no. 44 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
38	Bulban Road Wetland (no. 38 in DEPI 2013a) not currently mapped as a waterbody	E	Yes	If practicable	Yes (targeted)
39	Chartwell No. 1 Wetland (no. 7 in DEPI 2013a; between and east of waterbody 44,930 and 44,620) not currently mapped as a waterbody	E	Yes	If practicable	Yes (targeted)
40	Chartwell No. 2 Wetland (no. 15 in DEPI 2013a) not currently mapped as a waterbody	E	Yes	If practicable	Yes (targeted)
41	Chartwell No. 3 Wetland (no. 16 in DEPI 2013a) not currently mapped as a waterbody	E	Yes	If practicable	Yes (targeted)
42	Chirnside Swamp (Chirnside-Primes Swamp [DELWP wetland 70,056])	E	Yes	If practicable	Yes (targeted)
43	Cobbledick Road Ford cluster (no. 46 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
44	Deanside West Wetland (no. 2 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
45	Donnybrook Road Lake (Donnybrook Road No. 1 Wetland, in Biosite of regional) (no. 25 in DEPI 2013a)	E	No	(lost 2018/19)	(lost 2018/19)
46	ETP north of Boggy Creek wetland	E	Yes	If practicable	Yes (targeted)
47	Former Epsom Racecourse	E	Yes	If practicable	Yes (targeted)
48	Gisborne Racecourse Swamp	E	Yes	If practicable	Yes (targeted)
49	Golf Links Road, Hallam	E	Yes	If practicable	Yes (targeted)
50	Greens Road East Wetland No. 2 (no. 43 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
51	Greens Road Rail Reserve	E	Yes	If practicable	Yes (targeted)
52	Greens Road, Manor Lakes	E	Yes	If practicable	Yes (targeted)
53	Hallam Valley	E	Yes	If practicable	Yes (targeted)
54	Hearnes Swamp (Hernes Swamp), southern remnant (no. 20 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
55	Kalkallo Common	E	Yes	If practicable	Yes (targeted)

#	Name	Code	Value/ Condition to be monitored		
			Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
56	Kalkallo Creek Wetland (no. 22 in DEPI 2013a, waterbody ID 70,700 in waterbodies integrated)	E	Yes	If practicable	Yes (targeted)
57	Kirks Bridge Road West Wetland (no. 45 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
58	Koala Conservation Reserve	E	Yes	If practicable	Yes (targeted)
59	Kororoit Creek No. 2 Wetland (no. 12 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
60	Kororoit Creek No. 3 Wetland (no. 14 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
61	Little River Wetland (DELWP wetland 70,073 or no. 47 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
62	Live Bomb Wetland (no. 41 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
63	Mambourin Wetland (no. 42 in DEPI 2013a); not currently mapped as a waterbody	E	Yes	If practicable	Yes (targeted)
64	Mt Derrimut Grassland Reserve	E	Yes	If practicable	Yes (targeted)
65	Muddy Gates Lane Complex (no. 49 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
66	Old Melbourne Road	E	Yes	If practicable	Yes (targeted)
67	One Tree Hill Swamp (no. 35 in DEPI 2013a; DELWP wetland 70,080)	E	Yes	If practicable	Yes (targeted)
68	Paynes Road (South) Swamp (no. 5 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
69	Peninsula Link Interchange	E	Yes	If practicable	Yes (targeted)
70	Rabbitters Lake (no. 29 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
71	Rabitters Swamp (no. 40 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
72	Richmonds Grass Swamp (no. 32 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
73	Rockbank No. 1 Wetland (no. 11 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
74	Rockbank Railway Swamp (no. 4 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
75	Scenic Estate Conservation Reserve	E	Yes	If practicable	Yes (targeted)
76	Target Range Swamp (no. 34 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)

#	Name	Code	Value/ Condition to be monitored		
			Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
77	Troups Road Swamp (no. 3 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
78	West Quandong Swamp (no. 37 in DEPI 2013a)	E	Yes	If practicable	Yes (targeted)
79	William Angliss Native Grassland Reserve	E	Yes	If practicable	Yes (targeted)
80	Woodlot Lane	E	Yes	If practicable	Yes (targeted)
81	Wyndham Vale Swamp (no. 6 in DEPI 2013a)	E	No	No (lost 2018/19)	No (lost 2018/19)
82	Edgars Road Swamp	E	Yes	If practicable	Yes (targeted)
83	Tarneit SHW	E	Yes	If practicable	Yes (targeted)
84	Jacana Wetlands	F	Yes	Yes	Yes (targeted)
85	Growling Grass Frog habitat ponds	F	No	Targeted	Targeted
86	Dwarf Galaxias Conservation pond	G	No	Targeted	Targeted
87	Dwarf Galaxias habitat ponds	G	No	Targeted	Targeted
88	Hallam Valley Floodplain, O'Grady Road	G	No	Targeted	Yes (targeted)
89	Yarra Flats billabongs (Yarra Glen Billabong)	H	Yes	Yes	Yes
90	Morang (Yarrambat-Morang) Wetlands, including Wilton Vale Marsh, Mother-in-Laws Leap, Tortoise Pond, NE Wetland and Carex Pond	H	Yes	Yes	Yes
91	Cockatoo Creek floodplain	H	Yes	Yes	Yes
92	Rhyll Swamp (DELWP wetland 70,870)	H	Yes	Yes	Yes
93	Altona Treatment Plant	I	Yes	Yes	No
94	Andersons Swamp	I	Yes	Yes	Yes
95	Bailie's Billabong	I	Yes	Yes	Yes
96	Baillieu Wetlands (waterbodies 13,622, 13,713, 13,711, 14,945, 16,184, etc.)	I	Yes	Yes	Yes
97	Bayles Fauna Reserve (DELWP wetland 71,973 - wb 15,375)	I	Yes	Yes	Yes
98	Beaconsfield Reservoir	I	Yes	Yes	No
99	Bevnol Road wetland (waterbodies 2885, 2887, 31,408, 31,436, 31,484, 31,485 and 70168)	I	Yes	Yes	Yes

