MID-TERM REVIEW

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

Platypus

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

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

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Glossary of terms and abbreviations

AI	Attenuated Imperviousness
APC	Australian Platypus Conservancy
BAUF	business as usual future (for 2068)
CPUE	catch-per-unit-effort
CURR	current, 2018 baseline
DCI	Directly Connected Imperviousness
EA	Ecology Australia
eDNA	environmental DNA
HSM	habitat suitability model
HWS	Healthy Waterways Strategy 2018
MW	Melbourne Water
Platypus community	platypus individuals that can interact with one another within distinct river reaches including across multiple connected river systems (e.g. platypus community at Emu Creek and Deep Creek at Bulla)
Platypus population	a platypus community or multiple communities that are physically connected and share similar genetic characteristics
Platypus survey location	the reaches making up a live-trapping survey area. Multiple platypus survey sites are contained within a survey location.
Platypus survey site	the location of paired fyke nets within a platypus survey location (usually 4-6 sites within one location).
RCP	Representative Concentration Pathways: a greenhouse gas concentration (not emissions) trajectory adopted by the Intergovernmental Panel on Climate Change.
SCPO	Sub-catchment Performance Objective
SMP	Strategic Management Plan
Strategy	refers in this instance as the Healthy Waterways Strategy 2018
UBG	urban growth boundary

Acknowledgement of Traditional Owners

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

Evaluation overview

This report is one of several background reports feeding into the Healthy Waterways Strategy (HWS) mid-term review Science Inquiry (Melbourne Water 2023a).

It presents an evaluation of platypus status which is a key value in the HWS. The extent to which this technical report has evaluated each key evaluation question (KEQ), and their sub-KEQs, with respect to platypus as a value is summarised in Table 1.

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

KEQ	Sub-KEQ	Relevance to this report and overview
1 – To what extent have the performance objectives of the Strategy been achieved?	1a. To what extent has collaboration and co-delivery contributed to achieving the Performance Objective targets so far?	This will be answered through the Implementation Inquiry (Melbourne Water, *in prep*).
	1b. To what extent is strategy delivery on track to achieve the Performance Objective targets by 2028?	An overview of progress towards platypus related performance objectives is provided in Section 2.
3 – What is the state of waterway values?	3a. To what extent are key values on the target trajectory?	This question is evaluated for platypus in Section 3. We answer this question using two rubrics, each at a different spatial scale: 1. HWS sub-catchment scale - using Habitat Suitability Model predictions and eDNA survey data; and 2. Platypus community scale - 15 platypus communities where we have long-term live-trapping data, and using abundance, health, and distribution change information specific to each community.
	3b. What other spatial and temporal trends and patterns for key values are of significance for implementation?	This question is evaluated for platypus in Section 3. We focused this question on the following trends and patterns not highlighted in KEQ 2a but considered important for implementation: distribution changes at the sub-catchment scale, noteworthy health trends, and issues relating to data management and the suitability of the abundance metric we use.
2 – To what extent has progress been made towards the longer-term environmental condition targets for rivers, wetlands and estuaries?	2a. What environmental conditions (e.g. Water quality) and external conditions (e.g. policy) help explain current key value trends?	This question is evaluated for platypus in Section 3.
	2b. To what extent have projected known and emerging future threats changed from	A list of threats to platypus are provided in Section 4. Further information on threats is

KEQ	Sub-KEQ	Relevance to this report and overview
	2018? Have any assumptions about impacts to key values changed?	outlined in the Threat Technical Report (Melbourne Water 2023b)
4 -To what extent have the delivery methods of the Strategy been appropriate, effective, and efficient?	4a. To what extent are interventions appropriate and effective for achieving outcomes?	Section 4 provides an overview of interventions relevant to platypus management including where intervention monitoring is underway. Evaluation of interventions is presented in the Interventions Technical Report (Melbourne Water 2023c).
	4b. What are the key remaining knowledge gaps that need to be addressed in the next 5 years to improve strategy delivery or prepare for the next HWS?	Section 4 provides a summary of recent research and questions relating to platypus. Identification of remaining knowledge gaps is provided in the Science Inquiry Report (Melbourne Water 2023a).
	4c. How can collaborative governance enable effective and efficient delivery of the Strategy?	This will be answered through the Implementation Inquiry report (Melbourne Water, *in prep*).

Recommendations made within this document will relate to the delivery of the HWS and the attainment of targets across the time frame. They will be based on whether there is sufficient evidence to suggest an area of concern that would benefit from a near-term response.

1. Overview of platypus value

The platypus has been identified as a key environmental value in the Healthy Waterways Strategy (HWS) in recognition of the vital role they play in aquatic ecosystems as an apex predator and the high level of community interest around this unique native species.

Since the start of the current HWS in 2018, the Victorian Government has declared platypus a threatened species and listed them as vulnerable in Victoria. Further, the Flora and Fauna Guarantee Scientific Advisory Committee Preliminary Recommendations on a nomination for listing platypus as Vulnerable (FFG, July 2020) state that across Victoria "*the primary threat to platypuses appears to be reduction in surface water and flows due to drought, altered flow regimes and water extraction for domestic, industrial and agricultural purposes*". This listing solidifies the importance of this value within the HWS.

Platypus are thought to be historically widespread across major waterways in the Melbourne region (

Figure 1). However, their distribution has now substantially contracted (Figure 2).

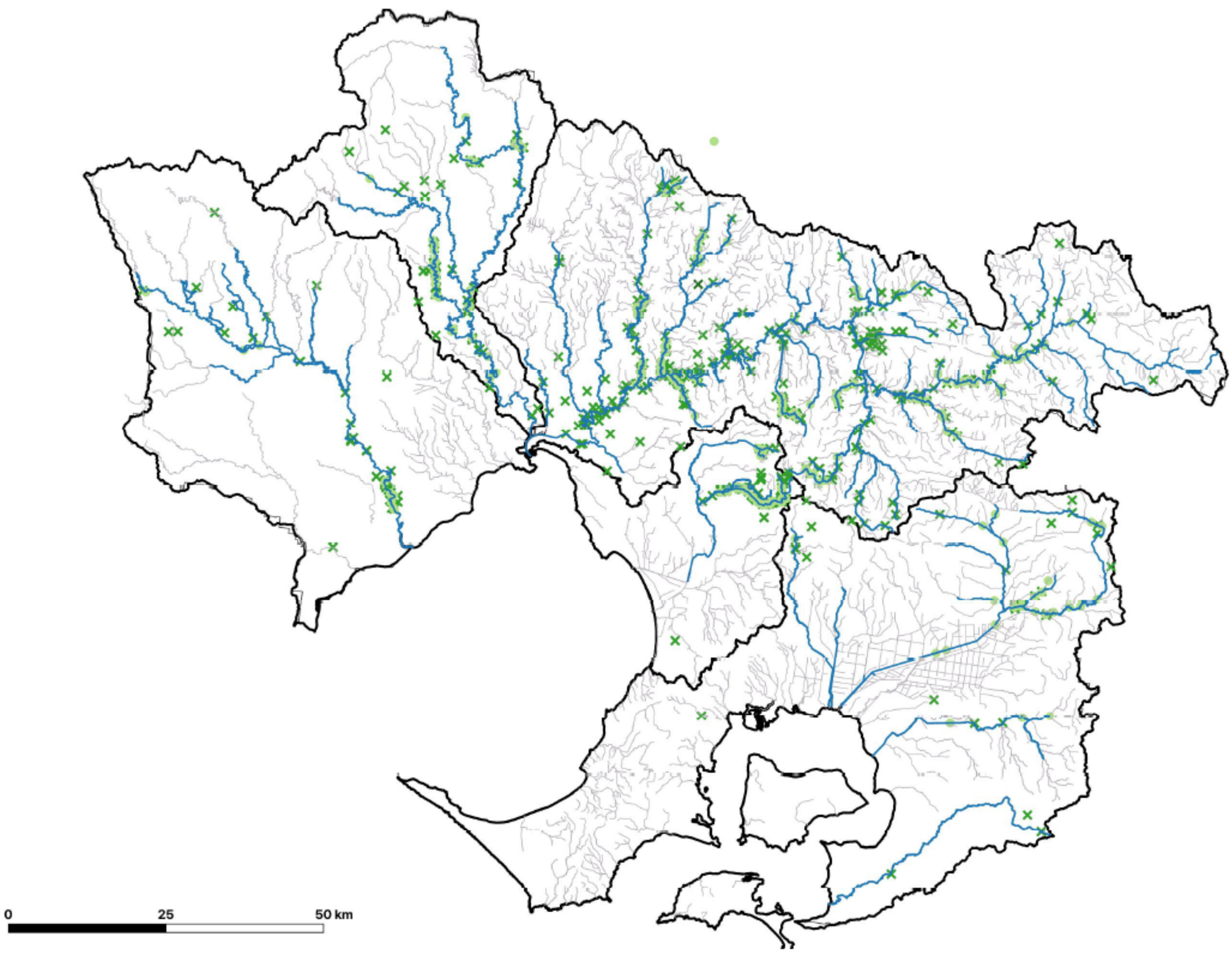


Figure 1. Presumed historical distribution of platypuses throughout Melbourne's catchments (blue lines), derived from ALA records (x), capture data 2007-13 (•), anecdotal reports, and assumed habitat suitability and connectivity of populations. Map is from the Platypus Strategic Management Plan for Melbourne's catchments (Griffiths and Weeks 2018).

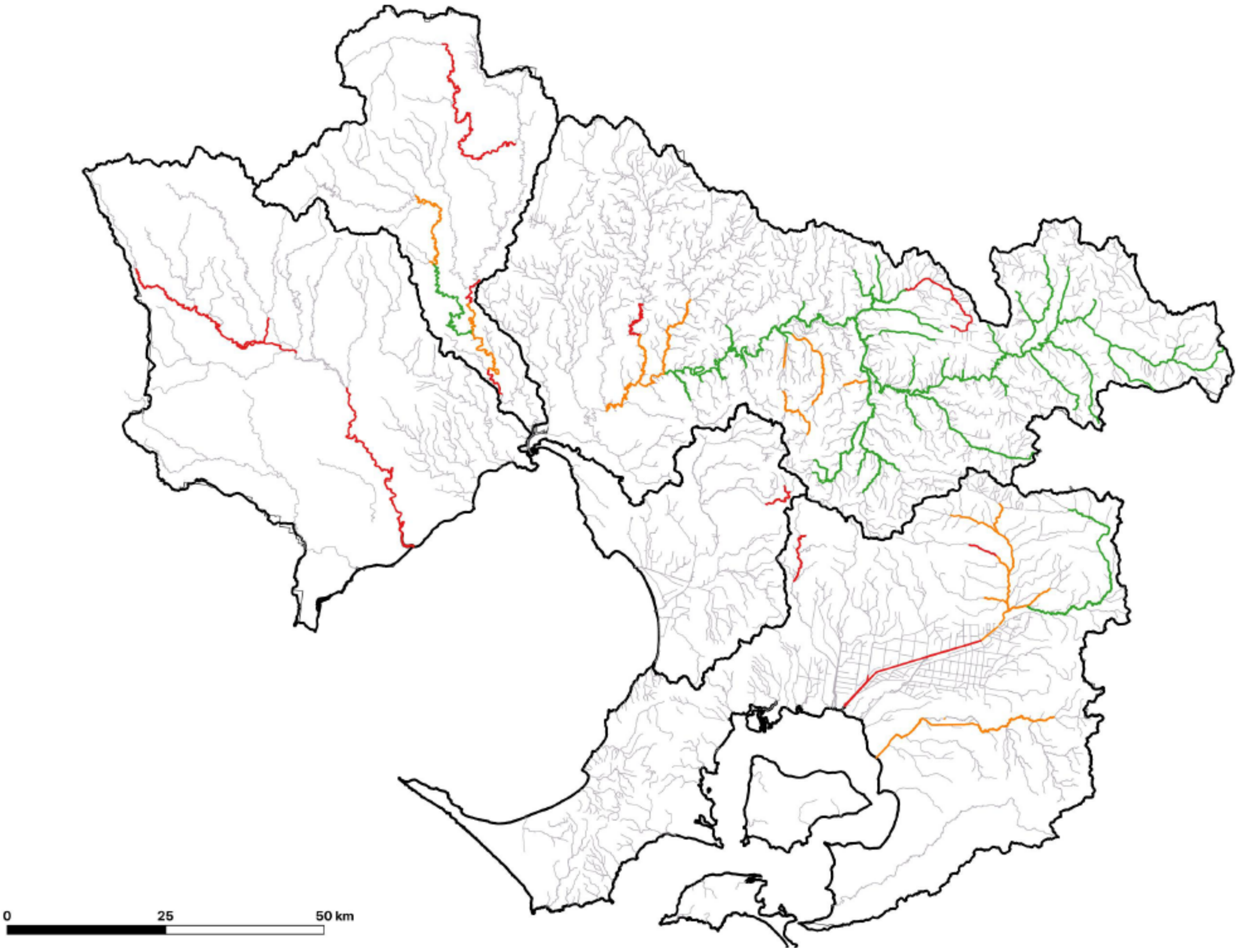


Figure 2. Current distribution and status of resident platypus populations throughout Melbourne's catchments. Current population status based on Griffiths et al. (2016), Griffiths & Weeks (2017) and Griffiths et al. (2017) using contemporary data generated by Melbourne Water's long-term platypus monitoring program and reliable community sightings (www.platypusSPOT.org). Red – Threatened, Orange – Vulnerable, Green – Resilient. Map is from the Platypus Strategic Management Plan for Melbourne's Catchments (Griffiths and Weeks 2018).

Platypus Strategic Management Plan

As part of developing the HWS, Melbourne Water commissioned the Platypus Strategic Management Plan for Melbourne's Catchments (SMP) (Griffiths and Weeks 2018), to better understand the status of populations, identify major threats and prioritise management actions and opportunities.

The platypus community status and management priority, as determined for the Platypus SMP, for all historical live-trapping monitoring locations within the Melbourne region are given in Table 2. As much as possible, we draw heavily on the outcomes of this SMP during the evaluation process (e.g. when evaluating KEQ3a). Further, we have carried forward many recommendations stated in the SMP, particularly recommendations that are yet to be adequately actioned and may require new Performance Objectives.

The major outcomes of the Platypus SMP are as follows:

- Widespread declines were identified in platypus populations within the Port Phillip and Westernport region over the past 20+ years, including recent localised extinctions in some catchments such as upper Plenty River and upper Dandenong Creek.
- Population declines were such that of the ten spatially independent populations identified, five were considered 'threatened' (Werribee Gorge, Lower Werribee, Upper Deep Creek, Monbulk Creek, Cardinia

Creek), two considered ‘vulnerable’ (Olinda Creek, Lang Lang River), and only three ‘resilient’ (Jacksons Creek, Yarra River, Bunyip/Tarago rivers).

- The Millennium Drought is thought to have significantly impacted many of these populations, with signs of recovery in some but not all populations in the years since the drought ended.
- Populations where localised extinctions have occurred, or where post-drought recovery has been limited, tend to be small, isolated and where habitat is degraded.
- Altered flow regimes are considered the greatest threat to Melbourne’s platypus populations, with declines and localised extinctions occurring in waterways where dry weather flows have been severely reduced. This is consistent with Habitat Suitability Model predictions for platypus that showed a strong relationship between platypus distribution and stream flows and the overriding influence of a drier future under the climate change scenario and substantial contractions in the distribution of suitable habitat for platypuses.
- Urbanisation was also identified as a major threat to platypuses due to a range of interactive impacts such as changes in wet and dry weather flows, reduced water quality (including sedimentation), simplified physical stream form, degraded riparian vegetation and reduced food resources (aquatic macroinvertebrates).
- Fragmentation and isolation of platypus populations, such as the creation of physical barriers (e.g. weirs, dams, stormwater pipes) or through the degradation of large sections of stream habitats, that makes platypus more vulnerable to extinction from natural or artificial disturbances (e.g. bushfires, pollution events) was also identified as a key threat to population persistence.
- Other threats to platypus across Melbourne (that may overlap with those described above) include clearing riparian vegetation, lack of instream habitat, poor water quality and direct mortality from litter entanglement or illegal freshwater cray/yabbie traps.

Much of the threatening conditions and processes outlined in the Platypus SMP are mirrored and emphasised in this evaluation document.

Table 2. The platypus community status and management priority determined within the Platypus Strategic Management Plan for Melbourne’s catchments (SMP) at each live-trapping monitoring location within the 10 broader populations in the Melbourne region. The conservation status of platypuses at each location was assessed based on several key population parameters described in (Griffiths, van Rooyen and Weeks 2016): demographics, recruitment, current abundance, habitat quality, fragmentation, long-term trends, and drought recovery.

Monitoring location	Population	Sub-catchment / Catchment	SMP conservation status	SMP management priority
McMahons Creek	Yarra	Yarra River Upper (Rural) / Yarra	**Resilient**	Medium
Warburton	Yarra	Yarra River Upper (Rural) / Yarra	**Resilient**	Medium
Woori Yallock Creek	Yarra	Woori Yallock Creek / Yarra	**Resilient**	Medium
Chum Creek	Yarra	Watts River (Rural) / Yarra	**Resilient**	Medium
Mullum Mullum Creek	Yarra	Mullum Mullum Creek / Yarra	**Resilient**	Medium
Yarra Junction	Yarra	Little Yarra River & Hoddles Creek / Yarra	**Vulnerable**	Medium
Lower Plenty	Yarra	Plenty River Lower / Yarra	**Vulnerable**	Medium
Plenty Gorge	Yarra	Plenty River Lower / Yarra	**Threatened**	Medium
Eltham	Yarra	Diamond Creek (Rural) / Yarra	**Vulnerable**	Medium
Olinda Creek	Olinda	Olinda Creek / Yarra	**Vulnerable**	High

Monitoring location	Population	Sub-catchment / Catchment	SMP conservation status	SMP management priority
Monbulk (Belgrave)	Monbulk Creek	Corhanwarrabul, Monbulk & Ferny Creeks / Dandenong	**Threatened**	High
Monbulk (Lysterfield)	Monbulk Creek	Corhanwarrabul, Monbulk & Ferny Creeks / Dandenong	**Threatened**	High
The Basin	--	Dandenong Creek Upper / Dandenong	**Extinct**	NA
Upper Tarago	Bunyip/Tarago	Tarago River / Westernport		Medium
Lower Tarago	Bunyip/Tarago	Tarago River / Westernport	**Vulnerable**	Medium
Labertouche	Bunyip/Tarago	Tarago River / Westernport	**Vulnerable**	Medium
Bunyip River	Bunyip/Tarago	Bunyip River Middle & Upper / Westernport	**Resilient**	Medium
Lang Lang River (Athlone)	Lang Lang	Lang Lang River / Westernport	**Vulnerable**	Low
Cardinia Creek	Cardinia	Cardinia, Toomuc, Deep & Ararat / Westernport	**Threatened**	Low
Werribee River Lower	Lower Werribee	Werribee River Lower / Werribee	**Threatened**	Medium
Werribee Gorge (Bacchus Marsh)	Werribee Gorge	Werribee River Middle / Werribee	**Transient**[1]	Low
Bulla	Jacksons Creek	Deep Creek Lower (Maribyrnong)	**Vulnerable**	High
Jacksons Creek (Lower Sunbury)	Jacksons Creek	Jacksons Creek (Maribyrnong)	**Resilient**	High
Darraweit Guim	Upper Deep Creek	Deep Creek Lower (Maribyrnong)	**Extinct**	Low

[1]Several lines of evidence (including prevalence of reliable sightings, eDNA findings and live-trapping results) obtained since the SMP was drafted indicates that a resident platypus population inhabits the Werribee River from Bacchus Marsh to approximately Ballan (Serena, Bloink and Williams 2023).

Long-term platypus monitoring, evaluation and reporting

A long-term platypus surveillance monitoring program exists to fulfil the following objectives as outlined in the Rivers Monitoring and Evaluation Plan (Rivers MEP 2020):

- Regularly report status of platypus populations in all 69 HWS sub-catchments.
- Use abundance of platypus populations to assess progress towards the HWS targets at the sub-catchment and catchment scale.
- Understand the health of platypus populations and their trajectory and what is driving trends. Use complimentary indicators to inform how platypus respond to environmental conditions and threats and provide additional lines of evidence to support conclusions about changes in presence and distribution of platypuses.
- Track trajectories of change in critical background conditions (i.e. discharge, stormwater and vegetation) that influence platypus as well conditions included in the habitat suitability models.

Data is collected in a variety of ways as part of a holistic monitoring strategy (Table 3) including; live-trapping surveys, eDNA sampling, and citizen science surveys (see below). These programs are briefly described below but are outlined in detail within the Rivers Monitoring and Evaluation Plan (Rivers MEP, 2020).

Live-trapping surveys

Live trapping methods have been in use in the region since 1995. Monitoring has been reasonably regular across the catchment over time but has been on hiatus since 2019. It is expected that live trapping will begin again in the autumn of 2023.

Live-trapping data provides valuable information on population abundance, demographics, recruitment, litter entanglement and recapture. These surveys also allow tissue samples to be collected from individuals to assess gene flow and genetic diversity.

While live-trapping surveys have been undertaken at a variety of locations since 1995, moving forward, surveys will be undertaken at 15 locations identified in the River MEP. These 15 locations are representative of 8 broader populations. The locations were selected due to (a) the presence of platypus, (b) the existence of long-term data and (c) because site access is favourable.

Live-trapping surveys are generally not conducted in waterways where platypus do not inhabit including in locations where they previously did inhabit but are now effectively extinct (e.g. upper Deep Creek and Toorourrong Reservoir).

Each platypus live-trapping survey location (with 5-6 sites per location) will be sampled every second year. Sampling is undertaken twice each sampling year in the same location to equate with the breeding season (Sept-Oct) and the emergence of juveniles from burrows (Mar-April).

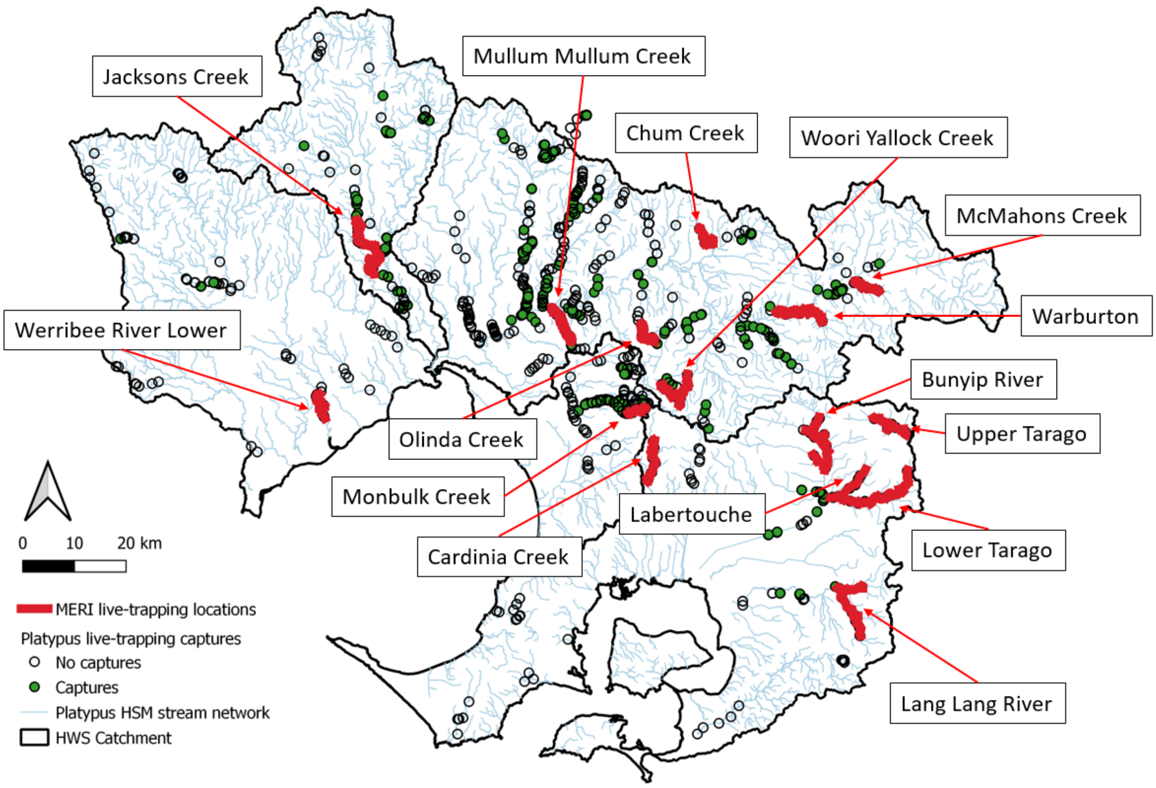


Figure 3. The location of all platypus live-trapping survey sites in the Melbourne region since 1995. The 15 live-trapping survey locations are also displayed.

eDNA

An eDNA monitoring strategy was developed jointly for fish, platypus and frogs. It covers the 69 HWS sub-catchments as it was designed to understand the distribution of the key values in the HWS. The program provides information on the likely presence (positive detection, equivocal detection) and absence (not detected) of platypus. For more detail refer to (Tingley, Wu and Weeks 2020), a detailed report on the methodology used to develop the sampling strategy.

Initially, over 600 eDNA samples were collected across the region as part of Melbourne Water's platypus monitoring program and were selected to understand detectability of platypus using eDNA versus live trapping (Lugg et al. 2018), and also used to independently validate HSM predictions (Coleman et al. 2022).

Since then, two eDNA surveys have been completed as part of the broader HWS MERI eDNA program: one in Spring 2021 and another in Autumn 2022. It was anticipated that the eDNA survey data would not be evaluated until after the baselining process (four sampling periods) had been completed. As such, results from the current eDNA survey data are incomplete.

Citizen science surveys

A number of on-going and superseded citizen science programs provide observational presence/absence data for platypus in the Melbourne region. These programs include PlatypusSpot, the Australian Platypus Monitoring Network (APMN), and PlatypusCount (superseded by APMN).

It was proposed that data from these programs may also contribute to evidence for changes in distribution according to the rubric for platypus. Data from these programs provide valuable presence/absence records across the Melbourne region and generally corroborate the known distribution patterns of platypus. In this instance, the citizen science program data did not provide additional information on platypus distribution that was not already known from live-trapping and eDNA surveys.

Table 3. Summary of platypus monitoring.

Monitoring method	Where monitoring is required	Monitoring frequency (when)	Monitoring responsibility	Baseline data	Data storage and access
Live trapping	15 core site locations, with 5-6 sites per location i.e. total 75-90 fyke nets	Each site sampled in Spring and Autumn every second year	Melbourne Water (MW) – Waterways and Biodiversity Team	HSM outputs Historical trends Monitoring site trend data	Cesar database. MW to consolidate all historical and future data into an in-house database
eDNA	Proposed 40-80 sites per HWS sub-catchment (then reviewed)	All sites sampled by 2022 and again by 2025/26 before final review	Melbourne Water – Waterways and Biodiversity Team	2016 and 2018 data collection (NOTE: the baseline program is not yet completed)	EnviroDNA online database. MW to consolidate all historical and future data into an in-house database
PlatypusCount	Yarra River 1) Warrandyte-View Bank and 2) Warburton-Yarra Junction	At least weekly	Australian Platypus Conservancy (APC), Citizens	2008-2018	APC online database. MW to consolidate all historical and future data into an in-house database. QA/QC will be required.

Monitoring method	Where monitoring is required	Monitoring frequency (when)	Monitoring responsibility	Baseline data	Data storage and access
Australian Platypus Monitoring Network	Anywhere, opportunistic	Anytime	Citizens		Australian Platypus Conservancy database.
PlatypusSpot	Anywhere, opportunistic	Anytime	Citizens	Na	Cesar database. MW to consolidate all historical and future data into an in-house database. QA/QC will be required.

Platypus value indicators

A number of indicators can be derived from the data collected as part of regular platypus monitoring (Table 4). These indicators represent important information on spatial and/or temporal changes in platypus abundance, health and distribution (Table 4). Some of these indicators have been used to answer key evaluation questions for platypus (3a, 2a and 3b).

Table 4. Summary of various indicators of spatial and/or temporal changes in platypus abundance, health and distribution.

Indicator	What it's useful for
Presence/absence (trappings, sightings, eDNA detections) **The recorded presence or absence of platypus at a site. This information has been used in the Strategy to calculate the probability of occurrence which forms the basis of habitat suitability model (HSM) predictions.**	Understanding spatial distribution of platypus across the region Spatial distribution from HSMs for various scenarios. Targets are based on this metric.
Platypus abundance **Catch-per-unit-effort (CPUE) calculated from live-trapping surveys – outlined in more detail below** **Number of sightings per site-visit (e.g. Platypus Count) can be used as an index of platypus activity across seasons and years**	Spatial and temporal trends of abundance within key populations. Monitoring of key sites will give an indication of changes in abundance of platypus over time in that area.
Platypus prevalence (eDNA detectability) **Proportion of sampled eDNA sites positive for platypus – for the 15 core location sub-catchments**	Information on platypus occurrence at the sub-catchment scale that will provide a quantitative (detected, not detected) assessment over time
Health (Recaptures) **Integrated health index**	Population health - Provides an understanding of population size, trap shyness, home ranges, age
Health (Sex ratios) **Calculated using the following formula:** **(Males / Males + Females) *100 (excluding juveniles)**	Population health - Spatial and temporal analysis can indicate whether the ratios are adequate
Health (Recruitment) **Represented as the proportion of juveniles within the total population**	Population health - Spatial and temporal analysis can indicate whether the ratios are adequate

Indicator	What it's useful for
Health (Platypus body condition) **Measurement of tail fat of trapped animals using a 1-5 rating scale of health: Tail Volume Index (TVI) for each site over time**	Population health - Trends over time
Health (length and weight of platypuses) **Measured using 5-kg scales, along with measurements of bill width, bill length, and total body length**	Population health - Trends over time
Health (Genetic diversity) **Tissue sampling to provide e.g. mean number of alleles, heterozygosity, population genetic differentiation**	Population health - Can indicate changes in effective population size and fragmentation of populations
Distribution change **Proportion of reaches with very low or low probability of occurrence (from HSMs) that have tested positive for platypus using eDNA** **No positive or equivocal platypus detections, using eDNA, in reaches or sub-catchments where we have previously recorded platypus**	Highlighting potential platypus range expansion, decline or unknown platypus populations

Platypus abundance

Platypus abundance was represented by a common abundance metric: catch-per-unit-effort (CPUE). CPUE is an abundance metric used to generate spatial and temporal population trends.

