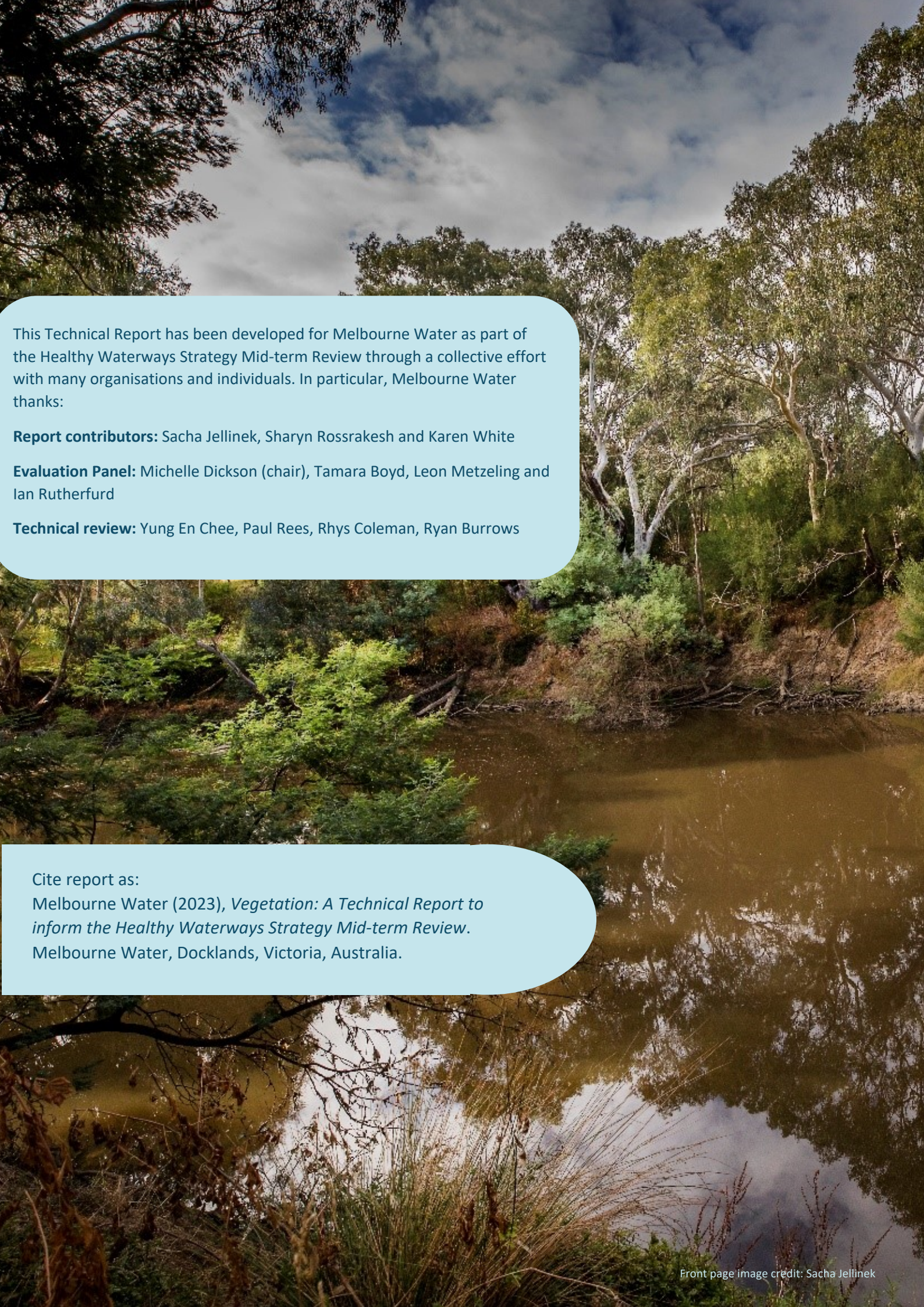
Healthy Waterways Strategy 2018-2028
Port Phillip & Westernport, Victoria