#	Name	Code	Value/ Condition to be monitored		
			Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
100	Bingham's Swamp (DELWP wetlands 70,068 and 70,071, mistakenly referred to as Rolling Thunder Wetland, or 'Unnamed wetland 1')	I	Yes	Yes	Yes
101	Blackburn Lake	I	Yes	Yes	Yes
102	Bombing Range Dam	I	Yes	Yes	Yes
103	Browns Road Wetland (waterbody 469)	I	Yes	Yes	Yes
104	Chelsea Heights Wetland (Carrum North Wetland or Center Swamp Drain wetland)	I	Yes	Yes	No
105	Coldstream West Billabong (waterbody 14,002)	I	Yes	Yes	Yes
106	Coolart Wetlands, Somers	I	Yes	Yes	Yes
107	Cranbourne Botanic Gardens (incl. waterbody 3209?)	I	Yes	Yes	No
108	Cunningham's Swamp	I	Yes	Yes	Yes
109	Deans Marsh, Rockbank	I	Yes	Yes	Yes
110	Devilbend Reservoir	I	Yes	Yes	Yes
111	Djerriwarrh Reservoir	I	Yes	Yes	No
112	Frankston Reservoir	I	Yes	Yes	No
113	Grasmere Creek Wetland (DELWP wetland 71,118)	I	Yes	Yes	Yes
114	Greens Road West swamps (DELWP wetland 70,419 and 70,416?)	I	Yes	Yes	Yes
115	Hann's Creek Wetland (waterbodies 20,872 and 21,004)	I	Yes	Yes	Yes
116	Jensz Swamp (DELWP wetland 70,062)	I	Yes	Yes	Yes
117	Laverton RAAF Swamp (Reserve 'C')	I	Yes	Yes	Yes
118	Melba's Dam (DELWP wetland 71,754, Biosite 1587)	I	Yes	Yes	Yes
119	Melton Reservoir	I	Yes	Yes	No
120	Melton Sewage Treatment Plant	I	Yes	Yes	No
121	Mornington Peninsula National Park (DELWP wetlands 70,254, 70,255, 70,256, 70,258, 70,259, 70,260, 70,260, 70,261)	I	Yes	No (too scattered)	No (too scattered)

#	Name	Code	Value/ Condition to be monitored		
			Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
122	Mount Rothwell Homestead Dam (waterbody 12,746 now called urban lake DUL434)	I	Yes	Yes	Yes (to determine if values lost)
123	Newell's Paddock Wetlands, Footscray	I	Yes	Yes	Yes
124	Paisley Challis Wetland, Jawbone Reserve	I	Yes	Yes	Yes
125	Paynes Road North Swamp (North Swamp)	I	Yes	Yes	Yes
126	Pobblebonk Wetland Reserve (waterbodies 31,893 and 31,899)	I	Yes	Yes	Yes
127	Portsea Swamp (Portsea Lagoon Wildlife Sanctuary) (DELWP wetland 70,267)	I	Yes	Yes	Yes
128	Riverend Park Training Facility (DELWP wetland 71,167)	I	Yes	Yes	Yes
129	SERO Wetland (waterbody 70,205)	I	Yes	Yes	Yes
130	Sewells Road Dams (DELWP wetlands 70,452, 70,532, 70,446, 70,445 and 70,456)	I	Yes	Yes	Yes
131	Shepherds Bush Billabong (waterbody 14,977)	I	Yes	Yes	Yes
132	Sorrento Golf Club (DELWP wetland 70,257)	I	Yes	Yes	No
133	Toorourrong Reservoir	I	Yes	Yes	Yes
134	Tootgarook Swamp (Boneo Swamp)	I	Yes	Yes	Yes
135	Towt's Swamp, Glenvale (DELWP wetland 71,900)	I	Yes	Yes	Yes
136	Trib of Coolart Creek Wetland (waterbody 21,701)	I	Yes	Yes	Yes
137	Truemans Road Recreational Reserve (Tootgarook Wetlands) (DELWP wetland 70,272)	I	Yes	Yes	Yes
138	Unnamed wetland Larwill & Costello 1016 (Could be waterbody 19,637?)	I	Yes	Yes	Yes
139	Unnamed wetland Larwill & Costello 795A (waterbodies 23,063, 23,130, 23,131, 23,208 and 23,248)	I	Yes	Yes	Yes
140	Unnamed wetland, Boneo (DELWP wetland 70,251)	I	Yes	Yes	Yes