Capture indices, such as CPUE, assume that the index is proportional to the actual population abundance and the relationship between the index and abundance is constant (Caughley 1977). Therefore, changes in CPUE over time or between survey sites, represent proportional changes in abundance (Conroy and Nichols 1996).

To calculate CPUE, the number of individual platypuses captured in a sampling period is standardised by the survey effort. Survey effort reflects the total number of sites sampled overnight during a survey period (Serena and Williams 2011). This standardisation allows comparison of capture rates across waterways, catchments and survey periods.

Although widely accepted as a measure of relative abundance, CPUE is undoubtedly a coarse index of abundance for platypuses and CPUE data must be interpreted as a broad indicator of population trajectories only. The difficulties in estimating population size for platypuses and the limitations of CPUE as an index of abundance have been discussed in previous reports (Griffiths and Weeks 2011, Griffiths and Weeks 2018).

Briefly, the number of platypus detected during the survey will be a function of (Griffiths, van Rooyen and Song, et al. 2018):

- the actual platypus abundance which is affected by a number of physical and biotic variables;
- the efficiency of the survey technique which can be influenced by the operator and equipment used;
- the time of surveys: spring (September-October) is a generally favourable period to capture males as they move around during the breeding season, though much less so for females (with October, in particular, being an exceptionally unproductive month to capture breeding age females as many are engaged in incubating eggs or caring for recently hatched young); juveniles are most reliably captured in their natal water body in late summer/early autumn (March-April) prior to dispersal (Serena and Williams 2011); and,

- Trap-shyness: lower recapture rates of individual platypus over time as individuals display learned net avoidance behaviour following their initial capture.

Platypus models and target setting

To set targets for platypus, the relationship between important characteristics of platypus (e.g. abundance and distribution), and the conditions that support them, needed to be documented.

Our understanding of conditions and/or threats that shape important characteristics of platypus was captured in a conceptual model for platypus (Figure 4) and a quantitative ecological model known as a habitat suitability model (HSM) for platypus. The overlap between these 2 models is also outlined in Figure 4.

Conceptual model

The conceptual model provided a communication tool for community and agencies to understand what conditions support platypus and which management levers are most applicable to drive long-term outcomes for platypus. It was also used to support target setting for parameters not included in the HSMs but which were considered important for platypus.

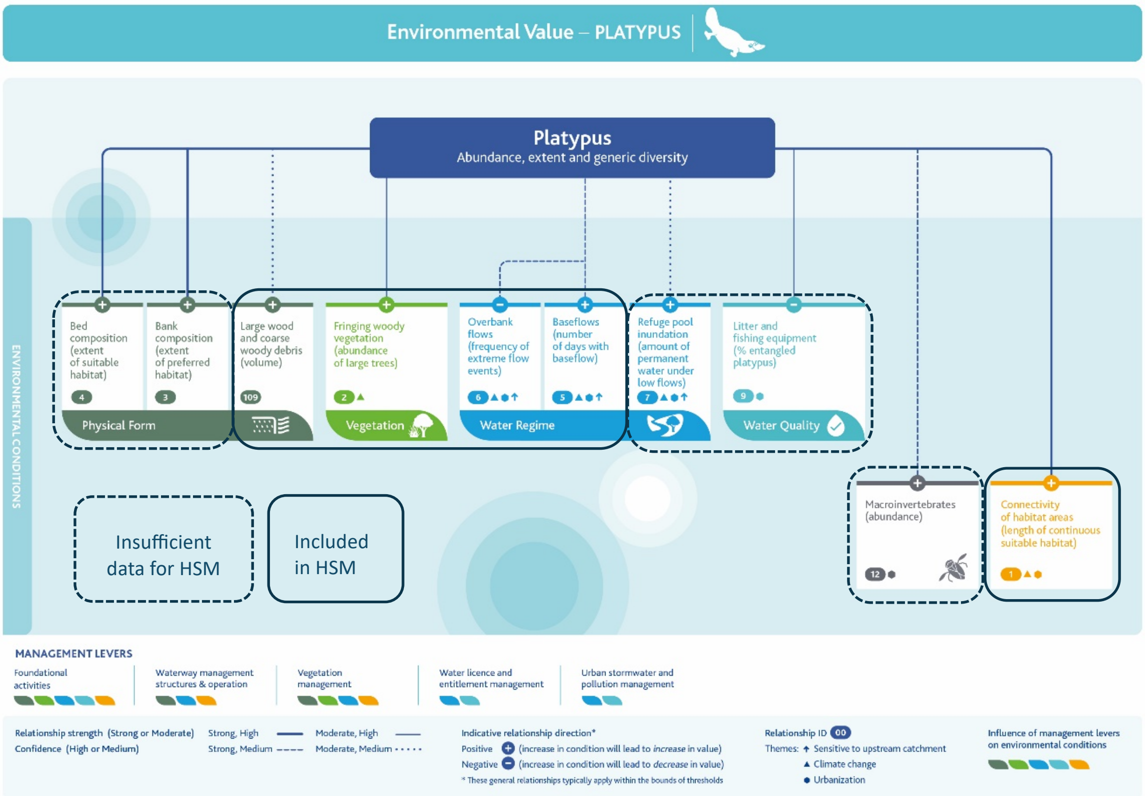


Figure 4. Platypus conceptual model highlighting the conditions included in the platypus HSMs.

Habitat Suitability Models

The development of HSMs has been a collaboration between researchers at Melbourne University (Waterways and Ecosystems Research Group) and Melbourne Water staff. HSMs are spatially-explicit quantitative ecological models that predict the likelihood of particular aquatic values being present in any stream reach across the Port Phillip and Westernport region.

The platypus HSMs were developed to support the 2018 HWS development. A thorough description of the HSMs can be found in the HWS Technical Resource document (Melbourne Water 2018) as well as in Chee et al. (2020) and specifically for platypus in Coleman et al. (2022).

In short, the HSMs analysed the relationships between the environmental characteristics at sites (e.g. stream flow, temperature, extent of streamside vegetation, and levels of catchment urbanization) where platypus are detected (and at sites where platypus are not detected) to develop a quantitative model that predicted the probability of occurrence (technically detection) at a site as a function of habitat characteristics. The models were constructed using data for platypus and predictor variables collected from 1995 to 2009 (Table 5).

Table 5. Predictor variables used in developing the Platypus HSMs.

Environmental predictor	Units	Source
Catchment area	km^2	
Mean annual discharge depth	mm	Gridded (5 km by 5 km) monthly surface runoff estimates from the Australian Water Availability Project (AWAP; Raupach et al., 2009) for the period from 1900 to 2017 were used to derive an estimate of mean annual runoff for each grid cell. Grid cells were intersected with sub-catchment boundaries to produce an estimate of runoff for each individual sub-catchment (weighted according to coverage by individual grid cells). Runoff for individual sub-catchments was then averaged over the entire contributing catchment area
Antecedent runoff	NA	Calculated from runoff estimates from the Australian Water Availability Project (Raupach et al., 2009) using functions from the SPEI (Standardized Precipitation–Evapotranspiration Index) R package (Beguería & Vincente-Serrano, 2017)
Mean annual air temperature	°C	Derived from STRANNTEMP in Stein et al.'s (2011) Environmental Stream Attributes v1.1 data set that supplements the Australian Bureau of Meteorology's Geofabric data set (www.bom.gov.au/water/geofabric/). STRANNTEMP is the average value of BIOCLIM variable 'Annual Mean Temperature' of all grid cells (in the 9″ DEM of Australia ver 3 2008) comprising the reach segment and associated valley bottoms.
Attenuated forest cover	NA	Walsh and Webb (2014)
Attenuated imperviousness	NA	Walsh and Webb (2014); Martin et al. (2014)

Two HSMs were developed for platypus: males-and-females of all life-stages (i.e. male and female, sub-adults/adults), and female-only sub-adult/adults that have smaller home ranges and much higher food resource requirements during certain times of the year (e.g. during lactation).

Although both models were used for analysis purposes, the males-and-females platypus model was used to set strategy targets. For each reach, the probability of occurrence was associated with one of five rating categories (Table 6).

Table 6. Platypus status rating categories.

Rating	Description	Probability of occurrence categories
Very High	Very high proportion of stream length likely to support platypus	0.4 – 1.0
High	High proportion of stream length likely to support platypus	0.3 – 0.4
Moderate	Moderate proportion of stream length likely to support platypus	0.2 – 0.3
Low	Low proportion of stream length likely to support platypus	0.1 – 0.2
Very low	Very low proportion of the stream length likely to support platypus	0.0 – 0.1

The current (baseline) state (CURR) of platypus was modelled using 2016 predictor variable datasets (see Table 7). As shown in Figure 5, platypus habitat suitability is generally greatest in the forested parts of Melbourne's waterways, particularly in waterways connected to the Yarra River and Bunyip River.

The power of the HSMs is in predicting future scenarios such as urban development and climate change. The results were a very useful communication tool at the HWS catchment collaboration forums during the development of the HWS.

A Business as Usual future for 2068 (BAUF) was modelled using an updated set of predictor variables that accounted for unmitigated changes associated with urbanisation and climate change that are also detailed in Table 7. The results showed significant contraction of platypus across the region (Figure 5), with the main driver being the drying aspect of the climate change scenario.

Table 7. Details of the current (CURR) scenario and the business-as-usual-future (BAUF) scenario.

Scenario Code	Mean annual air temperature (^{0}C)	Mean annual runoff depth (mm)	Attenuated Forest	Attenuated Imperviousness
CURR **Current (baseline) state**	2016 values	2016 values	2016 values	2016 values
BAUF **Business as usual future**	2016 values + 1.5 ^{0}C	Equivalent to a 25% reduction in the long term mean value at the mouth of the Yarra River*	2016 values	Fully developed scenario i.e. all 'urban' planning scheme zone codes assigned a fully developed AI value

*To represent drier conditions reflecting a 25% reduction in the long term mean annual flows at the mouth of the Yarra River, Walsh & Webb (2013) identified a 4-year period (that happened to be the 48 months prior to December 2000) where mean annual discharge was 75% of the long-term average. The monthly discharge estimates for this particular 4-year period was used as an analogue for drier conditions. (In practice, dryMeanQ for each reach was set to mean annual discharge calculated from monthly discharge estimates in Geofabric (Bureau of Meteorology 2011) over that particular 4-year period.)

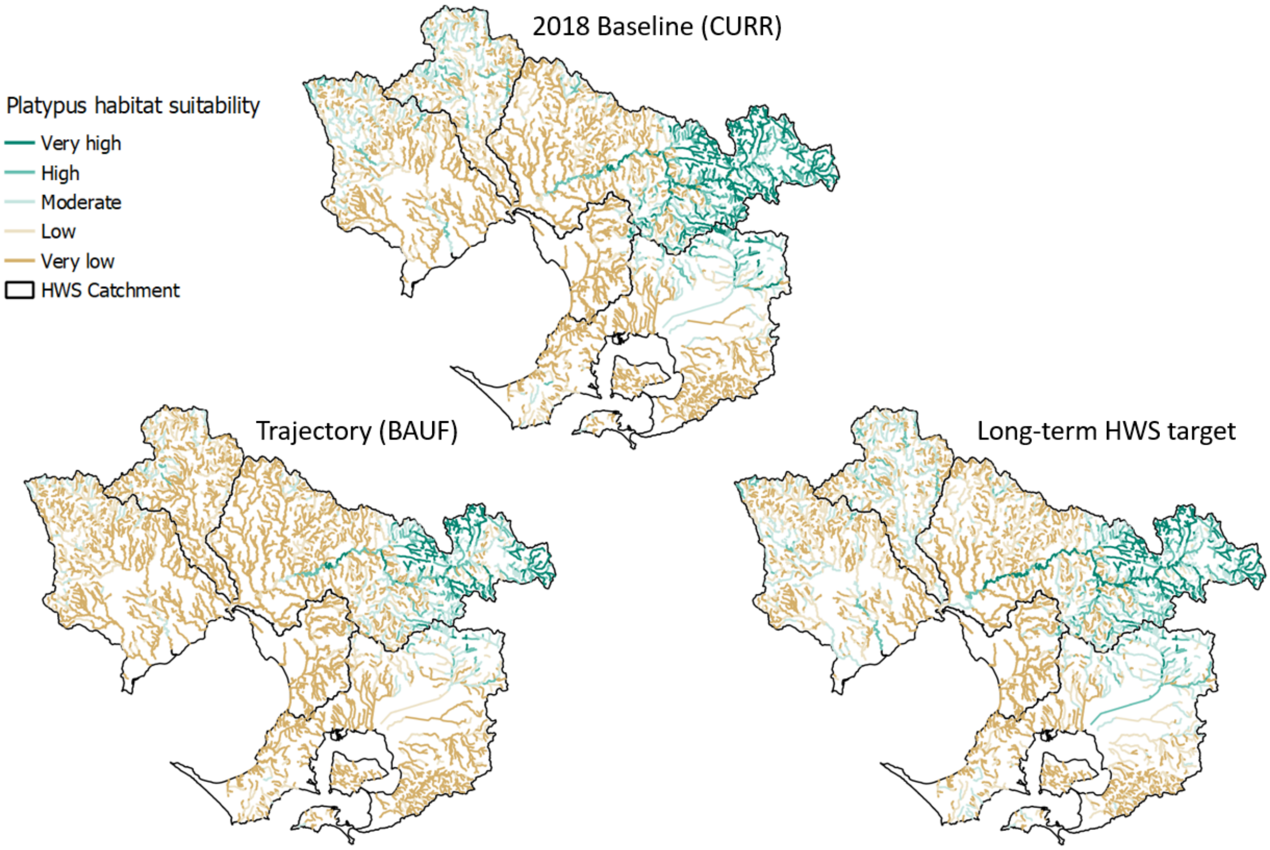


Figure 5. Modelled platypus habitat suitability from the habitat suitability model created in 2018. Habitat suitability predictions for the 2018 baseline (CURR), business as usual trajectory (BAUF), and long-term HWS target are displayed.

Targets and performance objectives

Targets were developed in the Strategy for waterway key values, including platypus, and the conditions that support them. The targets provide quantitative measures of progress towards the qualitative goals and vision within the program logic approach (see Appendix 1: Healthy Waterways Program Logic).

The targets are set for different timescales in reference to the period of time it can take for a measurable change to occur and be detected. For example, targets for key values are set for 10 – 50 years, reflecting the timescale required to achieve outcomes. This is because the conditions that support the key values need to change first, hence why targets for conditions are set at 10+ years. Performance objectives represent interim measures that guide activities and indicate progress towards improving waterway conditions, hence why the timescale is 1 – 10 years (Figure 6).

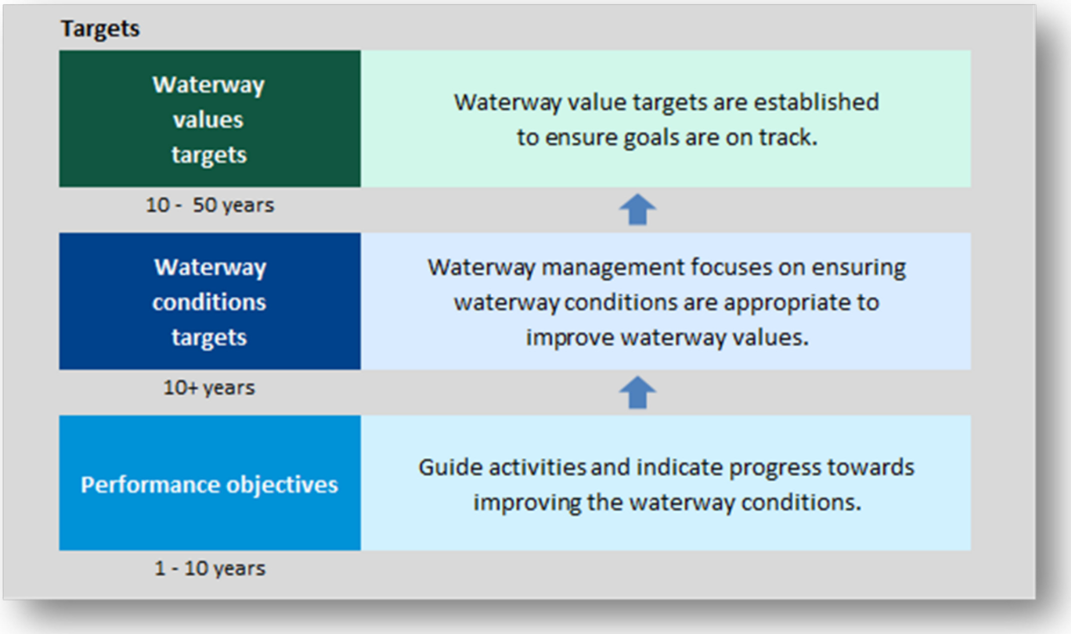


Figure 6. Hierarchy of targets in the Strategy.

The process for setting long-term targets for platypus and the associated conditions (e.g. vegetation extent and stormwater) was iterative. In addition to the business as usual future (BAUF) scenario, a number of management intervention scenarios were run to help communicate the cumulative effects of threats and management opportunities (e.g. revegetation and stormwater management) across the region, which in turn helped to set long term targets.

Another tool, Zonation, was then used to prioritise the most cost effective combination of interventions across the region. Zonation is a set of methods implemented in a software tool to support large-scale systematic spatial conservation prioritisation and planning (Moilanen, Franco, et al. 2005, Moilanen, Montesino Pouzols, et al. 2014). At several points feedback was sought from key stakeholders to check feasibility such as consideration of budgets, partnerships and policy changes.

Through the modelling process, it became clear that the drying climate scenario for platypus was particularly impactful on their distribution, even with major revegetation efforts and stormwater management interventions. Given this, a management scenario involving interventions to maintain baseflows through environmental water actions was considered feasible. This scenario was effectively a modification of the climate change scenario which allowed for warming but not drying. The final long term targets combined this scenario with the most cost effective HSM scenarios. Assuming the drying effect of climate change will be mitigated is a big assumption which should be reconsidered through this mid-term evaluation both in light of feasibility of actions along with the new climate change predictions which will be included in the updated HSMs.

The key assumptions made in setting long-term targets for platypus using the HSMs are outlined in Table 8. The reach scale results for the baseline, BAUF and the final long term target scenario were averaged to the HWS sub-catchment scale (69 units) by calculating a length-weighted average of reach-scale prediction values.

Table 8. Key high risk assumptions made in setting the long term targets for platypus.

Key assumption	HSM Predictor variable
It was assumed that in key locations flows (particularly base flows) could be maintained through interventions which could offset the likely climate change drying conditions. As such the mean annual runoff depth set to 2016 values.	Flow (mean annual runoff depth mm)
It was assumed that all new urban areas would be adequately treated i.e. there would be no increase in attenuated imperviousness, and there would be a reduction of 25% in attenuated imperviousness for existing urban areas achieved through urban renewal.	Attenuated imperviousness
It was assumed that a 20 m vegetated buffer either side of all priority reaches outside the UGB is achievable in the long term. It was assumed that a 10 m vegetated buffer is feasible to priority reaches within the UGB.	Attenuated forest cover

When setting targets, expert opinion helped refine the model predictions when outputs were considered unrealistic. This was the case for platypus, where the model predicts suitable habitat, but it is known that animals do not exist in those reaches, and the connectivity to existing populations is very low. For example, platypus do not permanently inhabitant streams along the Mornington Peninsula simply because they are too small and fragmented. These model over-rides meant that targets were not set for platypus in some sub-catchments.

While the HSMs and zonation were able to assist in setting targets for platypus and some environmental conditions (i.e. vegetation extent and stormwater), other important conditions are not explicitly modelled (e.g. pollution and predation threats). The conceptual model for platypus was also used to complement the HSM and Zonation outputs when determining platypus related Performance Objectives at the Sub-catchment level where particular threats were not accounted for in the HSMs (Melbourne Water 2018). The approach to setting long term condition targets and shorter term performance objectives for these parameters that sit outside of the HSMs is outlined below.

Water for the Environment The HSM do not currently include major flow diversions such as those from water supply dams. Long term targets and the 10 year performance objectives for flow regimes are based on existing flow studies which take into account a detailed analysis of flow requirements for instream values.

Water Quality (environmental) The HSM do not currently directly use water quality data as a model predictor, although to some extent, water quality is indirectly related to attenuated forest cover and AI. As such, for urban areas, the HSM analysis was considered suitable for setting priorities for water quality protection, except for certain known hot spots (e.g. immediately downstream of waste-water treatment facilities) where targeted investigations and solutions are required. In rural areas, priorities for managing intensive agriculture were guided by using the macroinvertebrate HSM predictions because our measure of the macroinvertebrate community (LUMaR) is representative of the general waterway condition across urban, agricultural and vegetated landscapes.

Physical form The HSM do not currently use physical form as a predictor variable and this is an area of future improvement. Bank vegetation and large woody debris (LWD) were included in the platypus model however there was not a large difference between management scenarios run with or without these predictors. This is partly due to the attenuated forest cover and AI variables being somewhat surrogate variables for physical habitat. For instance, if AI is low, then physical habitat is likely to be intact. A prioritisation process to identify sub-catchments where excessive erosion is a key risk was undertaken using existing geomorphological studies and expert opinion.

Vegetation Quality The HSM do not currently use vegetation quality as a predictor variable. In many cases, the attenuated forest cover predictor is highly correlated with the quality of vegetation. However, there are cases where reaches with relatively high attenuated forest cover may be highly degraded in terms of vegetation quality (e.g. high infestation of woody weeds). The impact of weeds on instream values is quite complex. Further work to include a predictor variable is underway. However, for the purpose of the HWS, there was an assumption made that instream values require a moderate level of vegetation quality. The HSMs were used to identify reaches where maintaining existing moderate quality vegetation was a priority.

Gaps in performance objectives

While there are performance objectives for most of the important aspects relating to platypus, there are a couple that are not in the HSMs and were missed during the development of the HWS. It would be worth considering specific performance objectives for litter entanglement and barriers (e.g. large dams and lakes) during this mid-term evaluation. Both threats were identified in the Platypus Strategic Management Plan.

2. Summary of current management actions and progress

The short-term (one to ten-year) quantitative steps by which long term 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).

This section provides a summary of the performance objectives which directly relate to protecting or improving platypus status across the 69 sub-catchments of the region. Progress towards other performance objectives, likely to also protect platypus, such as, managing agricultural runoff and protecting physical form can be found on the HWS website report card (https://healthywaterways.com.au).

The main sub-catchment performance objectives (SCPOs) and regional performance objectives (RPOs) which are assumed to benefit platypus are listed in Table 9. The progress toward achieving these performance objectives is summarised in Table 10. Whilst this is a very high-level summary, some projects that are part of intervention monitoring and research (e.g. Monbulk Creek Smart Water Network and habitat restoration, banning of opera house nets) are described in more detail in KEQ 4a and KEQ 4b.

Table 9. Main performance objectives which will benefit platypus.

SCPO group	SCPO theme/s	***Examples*** of SCPOs covered in this Rivers MEP	Related Regional Performance objectives
Vegetation	Increase vegetation extent Maintain or improve vegetation quality Protect high quality vegetation	Establish a continuous riparian vegetated buffer (XX km, XX ha) and maintain existing vegetation (XX km, XXX ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality). Maintain or achieve high and very high quality vegetation (Vegetation Quality level 4 and 5 - currently XX km) through effective monitoring and management of threats including protection of endangered EVCs in these reaches. Fill data gaps and ensure additional high quality reaches are also protected.	RPO-30 Climate change resilient revegetation management practices are understood and implemented by selecting plant species, provenances and vegetation communities that are suited to projected future climatic conditions.
Water for the environment	Increase environmental water reserve in regulated systems Maintain or improve flow regimes in unregulated systems	Investigate options to increase environmental water reserve for the catchment by X GL /year by 2028 to meet ecological watering objectives and cover projected shortfalls. Maintain critical flow components in refuge reaches along (e.g. Kororoit Creek) to protect instream environmental values. Identify and implement opportunities to reduce the key threat of summer low flow stress by addressing causal factors such as water for domestic and stock use,	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.

SCPO group	SCPO theme/s	*Examples* of SCPOs covered in this Rivers MEP	Related Regional Performance objectives
		climate change, diversions or urbanisation.	
Stormwater	Treat **new urban** development (maintain DCI) Treat new and **existing development** (reduce DCI)	To prevent decline in stormwater condition, treat upstream urban development so directly connected imperviousness (DCI) remains at current levels at Warrandyte, and at current levels along the main stem of the Yarra River. For every hectare of new impervious area, this requires harvesting around 5.1 ML/y and infiltrating 1.5 ML/y, which is about 0.7 GL/y and 0.2 GL/y for full development out to urban growth boundary. Improve stormwater condition by treating existing and future urban development from Darraweit Guim so directly connected imperviousness (DCI) is below 1% prior to connection to Deep Creek. For every hectare of impervious area, this requires harvesting around 4.0 ML/y and infiltrating 0.8 ML/y.	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.
Pests	Na	n/a	RPO-31 A risk-based approach is adopted to prevent, eradicate and contain pest plants and animals (including deer) and protect waterway assets.

Table 10. High-level summary of progress toward achieving sub-catchment performance objectives that directly and indirectly relate to platypus and MERI platypus locations. Sub-catchment performance objectives are grouped as relating to vegetation (riparian buffer establishment and protection/maintenance of vegetation quality), stormwater (harvest and infiltration), and water for the environment in both regulated and unregulated systems. Where available, the 2028 target is stated along with the progress (on-track (green shading), slightly off-track (orange shading) or off-track (red shading)) toward achieving this target as of 2021.

Platypus survey location	Sub-catchment / Catchment	HWS 2018 platypus status baseline	BAU trajectory	HWS 2068 platypus status target	Vegetation				Stormwater					Water for the Environment		
					Riparian buffer (ha)		Protect/maintain vegetation quality (ha/year)		Stormwater – harvest (ML)		Stormwater – infiltration (ML)		Storm water from new development (ML)	Water recovery target (GL) – regulated systems		Unregulated systems
					2028 Target	2021 Progress	2028 Target	2021 Progress	2028 Target	2021 Progress	2028 Target	2021 Progress		2028 Target	2028 Progress	Evidence of implemented actions (SFMP, LMP, EWAP, drought response plan)
Werribee																
Lower Werribee River	Werribee River Lower	Low	Low	Moderate	114	29.9	86	165	824	0	125	0	56	7	1.1 Entitlement delivery	NA
Middle Werribee River	Werribee River Middle	Low	Low	Low	199	21	480	1029	NA	NA	NA	NA	NA	7	1.1 No entitlement to benefit platypus	Some - Planning stage future environmental entitlement in Pykes Ck Reservoir
Maribyrnong																
NA	Deep Creek Upper	Moderate	Low	Moderate	575	170	64	164	169	0	49	0	47.5	NA	NA	No – trigger value needs review and implementation

Platypus survey location	Sub-catchment / Catchment	HWS 2018 platypus status baseline	BAU trajectory	HWS 2068 platypus status target	Vegetation				Stormwater					Water for the Environment		
					Riparian buffer (ha)		Protect/maintain vegetation quality (ha/year)		Stormwater – harvest (ML)		Stormwater – infiltration (ML)		Storm water from new development (ML)	Water recovery target (GL) – regulated systems		Unregulated systems
					2028 Target	2021 Progress	2028 Target	2021 Progress	2028 Target	2021 Progress	2028 Target	2021 Progress		2028 Target	2028 Progress	Evidence of implemented actions (SFMP, LMP, EWAP, drought response plan)
NA	Emu Creek	Moderate	Low	Moderate	159	17	130	122	695	21 (599 planned)	166	0	30	NA	NA	No EWAP
Jacksons Creek	Jacksons Creek	Moderate	Very Low	Moderate	389	63	516	579	400	0	96	0 (446 planned)	400	5	0 Opportunistic water share delivery	Some - Planning stage
Yarra																
Warburton	Yarra River Upper (Rural)	High	High	High	169	51	1097	798	66	0	34	0.27	1.8	10	0 entitlement delivery	NA
Chum Creek	Watts River (Rural)	Moderate	Moderate	Moderate	28	2.2	175	90	59	0	26	0	17.2	NA	NA	Some- drought response plan
McMahons Creek	Yarra River Upper (Rural)	High	High	High	169	51	1097	798	66	0	34	0	1.8	NA	NA	No (low risk)
Woori Yallock Creek	Woori Yallock Creek	High	Moderate	High	196	30	817	1080	91	0 (4 planned)	41	0.3	9.9	NA	NA	Yes- SFMP bans and

Platypus survey location	Sub-catchment / Catchment	HWS 2018 platypus status baseline	BAU trajectory	HWS 2068 platypus status target	Vegetation				Stormwater					Water for the Environment		
					Riparian buffer (ha)		Protect/maintain vegetation quality (ha/year)		Stormwater – harvest (ML)		Stormwater – infiltration (ML)		Storm water from new development (ML)	Water recovery target (GL) – regulated systems		Unregulated systems
					2028 Target	2021 Progress	2028 Target	2021 Progress	2028 Target	2021 Progress	2028 Target	2021 Progress		2028 Target	2028 Progress	Evidence of implemented actions (SFMP, LMP, EWAP, drought response plan)
																restrictions active
NA	Plenty River (Source)	Moderate	Low	Moderate	NA	NA	150	65	NA	NA	NA	NA	NA	NA	NA	No (low risk)
Mullum Mullum Creek	Mullum Mullum Creek	Very low	Very low	Very low	7	0	46	14	NA	NA	NA	NA	NA	NA	NA	Yes- LMP bans and restrictions active
Olinda Creek	Olinda Creek	Moderate	Low	Moderate	34	23	109	200	81	0	32	0	29.9	NA	NA	Yes - SFMP Bans and restrictions active
Dandenong																
Monbulk Creek	Corhanwarrabul, Monbulk and Ferny Creeks	Moderate	Very Low	Moderate	38	39	119	185	Treat existing	Planned	Treat existing	Planned		NA	NA	Some – planning stage Trigger value needs review

Platypus survey location	Sub-catchment / Catchment	HWS 2018 platypus status baseline	BAU trajectory	HWS 2068 platypus status target	Vegetation				Stormwater					Water for the Environment		
					Riparian buffer (ha)		Protect/maintain vegetation quality (ha/year)		Stormwater – harvest (ML)		Stormwater – infiltration (ML)		Storm water from new development (ML)	Water recovery target (GL) – regulated systems		Unregulated systems
					2028 Target	2021 Progress	2028 Target	2021 Progress	2028 Target	2021 Progress	2028 Target	2021 Progress		2028 Target	2028 Progress	Evidence of implemented actions (SFMP, LMP, EWAP, drought response plan)
Westernport																
Cardinia Creek	Cardinia, Toomuc, Deep and Ararat Creeks	Moderate	Low	Moderate	297	47	485	304	1213	62 (223 planned)	419	0	712	NA	NA	No
Bunyip River	Bunyip River Middle and Upper	High	Moderate	High	174	52	626	420	NA	NA	NA	NA	NA	1	0	No
Upper Tarago River	Tarago River	High	Moderate	High	260	17	338	242	392	0	162	0	52	1	0	No
Lower Tarago River	Tarago River	High	Moderate	High	260	17	338	242	392	0	162	0	52	1	0	NA
Lang Lang River	Lang Lang River	Low	Very Low	Low	768	14	780	47	3	0	17	0	6.9	NA	NA	No

3. Key evaluation questions

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

Evaluation methodology

Evaluation criteria were developed to guide the data analysis and evaluation of KEQ 3a (Table 11).