Vegetation

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

High quality vegetation	Information based on VV21 data that suggested that the vegetation in these sites was of high quality (4 – high or 5 – very high)
HWS	Healthy Waterways Strategy 2018
Low quality vegetation	Information based on VV21 data that suggested that the vegetation in these sites was of low quality (0 – no vegetation, 1 – very low, 2 – low)
PO	Performance objectives
Priority areas	These are areas in the Melbourne Water region where performance objectives for establishing and maintaining vegetation exist. These priority reaches were identified using the VV18 data, habitat suitability modelling for platypus, fish and macroinvertebrates and zonation outputs. In these areas management actions such revegetation, pest and weed control works, etc. will be undertaken to achieve targets.
Protection areas	These areas were identified by VV18 data as being of high vegetation condition (vegetation condition score of 4 – high or 5 – very high). These reaches were included within performance objectives which relate to protecting high quality vegetation. In these areas management actions such as pest and weed control works will be undertaken to achieve targets.
Threats	Impacts that may cause a decline in vegetation quality or condition
Vegetation Visions	A rapid monitoring method to assess vegetation condition/quality across the Melbourne Water areas. This method has had multiple iterations with the most recent version being updated in 2021 by Dellbotany.
VV09	The initial Vegetation Visions data collected in 2009 on river reaches.
VV18	Refers to the Vegetation Visions surveys undertaken in 2018 on river reaches. This data was largely undertaken by expert elicitation and field collection and expanded the VV09 data for river reaches.
VV21	Refers to Vegetation Visions field surveys undertaken in 2021. These areas were individual sites that were surveyed, as opposed to river reaches (VV18 data).

Acknowledgement of Traditional Owners

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

Evaluation overview

The Healthy Waterways Strategy (HWS) (Melbourne Water 2018) identifies vegetation as a key value in its own right as well as a supporting condition for other key values (e.g. birds, macroinvertebrates etc) as well as social values (e.g. amenity).

This report is one of several background reports feeding into the HWS mid-term review Science Inquiry (Melbourne Water, 2023a). It presents an evaluation of riparian vegetation, which is a key value in the HWS. The evaluation has focused on two key evaluation questions (KEQs) and their sub-KEQs:

- KEQ - What is the state of waterway values?
    - 3b. What other spatial and temporal trends and patterns for key values are of significance for implementation?

- KEQ - 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?

For the benefit of the reader, some background and contextual information is presented relating to the HWS development and implementation to date along with an overview of how each of the KEQs will be evaluated with respect to vegetation (*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
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 relevant performance objectives is provided in section 2. Evaluation results are outlined in the Implementation Inquiry (Melbourne Water, *in progress*)
3 – What is the state of waterway values?	3a. To what extent are key values on the target trajectory?	For information purposes (refer to section 3). Unable to evaluate due to limited data.
	3b. What other spatial and temporal trends and patterns for key values are of significance for implementation?	Evaluation results presented in Section 3
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?	Evaluation results outlined in section 3. Changes to external conditions is considered as part of the Implementation Inquiry (Melbourne Water, *in progress*)
	2b. To what extent have projected known and emerging future threats	For information purposes (refer to section 4). Evaluation of how threats have changed since 2018 is presented in the Threats Technical Report (Melbourne Water, 2023b)

KEQ	Sub-KEQ	Relevance to this report
	changed from 2018? Have any assumptions about impacts to key values changed?	
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?	For information purposes (refer to section 4). A stocktake of common interventions used across the region is presented in the Interventions 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?	Some background information is provided in Section 4. Identification of remaining knowledge gaps is outlined in Part F of 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 (Melbourne Water (*in prep*)).

Improving vegetation along riparian zones is one of the most important activities that can be done to improve overall stream health. These activities typically include actions such as revegetation, stock exclusion and pest plant and animal control. Flows and water quality are also important conditions required to support healthy vegetation along waterways.