#	Name	Code	Value/ Condition to be monitored		
			Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
141	Unnamed wetland, Larwill & Costello 1028, Sommers (waterbody 20,376?)	I	Yes	Yes	Yes
142	Unnamed wetland, Main Ridge (DELWP wetland 70,286)	I	Yes	Yes	Yes
143	Warringal Swamp	I	Yes	Yes	Yes
144	Waterways Estate (Mordialloc Creek Wetlands)	I	Yes	Yes	Yes
145	Woodlands Estate Wetlands	I	Yes	Yes	Yes
146	Tanunda Wetlands, Whittlesea, Plenty Gorge Park (waterbodies 49,764 to 49,692)	I	Yes	Yes	Yes
147	The Briars	I	Yes	Yes	Yes
148	Bittern Reservoir	I?	Yes	Yes	Yes
149	Banyule Billabong	J	Yes	Yes	Yes
150	Banyule Swamp	J	Yes	Yes	Yes
151	Bolin Bolin Billabong	J	Yes	Yes	Yes
152	Burke Road Billabong	J	Yes	Yes	Yes
153	Domain Chandon billabongs	J	Yes	Yes	Yes
154	Spadonis Billabong	J	Yes	Yes	Yes
155	Willsmere Billabong (The Kew Billabong)	J	Yes	Yes	Yes
156	Annulus Billabong	J	Yes	Yes	Yes
157	Yallock Creek Floodplain Wetlands	J	Yes	Yes	Yes
158	Yarra Bridge Streamside reserve	J	Yes	Yes	Yes
159	Cardinia Creek Retarding Basin	K	Yes	Yes	Yes
160	Cardinia Reservoir	K	Yes	Yes	No
161	Cherry Lake	K	Yes	Yes	Yes
162	Galada Tamboore	K	Yes	Yes	Yes
163	Dunnetts Road Swamp	K	Yes	Yes	Yes
164	Liverpool Road Retarding Basin	K	Yes	Yes	Yes
165	Monbulk Creek Retarding Basin	K	Yes	Yes	Yes
166	Police Road Retarding Basin	K	Yes	Yes	Yes

#	Name	Code	Value/ Condition to be monitored		
			Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
167	Riddell Road Retarding Basin (Lakewood Reserve Lake)	K	Yes	Yes	Yes
168	Silvan Reservoir	K	Yes	Yes	No
169	Sugarloaf Reservoir	K	Yes	Yes	No
170	Tamarisk Waterway Reserve	K	No	Yes	Yes
171	Tirhatuan Wetlands	K	Yes	Yes	Yes
172	Truganina Swamp	K	Yes	Yes	Yes (targeted)
173	Wannarkladdin Wetlands	K	Yes	Yes	Yes
174	Winton Wetlands, Dandenong Creek	K	Yes	Yes	Yes
175	Yan Yean Reservoir	K	Yes	Yes	No
176	Yering Backswamp	K	Yes	Yes	Yes
177	Abey Road Wetland, Melton South (DELWP wetland 70,437?)	L	Yes	Yes	Yes
178	Altona Lakes Golf Course	L	Yes	Yes	No
179	Altona Tip Swamp (Altona Tip Wetland)	L	Yes	Yes	Yes
180	Balliang East Dam (DELWP wetland 70,109?)	L	Yes	Yes	Yes
181	Bambra Park Swamp (DELWP wetland 70,438)	L	Yes	Yes	Yes
182	Black Swamp	L	Yes	Yes	Yes
183	Cherry Swamp	L	Yes	Yes	Yes
184	Davis Swamp, Balliang East	L	Yes	Yes	Yes
185	Dry Creeks Dam, Chartwell (same as Chartwell SHW wetlands?) (DELWP wetland 70,537 multiple polygons)	L	Yes	Yes	Yes (targeted)
186	Eynesbury Road Swamp, Exford (DELWP wetland 70,431)	L	Yes	Yes	Yes
187	Green Hills Swamps (DELWP wetlands 70,579 and 70,578?)	L	Yes	Yes	Yes
188	Holden Road Wetland (previously 'Unnamed wetland 2')	L	Yes	Yes	Yes
189	Mt Cottrell Road Swamp (DELWP wetland 70,575)	L	Yes	Yes	Yes