Three categories of significance were developed to prioritise findings at two scales; sub-catchments (69 sub-catchments) and platypus communities (15 communities). Evaluation is conducted at the sub-catchment scale because it considers results of the habitat suitability models which contain predictions for all reaches within a sub-catchment, and because this is the data and scale at which targets in the HWS were set.

Further, evaluation was also conducted at the platypus community scale because it considers other relevant data for platypus (i.e. health and abundance data) that is not available, or appropriate to be evaluated, at the sub-catchment scale.

The Melbourne region is thought to contain ten core platypus populations. However, Melbourne Water conducts live-trapping for platypus communities inhabiting 15 live-trapping locations in the region – as such, there can be multiple live-trapping locations, and platypus communities, within broader populations (e.g. there are four live-trapping locations within the Bunyip/Tarago platypus population).

Recommendations have been developed for sub-catchments and platypus communities that are rated as 'Significant for implementation' (see Section 5. Summary of the evaluation findings and recommendations).

Two rubrics were used to answer KEQ3a. For all the sub-catchments, we use Rubric 1 in Table 12.

At the platypus community scale, we use Rubric 2 in Table 13 which incorporates information on platypus abundance and health. These two rubrics differ from what is published in the Rivers MEP for platypus because this rubric relied on updated HSM predictions which were not ready at the time this work was undertaken.

NOTE - For the values synthesis (see the Science Inquiry Report), we combined the outcome of these two rubrics with updated HSMs for platypus with updated information on interventions (works-to-date): the criteria used for this synthesis assessment is available in the Synthesis Methods document (Melbourne Water, 2023d) and the results displayed in the Science Inquiry Report. We highlight, however, that the criteria incorporating the updated HSMs did not change the focus sub-catchments identified in the assessment of KEQ 3a in this report.

The strength of this approach is that the two rubrics make the most of the data we have collected over the long term. They incorporate a variety of data types describing platypus abundance, health, and distribution trends and were designed to place more emphasis on detecting sustained and persuasive changes in platypus trends.

Table 11. The evaluation criteria used to answer KEQ 3a: To what extent are key values on the target trajectory.

			Significance categories		
Sub KEQ	**Criteria**	**Evaluation scale**	**Not significant for implementation**	**Potentially significant for implementation**	**Significant for implementation**
3a. To what extent are key values on the target trajectory?	Platypus habitat-suitability models and distribution data indicate that targets will not be met (i.e. Rubric 1)	Sub-catchment (69)	On-track to achieving long term target	Potentially off-track to achieving long term target	Off-track - High chance that long-term targets will not be met
	Evidence for potential decline in platypus community status based on live-trapping and eDNA data (i.e. Rubric 2)	Platypus community (15)	SMP rated community as Resilient or Vulnerable *AND* Population health trajectory rated as ‘Improving’ or ‘Stable’	SMP rated community as Threatened *AND* Trajectory rated as ‘Stable’	SMP rated community as Vulnerable or Threatened *AND* Trajectory rated as ‘Not assessable / potentially declining’ or ‘Declining’

Sub-catchment evaluation

Rubric 1 (see Table 12) was used to determine the performance rating at the sub-catchment scale. The modelled HSM Baseline (2018) length-weighted average predictions of platypus habitat suitability, at the sub-catchment scale, and observed changes in platypus distribution (comparing historic live-trapping data with recent eDNA sampling data) were used for Rubric 1.

Changes in platypus distribution were based on differences between our current understanding of platypus distribution based on HSMs and live-trapping survey data with that of recent eDNA sampling data. For the HSMs, we only considered reaches above the very low category as very low predictions generally indicate that there is no platypus present within the reach. We used Spring 2021 and Autumn 2022 eDNA sampling data as an unbiased and quantitative assessment of potential current platypus distribution. Changes in platypus distribution at the sub-catchment scale were categorised as follows:

Stable: positive eDNA detections within sub-catchments where we have previously recorded platypus using live-trapping surveys OR negative eDNA detections within sub-catchments where we have not previously recorded platypus using live-trapping surveys.

Not improving: negative eDNA detections within sub-catchments where the long-term target was set to improve i.e. length-weighted average predictions from HSMs are predicted to improve one or more categories based on works and gross benefit (e.g. from Very Low to Low) over 50 years.

Potentially decreasing: negative eDNA detections in sub-catchments where we have previously recorded platypus using live-trapping surveys.

Table 12. Rubric 1. Rubric to evaluate if platypus is on-track to achieve targets outlined in the HWS at the sub-catchment scale.

Performance rating	Performance criteria / evidence
On-track to achieving long term target	**On-track** Length-weighted average predictions (2018) from HSMs fall into Low, Moderate, High or Very High category *And* Range of distribution is stable based on eDNA records and other data on presence
	On-track (expected eDNA negative) No targets were set due to lack of data or very unlikely presence of platypus (e.g. very low HSM predictions) AND negative eDNA records
	On-track (unexpected eDNA positive) No targets were set due to lack of data or very unlikely presence of platypus AND at least one unexpected positive eDNA record
Potentially off-track to achieving long term target	**Potentially off-track** Length-weighted average predictions (2018) from HSMs are predicted to improve one or more categories based on works and gross benefit (e.g. from Very Low to Low) over 50 years *And* Range of distribution has not improved based on lack of positive eDNA records and other data on presence
High chance that long-term targets will not be met	**Off-track** Length-weighted average predictions (2018) from HSMs fall into Moderate, High or Very High category *And* Range of distribution is potentially decreasing based on lack of positive eDNA records and other data on presence

Platypus community evaluation

Rubric 2 (Table 13) was used to determine the status rating of platypus communities inhabiting the 15 on-going live-trapping locations in the region. Below we explain how platypus CPUE (index of abundance), six health metrics, and range distribution change were used within Rubric 2.

Trends in core population abundance

Temporal variation in platypus CPUE was used as a proxy for population abundance trends (stable, increasing, decreasing, variable, or not assessable). Trend lines were fitted using the 'loess' scatter plot smoothing function with the following function arguments in R statistical software (R Core Development Team, 2018): family='gaussian'; span=1; degree=1. 'loess' is considered the most appropriate method as it robustly fits a smoothed curve without prior assumptions about the shape or form of the curve (Cleveland et al, 1992).

We assigned trends based on the degree of CPUE change over a defined timeframe. The threshold for CPUE change was 0.6: this value is the mean 95% confidence interval of platypus CPUE data (1995 - 2019) from the following platypus monitoring locations (Running Creek, Toorourrong, Eltham, Belgrave).

We applied the same threshold to assess population abundance trends over the entire data period (1995 - 2019) and for data collected within the past 10 years. We assessed trends at two different timescales as it was evident, after viewing the CPUE plots, that the trends for the entire data period did not necessarily reflect more recent CPUE trends.

Each trend was assigned '0' (for stable, variable and not assessable), '1' (for increasing), or '-1' (for decreasing). The numeric value from the two trends (i.e. entire data period and past 10 years) were then averaged to produce a final composite value and final trend (Figure 7).

Trend	Numeric value
Stable / variable / not assessable	0
Increasing	1
Decreasing	-1

average

Value	Final trend
-0.5 – 0.5	Stable
> 0.5	Increasing
< -0.5	Decreasing

Figure 7. Trend evaluation process for CPUE.

Trends in core community health

Six different community health metrics were used to assess trends in platypus community health (see Platypus value indicators): sex ratio, tail volume index, weight, length, and % juveniles, and genetic health.

Trend lines were fitted for five metrics (sex ratio, tail volume index, weight, length, and % juveniles) using the 'loess' scatter plot smoothing function, as was done for platypus population CPUE.

Trend assessments (i.e. stable, skewed, etc.) were determined by visual appraisal of trend lines and were assigned '0' (variable and not assessable), '1' (for stable or increasing), or '-1' (for decreasing or skewed). Health trends are available in Appendix 2: Platypus health metrics.

Trends in genetic health was assessed by summarising information on the platypus population genetic health within the Platypus Strategic Management Plan for Melbourne's Catchments (Griffiths and Weeks 2018). Population genetic health was represented as genetic diversity, with populations in each major catchment categorised as high or low. A high genetic diversity was given a value of 1 and a low genetic diversity was given a value of -1.

The final populations health trend were determined for each location after averaging the trends of all health metrics according to the process in Figure 8.

Trend	Numeric value
Variable / not assessable	0
Stable	1
Decreasing / skewed	-1

average

Value	Final trend
-0.5 – 0.5	Variable / unknown
> 0.5	Stable
< -0.5	Decreasing

Figure 8. Trend evaluation process for platypus community health.

Distribution change

Platypus distribution within each platypus community was assigned as 'stable', 'potentially declining', or 'declining' based on the following criteria:

- Stable: positive eDNA records in live-trapping survey area;
- Potentially declining: only equivocal or negative eDNA records in live-trapping survey area; or
- Declining: only negative eDNA records in live-trapping survey area.

Table 13. Rubric 2 – assigning status trajectory for platypus communities.

Status trajectory	Performance criteria / evidence
Improving	At least one of the following is improving: Community abundance (CPUE) Health index *AND* Stable range of distribution (i.e. positive eDNA records in live-trapping survey area)
Stable	Stable trends for the following: Community abundance (CPUE) Health index *AND* Stable range of distribution (i.e. positive eDNA records in live-trapping survey area)
Not assessable / potentially declining	Unknown or variable trends for one of the following: Community abundance (CPUE) Health index *AND / OR* Potentially declining range of distribution (i.e. only equivocal or negative eDNA records in live-trapping survey area)
Declining	Declining trends for one or both of the following: Community abundance (CPUE) Health index *AND* Declining range of distribution (i.e. only negative eDNA records in live-trapping survey area)

Evaluation results and discussion

Rubric 1: Sub-catchment evaluation

Summary. There is a high chance that long-term targets will not be met for three sub-catchments: Plenty River (Source), Deep Creek Upper, and Emu Creek. Despite 'Moderate' to 'Very High' modelled habitat suitability, platypus were not detected in waterways within these sub-catchments. The decline of platypus in Plenty River (Source) and Deep Creek Upper has been previously documented and their communities are effectively extinct and therefore the management priority is stated as low in the Platypus SMP. Despite a Moderate habitat suitability in the Emu Creek sub-catchment, there is evidence of declining CPUE, and it is thought that platypus may now be restricted to lower reaches of the creek near its confluence with Deep Creek.

The graphical outcome of Rubric 1 can be viewed below in Figure 9. More than 88% of sub-catchments (61) were considered to be on-track based on Rubric 1 (Figure 9). Three sub-catchments were off-track and five were potentially off-track.

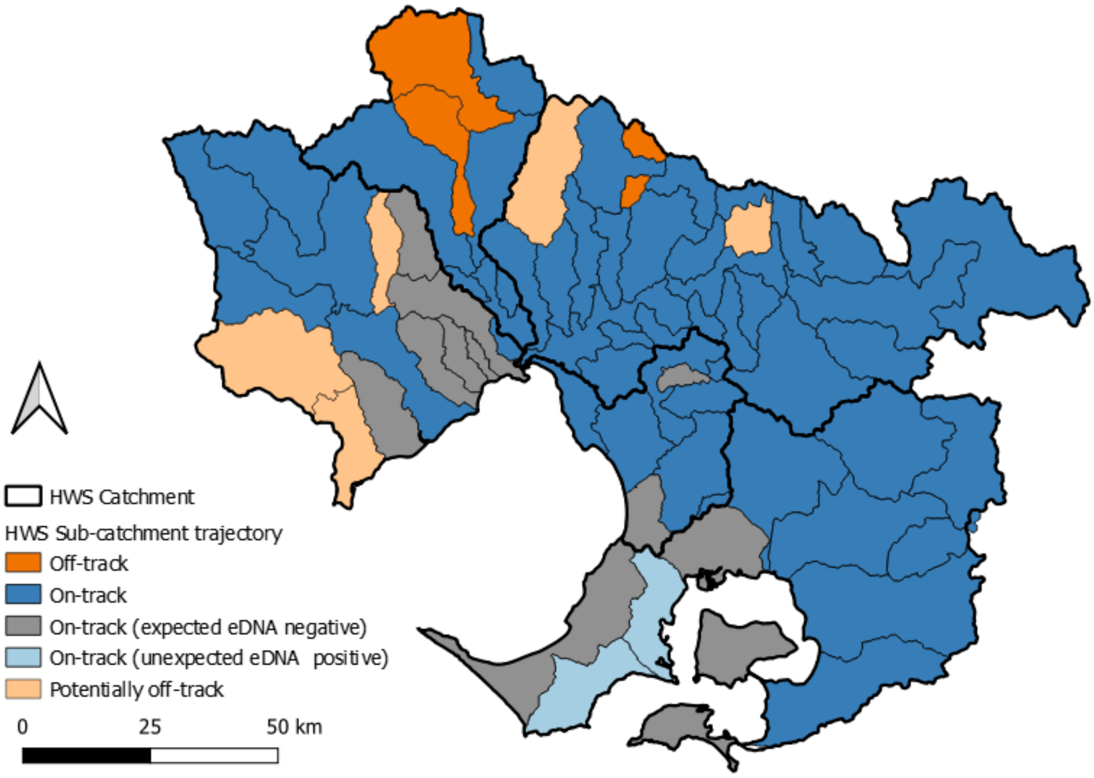


Figure 9. The performance rating, determined using Rubric 1, given to HWS sub-catchments to evaluate if platypus is on-track to achieve long-term targets outlined in the HWS at the sub-catchment scale.

Significant for implementation

There is a high chance that long-term targets will not be met for three sub-catchments (Figure 9):

- Plenty River (Source) - Yarra catchment
- Deep Creek Upper - Maribyrnong catchment
- Emu Creek - Maribyrnong catchment

Plenty River (Source)

The length-weighted average predictions from HSMs were rated as Moderate for the Plenty River (Source) sub-catchment. However, substantial parts of the river network above the Toorourrong Reservoir are rated as high habitat suitability. The following description accompanied the HSM length-weighted average prediction for Plenty River (Source) sub-catchment:

> *Platypus score is moderate. Recent drought and bushfires have been implicated in severe decline or complete loss of this population. Reduced flows from climate change are a significant threat and will reduce score to low unless they can be maintained.*

No platypus have been captured in the Toorourrong Reservoir or upstream waterways since November 2010 (Figure 10) (Kelly, Griffiths and Weeks 2013), recent eDNA surveys have not detected the presence of platypus (see Figure 24), and this community has been labelled extinct with a low management priority (Griffiths and Weeks 2018).

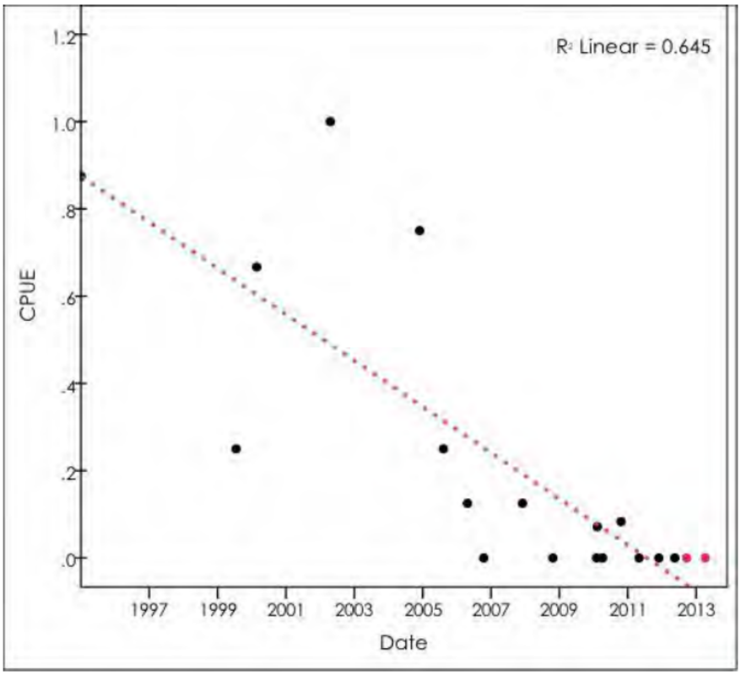


Figure 10. Platypus CPUE at Toorourrong Reservoir over time. Graph displays all available CPUE data for all historic (black) and 2012/13 (red) surveys. All data prior to mid-2007 were derived from APC reports. A regression line indicates a significant trend in CPUE. Figure adapted from Kelly et al. (2013).

Deep Creek Upper

The length-weighted average predictions from HSMs were rated as Moderate for the Deep Creek Upper sub-catchment. The following description accompanied the HSM length-weighted average prediction for Deep Creek Upper sub-catchment:

> *Platypus is moderate due to a lack in flows and instream and riparian habitat, with a predicted decline to low with impacts of a drier climate. Management of flows and improvements to riparian vegetation is expected to maintain current score in the face of climate change.*

All 25 eDNA survey points for Deep Creek Upper returned a negative result. Live-trapping surveys have historically been conducted at three locations along Deep Creek: Darraweit Guim, Lancefield, and Romsey. Live-trapping surveys at Lancefield and Romsey were only conducted in Spring 2012, with one individual captured at Romsey. Although Autumn 2013 live-trapping were planned at Lancefield and Romsey, low water levels in Deep Creek prevented surveys (Kelly, Griffiths and Weeks 2013).

The platypus community at Darraweit Guim was surveyed between 1994 and 2014 and displayed declining trends through time associated with the Millennium Drought and extended periods of no flow and channel drying (Griffiths and Weeks 2018). No platypus were recorded during the 2012/13 (Kelly, Griffiths and Weeks 2013) and 2013/14 (Griffiths, Kelly, et al. 2014) surveys and live-trapping as part of the Melbourne Water Urban Platypus Program was discontinued in 2014 (Figure 11). Platypus are considered to be extinct in Deep Creek; public sightings indicate that individuals may be present at certain times but in very low numbers (Griffiths, van Rooyen and Song, et al. 2018) . Given this population is presumed extinct, the Platypus SMP rated the management priority as low.

Darraweit Guim (rolling)
2013/14 Survey Results

4 | 19

	Trap night	No. Platypus	CPUE
Spring	10	0	0.000
Autumn	10	0	0.000
Total	20	0	0.000

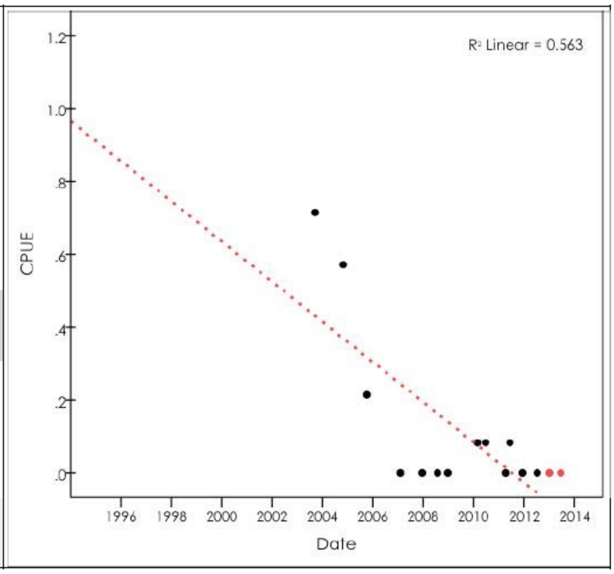


Figure 11. Summary of the 2013/14 platypus live-trapping survey results for Darraweit Guim. Includes seasonal and overall information on survey effort, number of individuals captured, and CPUE. Graph displays all available CPUE data for all historic (black) and 2013/14 (red) surveys. All data prior to mid-2007 were derived from APC reports. A regression line indicates a significant trend in CPUE. Figure adapted from Griffiths et al. (2014).

Emu Creek

The length-weighted average predictions from HSMs were rated as Moderate for the Emu Creek sub-catchment. The following description accompanied the HSM length-weighted average prediction for Emu Creek sub-catchment:

> *Platypus is moderate due to a lack of flows and instream and riparian habitat. They are most likely to be found in the lower reaches near the confluence of Deep Creek. The score is expected to decline to low as a result of urbanisation and climate change. Management of stormwater and rural flows, as well as improvements to riparian vegetation is expected to maintain score as moderate.*

All seven recent (Spring 2021 and Autumn 2022) eDNA survey points in Emu Creek returned a negative result. Further, earlier eDNA samples collected in 2017/2018 also did not detect any platypus in Emu Creek (Griffiths, van Rooyen and Song, et al. 2018).

No live-trapping surveys have been conducted within the Emu Creek sub-catchment. The platypus within the Emu Creek sub-catchment are thought to be largely restricted to the lower reaches where it meets Deep Creek near Bulla (Griffiths, van Rooyen and Song, et al. 2018) – this community has decreased over time (Figure 12) (Griffiths, van Rooyen and Weeks 2016).

2015/16 survey results

	Trap night	No. Platypus	CPUE
Spring	6	0	0.000
Autumn	--	--	--
Total	6	0	0.000

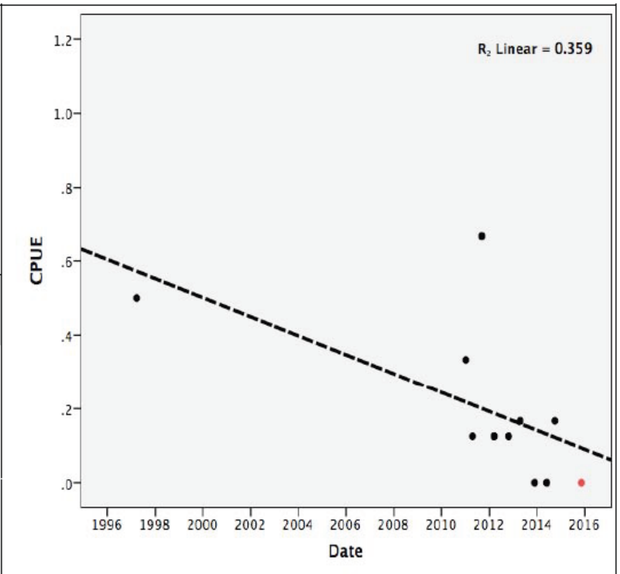


Figure 12. Summary of the 2015/16 platypus live-trapping survey results for Bulla. Includes seasonal and overall information on survey effort, number of individuals captured, and CPUE. Graph displays all available CPUE data for all historic (black) and 2015/16 (red) surveys. All data prior to mid-2007 were derived from APC reports. A regression line indicates a significant trend in CPUE. Figure adapted from Griffiths et al. (2016).

Potentially significant for implementation

The following sub-catchments were determined to be potentially significant for HWS implementation:

- Steels and Pauls Creek (Rural),
- Merri Creek Upper,
- Little River Lower,
- Little River Upper, and
- Toolern Creek.

The length-weighted average habitat suitability of these sub-catchments are predicted to improve from a rating of ‘Very Low’ (2018 baseline) to a rating of ‘Low’ (2068 target). However, no platypus were detected in these sub-catchments from two recent eDNA surveys.

All of these sub-catchments were rated as ‘Very Low’ in 2018 because they were characterised by a lack of instream and riparian habitat, naturally low flows, fragmentation, and/or urban stormwater impacts. The improvement from ‘Very Low’ to ‘Low’ habitat suitability was predicted based on the improvement of these conditions as well as from stakeholder engagement as stakeholders expressed support for an improvement in habitat suitability.

Note that platypus are not generally expected in these sub-catchments and eDNA sampling throughout the network is still incomplete. Given that the likelihood of platypus inhabiting waterways within these sub-catchments is low to very low, and we are only five years into the strategy, we downplay the implementation significance of this finding.

However, we will add these sub-catchments to our “watch list” and re-assess the outcome of the rubric once we have completed the baseline eDNA monitoring program – four separate sampling campaigns are needed (Tingley, Wu and Weeks 2020) and this is likely to be completed in 2024.

Rubric 2: Platypus community evaluation

Overall, two of the 15 platypus communities, Cardinia and Lang Lang, were given a performance rating of 'Not assessable / potentially declining' (Table 15). These two communities were thus considered to be 'Significant for implementation'. As outlined in Rubric 2, these ratings were assigned as their community status was 'Not assessable / potentially declining' and the Platypus SMP rated these communities as either vulnerable or threatened (Table 15).

None of the 15 platypus communities were rated as declining (Table 15). However, two communities, Cardinia and Lang Lang, lacked data for sufficient evaluation and/or were deemed to be potentially declining (Table 15). The overall community status rating was based on the following trends in abundance, heath, and distribution.

- **Abundance**. The abundance trajectory of platypus communities that are regularly monitored as outlined in the Rivers MEP were determined to be stable (Figure 13). Although we have rated abundance trajectory as stable, we highlight that abundance, as represented by CPUE, may have declined since 1995 in some communities (Figure 13). It should be noted that caution is warranted with respect to accepting that CPUE accurately captures long-term temporal trends in abundance in this instance, given that (1) the analysis amalgamates live-trapping information obtained by two different sets of operators (working from 1995 to mid-2007 and mid-2007 to 2018, respectively), and (2) platypus live-trapping results are potentially sensitive to operator-related differences (see section 1).
- **Health**. The health trajectory was determined to be stable for 13 of the platypus communities, with insufficient data to properly assess the health of the Cardinia and Lang Lang communities **(Table 15)**.
- **Distribution**. We recorded positive eDNA detections within reaches occupied by 14 of the 15 platypus communities (Table 14). No positive eDNA detections were recorded in live-trapping reaches of Cardinia Creek. However, there was one positive eDNA detection in Cardinia Creek below the live-trapping survey area.

Significant for implementation

Cardinia platypus community

The Cardinia platypus community was determined to be 'Significant for implementation' for the following reasons:

- the community is rated as 'Threatened' in the Platypus SMP;
- unknown recent trends in community health, owing to the small number of individuals, and;
- consistently low trends in abundance.

The Cardinia platypus community is a small, translocated community and the reasons for its decline have been noted in the Platypus SMP (Griffiths and Weeks 2018). A thorough description of this community and the reasons for its decline are stated in KEQ 2a 'Cardinia platypus community'.

Lang Lang platypus community

The Lang Lang platypus community was determined to be 'Significant for implementation' for the following reasons:

- the community is rated as 'Vulnerable' in the Platypus SMP, and;
- unknown recent trends in community health, as the last live-trapping survey was conducted in March 2013.

A thorough description of this community and the reasons for its decline are stated in KEQ 2a 'Lang Lang platypus community'.

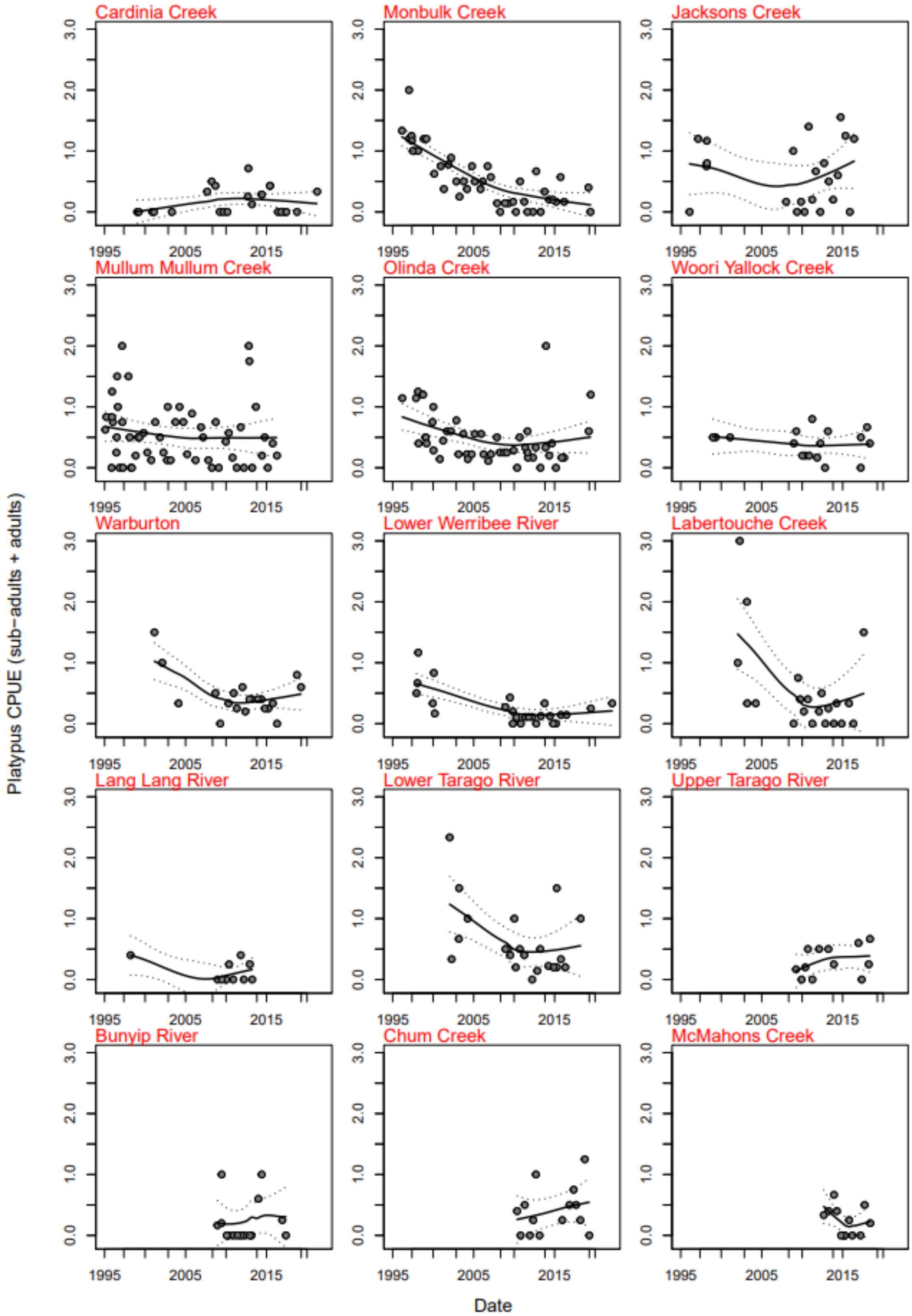


Figure 13. Platypus abundance trends as catch-per-unit-effort (CPUE) for 15 monitoring locations (representing 10 core populations) across the Melbourne region. Trend lines were fitted using the 'loess' scatter plot smoothing function with the following function arguments in R statistical software (R Core Development Team, 2018): family='gaussian'; span=1; degree=1. 'loess' is considered the most appropriate method as it robustly fits a smoothed curve without prior assumptions about the shape or form of the curve (Cleveland et al, 1992).