The HWS set long term targets for vegetation value along with 10 year Performance Objectives (POs) in priority areas using best available data and decision support tools. This report provides a summary of these POs and the progress which has been made. Annual reporting is both qualitative and quantitative and has proven to be a valuable process, particularly for Melbourne Water, to understand where effort is needed. While Melbourne Water has been managing riparian vegetation for many years there has not been a commensurate level of investment in monitoring and evaluation. The HWS MERI has enabled this focus and the mid-term evaluation is an important opportunity to learn and adapt.

During the development of the MERI framework (Melbourne Water, 2019), it was recognized that existing datasets on the condition of vegetation along our waterways was inadequate for the purposes of tracking targets, threats and understanding broad changes in condition over time. As a result, a new field based method was developed, a substantial budget was secured for a long term monitoring program and the first round of data collection was carried out in Spring 2021. This represents a significant step forward in monitoring vegetation condition across the region. This dataset known as Vegetation Visions (VV21), is the primary data used to understand spatial patterns (and some potential temporal trends) of vegetation across the region enabling us to identify important findings for the HWS going forward.

Recommendations made within this document 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 vegetation as a value

The Healthy Waterways Strategy (HWS) (Melbourne Water 2018) identifies vegetation as a key value as well as a supporting condition for other key values (e.g. birds, macroinvertebrates etc) as well as social values (e.g. amenity).

Riparian and aquatic vegetation are important components of a healthy, functioning waterway. Vegetation provides a number of functions important to river health including:

- bank stabilisation and erosion control (including coasts)
- improvement to water quality through buffering and natural filtering
- shade and regulation of water temperature
- shelter and provision of habitat and connectivity for wildlife and pathways of gene-flow through the landscape
- provision of organic matter, including large wood, fundamental in the food chain of waterway ecosystems as well as instream habitat.

The notion of vegetation as a value describes it's worth or merit, which is based on a belief system that society holds. For example, native vegetation has value due to sensory, aesthetic, landscape connection and naturalness perceptions. Vegetation as a condition describes the quantity state of a value and is based on empirical facts that can be observed and tested (e.g. extent and quality).

Conceptual model for vegetation

The conceptual model developed for the HWS has been recently updated to better represent the conditions which are required to support vegetation communities and threats to vegetation which were not previously in the model (Figure 1).