#	Name	Code	Value/ Condition to be monitored		
			Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
190	Newport Lakes (North Lake, South Lake and smaller ponds)	L	Yes	Yes	Yes
191	O'Herns Road Swamp, Craigieburn (DELWP wetland 70,406?)	L	Yes	Yes	Yes
192	Ripley Road Swamp (DELWP wetland 70,078)	L	Yes	Yes	Yes
193	Robinson Road Swamp (waterbody 44,608?)	L	Yes	Yes	Yes
194	Ross Swamp (DELWP wetland 70,066)	L	Yes	Yes	Yes
195	Sewells Road Swamp (DELWP wetland 70,455)	L	Yes	Yes	Yes
196	Sharkeys Swamp (waterbody 12,837 now called urban lake DUL436)	L	Yes	Yes	Yes (to determine if values lost)
197	Spring Street Swamp, Beveridge (waterbodies 63,750 and 63,762 and one other)	L	Yes	Yes	Yes
198	Toorourrung Reservoir/ Plenty Creek	L	Yes	Yes	Yes
200	Werribee CSIRO Swamp (now Heathdale Glen Orden Wetland)	L	Yes	Yes	Yes (to determine if values lost)
201	Cox's Property Billabongs (wb 14188, 14192, 14197, 14836, 14840, 14907 and 14908)	M	Yes	Yes	Yes
202	Dandenong Valley Wetland (Rigby's Wetland)	M	Yes	Yes	Yes
203	Leisure Land (Langwarrin South RB)	M	Yes	Yes	Yes
240	Gordon Rolfe Reserve	M	Yes	Yes	Yes (targeted)
241	The Pines Flora and Fauna Reserve wetlands	M	Yes	Yes	No
242	French Island coastal and freshwater wetlands	M	Yes	Yes	Yes
204	Eumemmerring Creek Wetland (Frog Hollow Wetland)	N	Yes	Yes	No
205	Golf Links Road Wetland	N	Yes	Yes	No
206	Hallam Valley RB Wetland	N	Yes	Yes	No
207	Hampton Park East (Kilberry Boulevard)	N	Yes	Yes	No
208	North Heatherton Road Wetland	N	Yes	Yes	No

#	Name	Code	Value/ Condition to be monitored		
			Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
209	Hampton Park RB East (Rivergum Creek Wetland)	N	Yes	Yes	No
210	South Heatherton Road Wetland	N	Yes	Yes	No
211	Troups Creek Wetland	N	Yes	Yes	No
212	Waterford Valley Wetland (Karoo Road Wetland)	N	Yes	Yes	No
213	Albert Park Lake	O	Yes	Yes	No
214	Aura Vale Lake	O	Yes	Yes	No
215	Caulfield Park Lake	O	Yes	Yes	No
216	Coburg Lake	O	Yes	Yes	No
217	Edwardes Lake	O	Yes	Yes	No
218	Emerald Lake	O	Yes	Yes	No
219	Greenvale Reservoir	O	Yes	Yes	No
220	Hays Paddock Billabong	O	Yes	Yes	Yes
221	Jells Park	O	Yes	Yes	No
222	Kalparrin Gardens	O	Yes	Yes	No
223	Karkarook Park Lake	O	Yes	Yes	No
224	Koomba Park	O	Yes	Yes	No
225	Lillydale Lake	O	Yes	Yes	No
226	Lysterfield Lake	O	Yes	Yes	No
227	Pipemakers Park	O	Yes	Yes	No
228	Pykes Creek Reservoir	O	Yes	Yes	No
229	Queens Park	O	Yes	Yes	No
230	Ringwood Lake	O	Yes	Yes	No
231	Rossalynne Reservoir	O	Yes	Yes	No
232	Westgate Park	O	Yes	Yes	Yes
233	Wilson Botanic Park, Berwick	O	Yes	Yes	Yes
234	Lang Lang Floodplain Wetlands	P	Yes	Yes	Yes
235	Brushy Creek Sed Ponds	P	No	No	No

#	Name	Code	Value/ Condition to be monitored		
			Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
236	Hawkstowe Wetlands	P	No	No	No
237	Laurimar Park Estate Wetlands	P	No	No	No
238	Mill Park Lakes	P	No	No	No
239	Simons Creek Wetland	P	No	No	No
243	Button-grass Wetland, Bunyip	I	No	If practicable	Yes (targeted)
244	Bass Recreation Reserve Billabong	J	Yes	Yes	Yes
245	Swan Lake	I	Yes	Yes	Yes
246	Kitty Miller Wetlands	I	Yes	Yes	No
247	Tooronga Plateau wetlands	H	No	If practicable	Yes (targeted)
248	Holden Proving Ground Wetlands	L	No	If practicable	Yes
249	Wetland 72,248	E	No	No	Yes (targeted)
250	Wetland 70,662	E	No	No	Yes (targeted)

Appendix C Wetland bird species

We wish to effect changes in a 'response guild' of birds. For our purposes, wetland birds, as a whole, are considered our response guild. We wish to increase habitat for these species to improve annual survival and breeding success, and so increase both populations and species' resilience.