Table 14. Summary of eDNA detections (positive, equivocal, negative) from Spring 2021 and Autumn 2022 surveys in reaches comprising the 15 MERI platypus live-trapping locations.

MERI live-trapping location	# eDNA sampling points	# positive detections	# equivocal detections	# negative detections
Jacksons Creek	7	5	0	2
Lower Werribee River	16	6	4	6
Mullum Mullum Creek	13	8	1	4
Chum Creek	5	4	1	0
Woori Yallock Creek	6	4	1	1
Warburton	9	7	1	1
McMahons Creek	7	5	0	2
Monbulk Creek	7	2	5	0
Cardinia Creek	6	0 (1 positive detection below survey reaches)	0	6
Bunyip River	9	7	2	1
Upper Tarago River	8	6	0	2
Lower Tarago River	11	6	1	4
Labertouche	6	4	0	2
Lang Lang River	9	2	0	7

Table 15. The platypus community status and management priority determined within the Platypus Strategic Management Plan (SMP) at each live-trapping monitoring location in the Melbourne region. The live-trapping monitoring status is also given.

Monitoring location	SMP platypus status	Abundance trajectory	Health trajectory	Distribution trajectory	Community status	Performance rating
McMahons Creek	**Resilient**	Stable	Stable	Stable	Stable	Stable
Warburton	**Resilient**	Stable	Stable	Stable	Stable	Stable
Woori Yallock Creek	**Resilient**	Stable	Stable	Stable	Stable	Stable
Chum Creek	**Resilient**	Stable	Stable	Stable	Stable	Stable
Olinda Creek	**Vulnerable**	Stable	Stable	Stable	Stable	Stable
Mullum Mullum Creek	**Resilient**	Stable	Stable	Stable	Stable	Stable
Upper Tarago	**Resilient**	Stable	Stable	Stable	Stable	Stable
Lower Tarago	**Vulnerable**	Stable	Stable	Stable	Stable	Stable
Labertouche	**Vulnerable**	Stable	Stable	Stable	Stable	Stable
Lang Lang River (Athlone)	**Vulnerable**	Stable	Variable / Unknown	Stable	Not assessable / potentially declining	Not assessable / potentially declining
Cardinia Creek	**Threatened**	Stable	Variable / Unknown	Potentially declining	Not assessable / potentially declining	Not assessable / potentially declining
Bunyip River	**Resilient**	Stable	Stable	Stable	Stable	Stable
Werribee River Lower	**Threatened**	Stable	Stable	Stable	Stable	Stable
Monbulk (Belgrave)	**Threatened**	Stable	Stable	Stable	Stable	Stable
Jacksons Creek (Lower Sunbury)	**Resilient**	Stable	Stable	Stable	Stable	Stable

Recommendations

- Prioritise resources to conduct live-trapping surveys for the Lang Lang and Cardinia platypus communities, and at all other locations as described in the Rivers MEP, and re-assess trajectory when sufficient data is available.
- Continue eDNA monitoring in sub-catchments where platypus are considered to be effectively extinct (Plenty River (Source) and Deep Creek Upper). There may be a need to review performance objectives and communicate this information.

KEQ 2a. What environmental conditions (e.g. Water quality), external conditions (e.g. drought) and threats (e.g. low flow conditions, development) help explain current key value trends?

Evaluation methodology

We focused our evaluation of KEQ2a on the sub-catchments and platypus communities that we determined to be 'Significant for implementation' from KEQ3a. For each of these sub-catchments (3) and platypus communities (2), we summarised evidence from the literature (scientific reports and industry communications) and available data on the environmental conditions, external conditions, and threats that underpin the current trajectory of platypus.

Evaluation results and discussion

Plenty River (Source) platypus

Summary. Repeated draining of Toorourrong Reservoir due to capital works, high flows events, bushfire, and fragmentation are all believed to have contributed to the decline of platypus in Plenty River (Source).

The decline of platypus communities in the Plenty River (Source) sub-catchment has been documented (Kelly, Griffiths and Weeks 2013), and mirrors decline in other western and northern parts of the Yarra catchment (Griffiths and Weeks, Platypus Stategic Management Plan for Melbourne's Catchments 2018). The Toorourrong Reservoir once had a very high platypus abundance but this community suffered a rapid decline that was attributed to cumulative impacts of a major flood in 2005, extended drought conditions in the summers of 2002/03 and 2006/07, intense bushfires in 2009, the repeated draining of Toorourrong Reservoir, and isolation of the population (Kelly, Griffiths and Weeks 2013, Jacobs 2016, Griffiths and Weeks 2018). Few breeding females (possibly as few as two) were thought to have survived these events at the start of the century (Serena and Williams 2008). It is worth noting that the extinction of a platypus population in Cardinia Creek was directly linked to the Ash Wednesday bushfires in 1983 (Serena and Willaims 2004), most likely as a consequence of flow cessation and disappearance of refuge pools following the fire; highlighting the detrimental impacts that severe bushfire may have for platypus communities and the aquatic ecosystems that support their existence, particularly where barriers, such as large dams (Mijangos, et al. 2022) and poor instream habitat, prevent recolonization after these severe disturbances. The potential impact of bushfires on platypus is still subject to research and debate. Negligible fire effects for platypus have recently been reported elsewhere in Australia (Serena, Lyon, et al. 2023) (Serena et al, *in press*).

The 2013 HWS Annual Report recognized that habitat suitability has improved remarkably due to reservoir upgrades, which "drought proofed" the area and reduced barriers to dispersal, and recommended reintroducing platypuses to Toorourrong Reservoir (Kelly, Griffiths and Weeks 2013). The platypus HSMs from the HWS confirm that platypus habitat suitability is rated as Moderate for Plenty River (Source) sub-catchment but that reaches rated as High exist in tributaries upstream of Toorourrong Reservoir (Figure 14). Further, these reaches are associated with 'Very High' ratings for macroinvertebrates, vegetation, and stormwater control (Figure 14). Despite this, it was also highlighted that habitat suitability remained poor downstream of the reservoir in the Plenty River Upper sub-catchment (Kelly, Griffiths and Weeks 2013). Additionally, in-stream connectivity is currently rated as Moderate for the Plenty River (Source) catchment. All-in-all, aquatic habitat upstream of Toorourrong

Reservoir is ideal for platypus but poor environmental conditions downstream (in Plenty River Upper sub-catchment) effectively work to prevent natural re-introductions from known platypus populations (i.e. Plenty Gorge).

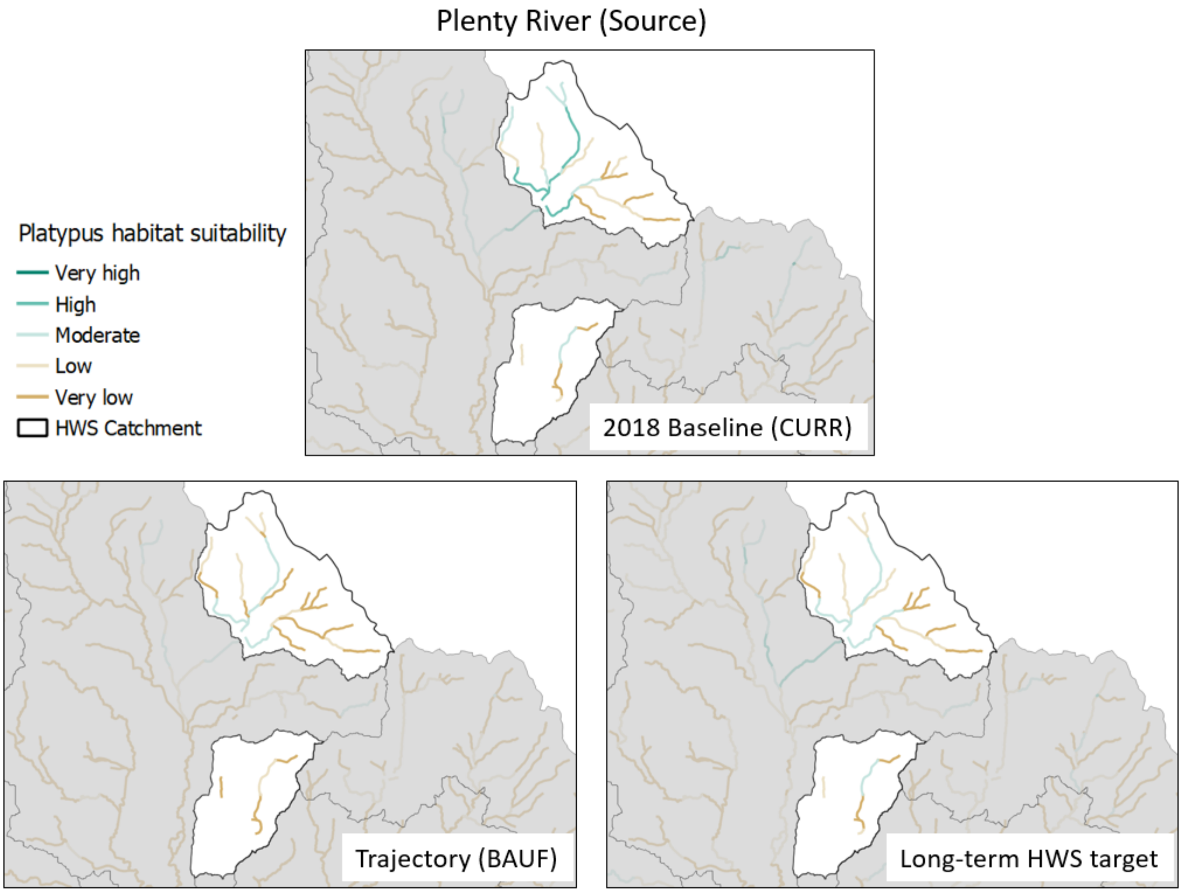


Figure 14. Modelled habitat suitability for platypus in the Plenty River (Source) sub-catchment for the following three scenarios: predictions for the 2018 baseline (CURR), business as usual trajectory for the future assuming no interventions (2070; BAUF), and long-term (2070) HWS target.

Deep Creek Upper - Maribyrnong catchment

Summary. Reduced flows, fragmentation, and poor riparian vegetation may all contribute to the decline in platypus in Deep Creek Upper.

The platypus communities in upper Deep Creek represent one of the 10 distinct platypus populations across Melbourne (Griffiths and Weeks 2018). The Platypus SMP (Griffiths and Weeks 2018) listed the following key threats (and the rating of that threat) to the population in upper Deep Creek:

- Poor flow regimes (High threat)
- Fragmentation (High threat)
- Poor riparian zone (Moderate threat)
- Poor in-stream complexity (Low threat)
- Genetic diversity/inbreeding (Low threat)

Increasing cease-to-flow underpins the platypus decline in Deep Creek

The decline of platypus in the Deep Creek Upper sub-catchment in the early 2000's is associated with flow regime characteristics known to be detrimental to platypus communities (Figure 15) (Griffiths, Maino and Weeks 2019). In particular, the frequency and duration of cease-to-flow events is greater post-2000, and flow regime variability appears to increase over the same period (Figure 15). The occurrence of low flow events was noted by Cesar in 2013 during live-trapping surveys as water levels were too low to conduct surveys in Autumn 2013 (Kelly, Griffiths and Weeks 2013).

Platypus are presumed to have been historically distributed throughout much of Deep Creek (see Figure 1)

A reduction in flows and increase in flow intermittency is thought to have broadly coincided with major declines or the disappearance of platypus in Deep Creek and other systems in western Melbourne (i.e. upper Werribee and Lerderderg Rivers) (Griffiths and Weeks 2018).

The broader influence of flow regimes on Melbourne's platypus populations was investigated by Cesar on behalf of Melbourne Water in 2019 (Griffiths, Maino and Weeks 2019). An increase in the cease-to-flow duration and an increase in flow variability had the largest negative impacts on platypus abundance in Melbourne (Figure 16). Further, the impact was greater when these conditions were sustained for longer. In contrast, the most "healthy" platypus populations in Melbourne were typically characterized by flow regimes with low or no cease-to-flow periods and low flow variability (Griffiths, Maino and Weeks 2019). High flow variability and very low or cease to flow events are known to have negative impacts on the temporal and spatial dynamics of macroinvertebrate assemblages (Walsh, et al. 2001, Marchant and Grant 2015, Chessman 2009) and this is most likely the mechanism by which sub-optimal flow regimes are impacting platypus abundance (Griffiths, Maino and Weeks 2019).

Reduced flow conditions was a major factor underpinning the predicted decline in future platypus habitat suitability (sub-catchment length-weighted average) in the Deep Creek Upper sub-catchment from Moderate (2018 baseline) to Low (2070 prediction). The platypus habitat suitability in Deep Creek Upper can be seen in Figure 17. The following description accompanied the HSM length-weighted average prediction for Deep Creek Upper sub-catchment:

> *Platypus is moderate due to a lack in flows and instream and riparian habitat, with a predicted decline to low with impacts of a drier climate. Management of flows and improvements to riparian vegetation is expected to maintain current score in the face of climate change*

Due to the importance of flow regime characteristics for platypus communities, the following PO's were instituted for Deep Creek Upper sub-catchment (Appendix 3. Flow-related Performance Objectives for locations determined to be 'Significant for implementation'):

> *PO 189. Maintain critical flow components in refuge reaches along Deep Creek to protect Yarra pygmy perch, platypus and other instream values.*
> *PO 190. Reduce threat of summer low flow stress by addressing causal factors such as water for domestic and stock use, diversions and climate change.*

Deep Creek is effectively an unregulated system and there are currently no statutory surface water management plans in the Maribyrnong catchment. Refuge reaches have been identified in Deep Creek Upper for Yarra Pygmy Perch. Importantly, during long-term target setting for sub-catchments, one of the key assumptions was that "*… in key locations flows (particularly base flows) could be maintained through interventions which could offset the likely climate change drying conditions. As such the mean annual runoff depth set to 2016 values.*" In unregulated systems, where flow regime control actions are limited to the implementation of sustainable diversion limits, how realistic is this assumption?

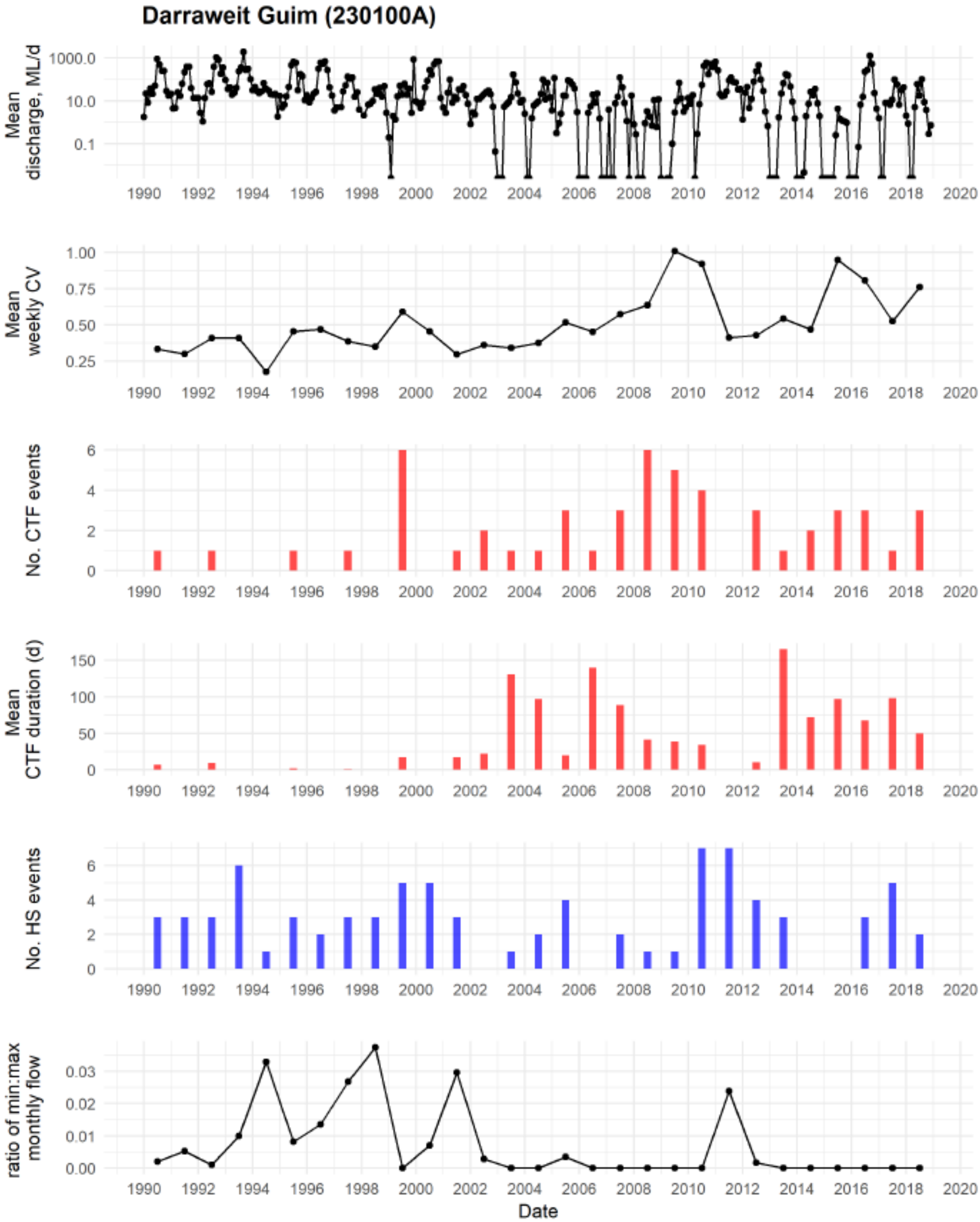


Figure 15. The characteristics of the flow regime for Deep Creek measured at Darraweit Guim: mean monthly discharge (megalitres per day), mean weakly flow variation (coefficient of variation), number of cease-to-flow events per year, mean cease-to-flow duration (days), number of high spell events, and the ratio of minimum to maximum monthly flow. Source: Griffiths et al (2019).

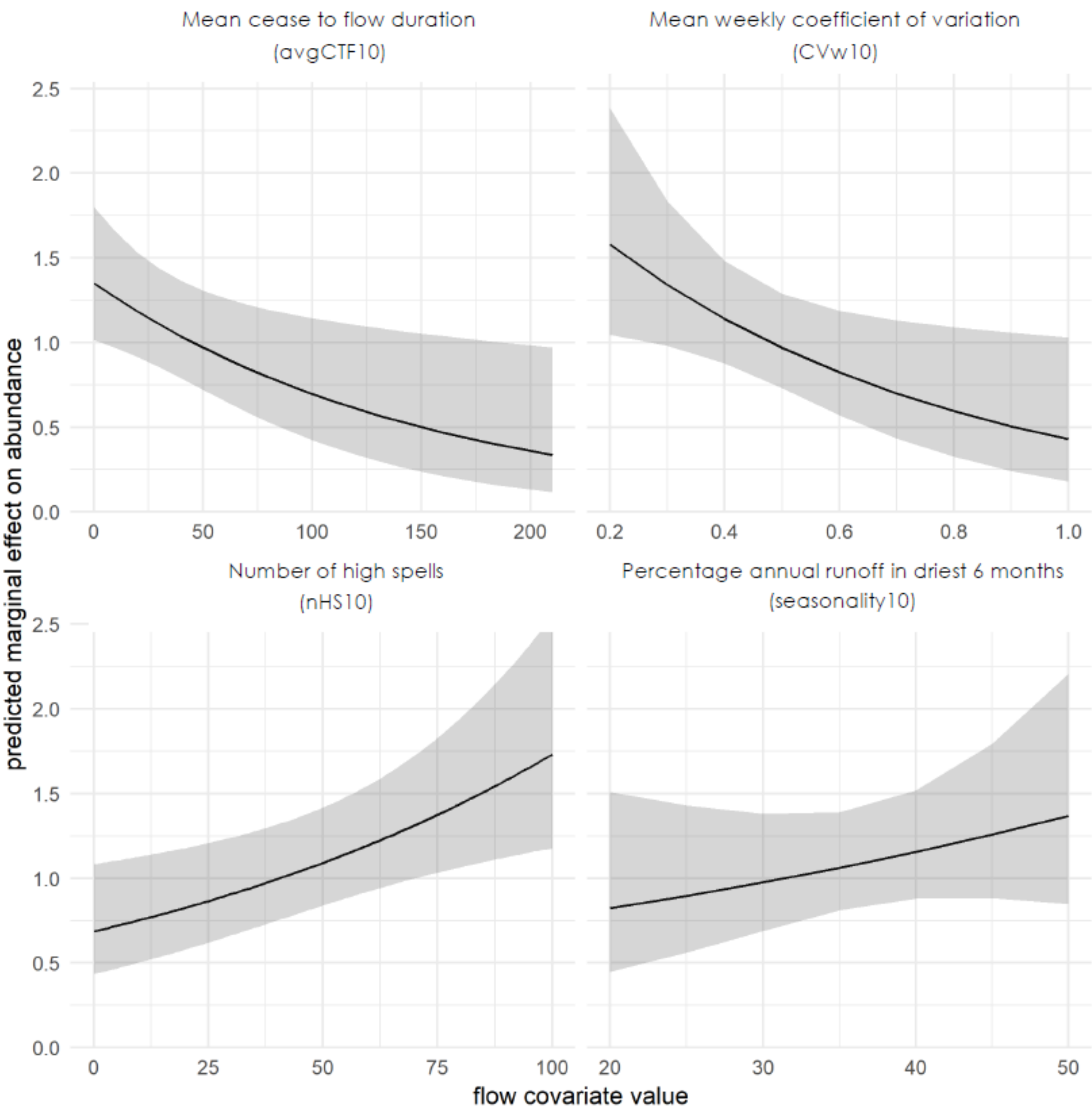


Figure 16. The predicted association between flow covariates and platypus abundance across the Melbourne region. Shaded regions indicated the 95% confidence interval. Originally published in Griffiths et al (2019).

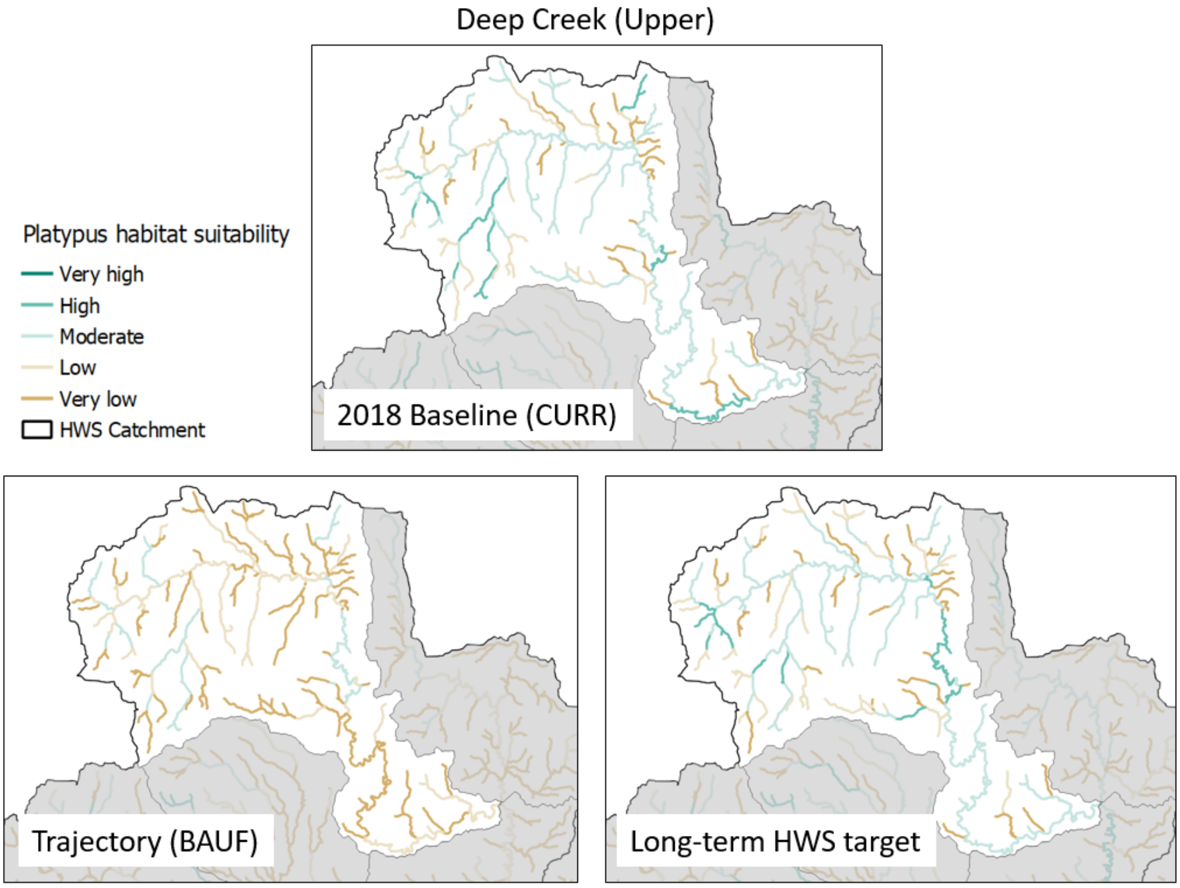


Figure 17. Modelled habitat suitability for platypus in the Deep Creek Upper sub-catchment for the following three scenarios: predictions for the 2018 baseline (CURR), business as usual trajectory for the future assuming no interventions (2070; BAUF), and long-term (2070) HWS target.

Fragmentation has been exacerbated by poor in-stream habitat and deteriorating flow regimes

Poor platypus habitat suitability in lower reaches of Deep Creek (Figure 17) are thought to act as a barrier, along with surface-flow cessation, to effective dispersal of individuals and connectedness to other populations (Griffiths and Weeks 2018).

Poor riparian zone

A further decline in riparian vegetation condition, without intervention, was also a factor contributing to the predicted decline in future platypus habitat suitability in the Deep Creek Upper sub-catchment. Vegetation extent was rated as Low, and vegetation quality Moderate, for the 2018 baseline assessment for the HWS (Figure 17). The current poor state of riparian vegetation condition is reflected in the large riparian buffer establishment target for Deep Creek Upper sub-catchment (Appendix 4. Vegetation-related Performance Objectives for locations determined to be ‘Significant for implementation’): unlike for the environmental flow objectives, progress is on track to achieve buffer establishment and maintain existing vegetation (Appendix 5: Vegetation establishment and maintenance targets and progress).

Emu Creek - Maribyrnong catchment

Summary. Platypus in Emu Creek are thought to exist in the lower reaches near the confluence with Deep Creek. eDNA has not yet been sampled in lower reaches of Emu Creek. Reduced flows and lack of adequate in-stream and riparian habitat contribute to the 'Moderate' habitat suitability rating at Emu Creek.

The platypus within the Emu Creek sub-catchment are thought to be largely restricted to the lower reaches where it meets Deep Creek, near Bulla, as flow conditions are more permanent and refuge reaches likely present (Griffiths, van Rooyen and Song, et al. 2018). The community is thought to span Emu Creek and Deep Creek and individuals from Bulla have been recorded in Jacksons Creek, illustrating the broader connectedness with the Jacksons Creek community when adequate surface water is available (Griffiths, van Rooyen and Song, et al. 2018). Abundance at Bulla has decreased over time (Figure 18). The decline in this population has been linked with declines in flow regime characteristics (Figure 19) similar to that occurring upstream at Darraweit Guim in the Deep Creek Upper sub-catchment.

Platypus habitat suitability is rated as 'Moderate' at Emu Creek due to a lack of flows and instream and riparian habitat - the following description accompanied the HSM length-weighted average prediction for the Emu Creek sub-catchment:

> *Platypus is moderate due to a lack of flows and instream and riparian habitat. They are most likely to be found in the lower reaches near the confluence of Deep Creek. The score is expected to decline to low as a result of urbanisation and climate change. Management of stormwater and rural flows, as well as improvements to riparian vegetation is expected to maintain score as moderate.*

Platypus have been detected just downstream of the confluence of Emu Creek with Deep Creek, near Bulla, in recent eDNA sampling. Further, there has been no eDNA sampling along reaches of Emu Creek near its confluence with Deep Creek – the nearest sampling location has been ~5 km upstream of the confluence. Given the connectedness of this platypus community, and the lack of eDNA sampling near the known inhabited reaches by platypus (the confluence with Deep Creek), it is possible that the absence we observed does not reflect their actual distribution along lower Emu Creek.