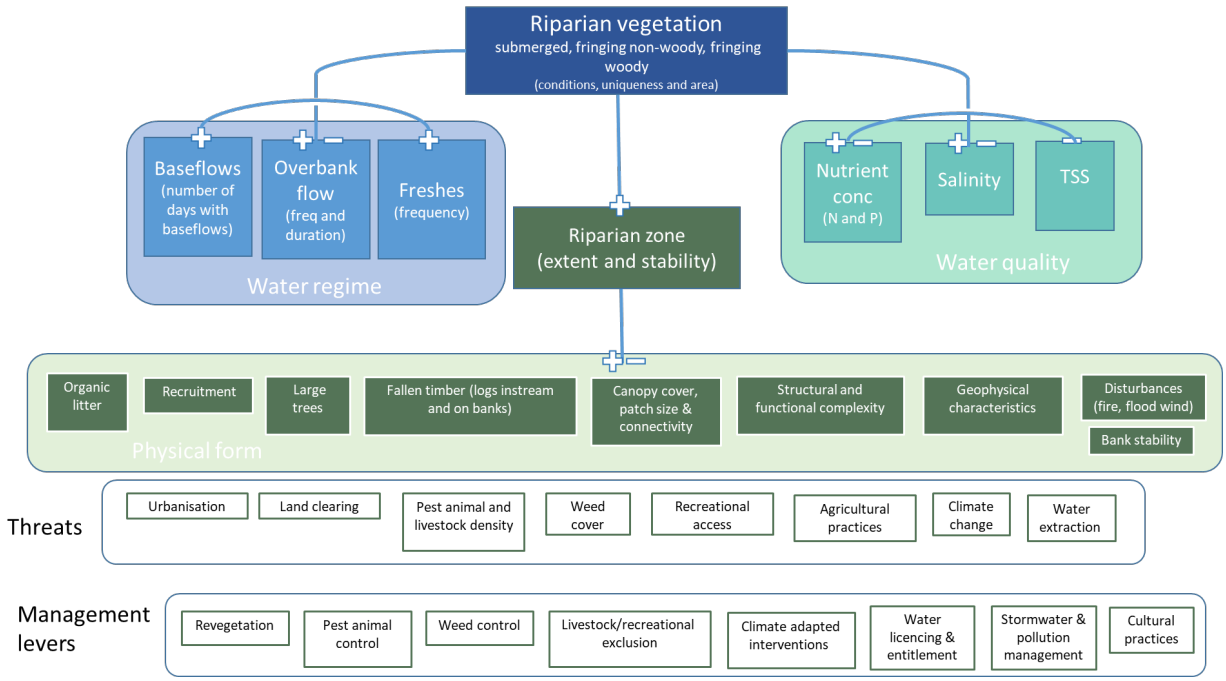


Figure 1. Conceptual model for vegetation in the Melbourne Water region. Blue represents conditions relating to the water regime, aqua is conditions relating to water quality, and dark green elements represent physical form conditions.

Vegetation value metrics and long-term target setting

A metric for defining vegetation value was developed for the HWS which combines two measures, Uniqueness and Naturalness. Uniqueness is a qualitative indicator consisting of a score of rarity based on known benchmarks such as Environment Protection and Biodiversity Conservation (EPBC) listing, while naturalness is a quantitative indicator that consists of two components; Vegetation Extent and Vegetation Quality (see Figure 2).

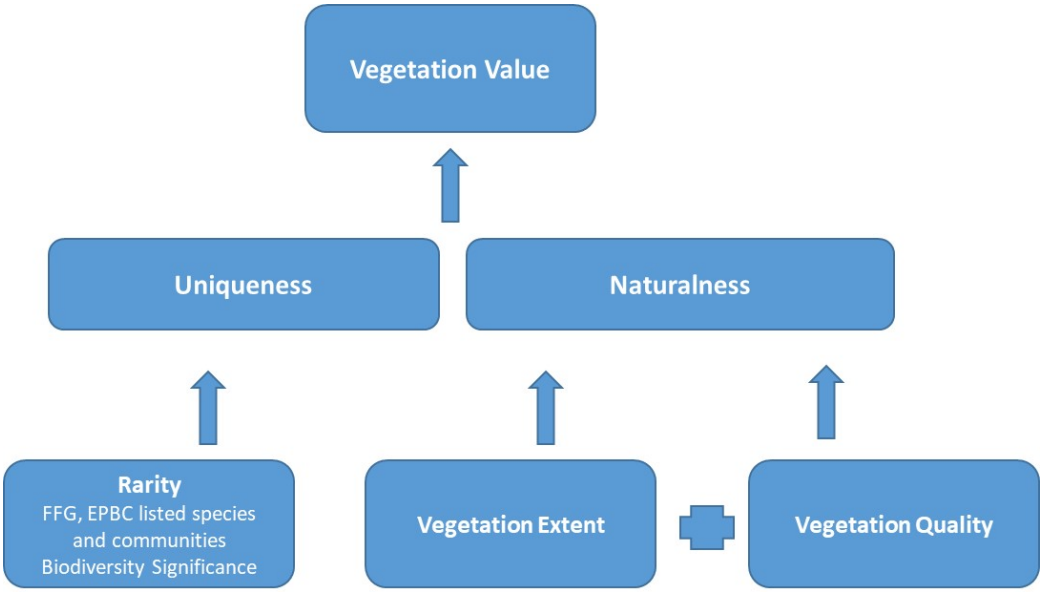


Figure 2. Components of the vegetation key value which define the metrics used to quantify the value across the region at a sub-catchment scale.

The methods for each of these components is outlined in Appendix A.

HWS baseline - 2018 state

Using the methodology outlined in Appendix A, vegetation value data (from very low to very high) were mapped at the reach scale and provided as information to the co-design workshops and stored on the HWS website as background information.

For the Strategy and the purpose of deriving trajectories and targets, the value data was averaged to the sub-catchment scale, using a length weighted average.