Wetland species of bird are defined as the "Bird families ... grebes (Podicipidae), pelicans (Pelicanidae), cormorants (Phalacrocoridae), darters (Anhingidae), herons, egrets and bitterns (Ardeidae), spoonbills and ibis (Threskiornithidae), rails and crakes (Rallidae), ducks, geese and swans (Anatidae), cranes (Gruidae), several families of shorebirds (Recurvirostridae, Charadriidae, Scolopacidae, Rostratulidae [Glareolidae, Haematopodidae) and terns (Sternidae [or Laridae])".[15]

In addition, the Orange-bellied Parrot, Azure Kingfisher, four species of passerine birds and three species of raptor are included as wetland species because of their use of wetland habitats:[16]

- Orange-bellied Parrot (*Neophema chrysogaster*)
- Azure Kingfisher (*Ceyx azureus*)
- Little Grassbird (*Poodytes gramineus*)
- Australian Reed-Warbler (*Acrocephalus australis*)
- Golden-headed Cistiocola (*Cisticola exilis*)
- White-fronted Chat (*Epthianura albifrons*)
- Swamp Harrier (*Circus approximans*)
- White-bellied Sea-Eagle (*Haliaeetus leucogaster*)
- Eastern Osprey (*Pandion haliaetus*)

Listed species (i.e. threatened or migratory) are identified in Table C1 (below).

Table C1 Wetland species of bird recorded in the Port Phillip and Westernport region (source: Birdlife Australia bird database, September 2019).

Common name	Scientific name	EPBC Act	VROT
Magpie Goose	*Anseranas semipalmata*		NT
Plumed Whistling-Duck	*Dendrocygna eytoni*		
Blue-billed Duck	*Oxyura australis*	Migratory	EN

[15] Rogers, D. (2018) 2018-19 Monitoring to Assess Bird Responses to Environmental Water Delivery in Victoria. Report prepared for Water and Catchments, DELWP Victoria by the Arthur Rylah Institute for Environmental Research, Heidelberg, Victoria; p. 3.
[16] We may include the Helmeted Honeyeater (*Lichenostomus melanops cassidix*) as a 'wetland species' following review.

Common name	Scientific name	EPBC Act	VROT
Pink-eared Duck	*Malacorhynchus membranaceus*		
Cape Barren Goose	*Cereopsis novaehollandiae*		
Black Swan	*Cygnus atratus*		
Australian Shelduck	*Tadorna tadornoides*		
Hardhead	*Aythya australis*		VU
Australasian Shoveler	*Spatula rhynchotis*		VU
Northern Shoveler	*Spatula clypeata*	Migratory	
Pacific Black Duck	*Anas superciliosa*		
Grey Teal	*Anas gracilis*		
Chestnut Teal	*Anas castanea*		
Freckled Duck	*Stictonetta naevosa*	Migratory	EN
Musk Duck	*Biziura lobata*		VU
Australian Wood Duck	*Chenonetta jubata*		
Australasian Grebe	*Tachybaptus novaehollandiae*		
Hoary-headed Grebe	*Poliocephalus poliocephalus*		
Great Crested Grebe	*Podiceps cristatus*		
Lewin's Rail	*Lewinia pectoralis*		VU
Buff-banded Rail	*Hypotaenidia philippensis*		
Australian Spotted Crake	*Porzana fluminea*		
Baillon's Crake	*Zapornia pusilla*		VU
Spotless Crake	*Zapornia tabuensis*		
Australasian Swamphen	*Porphyrio porphyrio*		
Dusky Moorhen	*Gallinula tenebrosa*		
Black-tailed Native-hen	*Tribonyx ventralis*		
Eurasian Coot	*Fulica atra*		
Brolga	*Antigone rubicunda*		VU
South Island Pied Oystercatcher	*Haematopus finschi*		
Australian Pied Oystercatcher	*Haematopus longirostris*		
Sooty Oystercatcher	*Haematopus fuliginosus*		NT
Banded Stilt	*Cladorhynchus leucocephalus*		

Common name	Scientific name	EPBC Act	VROT
Red-necked Avocet	*Recurvirostra novaehollandiae*		
Pied Stilt	*Himantopus leucocephalus*		
Grey Plover	*Pluvialis squatarola*	Migratory	EN
Pacific Golden Plover	*Pluvialis fulva*	Migratory	VU
American Golden Plover	*Pluvialis dominica*	Migratory	
Red-capped Plover	*Charadrius ruficapillus*		
Double-banded Plover	*Charadrius bicinctus*	Migratory	
Lesser Sand Plover	*Charadrius mongolus*	EN	CR
Greater Sand Plover	*Charadrius leschenaultii*	VU	CR
Oriental Plover	*Charadrius veredus*	Migratory	
Hooded Plover	*Thinornis cucullatus*		VU
Black-fronted Dotterel	*Elseyornis melanops*		
Banded Lapwing	*Vanellus tricolor*		
Masked Lapwing	*Vanellus miles*		
Red-kneed Dotterel	*Erythrogonys cinctus*		
Australian Painted Snipe	*Rostratula australis*	EN	CR
Whimbrel	*Numenius phaeopus*	Migratory	VU
Little Curlew	*Numenius minutus*	Migratory	
Eastern Curlew	*Numenius madagascariensis*	CR	VU
Bar-tailed Godwit	*Limosa lapponica*	VU	
Hudsonian Godwit	*Limosa haemastica*		
Black-tailed Godwit	*Limosa limosa*	Migratory	VU
Ruddy Turnstone	*Arenaria interpres*	Migratory	VU
Great Knot	*Calidris tenuirostris*	CR	EN
Red Knot	*Calidris canutus*	EN	EN
Ruff	*Calidris pugnax*	Migratory	
Broad-billed Sandpiper	*Calidris falcinellus*	Migratory	
Sharp-tailed Sandpiper	*Calidris acuminata*	Migratory	
Stilt Sandpiper	*Calidris himantopus*		
Curlew Sandpiper	*Calidris ferruginea*	CR	EN