Performance Objective (PO) 203 for Emu Creek aims to reduce the threat of summer low flows (Appendix 3. Flow-related Performance Objectives for locations determined to be 'Significant for implementation'). There has been no progress toward achieving this.

PO's exist to establish riparian buffers and protect/maintain vegetation quality for Emu Creek (Appendix 4. Vegetation-related Performance Objectives for locations determined to be 'Significant for implementation'). Only 17 ha of the 159 ha riparian vegetation establishment target has been achieved, while the management of high-quality vegetation is considered to be on-track (around 102 ha of high quality vegetation was managed in 2020/21) (Appendix 5: Vegetation establishment and maintenance targets and progress).

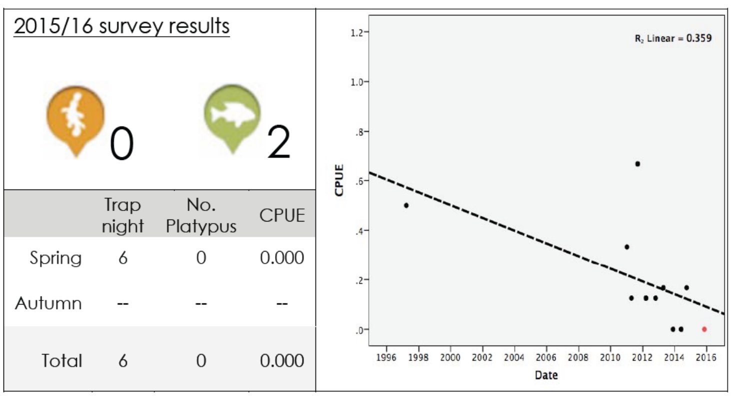


Figure 18. Temporal variation in platypus abundance, as catch-per-unit-effort (CPUE), for the Bulla community.

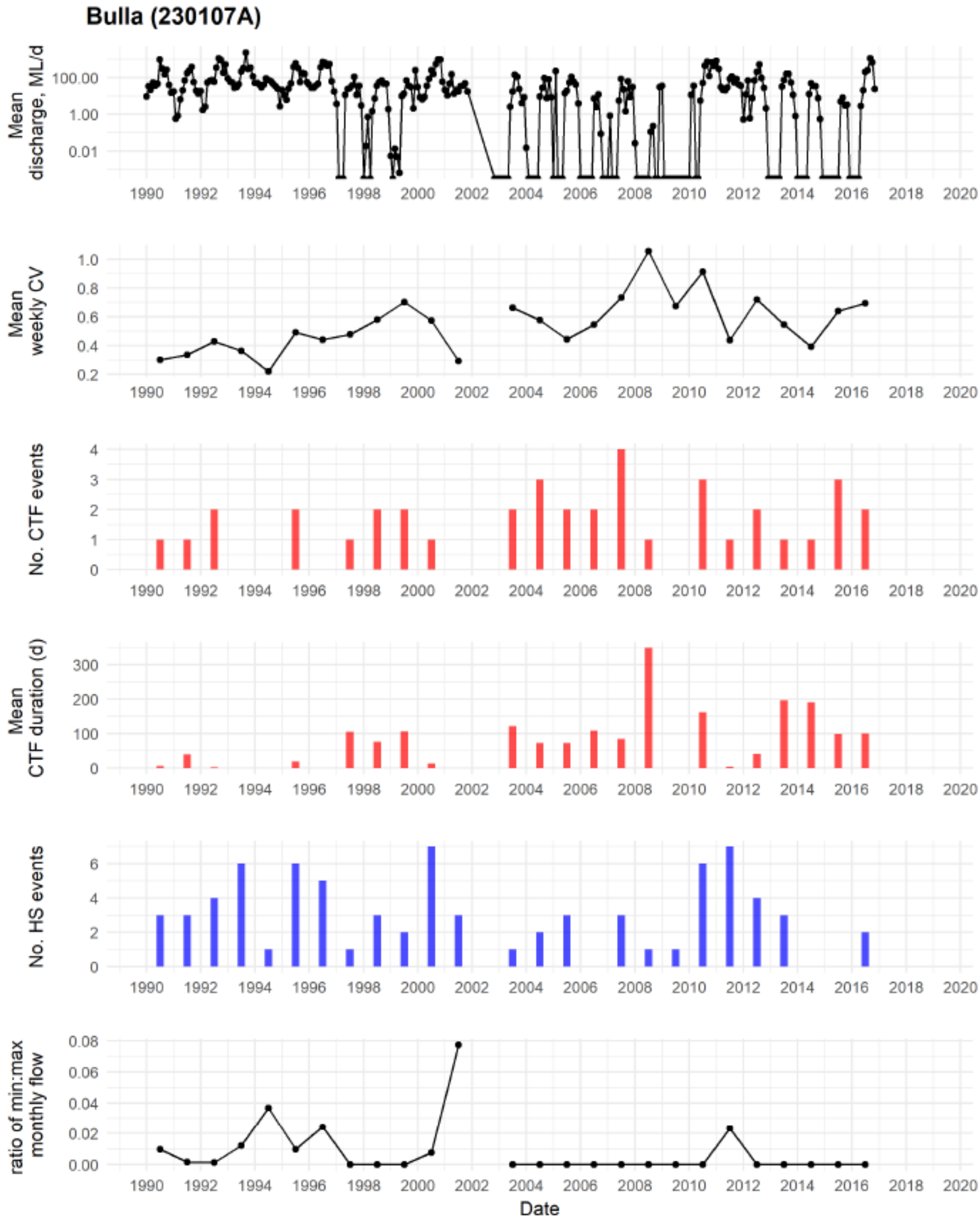


Figure 19. The characteristics of the flow regime for Deep Creek measured at Konagaderra (Bulla): mean monthly discharge (megalitres per day), mean weakly flow variation (coefficient of variation), number of cease-to-flow events per year, mean cease-to-flow duration (days), number of high spell events, and the ratio of minimum to maximum monthly flow. Source: Griffiths et al (2019).

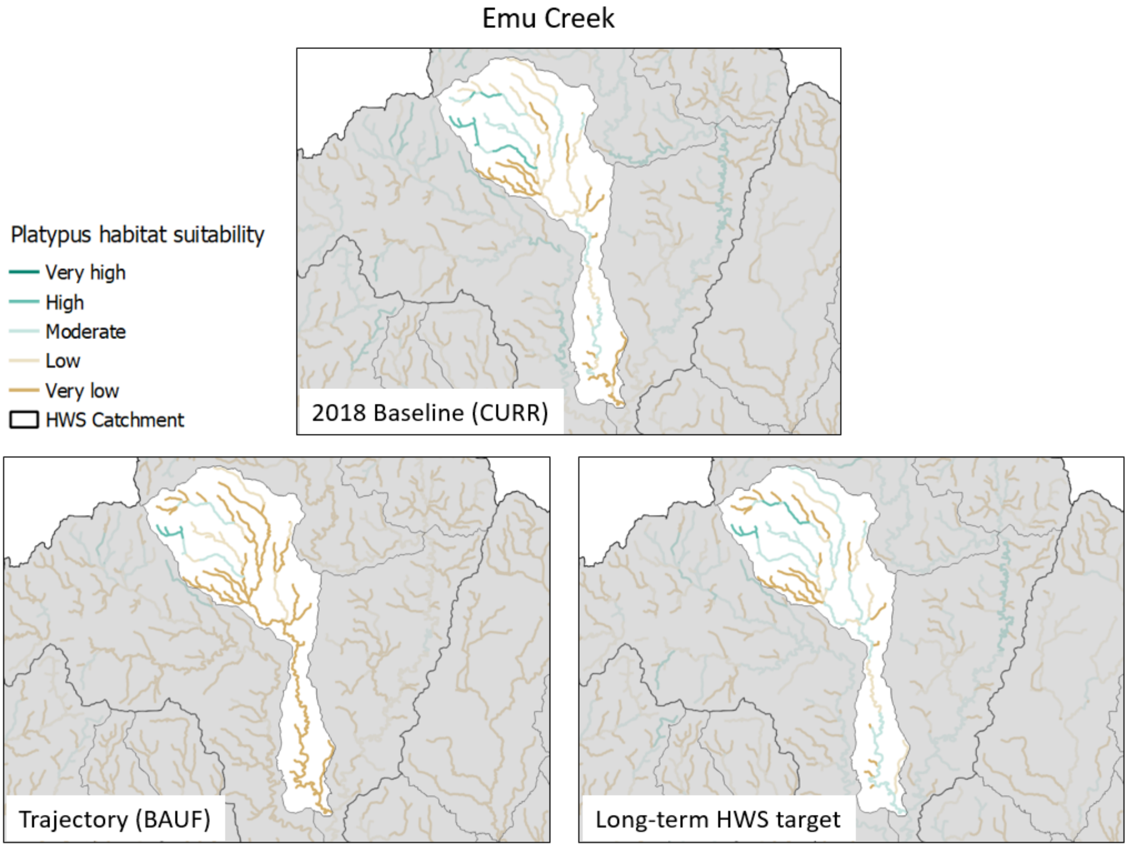


Figure 20. Modelled habitat suitability for platypus in the Emu Creek sub-catchment for the following three scenarios: predictions for the 2018 baseline (CURR), business as usual trajectory for the future assuming no interventions (2070; BAUF), and long-term (2070) HWS target.

Cardinia platypus community

Summary: The variable/unknown health trajectory of platypus in Cardinia Creek is largely reflective of the low abundance and thus capture rate which is, in turn, likely reflective of multiple pressures (adverse conditions and threats) affecting this population. Fragmentation (relatively small stretch of suitable habitat) and low genetic diversity were thought to be the main threats to the long-term survival of this population and their short-term persistence at the time of the Platypus SMP publication. Altered flow may also be impacting the Cardinia platypus population. Many of these pressures existed before the reintroduction program and continue to affect the population.

The current platypus community at Cardinia Creek exists due to a reintroduction program initiated in 2004 by Melbourne Water and the Australian Platypus Conservancy. Platypus are thought to have disappeared from Cardinia Creek following the Ash Wednesday bushfires in 1983 (Serena and Willaims 2004); although, the population is thought to have been in decline prior to these bushfires (Griffiths and Weeks 2018). A more thorough description of the reintroduction program can be found in the Platypus SMP and Serene and Williams (2004).

Overall abundance is considered low in Cardinia Creek (Figure 13) and the population is considered to be in decline (Griffiths and Weeks 2018). The Platypus SMP stated that the viability of the population was very poor for the following reasons:

- low abundance,
- very small effective population size,
- low/declining genetic diversity,
- isolation, and
- restricted habitat availability.

Further, a recent Ecology Australia report has also raised the possibility of alerted flow regimes (reduced baseflow and greater flow variability since 2013) impacting the Cardinia platypus population (Bloink 2020)**.**

Habitat suitability for platypus is variable in the Cardinia, Toomuc, Deep and Ararat Creeks sub-catchment (Figure 21). The length-weighted average predictions from HSMs were rated as Moderate, with habitat suitability generally better in reaches of Cardinia Creek upstream of the Princess Freeway. These upstream reaches of Cardinia Creek are associated with better habitat suitability for macroinvertebrates, higher quality rating for vegetation, and better stormwater condition than downstream reaches (Figure 21).

The Platypus SMP (Griffiths and Weeks 2018) listed the following key threats to the population in Cardinia Creek (supporting text included where available):

- Fragmentation (High threat) - The current distribution of platypuses and suitable habitat for this population is only approximately 10 km with no potential to connect with any adjacent population. This area is considered too small to support a self-sustaining population.
- Genetic diversity/inbreeding (High threat) - A small founder group (10 individuals) with unknown genetic relationships and contribution, combined with the current very low estimate of genetic diversity suggests that this population needs genetic intervention.
- Enclosed yabby traps (Moderate threat) - The use of enclosed yabby traps, such as opera house nets appears to be common throughout the area, presumably targeting spiny crayfish. At least two platypuses are known to have drowned. With a very small population size, direct mortality from these sources can have a significant impact.
- Poor flow regimes (Moderate threat) - Consistent releases of water from Cardinia Reservoir is considered a key factor supporting platypuses in upper Cardinia Creek. Flow regimes in the lower reaches are considered poor with very low baseflows, regular cease to flow events, and high variability (urban stream syndrome).
- Urbanisation (Low threat) - Substantial urban development of the catchment surrounding lower Cardinia Creek has the potential to further degrade this waterway and prevent expansion of the small platypus population currently occupying the upper reaches.
- Poor riparian zone (Low threat) - buffer zone of remnant native vegetation exists along upper Cardinia Creek, contributing to relatively good habitat quality in this limited area. However, extensive land clearing for agriculture and urbanisation (with extensive areas of new urban growth to occur), and channelisation of the creek has occurred in the lower reaches leading to poor habitat quality, including high turbidity.
- Litter entanglement (Low threat).

Intervention to prevent localized extinction was recommended, but only if the available in-stream habitat could be increased to support a self-sustaining population. The current distribution is restricted to approximately 10 km of stream reach and an additional 10-40 km of additional in-stream habitat was estimated to be required to support a self-sustaining population (Griffiths and Weeks 2018).

It is worth highlighting that while eDNA surveys in Spring 2021 and Autumn 2022 did not detect the presence of platypus, an Ecology Australia survey in April 2022 caught two adult male platypus (Figure 13). It is possible that the low abundance of platypus in Cardinia Creek impacts detection probability via eDNA sampling as well during live-trapping surveys.

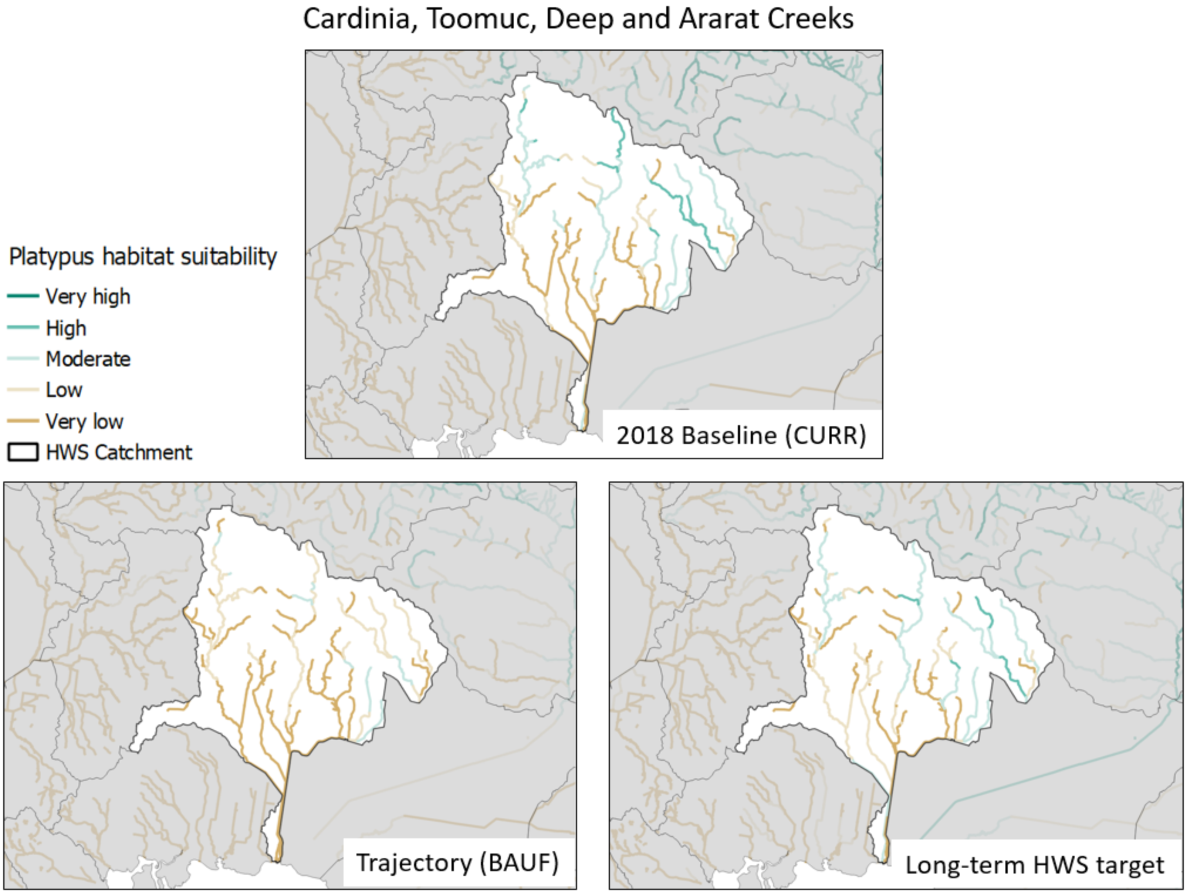


Figure 21. Modelled habitat suitability for platypus in the Cardinia, Toomuc, Deep and Ararat Creeks sub-catchment for the following three scenarios: predictions for the 2018 baseline (CURR), business as usual trajectory for the future assuming no interventions (2070; BAUF), and long-term (2070) HWS target.

Lang Lang platypus community

Summary. The unknown status of the Lang Lang platypus community and population may be reflective of multiple changed conditions and threats.

Habitat suitability for platypus is generally poor in the Lang Lang River (Figure 22). The length-weighted average predictions from HSMs were rated as Low for the Lang Lang sub-catchment, with very little riparian vegetation, poor in-stream habitat, and flow stress being some of the major conditions leading to this rating (Figure 22). The importance of these conditions, as underlying determinates of the current (2018) platypus habitat suitability, is reflected in the description accompanying the HSM length-weighted average prediction for the Lang Lang sub-catchment:

> *Platypus (pudgyer or murrin moorroo) are currently rated as low due to a lack of instream and riparian habitat and as such capture rates of platypus (pudgyer or murrin moorroo) are generally low. The impacts of climate change on flows are likely to add extra stress the population. Managing flows and improving riparian vegetation are required to protect and enhance the current population.*

Despite generally poor environmental conditions in the Lang Lang River, macroinvertebrate habitat suitability is still rated as High and Very High in many reaches, indicating that adequate food resources may generally be availability for platypus (Figure 22). However, macroinvertebrate health (as LUMaR) is declining at the long-term MERI monitoring site along the Lang Lang River (Figure 23) – this was noted in the mid-term evaluation technical document for macroinvertebrates. We are unsure how habitat suitability and macroinvertebrate health (as LUMaR) relate to macroinvertebrate abundance which is the most important characteristic describing food resources for platypus.

The Platypus SMP listed the following threats to the Lang Lang platypus population (supporting text included where available):

- **Poor riparian zone** (Moderate threat) - Very little native riparian vegetation remains due to extensive clearing for agriculture, invasive willows, and unrestricted stock access.
- **Poor in-stream habitat** (Moderate threat) - Lack of benthic complexity, large areas of silt or clay substrate with low presence of LWD.
- **Poor flow regimes** (Moderate threat)
- **Fragmentation** (Low threat) - The lower Lang Lang and Bunyip Rivers may have once been connected by extensive swampland. Channelisation of the lower Lang Lang and lower Bunyip Rivers has effectively isolated these two systems. The current population size in the Lang Lang River is assumed to be relatively small due the low abundance, poor habitat quality, and limited available habitat.
- **Genetic diversity/inbreeding** (Low threat) - there are no genetic estimates for this population due to low sample size for this region. The small population size suggests that genetic diversity and inbreeding may be an issue for this population.
- **Enclosed yabby traps** (Low threat)

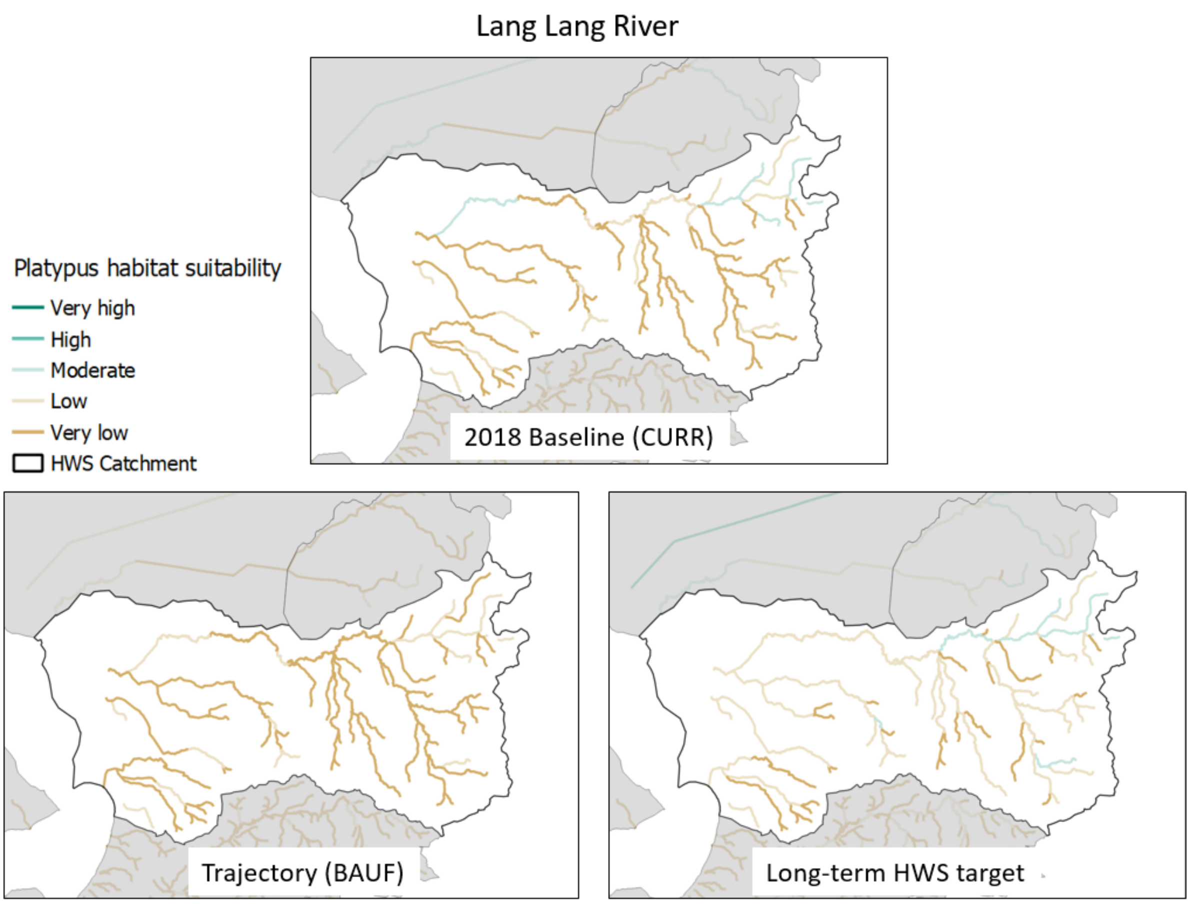


Figure 22. Modelled habitat suitability for platypus in the Lang Lang River sub-catchment for the following three scenarios: predictions for the 2018 baseline (CURR), business as usual trajectory for the future assuming no interventions (2070; BAUF), and long-term (2070) HWS target.

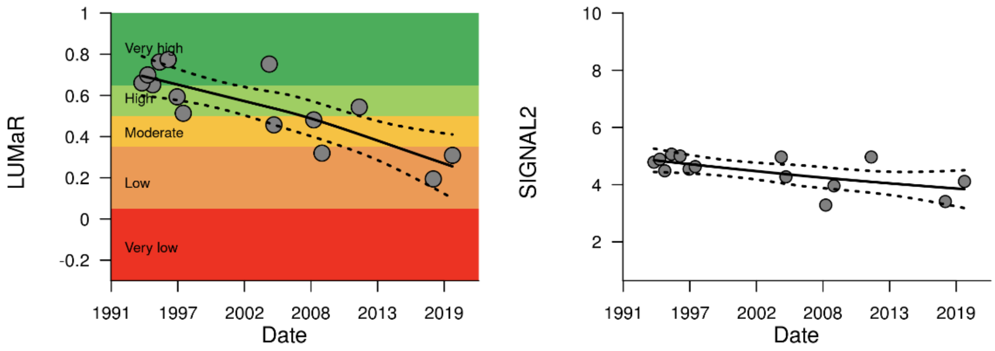


Figure 23. The (left) LUMaR index values (grey dots) and (right) SIGNAL2 scores (grey dots) for Lang Lang River (LNG-16294-3). The trend line (solid line) and 95 % confidence intervals of the trend line (dashed line) are also displayed.

Other changes in conditions and threats that impact platypus

There are a number of conditions and threats that may impact platypus but that have not yet been specifically raised in the response to KEQ 2a. Below, we outline and discuss some key conditions and threats and how they may relate to overall changes in platypus as a value.

Litter entanglement including traps

In Melbourne, platypus mortality has frequently been attributed to entanglement in litter and illegal fishing equipment (Serena and Williams 2010). This reality is reflected in recent data on platypus deaths (Table 16). Litter and illegal fishing pose a significant risk to platypus populations, especially when combined with other factors such as small population size. Opera house nets were thought to be the leading cause of platypus mortality across Victoria (Serena and Williams 2010). For example, seven platypus were discovered dead in a single opera house net in the Werribee River in 2018, representing ~14% of the individuals in this population (Table 16). However, the sale and use of opera house nets were prohibited in 2019. Since this ban, drowning deaths of platypus, rakali and freshwater turtles are thought to have significantly declined (Sverns 2020).

The tapered shape of platypus and its benthic feeding habits make it susceptible to becoming entangled in various types of ringed or looped litter such as rubber bands (Serena and Williams 2022). Litter entanglement can reduce the general fitness of individuals and even lead to serious injury or death (Serena and Williams 2022). Reported rates of litter entanglement in Melbourne's catchments has varied over the years, with Serena and Williams (2008) estimating that 5-10% to be affected by litter, Serena and Williams (2022) estimating 4%, and our own data suggesting that 2.8% of platypus captured are affected by litter (Table 17). A small sample size makes it difficult to unpack temporal trends in platypus entanglements. However, there are proportionally more entanglements in the Werribee River than in other areas (Table 17) – a trend supported by Serena and Williams (2022), who found greater entanglements in urban compared to regional areas.

Table 16. Recorded and confirmed causes of platypus deaths in the Melbourne region (2017-2020) (Sverns 2020).

Catchment	Sub-catchment	Year	Number killed	Cause of death
Yarra	Diamond Creek	2017	1	Opera House
	Woori Yallock	2018	1	Opera House
		2020	1	Dog or fox
	Watts River	2019	1	Opera House
Westernport	Tarago River	2017	5	Opera House
Werribee	Werribee River Lower	2018	7	Bait trap

Table 17. Summary of evidence of platypus litter entanglement in each HWS catchment from the MW live-trapping dataset.

Melbourne Water live-trapping data (since October 2007)			
Catchment	Platypus count	Evidence of litter entanglement	% entanglement
Yarra	367	14	3.81
Westernport	129	2	1.55
Werribee	28	2	7.14
Dandenong	55	1	1.82
Maribyrnong	90	0	0.00
Region average	669	19	**2.84**

Pharmaceuticals

A diverse array of pharmaceuticals contaminate surface waters, yet their presence and impact to aquatic food webs remain largely unknown. A study published in 2018, where Melbourne Water was an industry partner, investigated the pharmaceutical concentrations in benthic aquatic invertebrates in the Melbourne region and estimated the bio-accumulation in platypus (Richmond, et al. 2018). Over 60 pharmaceuticals were detected in benthic aquatic invertebrates with similar concentrations found in aquatic invertebrate larvae and riparian predators (spiders) suggesting trophic transfer was possible. It was estimated that platypus, while feeding on contaminated invertebrates in one day, could ingest some drug classes, such as anti-depressants, at as much as one-half of the recommended therapeutic dose for humans. The direct and indirect consequences of pharmaceutical ingestion by platypus are unknown. However, a growing body of evidence demonstrates that many pharmaceuticals disrupt ecological interactions, functions and communities. For example, amphetamines and antidepressants in stream water impact the timing of emergence of aquatic insects and fish behaviour is altered by consuming prey contaminated by antidepressants (Brodin, et al. 2014).

Recommendations

- Investigate the potential to, and feasibility of, re-introducing platypus to Toorourrong Reservoir. As stated in Kelly et al (2013), this would "improve the long-term conservation status of platypuses in the Lower Yarra Catchment and rejuvenate a previous platypus stronghold". Large pools, such as Toorourrong Reservoir, provide refuge habitats for platypus during extended dry periods in places where flow is intermittent. Further, large pools can provide valuable platypus foraging habitat: up to six animals were recorded feeding concurrently at Toorourrong Reservoir in 2000 (Easton, Williams and and Serena 2008). The potential impacts on donor populations must be taken into consideration. Further, lessons must be learnt from previous platypus introductions.
- Guidelines for reservoir capital works that aim to minimise impacts to platypus. For example, avoiding works during the lactation period (November to March in Victoria) when maternal females need to forage extensively to satisfy high energetic costs of lactation and dependent young are restricted to the burrow (Griffiths and Weeks 2018) and avoiding repeated reservoir draining over short time frames and draining below the level required to sustain platypus habitat and food supply.
- Ensure that performance objectives for vegetation, stormwater, and water for the environment are prioritised (a) in the reaches of sub-catchments where platypus are known to inhabit and (b) among reaches to re-establish connectivity. Many recommendations in the Platypus SMP focus on improving habitat quality and re-establishing connectivity among isolated platypus communities and populations – such as, between Toorourrong Reservoir and Plenty River Gorge and between Deep Creek upper (Darraweit Guim) and lower (Bulla).
- Proactively investigate the sustainable diversion limits in unregulated sub-catchments that support platypus (e.g. Deep Creek Upper). What more can be done to protect platypus in unregulated waterways and sub-catchments?
- Sample for eDNA in lower Emu Creek where platypus are known to inhabit (potentially align with UoM Sunbury sampling at Emu Creek on private land).
- Investigate opportunities to improve habitat (10-40 km additional) for the existing platypus community in Cardinia Creek, and change the riparian vegetation (increase extent) targets if appropriate. What can be achieved upstream of the Princess Freeway?
- Live-trapping surveys should be prioritised in the Lang Lang sub-catchment to better understand the current state of the Lang Lang platypus community.
- Investigate the role that poor in-stream habitat has for the Lang Lang and other platypus communities.
- Investigate links between macroinvertebrate condition (abundance and diversity), water quality and platypus, and integrate into current monitoring and reporting where possible.
- Add performance objectives around improving connectivity to overcome the impacts of major storages (e.g. Lilydale Lake, Tarago River, and maybe Toorourrong Reservoir) which are currently likely acting as barriers to platypus movement.