Common name	Scientific name	EPBC Act	VROT
Long-toed Stint	*Calidris subminuta*	Migratory	NT
Red-necked Stint	*Calidris ruficollis*	Migratory	
Sanderling	*Calidris alba*	Migratory	NT
Little Stint	*Calidris minuta*		
Pectoral Sandpiper	*Calidris melanotos*	Migratory	NT
Latham's Snipe	*Gallinago hardwickii*	Migratory	NT
Terek Sandpiper	*Xenus cinereus*	Migratory	EN
Common Sandpiper	*Actitis hypoleucos*	Migratory	VU
Grey-tailed Tattler	*Tringa brevipes*	Migratory	CR
Common Greenshank	*Tringa nebularia*	Migratory	VU
Wood Sandpiper	*Tringa glareola*	Migratory	VU
Marsh Sandpiper	*Tringa stagnatilis*	Migratory	VU
Wilson's Phalarope	*Steganopus tricolor*		
Red-necked Phalarope	*Phalaropus lobatus*	Migratory	
Australian Pratincole	*Stiltia isabella*		NT
Oriental Pratincole	*Glareola maldivarum*	Migratory	
Black Noddy	*Anous minutus*		
Silver Gull	*Chroicocephalus novaehollandiae*		
Pacific Gull	*Larus pacificus*		NT
Kelp Gull	*Larus dominicanus*		
Bridled Tern	*Onychoprion anaethetus*	Migratory	
Little Tern	*Sternula albifrons*	Migratory	VU
Fairy Tern	*Sternula nereis*	VU	EN
Australian Gull-billed Tern	*Gelochelidon macrotarsa*		EN
Caspian Tern	*Hydroprogne caspia*	Migratory	NT
Whiskered Tern	*Chlidonias hybrida*		NT
White-winged Black Tern	*Chlidonias leucopterus*	Migratory	NT
White-fronted Tern	*Sterna striata*		NT
Common Tern	*Sterna hirundo*	Migratory	
Arctic Tern	*Sterna paradisaea*		

Common name	Scientific name	EPBC Act	VROT
Crested Tern	*Thalasseus bergii*		
Australian Pelican	*Pelecanus conspicillatus*		
Australasian Bittern	*Botaurus poiciloptilus*	EN	EN
Australian Little Bittern	*Ixobrychus dubius*		EN
Nankeen Night-Heron	*Nycticorax caledonicus*		NT
Cattle Egret	*Bubulcus ibis*	Migratory	
White-necked Heron	*Ardea pacifica*		
Great Egret	*Ardea alba*	Migratory	VU
Intermediate Egret	*Ardea intermedia*		EN
White-faced Heron	*Egretta novaehollandiae*		
Little Egret	*Egretta garzetta*		
Eastern Reef Egret	*Egretta sacra*		
Australian White Ibis	*Threskiornis moluccus*		
Straw-necked Ibis	*Threskiornis spinicollis*		
Yellow-billed Spoonbill	*Platalea flavipes*		
Royal Spoonbill	*Platalea regia*		NT
Glossy Ibis	*Plegadis falcinellus*	Migratory	NT
Little Pied Cormorant	*Microcarbo melanoleucos*		
Great Cormorant	*Phalacrocorax carbo*		
Little Black Cormorant	*Phalacrocorax sulcirostris*		
Black-faced Cormorant	*Phalacrocorax fuscescens*		NT
Pied Cormorant	*Phalacrocorax varius*		NT
Australasian Darter	*Anhinga novaehollandiae*		
Osprey	*Pandion haliaetus*		
Swamp Harrier	*Circus approximans*		
White-bellied Sea-Eagle	*Haliaeetus leucogaster*		VU
Orange-bellied Parrot	*Neophema chrysogaster*	CR	CR
Azure Kingfisher	*Ceyx azureus*		NT
White-fronted Chat	*Epthianura albifrons*		
Golden-headed Cisticola	*Cisticola exilis*		

Common name	Scientific name	EPBC Act	VROT
Little Grassbird	*Poodytes gramineus*		
Australian Reed-Warbler	*Acrocephalus australis*	Migratory	

Appendix D Revised Wetland Bird Value scores

Using data from Birdlife Australia's extensive regional dataset we have developed a wetland bird index (see Birdlife Australia 2020 and the final method adopted as described above in Section 13).

We have calculated this metric for five-year periods (set to represent [i] the period of the late Millennium Drought, [ii] post-drought, [iii] the 2013 HWS and [iv] the period of the 2018 HWS). Final scores are presented below for those wetlands with 20 or more suitable surveys in any time period. The effects of modifiers (i.e. no. breeding species recorded and no. listed species recorded) are explained in the table.

It is noteworthy that a number of wetlands can be seen to improve score between the first period (Millennium Drought) and the second (post-Drought). Similarly, major habitat improvement works at the WTP's Western Lagoon from 2010 can be seen to have influenced the bird index for that wetland.

Scores for the fourth period (i.e. the period of the 2018 HWS) – although only calculated for wetlands with 20 surveys – are likely to be underestimates. This score is calculated after only one year, 2018/2019, and modifiers such as listed species recorded will no doubt increase the greater the time period considered.

By the mid-term review we will have four years of data for the period of the 2018 HWS and we expect results to be comparable with preceding five-year blocks.

Table D1. Revised wetland bird community scores for wetlands (for which we have adequate survey data to generate a score).

Wetland	2003/2004 to 2007/2008	2008/2009 to 2012/2013	2013/2014 to 2017/2018	2018/ 2019
Edithvale Wetlands	High to Very High through listed species	High to Very High through listed species	High to Very High through listed species	High to Very High through listed species
Seaford Wetlands	Moderate to Very high through listed species	Moderate to Very high through listed species	Moderate to Very high through listed species	
Eastern Treatment Plant	Very High	Very High	Very High	Very High
ETP South - Serpentine Area			Low to High through listed species	
ETP - The Doughnut			Very Low	
ETP South - Turf Farm			Low to High through listed species	

Wetland	2003/2004 to 2007/2008	2008/2009 to 2012/2013	2013/2014 to 2017/2018	2018/ 2019
ETP South - Banyan Waterhole	Low to High through listed spp	Moderate to Very high through listed spp	Low to Very high through listed spp	Low to Moderate through listed spp
ETP South - Rossiter Rd Lagoon			Low to Moderate through listed spp	
ETP South - PARCS Wetland	Low to moderate through listed spp	Low	Low to Moderate through listed spp	
Boggy Creek, Carrum			Low	
Braeside Park	Very low to Moderate through listed spp	Low to High through listed spp	Low to Moderate through listed spp	
Wannarkladdin Wetlands - East			Very Low	
Wannarkladdin Wetlands - North			Very low	
Wannarkladdin Wetlands - West			Low	
Monbulk Creek RB (Birdsland)			Low	Low to Moderate through breeding spp
Riddell Rd RB (Lakewood Nature Reserve)			Low	
Tirhatuan Wetlands			Very low	Very low
Winton Wetlands			Very low	Very low
Namatjira Wetlands (Clayton South Wetland)			Low	
Karkarook Park		Very low to Moderate through listed spp	Low to High through listed spp	
Jells Park Lake			Low to High through breeding spp	Low to High through breeding spp
Berwick Springs Wetlands			Low to Moderate through listed spp	
Shepherd's Bush Billabong			Very low	
Cranbourne Botanic Gardens wetlands		Very low to Moderate through breeding spp	Very low to Moderate through breeding spp	Very low

Wetland	2003/2004 to 2007/2008	2008/2009 to 2012/2013	2013/2014 to 2017/2018	2018/ 2019
Lysterfield Lake		Very low	Low	
Dandenong Wetlands, Koomba Park			Very low	Very low
Dandenong Valley Wetland (Rigby's Wetland)		Moderate	Low to high through listed spp	Low
Woodlands Estate Wetlands			Moderate to High through listed spp	
Springvale Road Wetlands		Moderate	Low to Moderate through listed spp	
Koomba Park North			Very low	Very low
Waterford Wetlands		Low to Moderate through breeding spp	Low	
Heatherton Rd North Wetland		Low to moderate through breeding and listed spp	Low	
Heatherton Rd South Wetland		Low to Moderate through listed spp	Low	
Frog Hollow Wetland		Low to Moderate through breeding spp	Low to Moderate through breeding spp	
Golf Links Rd Wetland		Low	Low	
Hallam Valley Floodplain		Moderate to high through breeding spp	Moderate	
Hallam Valley Floodplain, Troups Creek		Moderate	Moderate	
Kilberry Boulevard		Low	Low	
River Gum Creek Reserve		Moderate to high through breeding spp	Moderate	
Flemington Racecourse			Low	
Valley Lake Reserve			Very Low	
Cheetham Saltfields			High to Very high through listed spp	
RAAF Lake			Very Low	