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

Evaluation methodology

An evaluation of other aspects of platypus condition not specifically related to the HWS targets was carried out using the new eDNA data designed to highlight notable changes in platypus distribution and health trends.

Evaluation criteria were developed to guide the data analysis and evaluation of KEQ 3b (Table 18). Three significance categories were developed to prioritise findings for sub-catchments or platypus communities. Where necessary, recommendations have been developed for sub-catchments or platypus communities rated as 'Significant for implementation'. In addition, we discuss and state recommendations related to methodological and data issues associated with the long-term platypus live-trapping surveys.

Table 18. The evaluation criteria used to answer KEQ 3b: What other spatial and temporal trends and patterns for key values are of significance for implementation?

Sub KEQ		**Standards**		
	Criteria	**Not significant for implementation**	**Potentially significant for implementation**	**Significant for implementation**
3b. What other spatial and temporal trends and patterns for key values are of significance for implementation?	Notable changes in platypus distribution	Positive eDNA detections in sub-catchments where platypus have previously been detected *OR* Negative eDNA detections in sub-catchments where platypus have previously not been detected	Equivocal eDNA detections in sub-catchments where platypus have previously not been detected	Positive eDNA detections in sub-catchments where platypus have previously not been, or are rarely, detected *OR* Negative eDNA detections in sub-catchments or locations where platypus have previously been detected
	Noteworthy population health trends	Relatively good population health trends	NA	Consistently different populations health trends than other locations
<u>Other important trends and patterns for implementation</u> **Methodological and data issues associated with the long-term platypus live-trapping surveys** • **Practitioner conducting live-trapping surveys** • **Data storage and accessibility**				

Evaluation results and discussion

Notable changes in platypus distribution

Summary. Platypus were detected (eDNA result = positive) in five sub-catchments we have not previously captured platypus, but it is likely that their positive detection represents occasional vagrants dispersing and not range expansion as habitat suitability is rated 'Very low' or N/A.

The Spring 2021 and Autumn 2022 eDNA sampling largely confirmed our existing understanding of platypus distribution throughout the Melbourne region gained using live-trapping surveys, with platypus detected (eDNA result = positive or equivocal) in more than 85% of sub-catchments where platypus have been caught since 1995 (Figure 22). Confirmation from additional eDNA surveys is required before we can place any confidence in detections within these sub-catchments, particularly for negative detections as the full eDNA monitoring program has not yet been completed.

Positive eDNA detections in sub-catchments where platypus have previously not been, or are rarely, detected. The Spring 2021 and Autumn 2022 eDNA sampling produced positive detections for platypus at the following sites within five sub-catchments we have not previously captured platypus or where persistent communities are not expected (Figure 22):

- Brushy Creek (Brushy Creek sub-catchment; Yarra),
- Stony Creek (Stony Creek sub-catchment, Maribyrnong),
- Taylors Creek (Taylors Creek sub-catchment, Maribyrnong),
- Merricks Creek (Mornington Peninsula South-Eastern Creeks, Westernport), and
- Kings Creek (Mornington Peninsula North-Eastern Creeks, Westernport).

These five sub-catchments are either rated as 'Very low' platypus habitat suitability or are not expected to harbor persistent platypus populations (N/A). As such, we caution much focus on these positive detections as they likely do not represent true changes in permanent platypus distribution but only vagrant individuals dispersing across the landscape.

Mornington Peninsula streams have been assumed to have never supported permanent platypus (pudgyer or murrin moorroo) populations due to the small size of the streams (Griffiths and Weeks 2018). For this reason, there is no assessment or setting of targets in the HWS, with HSM predictions set as 'No data' for Mornington Peninsula South-Eastern Creeks and Mornington Peninsula North-Eastern Creeks sub-catchments. It is possible that recent positive detections using eDNA are due to occasional vagrants dispersing via Port Phillip or Western Port bays, as previously stated (Griffiths and Weeks 2018), or represent false positives.

The positive detection in Taylors Creek was from a water sample collected near the confluence with the Maribyrnong River. Habitat suitability within the Taylors Creek sub-catchment is rated as 'Very low' and platypus are no longer expected to be found in Taylors Creek, as a result of large-scale urbanisation and lack of suitable habitat, except for potential use of the lower reaches near the confluence with Maribyrnong River. As such, this likely represents the detection of an individual or individuals occasionally visiting the lower reaches of Taylors Creek.

Unexpected equivocal detections. The Spring 2021 and Autumn 2022 eDNA sampling produced equivocal detections for platypus at the following sites within seven sub-catchments we have not previously captured platypus or where persistent communities are not expected (Figure 22):

- Dandenong Creek (Dandenong Creek Middle sub-catchment, Dandenong),
- Lerderderg River (Lerderderg River sub-catchment, Werribee),
- Toolern Creek (Toolern Creek sub-catchment, Werribee),
- Aitken Creek (Merri Creek Upper sub-catchment, Yarra),
- Koonung Creek (Koonung Creek sub-catchment, Yarra),
- Gardiners Creek (Gardiners Creek sub-catchment, Yarra), and
- Moonee Ponds Creek (Moonee Ponds Creek, sub-catchment, Maribyrnong).

With the exception of Lerderderg, for which length-weighted average predictions of habitat suitability is rated as 'Low', equivocal detections were from sub-catchments predicted to have a 'Very low' habitat suitability. Ongoing eDNA surveys across the Melbourne Water region will continue to shed light on the presence and potential movement of platypus in waterways where they don't commonly reside.

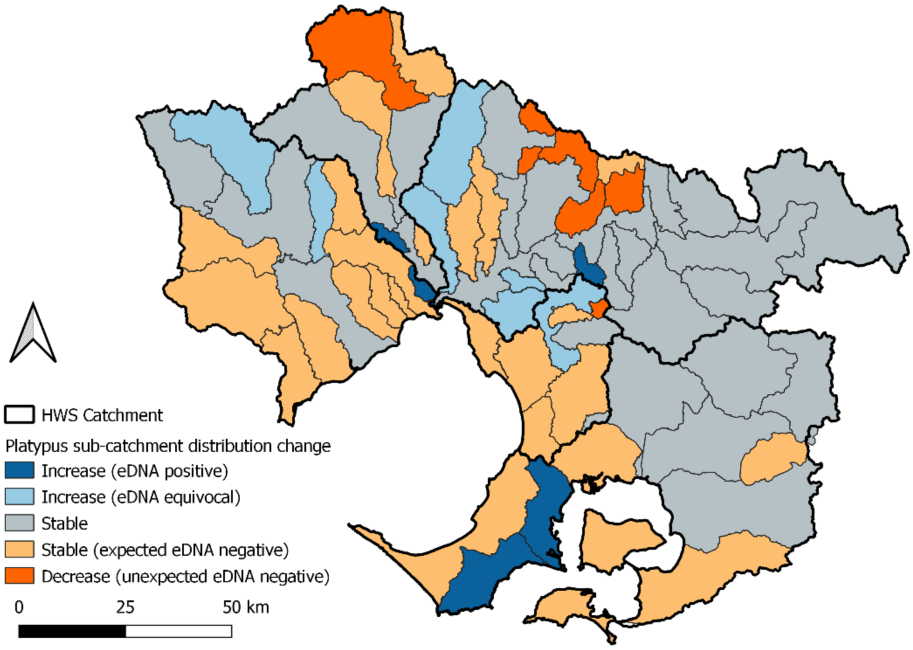


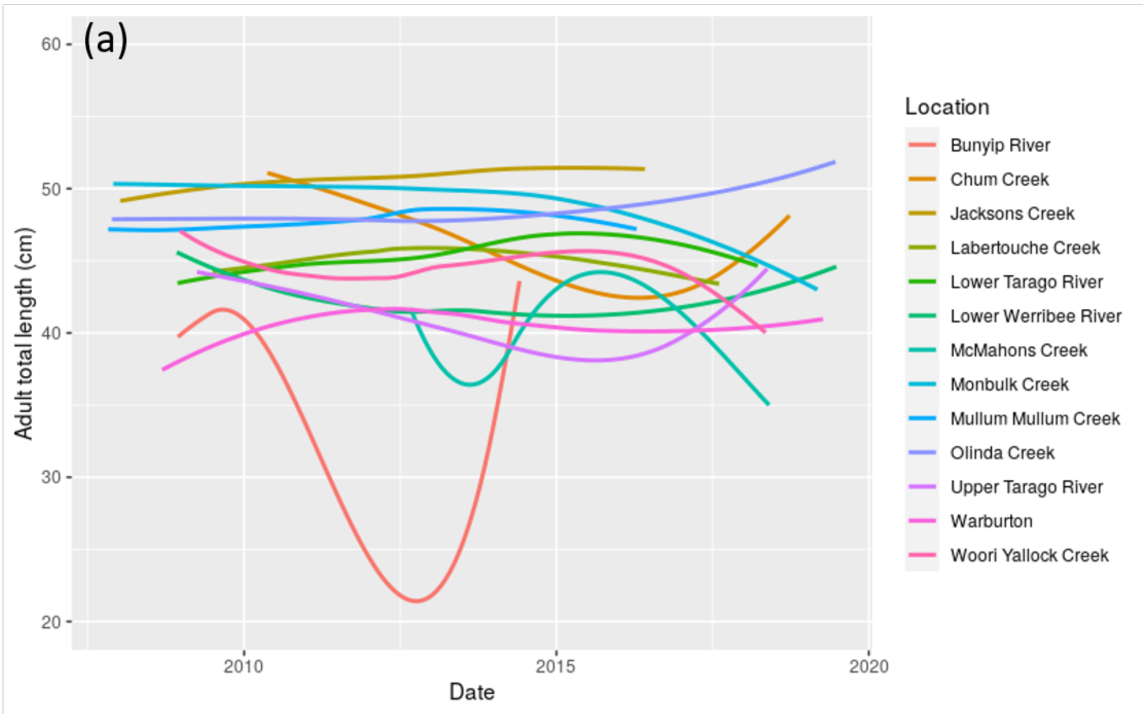
Figure 24. A map of the Melbourne Water region displaying changes in platypus distribution at the sub-catchment scale as determined from differences between recent (Spring 2021 and Autumn 2022) eDNA surveys and known presence/absence based on live-trapping surveys.

Noteworthy population health trends

Summary. Large platypus have been consistently recorded in Jacksons Creek below the Sunbury (Sewage) Treatment Plant.

Jacksons Creek was found to have consistently larger (length and weight) platypus compared to other monitored locations across the Melbourne region (Figure 25). The Jacksons Creek platypus community exists along a reach affected by the Sunbury (Sewage) Treatment Plant. It is possible that greater aquatic productivity in Jacksons Creek from the Sunbury Treatment Plant has contributed to the greater size of platypus at this location. However, greater platypus capture rates in the Melbourne region have been associated with lower concentrations of nutrients and suspended solids (Serena and Pettigrove 2005), suggesting that the influence of water quality on platypus may not be beneficial. Further, larger platypus have been associated with drier locations in southern Australia, including the Yarra River basin (Furlan, et al. 2011). It was posited that this may reflect the need to store more fat to deal with food shortages during dry periods (Furlan, et al. 2011). However, the extent to which climate and nutrients interact to impact platypus across Melbourne is yet to be adequately investigated.

The platypus community at Monbulk Creek was also found to have consistently larger (length and weight) platypus compared to other monitored locations across the Melbourne region (Figure 25). However, the decline in recent years is likely linked to the death of a long-lived and large male platypus that was consistently trapped at Monbulk Creek. This highlights the potential influence that individuals can have on morphological populations metrics, particularly when they are repeatedly trapped.



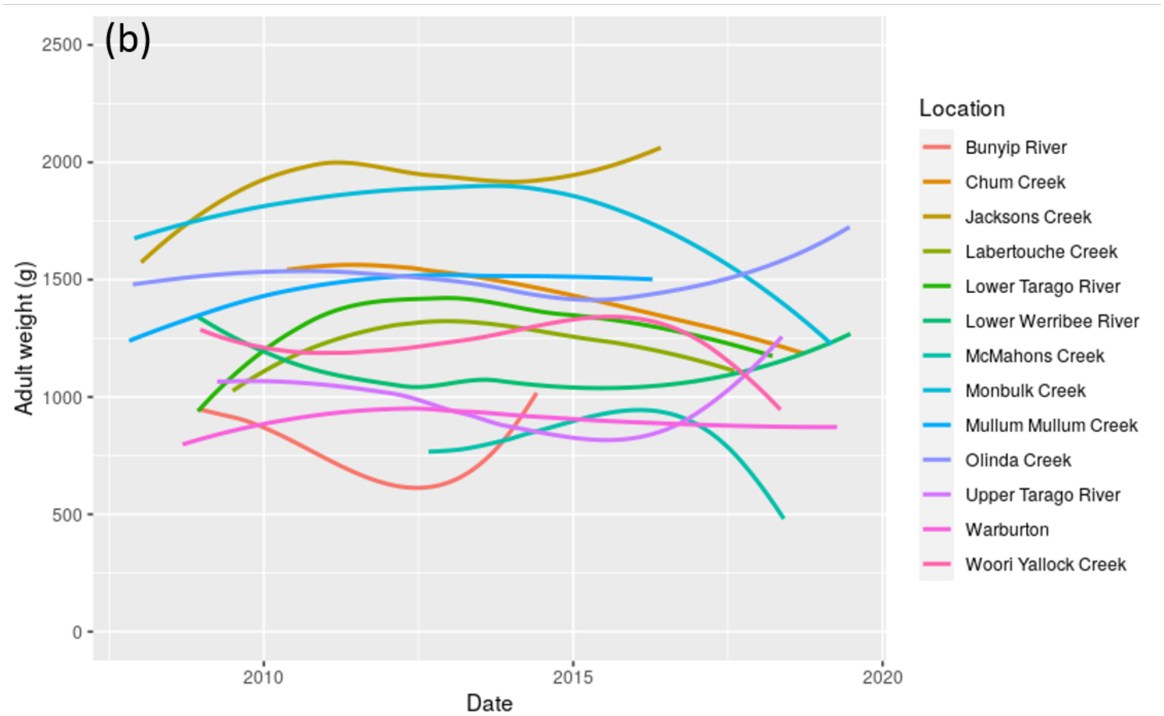


Figure 25. Trend lines for platypus (a) length and (b) weight in 13 locations surveyed across the Melbourne region. Trend lines were not produced for Cardinia and Lang Lang due to minimal data. Trend lines were fitted using the 'loess' scatter plot smoothing function with the following function arguments in R statistical software (R Core Development Team, 2018): family='gaussian'; span=1; degree=1. 'loess' is considered the most appropriate method as it robustly fits a smoothed curve without prior assumptions about the shape or form of the curve (Cleveland et al, 1992).

Methodological, reporting metrics, and data issues associated with the long-term platypus live-trapping surveys

Summary. Methodological and data management issues exist and continue to hamper the on-going use of platypus data, particularly the live-trapping data.

Live-trapping survey methodology and reporting metrics

Platypus live-trapping surveys in the Melbourne region have been conducted by multiple practitioners: the Australian Platypus Conservancy (APC), Cesar, and Ecology Australia (EA). APC and Cesar have collected the majority of the live-trapping data. Most of APC's surveys were conducted between 1995 and 2007, while Cesar has conducted surveys after 2007. This temporal change in practitioners is confounded with other environmental changes that can impact platypus (e.g. The Millennium Drought, urbanisation) and overall declines in some platypus communities and populations. It remains plausible that the practitioner conducting the surveys, as well as changes in survey effort, may impact live-trapping captures and thus our abundance index (CPUE). The potential effect of practitioner change and sampling effort variability on platypus capture probability needs to be investigated. If we do not understand the potential effect of practitioner and sampling effort variation on platypus abundance, we may not be able to adequately describe spatial and temporal patterns in platypus abundance including the influence of environmental threats and changes in conditions due to interventions.

Given the potential issues associated with our abundance index (CPUE), and the limitations of CPUE as an index of abundance discussed in Section 1 above (

Platypus abundance), alternative metrics representing platypus community and population abundance (metrics that are ecologically relevant but perhaps less influenced by survey methodology) should be investigated.

Data storage and accessibility

Melbourne Water has one of Australia's largest data series describing platypus abundance, distribution, and health, particularly in an urban setting. New data collection technology, such as eDNA sampling, is increasing the spatial and temporal extent of this data series. Currently, data is collected and collated in a variety of ways including: live-trapping surveys, habitat suitability modelling, eDNA sampling, the Victorian Biodiversity Atlas, as well as through citizen science initiatives (PlatypusSpot and PlatypusCount). The lack of a database to store and access this diverse dataset inhibits efforts to investigate trends and track trajectories and enable internal (Melbourne Water) and external (stakeholders) data sharing.

Recommendations

- Re-assess the presence/absence of platypus across the Melbourne region when the eDNA baselining process has been completed (reported distribution change trends above are only preliminary).
- Create a dedicated platypus database that includes all data types (live-trapping, eDNA, habitat suitability modelling, citizen science program data).
- Undertake data analysis into the potential influence of live-trapping methodology, including effects of practitioner and sampling effort, on platypus abundance across the Melbourne region.
- Investigate alternative metrics (other than CPUE) representing ecological meaningful aspects of platypus community such as population persistence and reproductive health.

4. Information relevant to remaining KEQs

This section provides an update on information that is relevant to the remaining KEQs and an overview of the evaluation approach that will be conducted in other reports.

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

What's changed?

A project has been initiated to look at 'what's changed' since the HWS was released. It considers both changes in the operating / external environment e.g. CMA merger with Melbourne Water and the new General Environmental Duty along with an evaluation of how each of the bio-physical threats (e.g. urbanization) have changed since 2018 (e.g. opera house trap threat have decreased). The results of this project will feed into KEQ2b and be presented in the Science Inquiry (Melbourne Water, 2023a).

The project will focus on:

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

The project will consider the impacts and implications of these changes. Table 19 below presents a preliminary list of bio-physical threats that relate to platypus. It should be noted that climate change is considered both a threat in its own right and something that influences individual threats to varying degrees.

Table 19. Draft list of threats to platypus and links to related Melbourne Water.

Threat	Examples	Environmental conditions
Urbanisation (DCI)	Directly connected impervious surfaces change flow regime and degrade water quality	Water quality, Water Regime, Stormwater, Physical Form
Urbanisation (toxicants/contaminants/microplastics/pathogens)	industry, untreated sewerage ingress, construction phase of development	Water quality
Litter	commercial areas, fishing equipment	Litter
Physical modifications	piping of headwater streams, channelisation of waterways, building over wetlands, LWD removal, illegal alteration of waterway	Physical Form, Vegetation
STPs and ERSs and septic tanks	STPs discharges, ERS spills, poor septic performance/maintenance	Water quality

Threat	Examples	Environmental conditions
Recreational access	Motor bikes, noise, light, tracks,	Water quality, Vegetation
Fish barriers	gauging station weirs, dam walls, erosion control structures	Instream connectivity
Pest plants (inc biosecurity)	high risk weeds	Vegetation
Pest animals (inc biosecurity)	deer, rabbits, over abundant wildlife, exotic fish	Vegetation
Stock access	unfenced grazing land	Vegetation
Vegetation clearing	illegal tree removal, forestry, recreation eg mtn bike tracks, 4WD tracks	Vegetation
Farm dams	on-line and off-line dams, licensed and unlicensed	Water Regime
Water extraction	water supply dams, surface water diversions, groundwater extractions	Water Regime
Agriculture	Agriculture, intensification of agriculture, pesticide drift	Water Quality, Water Regime
'natural' disturbances	Bushfires, floods, storms, wind	Water Quality, Water Regime, Physical Form, Vegetation
Climate change	water temperature increases, reduction in flow, increased storm intensity, increased urban heat, sea level rise	Water Quality, Water Regime, Physical Form, Vegetation

Climate change

Though this will be covered more thoroughly in the Habitat Suitability Model-Climate Change Technical Report (Y. E. Chee, et al. 2022), it is worth highlighting that our understanding of how climate change may impact environmental conditions in the future has changed substantially since 2018 and continues to evolve. Predictions about future stream flow and air temperature that were used in the Strategy, though relevant and current at the time, are now largely predicted to be hotter and dryer than what was used in models during the strategy development period.

The emission scenarios that have been explored since 2018 and how related climate variables will be used to update the HSMs is available, in detail, in the Habitat Suitability Model-Climate Change Technical Report (Y. E. Chee, et al. 2022); however, some information is presented below.

There are two emission scenarios that are generally being widely used to formulate predictions; Representative Concentration Pathways (RCP) 4.5 and RCP 8.5. These scenarios are used to explore 2070 predictions of annual stream run-off depth (flow) and mean annual air temperature; two important parameters in the HSMs.

The 2070 time period aligns with what was used to develop the Business as Usual (BAU) future and Target future predictions used during the Strategy development.

Below is a representation of the difference in mean annual run-off under RCP 4.5 (Figure 26) and RCP 8.5 (Figure 27) predicted futures and the Business and Usual (BAU) future scenario used for running the HSMs in 2018. Both emission scenarios predict lower flow conditions in general than what was originally predicted in the HSMs, especially in the Yarra and Westernport catchments. Browns indicate drier than dryMeanQ (used for BAU predictions) and blue-greens indicate wetter than dryMeanQ.

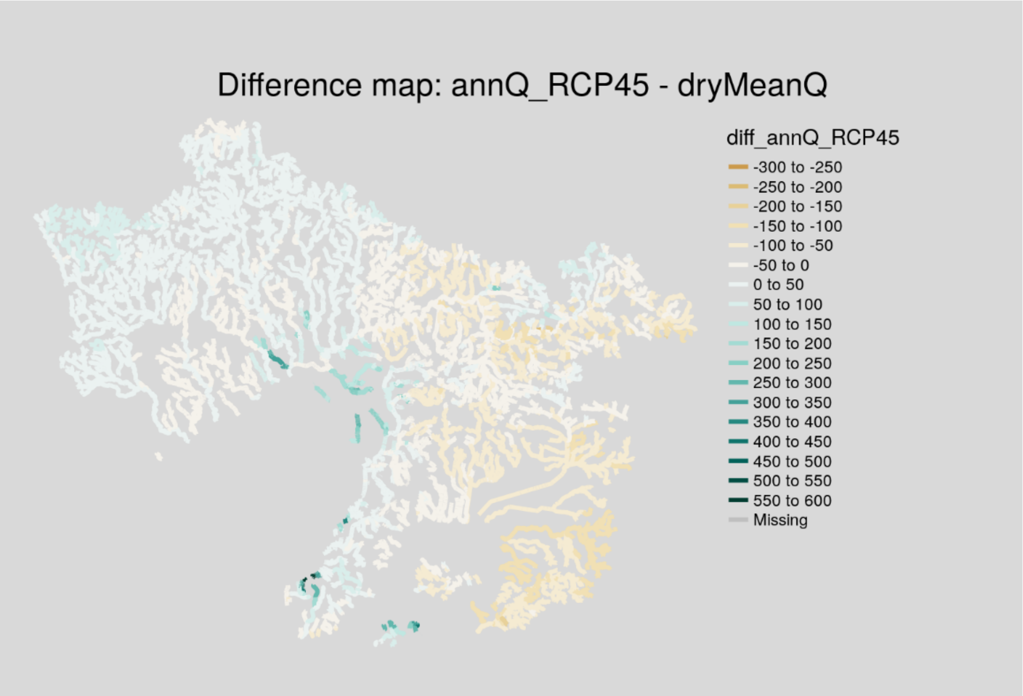


Figure 26. Map depicting the differences between mean annual runoff under RCP 4.5 and the Business and Usual (BAU) future scenario used in HSM predictions.

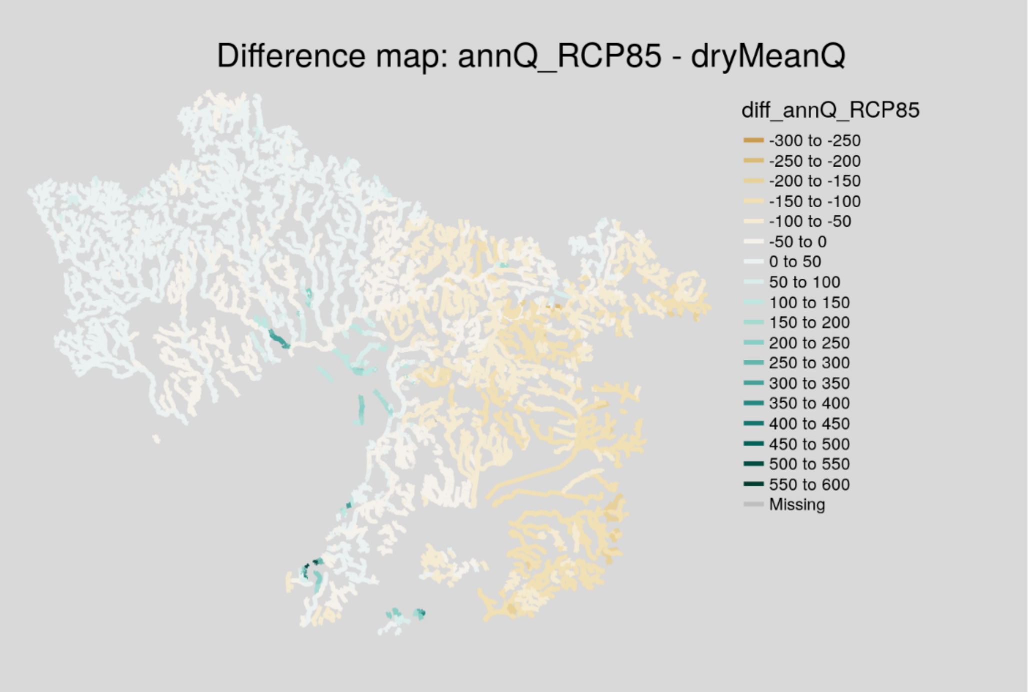


Figure 27. Difference map depicting the differences between mean annual runoff under RCP 8.5 and the Business and Usual (BAU) future scenario used in HSM predications.

Additionally, there are 6 models for air temperature that are currently being explored to predict how mean annual air temperature may be affected by climate change. For both emission scenarios, RCP 4.5 and RCP 8.5, all 6 models predict warmer temperatures than what was used in modelling climate warming impact for HWS 2018.

Below are just two representations of the difference in mean air temperature under RCP 4.5 (Figure 28) and RCP 8.5 (Figure 29) predicted futures compared to the Business and Usual future scenario used for running the HSMs in 2018. These are offered as examples of the range in outputs that are being explored. More will be detailed in the Habitat Suitability Model paper in November.

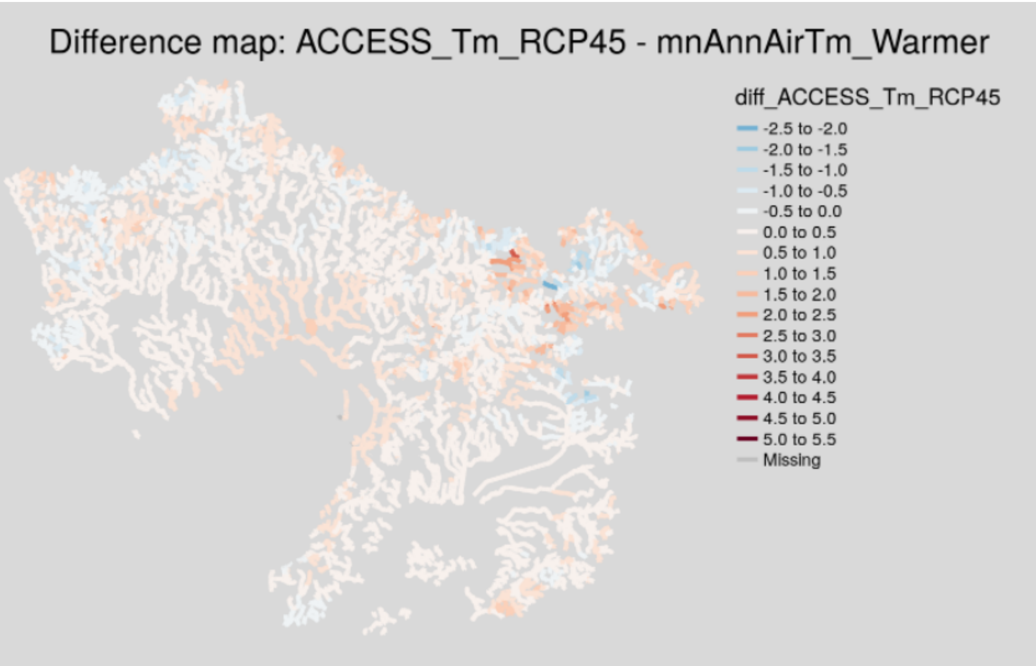


Figure 28. Difference map depicting the differences between mean air temperature using the ACCESS model under RCP 4.5 and the Business and Usual (BAU) future scenario used in HSM predictions.

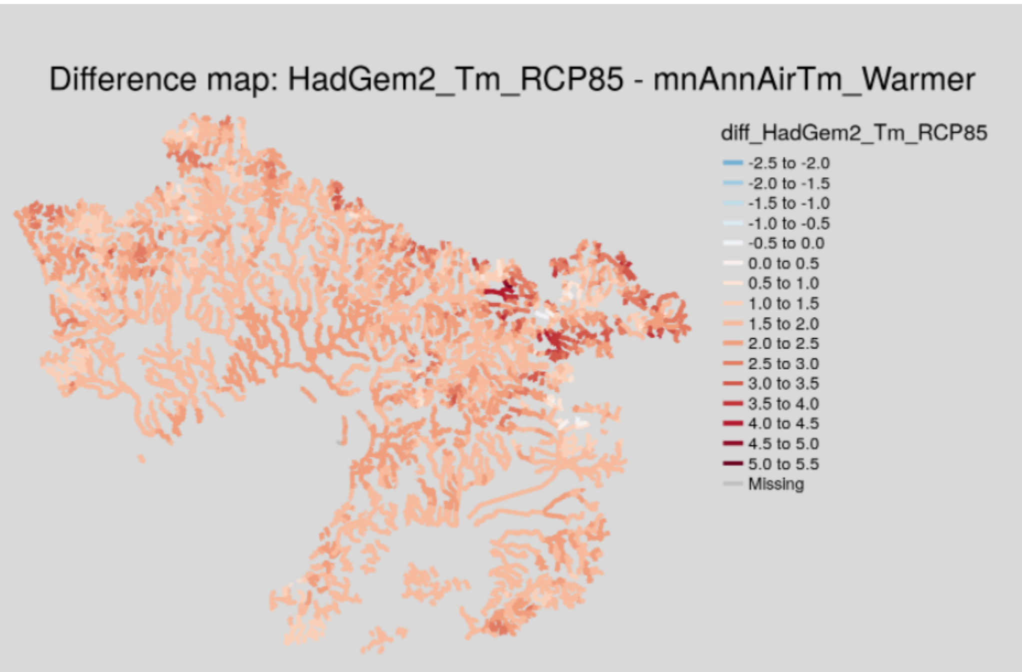


Figure 29. Difference map depicting the differences between mean air temperature using the HadGen2 model under RCP 8.5 and the Business and Usual (BAU) future scenario used in HSM predications.

These updated climate change predictions are important given that one of the key assumptions used during the target setting process was that flows could be mitigated in key locations:

> *It was assumed that in key locations flows (particularly base flows) could be maintained through interventions which could offset the likely climate change drying conditions. As such the mean annual runoff depth set to 2016 values.*

This assumption will need to be revisited to ensure that it (a) is realistic and achievable (b) reflects the most likely climate scenarios.

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

Introduction

Across research literature, various definitions exist for the term intervention. The literature highlights that interventions are context-specific, covering private and public actions, policy, or project-based activities. The Merriam-Webster online dictionary defines intervention as:

"the act of interfering with the outcome or course especially of a condition or process (as to prevent harm or improve functioning)" (Merriam-Webster, 2018)

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

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

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

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

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

This section includes a summary of interventions that directly protect or improve platypus. A full evaluation of interventions is outlined in the HWS Technical Report on Interventions (Melbourne Water, 2023c). This section provides some insights into the information which will feed into this evaluation.

Overview of interventions most relevant to platypus

Many different types of interventions are used for other key values that also benefit platypus that are currently applied for the Healthy Waterways Strategy (Table 20). Many of these have been used widely in the region over the years with medium to high confidence in the appropriateness and effectiveness of the interventions based on evidence from works and applied research in the region and beyond over the past few decades. For example, the Habitat Suitability Models used to help develop the HWS indicate that revegetation and stormwater management scenarios are potentially effective interventions for platypus.

It is not proposed to evaluate those interventions with high confidence as part of the mid-term evaluation. Instead, the interventions with low confidence but require high investment will be shortlisted. Intervention monitoring is about testing assumptions or where confidence is low through a structured adaptive management approach involving setting clear management objectives and testing alternative interventions. It is typically about testing on-ground management actions using an experimental design (Rivers MEP, 2020).

Table 20. Platypus on ground interventions (direct and indirect) used in relation to the Healthy Waterways Strategy.

Intervention type	Specifics	Confidence (for platypus)	Adoption Stage
Revegetation	Tube stock (including long stemming) Direct seeding	High Low - High	Part of BAU Early adoption
Barrier removal	Weir removal	Medium	Part of BAU
Sewage treatment plant discharges	Benefits from maintaining low flow conditions Impacts from pharmaceuticals	Medium Low	Part of BAU Research underway
Stormwater harvesting and infiltration	Harvesting excess volumes and infiltrating to maintain baseflows - smart tanks - IWM	Low to Medium	Part of BAU
Water licensing and flow release	Flow releases Bans and restrictions	Med- High	Part of BAU Part of BAU (catchment specific)
Habitat improvement	Large woody debris Rocks / riffle installation Weeding	Low - Medium	Early adoption
Translocation	Relocation of individuals from one healthy population to another to improve genetic variability and population health	Low	Early adoption
Litter management	Improved control of litter in known high platypus occupancy areas e.g. Diamond Creek Eltham and Werribee River lower - Litter traps - Compliance and enforcement - Educations and community engagement - Policy change e.g. opera house traps	Med - High	Mixed. Ranges from BAU (e.g. education and comm engagement) to early adoption (enforcement)

Many of the interventions listed in Table 20 are also used for other environmental key values such as birds, fish, vegetation and macroinvertebrates and several of these will be evaluated for these values. While some interventions have been installed as part of the HWS 2018 primarily for platypus, only a small selection have sufficient information available for the mid-term review. Research projects that are in the early stages of initiation, such as the Monbulk Smart Tanks project and the Managing Litter for Platypus Management (Masters project), are likely to be suitable for end-of-strategy evaluation. A summary of the interventions and the associated intervention monitoring research projects that are proposed to be included in the mid-term review are listed in Table 21.

Table 21. Summary of platypus intervention research projects to be included in mid-term review

Intervention Group	Intervention type	Specifics	Current use in region	Relevant research project
Establish	Habitat improvement	Rocks / riffle installation Weeding Revegetation	Low to Med	Platypus enhancement project in Monbulk Creek

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

A number of knowledge gaps were stated in the Platypus SMP. In Table 22 below we state these knowledge gaps, indicate if they remain unanswered, and discuss relevance to the findings of this evaluation.

Table 22. The knowledge gaps listed in the Platypus SMP, progress toward achieving knowledge gaps, and the relation of the knowledge gap to this evaluation document.

Platypus SMP knowledge gap	Progress toward achieving knowledge gap and supporting documents	Relation to this evaluation document
Identifying the key flow variables that impact platypuses (and macroinvertebrates) including threshold tolerance levels.	Research report: Identifying key flow variables and quantifying their impact platypus populations (Griffiths, Maino and Weeks 2019) Report: Understanding the environmental water requirements of platypus (Jacobs 2016)	Increasing frequency of cease-to-flow events was linked to declines in platypus in Deep Creek Upper sub-catchment. Concerns have been raised about the ability of Sustainable Diversion Limits in unregulated sub-catchments to deliver flow regimes that benefit platypus.
Investigate the relationship between platypus populations and macroinvertebrate communities.	Partially answered.	Macroinvertebrates are a key food resource for platypus and is a key condition in the platypus conceptual model. However, we still lack definitive information on links between platypus abundance and health with in-stream macroinvertebrate characteristics (abundance, community composition, various indices).
Understanding carrying capacity and minimum habitat patch size required to support a self-sustaining population.	Partially answered.	It is unknown whether there is enough available habitat and resource at Cardinia Creek to support a self-sustaining population. Griffiths and Weeks (2018) suggested that an increase in available in-stream habitat (10-40 km) would be needed to support a self-sustaining population.
Improving estimates of platypus abundance and population trajectories.	Partially answered.	The limitations of how we currently represent abundance (CPUE) has been recognized and alternative metrics discussed (Griffiths and Weeks 2011). However, there has been no quantitative investigation of the underlying issues of CPUE or the suitability of alternative metrics. Investigations should focus on assessing how methodological issues (survey effort and practitioner) can impact CPUE and whether there are alternative indices of abundance that can be adopted.
Evaluating the success of reintroductions/translocations,	Partially answered.	Post-translocation reports have tracked the progress of the Cardinia Creek translocation. However, the long-term

Platypus SMP knowledge gap	Progress toward achieving knowledge gap and supporting documents	Relation to this evaluation document
particularly for genetic management of populations		viability of this community has been questioned (i.e. Griffiths and Weeks, 2018). This information will guide potential efforts to re-introduce platypus to other locations in the region e.g. Toorourrong Reservoir.
Improved understanding of the distribution of platypuses and resolution of discrete platypus populations	Partially answered.	eDNA sampling has improved the spatial resolution of our understanding of platypus distribution. Continued sampling will greatly improve this understanding and allow investigations of temporal changes of platypus distribution.

This KEQ will be addressed as part of the Science Inquiry Report (Melbourne Water 2023a). The approach is still being developed but likely to involve the following key steps:

Summarise research findings and recommendations

- Consolidation of key research findings and recommendations from the Melbourne Waterway Research-Practice Partnership, Aquatic Pollution Prevention Partnership (A3P) and other Melbourne Water Waterways and Wetlands Program projects.

Prioritise remaining knowledge gaps

- Review and prioritise knowledge gaps identified in the fact sheets prepared the mid-term evaluation of existing Melbourne Waterway Research-Practice Partnership, Aquatic Pollution Prevention Partnership (A3P) and other Melbourne Water Waterways and Wetlands Program projects.
- Review and prioritise knowledge gaps identified through each KEQ evaluation paper
- Review the conceptual and quantitative models (HSMs) to identify documented low confidence relationships between conditions and values and interventions and conditions

Fact sheets presenting results of current platypus focused research are available in Table 23 for information purposes. These fact sheets contain recommendations for knowledge adoption and any future knowledge gaps. These will be reviewed and considered for mid-term evaluation purposes in the Science Inquiry Report. Table 23 below is a list of current research projects that relate to platypus, some of which are summarised in the attached paper.

Table 23. Current Melbourne Waterway Research-Practice Partnership, Aquatic Pollution Prevention Partnership (A3P) and other Melbourne Water Waterways and Wetlands Program projects related to platypus.

Research Project name	Fact sheet status
Monbulk Creek Smart Tank project	Available on the Healthy Waterways Strategy website (healthywaterways.com.au)

5. Summary of the evaluation findings and recommendations

KEQ3a To what extent are key values on the target trajectory?

There is a high chance that long-term targets will not be met for three sub-catchments: Plenty River (Source), Deep Creek Upper, and Emu Creek. Despite 'Moderate' to 'Very High' modelled habitat suitability, platypus were not detected via eDNA in waterways within these sub-catchments.

Two platypus communities, Cardinia and Lang Lang, were given a performance rating of 'Not assessable / potentially declining'. These ratings were assigned as there is evidence of abundance decline at the introduced Cardinia Creek platypus community and we have insufficient data to assess the status and trajectory of the Lang Lang River platypus population.

Recommendations:

- Prioritise resources to conduct live-trapping surveys for the Lang Lang and Cardinia platypus communities, and at all other locations as described in the Rivers MEP, and re-assess trajectory when sufficient data is available.
- Continue eDNA monitoring in sub-catchments where platypus are considered to be effectively extinct (Plenty River (Source) and Deep Creek Upper). There may be a need to review performance objectives and communicate this information.

KEQ 2a. What environmental conditions (e.g. Water quality), external conditions (e.g. drought) and threats (e.g. development) help explain current key value trends?

Repeated draining of Toorourrong Reservoir due to capital works, as well as high flows events, bushfire and fragmentation have all contributed to the decline of platypus in Plenty River (Source).

Reduced flows, fragmentation, and poor riparian vegetation have all contribute to the decline in platypus in Deep Creek Upper.

Platypus in Emu Creek are thought to only exist in the lower reaches near the confluence with Deep Creek. eDNA has not yet sampled in lower reaches of Emu Creek. Reduced flows and lack of adequate in-stream and riparian habitat contribute to the 'Moderate' habitat suitability rating at Emu Creek.

The variable/unknown health trajectory of platypus in Cardinia Creek is largely reflective of the low abundance and thus capture rate which is, in turn, likely reflective of multiple pressures (adverse conditions and threats) affecting this population. Fragmentation (relatively small stretch of suitable habitat) and low genetic diversity are the main threats to the long-term survival of this population and their short-term persistence. Many of these pressures existed before the reintroduction program and continue to affect the population.

The unknown status of the Lang Lang platypus community and population may be reflective of multiple changed conditions and threats.

Recommendations:

- Investigate the potential to, and feasibility of, re-introducing platypus to Toorourrong Reservoir. As stated in Kelly et al (2013), this would "improve the long-term conservation status of platypuses in the Lower Yarra Catchment and rejuvenate a previous platypus stronghold". Large pools, such as Toorourrong Reservoir, provide refuge habitats for platypus during extended dry periods in places where flow is intermittent. Further, large pools can provide valuable platypus foraging habitat: up to six animals were recorded feeding concurrently at Toorourrong Reservoir in 2000 (Easton, Williams and and Serena 2008). The potential impacts on donor populations must be taken into consideration.

- Guidelines for reservoir capital works that aim to minimise impacts to platypus. For example, avoiding works during the lactation period (November to March in Victoria) when maternal females need to forage extensively to satisfy high energetic costs of lactation and dependent young are restricted to the burrow (Griffiths and Weeks 2018) and avoiding repeated reservoir draining over short time frames and draining below the level required to sustain platypus habitat and food supply.
- Ensure that performance objectives for vegetation, stormwater, and water for the environment are prioritised (a) in the reaches of sub-catchments where platypus are known to inhabit and (b) among reaches to re-establish connectivity. Many recommendations in the Platypus SMP focus on improving habitat quality and re-establishing connectivity among isolated platypus communities and populations – such as, between Toorourrong Reservoir and Plenty River Gorge and between Deep Creek upper (Darraweit Guim) and lower (Bulla).
- Proactively investigate the sustainable diversion limits in unregulated sub-catchments that support platypus (e.g. Deep Creek Upper). Have these changed and are we doing enough to protect platypus in unregulated sub-catchments?
- Sample for eDNA in lower Emu Creek where platypus are known to inhabit (potentially align with UoM Sunbury sampling at Emu Creek on private land).
- Investigate opportunities to improve habitat (10-40 km additional) for the existing platypus community in Cardinia Creek, and change the riparian vegetation (increase extent) targets if appropriate. Given that habitat suitability deteriorates substantially below existing urban areas, can this be achieved within reaches upstream of the Princess Freeway?
- Live-trapping surveys should be prioritised in the Lang Lang sub-catchment to better understand the current state of the Lang Lang platypus community.
- Investigate the role that poor in-stream habitat and sediment quality has for the Lang Lang and other platypus communities.
- Investigate links between macroinvertebrate condition (abundance, not just diversity) and platypus, and integrate into current monitoring and reporting where possible.
- Add performance objectives around improving connectivity to overcome the impacts of major storages (e.g. Lilydale Lake, Tarago River, Toorourrong Reservoir) which are currently acting as barriers to platypus movement.

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

Platypus were detected (eDNA result = positive) in five sub-catchments we have not previously captured platypus, but it is likely that their positive detection represents occasional vagrants dispersing and not range expansion as habitat suitability is rated 'Very low' or N/A.

Large platypus have been consistently recorded in Jacksons Creek below the Sunbury (Sewage) Treatment Plant.

Methodological and data management issues exist and continue to hamper the on-going use of platypus data, particularly the live-trapping data.

Recommendations:

- Re-assess the presence/absence of platypus across the Melbourne region when the eDNA baselining process has been completed (reported distribution change trends above are only preliminary).
- Create a dedicated platypus database that includes all data types (live-trapping, eDNA, habitat suitability modelling, citizen science program data).
- Undertake data analysis into the potential influence of live-trapping methodology, including effects of practitioner and sampling effort, on platypus abundance across the Melbourne region.
- Investigate alternative metrics (other than CPUE) representing ecological meaningful aspects of platypus community such as population persistence and reproductive health.

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7. Appendices

Appendix 1: Healthy Waterways Program Logic

Program Logic

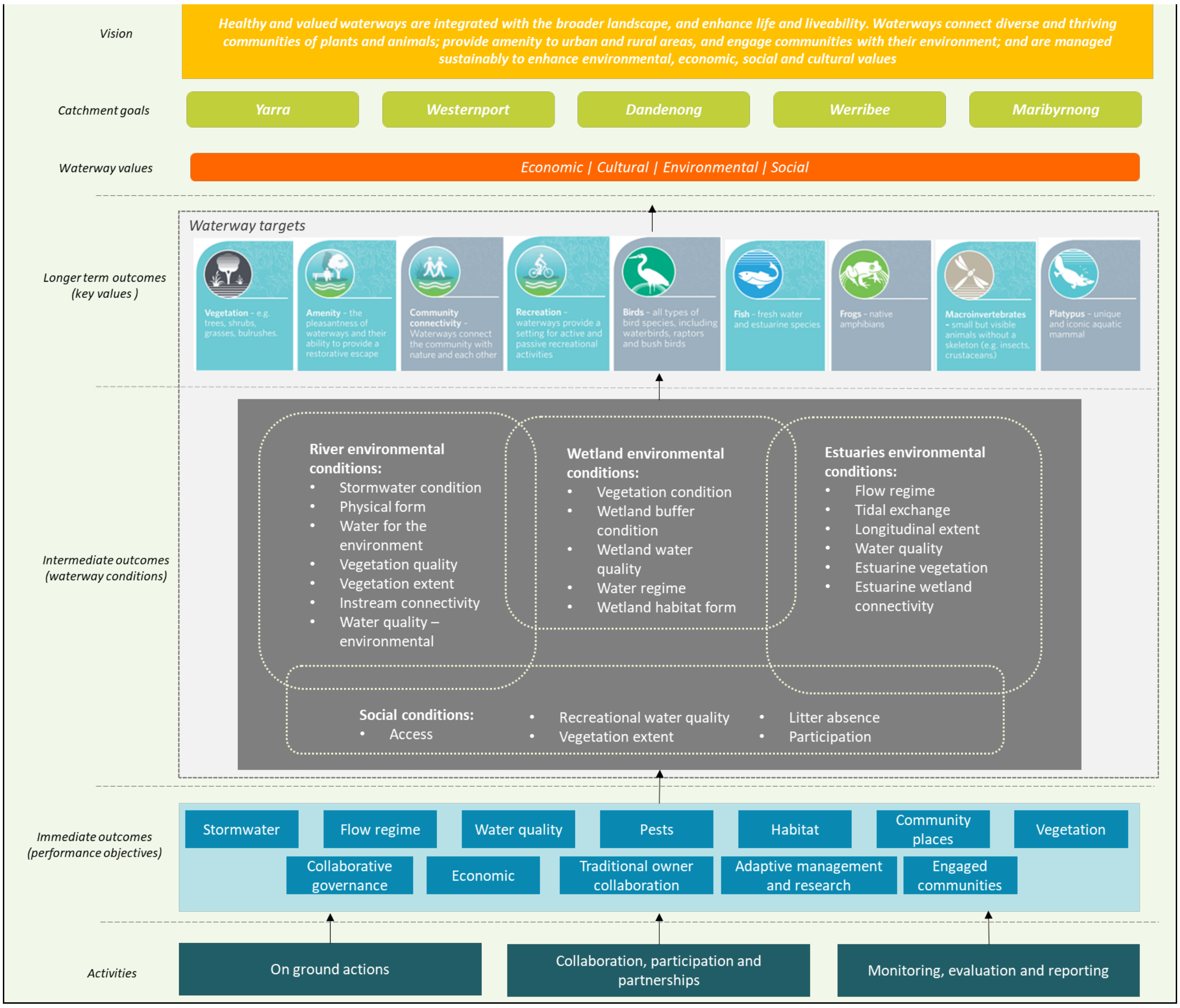
Program logic is an approach commonly used in natural resource management that uses a diagram to demonstrate the rationale for a program, including the relationships between actions, targets, goals and ultimately how the vision is expected to be achieved.

It provides the rationale for how, over the 10-year implementation period of the Strategy, the shorter-term outcomes (performance objectives) collectively contribute to either maintaining or improving the waterway conditions, in turn maintaining or improving the status of the key waterway values, and ultimately contributing to the regional and catchment visions and goals for waterways.

The overarching Strategy program logic recognizes that management activities and outcomes occur over a range of timeframes. It covers:

- Aspirational long-term regional vision and catchment goals: (50+ years)
- Longer term outcomes - key values targets (~ 20+ years)
- Intermediate outcomes - waterway condition targets (~10+ years)
- Immediate outcomes– performance objectives (1-10 years)
- Activities – on-ground actions, partnerships, governance, tracking performance

The program logic for the HWS 2018 is illustrated below.



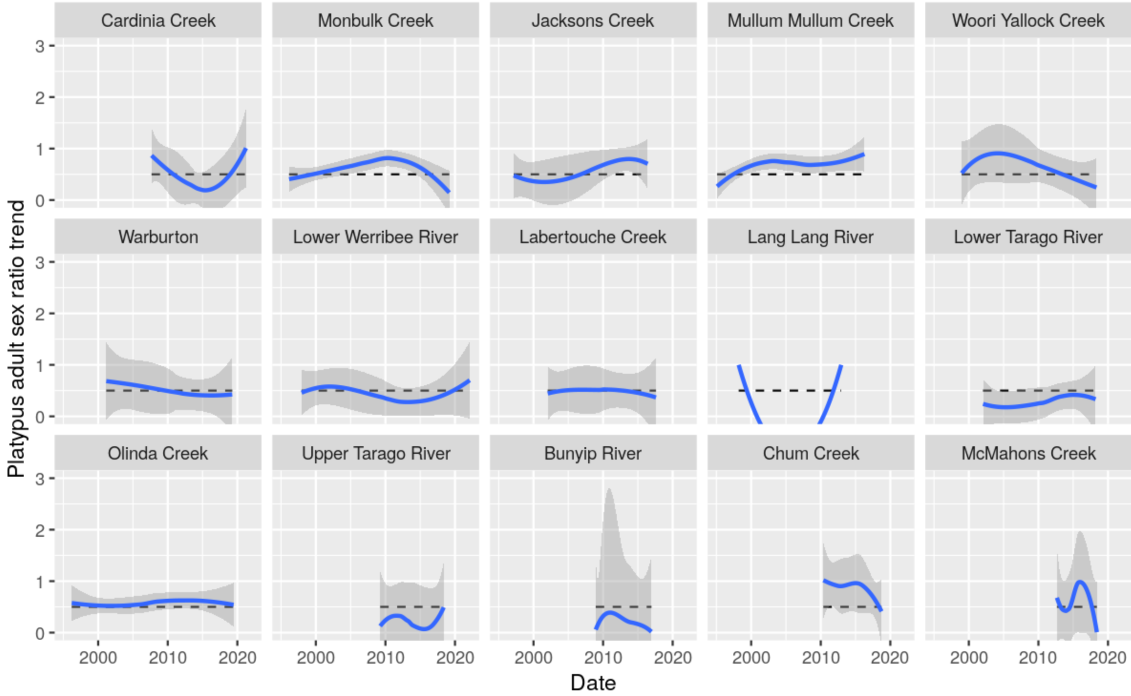
Vision
Healthy and valued waterways are integrated with the broader landscape, and enhance life and liveability. Waterways connect diverse and thriving communities of plants and animals; provide amenity to urban and rural areas, and engage communities with their environment; and are managed sustainably to enhance environmental, economic, social and cultural values
Catchment goals
Yarra
Westernport
Dandenong
Werribee
Maribyrnong
Waterway values
Economic | Cultural | Environmental | Social
Longer term outcomes (key values)
Waterway targets
Vegetation - e.g. trees, shrubs, grasses, bulrushes.
Amenity - the pleasantness of waterways and their ability to provide a restorative escape
Community connectivity - Waterways connect the community with nature and each other
Recreation - waterways provide a setting for active and passive recreational activities
Birds - all types of bird species, including waterbirds, raptors and bush birds
Fish - fresh water and estuarine species
Frogs - native amphibians
Macroinvertebrates - small but visible animals without a skeleton (e.g. insects, crustaceans)
Platypus - unique and iconic aquatic mammal
Intermediate outcomes (waterway conditions)
River environmental conditions:
Stormwater condition
Physical form
Water for the environment
Vegetation quality
Vegetation extent
Instream connectivity
Water quality – environmental
Wetland environmental conditions:
Vegetation condition
Wetland buffer condition
Wetland water quality
Water regime
Wetland habitat form
Estuaries environmental conditions:
Flow regime
Tidal exchange
Longitudinal extent
Water quality
Estuarine vegetation
Estuarine wetland connectivity
Social conditions:
Access
Recreational water quality
Vegetation extent
Litter absence
Participation
Immediate outcomes (performance objectives)
Stormwater
Flow regime
Water quality
Pests
Habitat
Community places
Vegetation
Collaborative governance
Economic
Traditional owner collaboration
Adaptive management and research
Engaged communities
Activities
On ground actions
Collaboration, participation and partnerships
Monitoring, evaluation and reporting

Appendix 2: Platypus health metrics

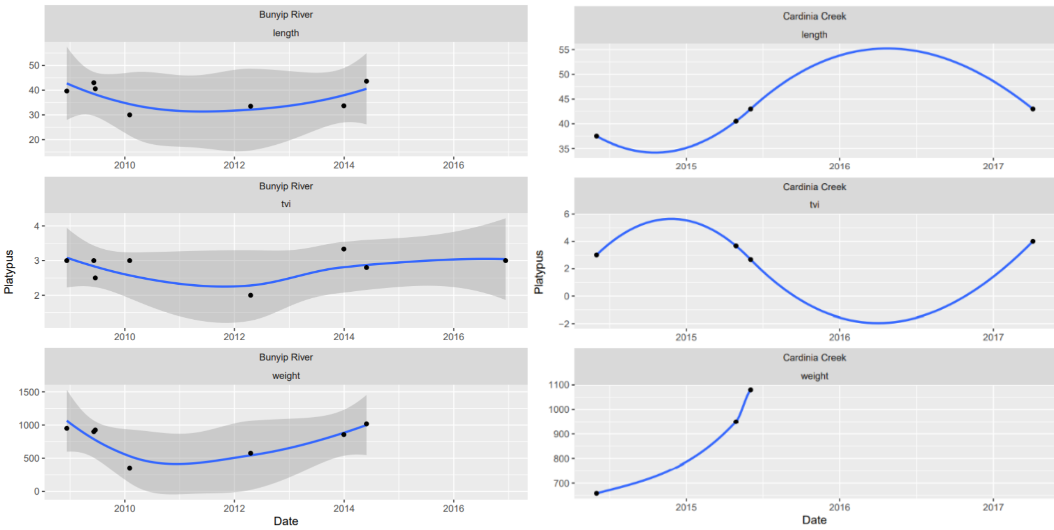
Health metric summary and final health trajectory for each platypus live-trapping location assessed.