Wetland	2003/2004 to 2007/2008	2008/2009 to 2012/2013	2013/2014 to 2017/2018	2018/ 2019
Cherry Lake			Moderate	Low to Moderate through listed spp
Truganina Swamp			Low to High through listed spp	Moderate
Jawbone Reserve		Moderate to Very high through listed species	Moderate to Very high through listed species	Moderate
Newport Lakes		Low to moderate through breeding spp	Low to moderate through breeding spp	Very Low
Western Port	Very low to very high through listed spp	Low to Very high through listed spp	Low to Very high through listed spp	Low to Very high through listed spp
Devilbend Reservoir	Moderate to high through listed spp	Moderate to high through listed spp	Moderate	
Tootgarook Swamp			Low to Moderate through listed spp	
Sanctuary Park Reserve			Low	
Truemans Road Landfill			Very Low	
Woods Reserve	Very low	Very low	Very low	
Coolart Lagoon			Low to High through breeding spp	Very low
Jacana Wetlands (North)			Low	
Trin Warren Tam-boore Wetlands			Low to Moderate through breeding spp	
PG-Marshland/Carex /Tortoise Pond			Low to Moderate through breeding spp	
PG- Mother in Law's Leap			Very Low	
PG- North East Wetland			Low to High through breeding spp	
Ruffey Lake Park			Very Low to Moderate through breeding spp	
Westgate Park	Low to High through breeding spp	Low to Moderate through breeding spp	Low	
Ringwood Lake Reserve North			Very Low	Very Low

Wetland	2003/2004 to 2007/2008	2008/2009 to 2012/2013	2013/2014 to 2017/2018	2018/ 2019
Spadonis Reserve Central		Very low		
Albert Park Lake			Very Low	
Bailey's Billabong			Very low	
WTP - Lake Borrie	Very low	Low to Moderate through listed spp		
WTP - T Section Lagoon	Very low to Very high through listed species	Moderate to Very high through listed species	Moderate to Very high through listed species	
WTP - Western Lagoon	Very low	Low to Very high through listed spp	Low to Very high through listed spp	
WTP - 35E Pond 8 Conservation Pond	Very low	Low to Moderate through listed spp	Very low to Moderate through listed spp	
WTP - 35E Pond 9 Conservation Pond		very Low to Moderate through listed spp	very Low to Moderate through listed spp	
WTP - 5W Ponds 9, 10 and 19	Very low	Very low to moderate through listed spp	Very low to High through listed spp	Very low to moderate through listed spp
WTP - 270S Borrow Pit	Very low	Low to High through listed spp	Low to High through listed spp	
WTP - 85WC Pond 17	Very low	very Low to Moderate through listed spp	very Low to Moderate through listed spp	
WTP - Summer Pond 1			Very low to Moderate through listed spp	
WTP - Summer Pond 2		Low to Very high through listed spp	Low to Very high through listed spp	

Appendix E Regional frog species

Frog species recorded in the Port Phillip and Westernport Region since 1836[17][18] are listed below. Common names given first follow Cogger 2014.[19]

Table E1. Frog species reported from the Port Phillip and Westernport Region.

Common name	Scientific name	EPBC	FFG	VROT	Allocated Guild[20][21][22]
Eastern Sign-bearing Froglet (Plains Froglet)	*Crinia parinsignifera*				
Common Eastern Froglet	*Crinia signifera*				Generalist pond frog
†Smooth Frog	*Geocrinia laevis*				
Eastern Smooth Frog (Victorian Smooth Froglet)	*Geocrinia victoriana*				Terrestrial breeder
†Western Banjo Frog	*Limnodynastes dorsalis*				
Eastern Banjo Frog	*Limnodynastes dumerilii*				Generalist pond frog/ Stream breeder
Brown-striped Frog (Striped Marsh Frog)	*Limnodynastes peronii*				Generalist pond frog
Spotted Grass Frog (Spotted Marsh Frog)	*Limnodynastes tasmaniensis*				Generalist pond frog
Brown Tree Frog (Southern Brown Tree Frog)	*Litoria ewingii*				Generalist pond frog
*Eastern Dwarf Tree Frog	*Litoria fallax*				
Lesueur's Frog (Rocky River Frog)	*Litoria lesueuri*				Obligate stream breeder
Victorian Frog (Plains Brown Tree Frog)	*Litoria paraewingi*				
Peron's Tree Frog	*Litoria peronii*				Generalist pond frog
Southern Bell Frog (Growling Grass Frog)	*Litoria raniformis*	VU	listed	EN	Wetland dependent

[17] Hamer 2011.
[18] van der Ree & Seck 2019.
[19] Cogger 2014.
[20] DELWP 2015.
[21] Gillespie & Hines 1999.
[22] Thomson et al. 2018.

Common name	Scientific name	EPBC	FFG	VROT	Allocated Guild[2021][22]
Verreaux's Tree Frog (Whistling Tree Frog)	*Litoria verreauxii*		listed		Generalist pond frog
Sudell's Frog (Common Spadefoot Toad)	*Neobatrachus sudelli*				
Haswell's Froglet (Red-groined Froglet)	*Paracrinia haswelli*				Generalist pond frog
Brown Toadlet (Bibron's Toadlet)	*Pseudophryne bibronii*		listed	EN	Wetland dependent
Southern Toadlet	*Pseudophryne semimarmorata*			VU	Wetland dependent/ terrestrial breeder
†Dendy's Toadlet	*Pseudophryne dendyi*				Terrestrial breeder

* Introduced/ naturalized population.

† Doubtful species record.