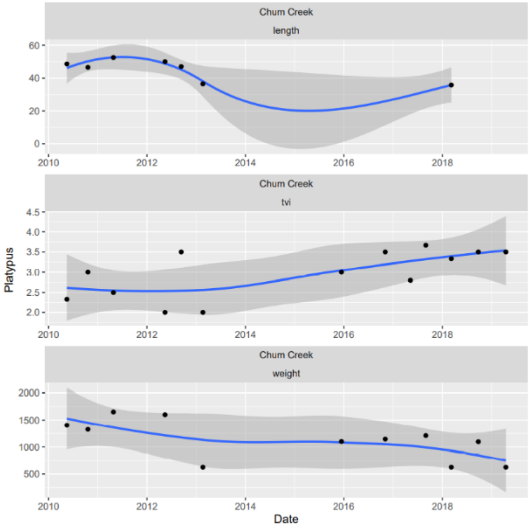
Health									
Location	Live-trapping location	Sex ratio	TVI	Weight	Length	% juveniles	Genetic	Average	Health trajectory
Yarra River Upper (Rural)	McMahons Creek	1	1	1	1	1	1	1	Stable
Yarra River Upper (Rural)	Warburton	1	1	1	1	1	1	1	Stable
Woori Yallock Creek	Woori Yallock Creek	1	1	1	-1	1	1	0.666666667	Stable
Watts River (Rural)	Chum Creek	1	1	-1	1	1	1	0.666666667	Stable
Olinda Creek	Olinda Creek	1	1	1	1	1	-1	0.666666667	Stable
Mullum Mullum Creek	Mullum Mullum Creek	-1	1	1	1	1	1	0.666666667	Stable
Tarago River	Upper Tarago	1	1	1	1	1	1	1	Stable
Tarago River	Lower Tarago	1	1	1	1	1	1	1	Stable
Tarago River	Labertouche	1	1	0	0	1	1	0.666666667	Stable
Lang Lang River	Lang Lang River	0	0	0	0	0	1	0.166666667	Variable/Unknown
Cardinia, Toomuc, Deep and Ararat Creeks	Cardinia Creek	0	0	0	0	0	1	0.166666667	Variable/Unknown
Bunyip River Middle and Upper	Bunyip River	1	1	1	1	-1	1	0.666666667	Stable
Werribee River Lower	Werribee River Lower	1	1	1	1	0	-1	0.5	Stable
Corhanwarrabul, Monbulk and Ferny Creeks	Monbulk	1	1	1	0	1	-1	0.5	Stable
Jacksons Creek	Jacksons Creek (Lower Sunbury)	-1	1	1	1	0	1	0.5	Stable

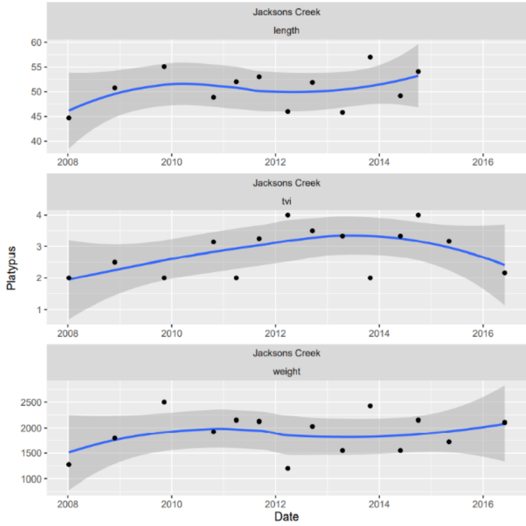
Sex ratio

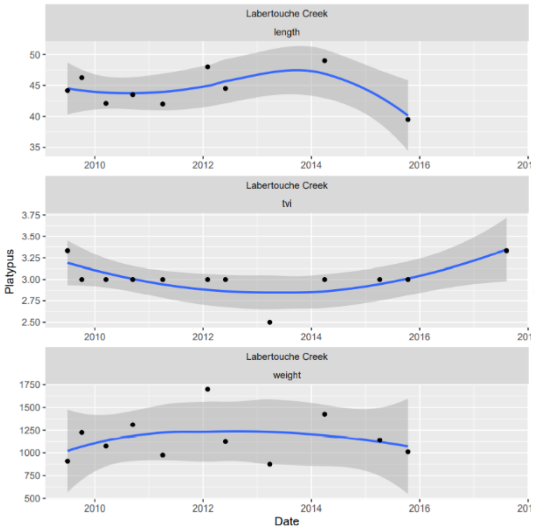


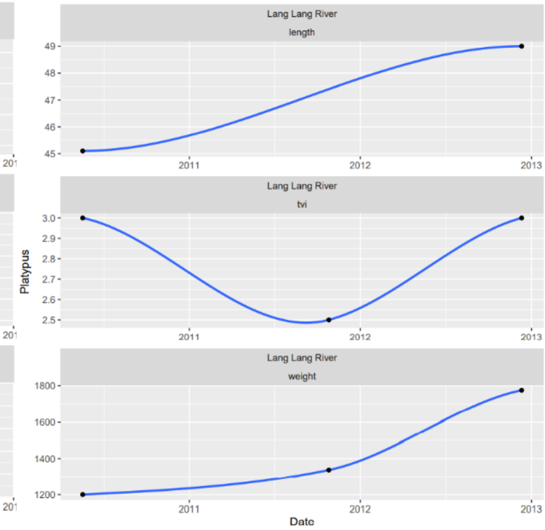
Length (cm), weight (g), and tail volume index (TVI)

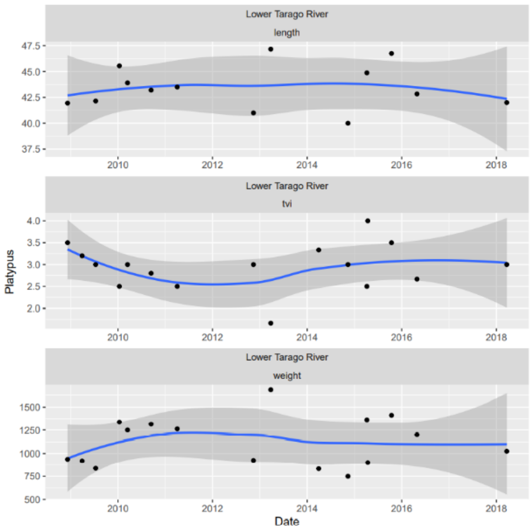


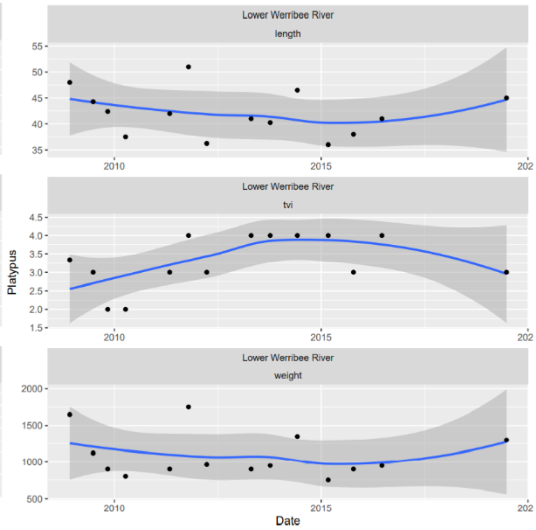

Chum Creek
length
Chum Creek
tvi
Chum Creek
weight
Platypus
Date

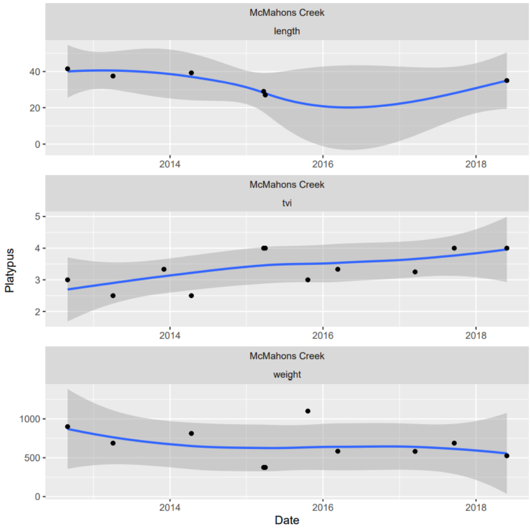

Jacksons Creek
length
Jacksons Creek
tvi
Jacksons Creek
weight
Platypus
Date

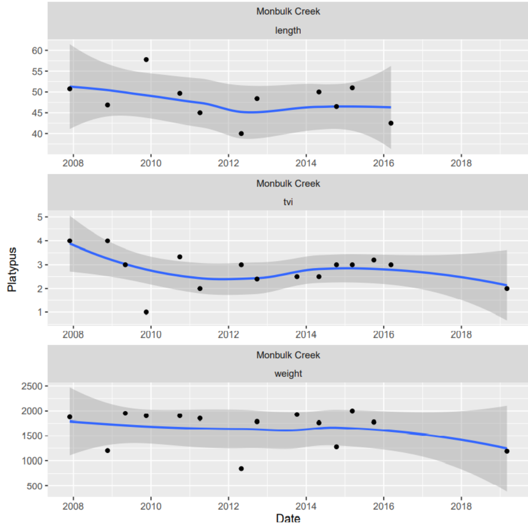

Labertouche Creek
length
Labertouche Creek
tvi
Labertouche Creek
weight
Platypus
Date

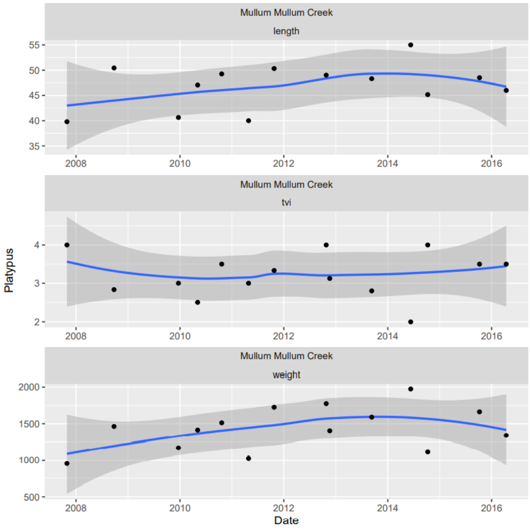

Lang Lang River
length
Lang Lang River
tvi
Lang Lang River
weight
Platypus
Date

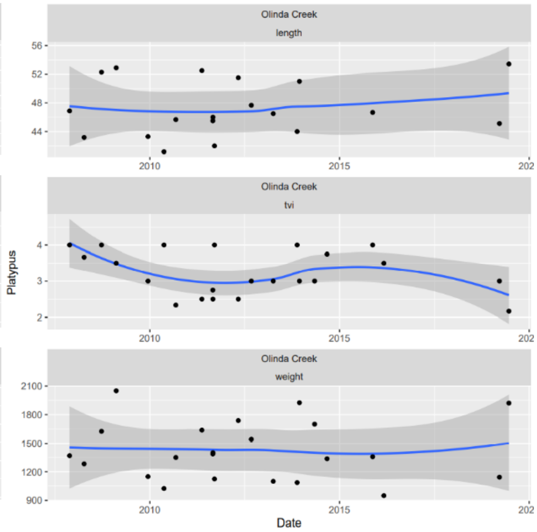

Lower Tarago River
length
Lower Tarago River
tvi
Lower Tarago River
weight
Platypus
Date

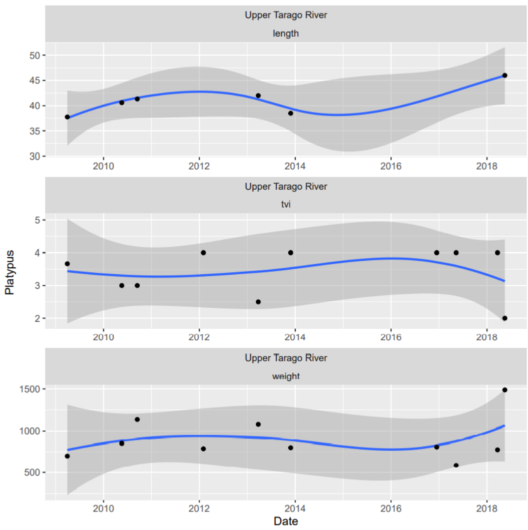

Lower Werribee River
length
Lower Werribee River
tvi
Lower Werribee River
weight
Platypus
Date

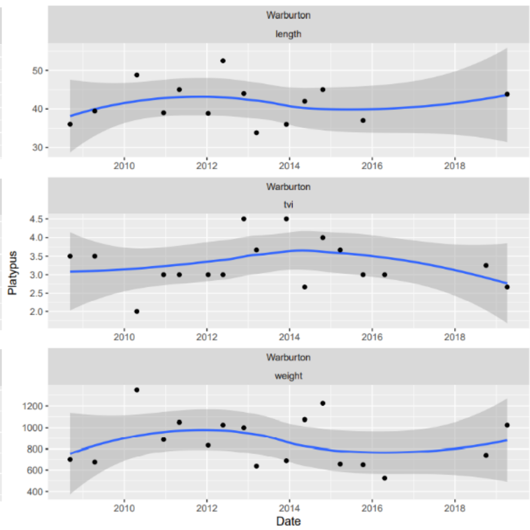

McMahons Creek
length
McMahons Creek
tvi
McMahons Creek
weight
Platypus
Date
2014
2016
2018

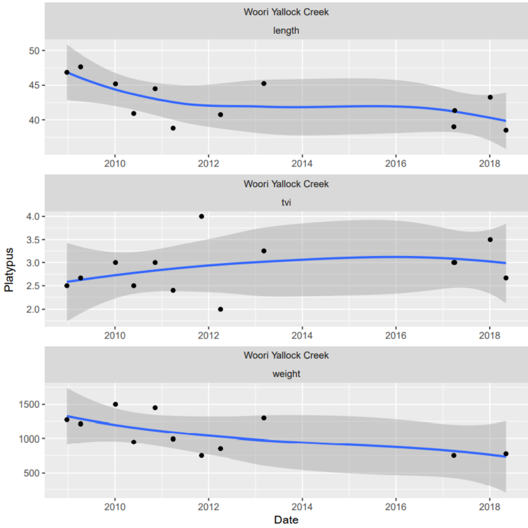

Monbulk Creek
length
Monbulk Creek
tvi
Monbulk Creek
weight
Platypus
Date
2008
2010
2012
2014
2016
2018


Mullum Mullum Creek
length
Mullum Mullum Creek
tvi
Mullum Mullum Creek
weight
Platypus
Date
2008
2010
2012
2014
2016

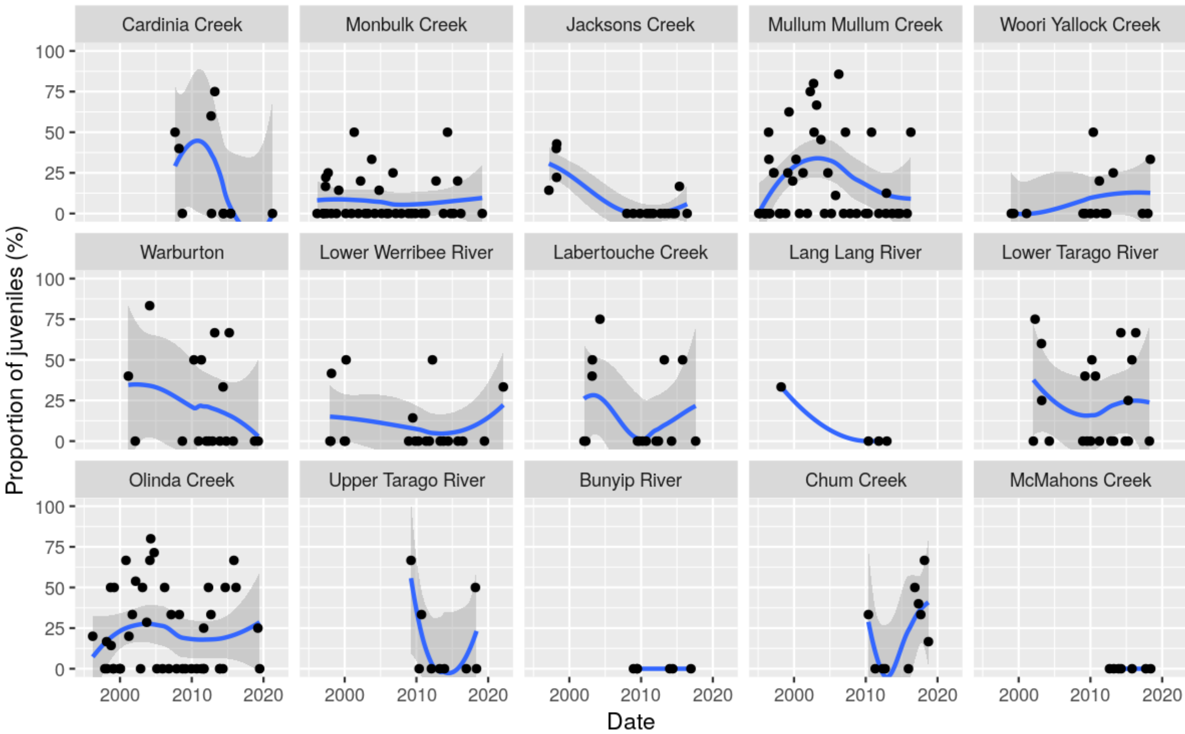

Olinda Creek
length
Olinda Creek
tvi
Olinda Creek
weight
Platypus
Date
2010
2015


Upper Tarago River
length
Upper Tarago River
tvi
Upper Tarago River
weight
Platypus
Date
2010
2012
2014
2016
2018


Warburton
length
Warburton
tvi
Warburton
weight
Platypus
Date
2010
2012
2014
2016
2018



Proportion of juveniles



Appendix 3. Flow-related Performance Objectives for locations determined to be ‘Significant for implementation’

UniquePOId	Catchment	SubCatchment	Group (website)	Scale	Theme (website)	Performance objective (HWS 2018)	Performance objective (website)	ReportDataType	**ReportTiming**
185	Maribyrnong	Deep Creek Lower	Water for the Environment	Sub-Catchment	Maintain/improve flow regime	Identify and implement opportunities to maintain or improve the flow regime in refuge reaches to support platypus and Yarra pygmy perch populations.	Identify and implement opportunities to maintain or improve the flow regime in refuge reaches to support platypus and Yarra pygmy perch populations.	Text (progress report)	**Annual**
189	Maribyrnong	Deep Creek Upper	Water for the Environment	Sub-Catchment	Maintain/improve flow regime	Maintain critical flow components in refuge reaches along Deep Creek to protect Yarra pygmy perch, platypus and other instream values.	Maintain critical flow components in refuge reaches along Deep Creek to protect Yarra pygmy perch, platypus and other instream values.	Text (progress report)	**Annual**
190	Maribyrnong	Deep Creek Upper	Water for the Environment	Sub-Catchment	Maintain/improve flow regime	Reduce threat of summer low flow stress by addressing causal factors such as water for domestic and stock use, diversions and climate change.	Reduce threat of summer low flow stress by addressing causal factors such as water for domestic and stock use, diversions and climate change.	Text (progress report)	**Annual**
203	Maribyrnong	Emu Creek	Water for the Environment	Sub-Catchment	Maintain/improve flow regime	Reduce threat of summer low flow stress by addressing causal factors such as water for domestic and stock	Reduce threat of summer low flow stress by addressing causal factors such as water for domestic	Text (progress report)	**Annual**

						use, climate change, diversions or urbanisation.	and stock use, climate change, diversions or urbanisation.		
529	Westernport	Cardinia, Toomuc, Deep and Ararat Creeks	Water for the Environment	Sub-Catchment	Maintain/improve flow regime	Identify and implement opportunities to maintain or improve the flow regime in refuge reaches to support key values including vulnerable platypus populations.	Identify and implement opportunities to maintain or improve the flow regime in refuge reaches to support key values including vulnerable platypus populations.	Text (progress report)	**Annual**
538	Westernport	Cardinia, Toomuc, Deep and Ararat Creeks	Water for the Environment	Sub-Catchment	Maintain/improve flow regime	Identify and implement opportunities to reduce the key threat of summer low flow stress by addressing causal factors such as water for domestic and stock use, climate change, diversions or urbanisation.	Identify and implement opportunities to reduce the key threat of summer low flow stress by addressing causal factors such as water for domestic and stock use, climate change, diversions or urbanisation.	Text (progress report)	**Annual**
554	Westernport	Lang Lang River	Water for the Environment	Sub-Catchment	Maintain/improve flow regime	Identify and implement opportunities to maintain or improve the flow regime in refuge reaches to support platypus (pudgyer or murrin moorroo) populations.	Identify and implement opportunities to maintain or improve the flow regime in refuge reaches to support platypus (pudgyer or murrin moorroo) populations.	Text (progress report)	**Annual**

562	Westernport	Lang Lang River	Water for the Environment	Sub-Catchment	Maintain/improve flow regime	Identify and implement opportunities to reduce the key threat of summer low flow stress by addressing causal factors such as water for domestic and stock use, climate change, diversions or urbanisation.	Identify and implement opportunities to reduce the key threat of summer low flow stress by addressing causal factors such as water for domestic and stock use, climate change, diversions or urbanisation.	Text (progress report)	**Annual**

Appendix 4. Vegetation-related Performance Objectives for locations determined to be 'Significant for implementation'

Unique PO Id	Catchment	Sub-Catchment	Group (website)	Scale	Theme (website)	Performance objective (HWS 2018)	Report Data Type	Report Timing
191	Maribyrnong	Deep Creek Upper	Vegetation	Sub-Catchment	Protect/maintain quality	Maintain or achieve high and very high quality vegetation (level 4 and 5 vegetation quality is currently 28 km) along Deep Creek and tributaries through effective monitoring and management of threats including protection of endangered EVCs. Fill data gaps in mapping of high quality vegetation.	Numerical (bar chart, Ha maintained and protected per yr; target line linear)	Annual
195a	Maribyrnong	Deep Creek Upper	Vegetation	Sub-Catchment	Establish buffers	Establish a continuous riparian vegetated buffer (144 km, 575 ha) and maintain existing vegetation (54 km, 215 ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality).	Numerical (bar chart, Ha of buffer est per yr; target line linear)	Annual
195b	Maribyrnong	Deep Creek Upper	Vegetation	Sub-Catchment	Protect/maintain quality	Establish a continuous riparian vegetated buffer (144 km, 575 ha) and maintain existing vegetation (54 km, 215 ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality).	Numerical (bar chart, Ha maintained and protected per yr; target line linear)	Annual

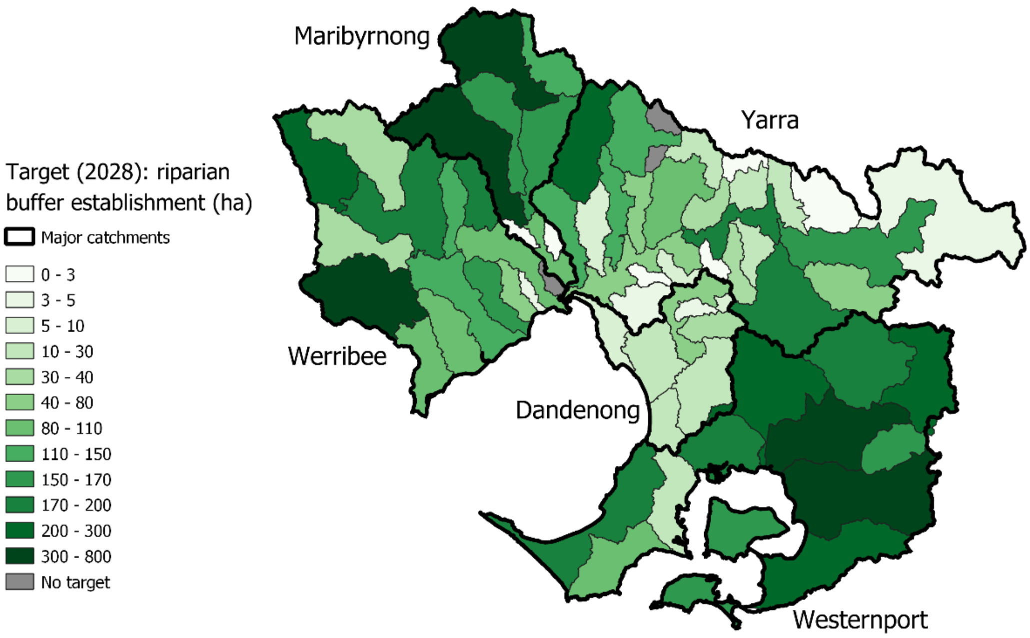
Unique PO Id	Catchment	Sub-Catchment	Group (website)	Scale	Theme (website)	Performance objective (HWS 2018)	Report Data Type	Report Timing
197	Maribyrnong	Deep Creek Upper	Vegetation	Sub-Catchment	Protect/maintain quality	Improve understanding of the extent, composition and condition of high and very high quality vegetation, and effectively monitor and manage both values and threats.	Numerical (bar chart, Ha maintained and protected per yr; target line linear)	Annual
202	Maribyrnong	Emu Creek	Vegetation	Sub-Catchment	Protect/maintain quality	Maintain or achieve high and very high quality vegetation (level 4 and 5 vegetation quality is currently 14 km) along Emu Creek and tributaries through effective monitoring and management of threats including protection of endangered EVCs. Fill data gaps in mapping of high quality vegetation.	Numerical (bar chart, Ha maintained and protected per yr; target line linear)	Annual
204a	Maribyrnong	Emu Creek	Vegetation	Sub-Catchment	Establish buffers	Establish a continuous riparian vegetated buffer (40 km, 159 ha) and maintain existing vegetation (33 km, 130 ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality).	Numerical (bar chart, Ha of buffer est per yr; target line linear)	Annual
204b	Maribyrnong	Emu Creek	Vegetation	Sub-Catchment	Protect/maintain quality	Establish a continuous riparian vegetated buffer (40 km, 159 ha) and maintain existing vegetation (33 km, 130 ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality).	Numerical (bar chart, Ha maintained and protected per yr; target line linear)	Annual
530a	Westernport	Cardinia, Toomuc, Deep and Ararat Creeks	Vegetation	Sub-Catchment	Establish buffers	Establish a continuous riparian vegetated buffer (74 km, 297 ha) and maintain existing vegetation (121 km, 485 ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality). In addition, maximise multiple benefits from vegetation management for social values in existing and planned urban areas.	Numerical (bar chart, Ha of buffer est per yr; target line linear)	Annual
530b	Westernport	Cardinia, Toomuc, Deep	Vegetation	Sub-Catchment	Protect/maintain quality	Establish a continuous riparian vegetated buffer (74 km, 297 ha) and maintain existing vegetation (121 km, 485 ha) along priority	Numerical (bar chart, Ha maintained and	Annual

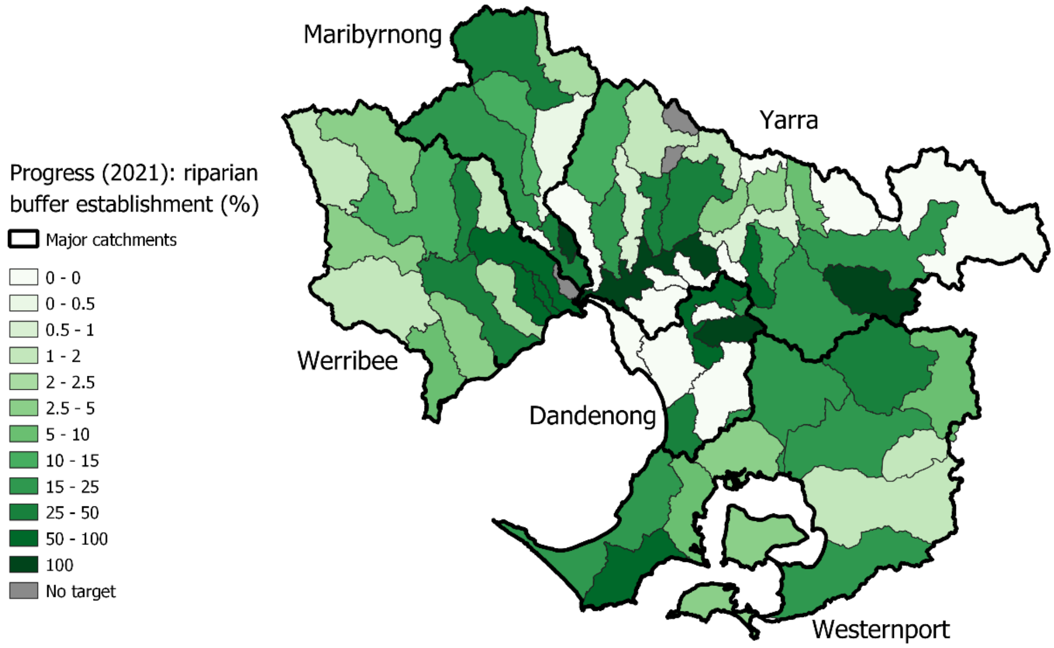
Unique PO Id	Catchment	Sub-Catchment	Group (website)	Scale	Theme (website)	Performance objective (HWS 2018)	Report Data Type	Report Timing
		and Ararat Creeks				reaches (using EVC benchmarks to at least a level 3 vegetation quality). In addition, maximise multiple benefits from vegetation management for social values in existing and planned urban areas.	protected per yr; target line linear)	
531	Westernport	Cardinia, Toomuc, Deep and Ararat Creeks	Vegetation	Sub-Catchment	Protect/maintain quality	Maintain or achieve high and very high quality vegetation (Vegetation Quality level 4 and 5 - currently 38 km) through effective monitoring and management of threats including protection of endangered EVCs in these reaches. Fill data gaps and ensure additional high quality reaches are also protected.	Numerical (bar chart, Ha maintained and protected per yr; target line linear)	Annual
555a	Westernport	Lang Lang River	Vegetation	Sub-Catchment	Establish buffers	Establish a continuous riparian vegetated buffer (100 km, 768 ha) and maintain existing vegetation (195 km, 780ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality).	Numerical (bar chart, Ha of buffer est per yr; target line linear)	Annual
555b	Westernport	Lang Lang River	Vegetation	Sub-Catchment	Protect/maintain quality	Establish a continuous riparian vegetated buffer (100 km, 768 ha) and maintain existing vegetation (195 km, 780ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality).	Numerical (bar chart, Ha maintained and protected per yr; target line linear)	Annual
797	Yarra	Plenty River (Source)	Vegetation	Sub-Catchment	Protect/maintain quality	Maintain or achieve high and very high quality vegetation (Vegetation Quality data level 4 and 5 - currently 27 km) through effective monitoring and management of threats including protection of endangered EVCs in these reaches. Fill data gaps and ensure additional high quality reaches are also protected.	Numerical (bar chart, Ha maintained and protected per yr; target line linear)	Annual
798	Yarra	Plenty River (Source)	Vegetation	Sub-Catchment	Protect/maintain quality	Improve understanding of the extent, composition and condition of high and very	Numerical (bar chart, Ha maintained and protected per	Annual

Unique PO Id	Catchment	Sub-Catchment	Group (website)	Scale	Theme (website)	Performance objective (HWS 2018)	Report Data Type	Report Timing
						high quality vegetation, and effectively monitor and manage both values and threats.	yr; target line linear)	
799	Yarra	Plenty River (Source)	Vegetation	Sub-Catchment	Protect/maintain quality	Maintain existing vegetation (38 km, 150 ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality).	Numerical (bar chart, Ha maintained and protected per yr; target line linear)	Annual

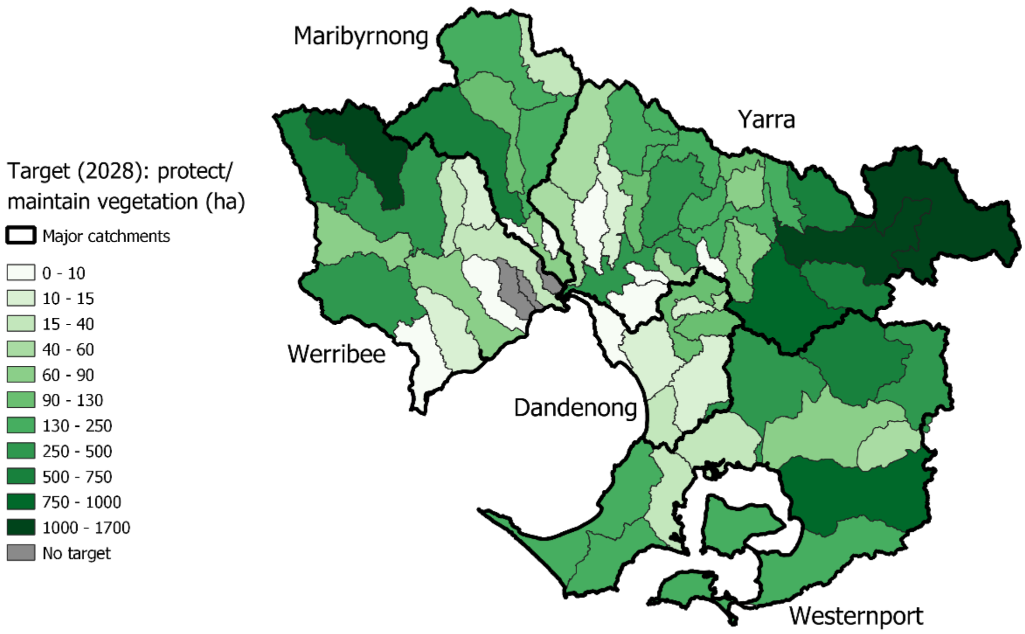
Appendix 5: Vegetation establishment and maintenance targets and progress

The top figure shows the sub-catchment performance objective targets (ha) for establishing vegetation along priority reaches (also referred to as Priority Areas). The bottom figure shows the percent progress towards the 10 year targets as of 2020/21 financial year.





The bottom figure shows the sub-catchment performance objective targets (ha) for protecting and maintaining existing vegetation along priority reaches (also referred to as Priority Areas). The bottom figure shows the percent progress towards the 10 year targets as of 2020/21 financial year. Note that 100% means that the full target area was adequately managed in that year.



978-1-921603-76-1 (PDF)

More Information

Healthy Waterways Strategy

Access the Mid-term Review Summary Report >>
Access the Mid-term Review Science Inquiry Report >>
Access the Implementation Inquiry Report >>

Contact: Waterway.Strategy@melbournewater.com.au