Forecast trajectory under a 'business as usual' scenario

A long term 'business as usual' trajectory was based on rules and assumptions around the likely impacts of significant future threats like climate change, urbanisation and invasive plants and animals. It was based on expert opinion which drew on existing studies of climate change impacts (e.g. South West Climate Change Portal and future urbanisation predictions. These assumptions are documented in the HWS resource document (Melbourne Water, 2020).

Long-term target setting

Long-term targets for vegetation value were based on the environmental condition targets for vegetation quality (e.g. protecting high quality vegetation) and vegetation extent (e.g. establishment of riparian buffers). The Habitat Suitability Models for instream biota and Zonation analyses of intervention action prioritisation were used to assist in setting these long term targets on the basis of protecting and improving the status of instream values – macroinvertebrates, fish and platypus.

There were 3 key assumptions built into the targets and how the performance objectives are reported:

1. That a minimum vegetation quality rating of 3 (moderate) is required to provide adequate riparian and instream habitat for other values. This assumption is based on a level 3 quality having at least reasonable over- and mid-storey vegetation of a suitable type to provide for habitat requirements of aquatic fauna and ecosystem functions such as shade, contributions of organic matter and large woody debris etc.
2. That a 20 m riparian buffer in rural areas and 10 m riparian buffer in urban areas will be achieved and that this is adequate to improve vegetation and instream values.
3. Area targets (ha) for protecting high quality vegetation assumed a 20 m buffer along both sides of the reach which had a high or very high vegetation quality rating.

Monitoring vegetation

A vegetation monitoring program has been established to track the progress of the Healthy Waterway Strategy and to provide information for adaptive management. The objectives of the vegetation monitoring program as outlined in the Rivers MEP (Melbourne Water, 2020) are summarised in Table 2 along with relevant monitoring datasets used and how they are applied for evaluation.

Table 2. Summary of vegetation monitoring objectives

Vegetation monitoring objective	Dataset	Evaluation timing
Track long term vegetation targets set out for each of the 69 sub-catchments in the HWS	Vegetation extent – remote sensing Vegetation Quality – Vegetation Visions (VV) (2009, 2018, 2021) Flora and Fauna Guarantee Act 1988 (Vic).	No new data available (will be ready for end of strategy review) Not possible due to methods. Hence unable to answer KEQ3a. Planned for end of strategy review
Monitor progress towards performance objective targets for vegetation establishment (extent) and protection/maintain (quality)	Spatial works mapping	Context for this report Implementation Enquiry
Broad scale surveillance of vegetation quality condition across the region to help understand how vegetation condition varies across the catchments	Vegetation Quality – Vegetation Visions (2018, 2021)	To evaluate KEQ3b for mid-term
Monitor key threats to vegetation such as pest plants and animals	Vegetation Quality – Vegetation Visions (2021)	To evaluate KEQ2a for mid-term and linked to deer research project
Develop a better understanding of impacts of climate change on different vegetation types across the region, and how to mitigate those effects	Detailed vegetation assessment (80 sites) (2021)	Linked to a research project and KEQ4b
Provide key input data into the instream biota HSMs which will be used to predict benefits of on-ground actions (such as revegetation) on instream macroinvertebrate, fish and platypus values	Spatial works mapping	For the instream evaluation paper (ie bugs, fish, platypus)

The Vegetation Visions (VV) data is the primary data set used in this report. The methodology for this dataset has evolved over the past 5 years from using expert elicitation to a rapid field assessment. The following provides a summary of these 2 methods.

Expert Elicited Vegetation Visions data (2009 and 2018 datasets)

The Vegetation Quality Visions approach was first developed in 2009 and was updated in 2018. It was designed to provide a snapshot of condition along with an achievable target condition for each reach for 2030 (e.g. Vision). For each vegetation quality level, the following characteristics are described: Vegetation structure, Species composition, - Instream vegetation, Vegetation continuity and connectivity, Weediness, Regeneration, and Typical land use setting.

Vegetation quality levels were determined via a series of workshops with Melbourne Water representatives and independent experts. Waterway reaches were rated from 1 (very low) to 5 (very high) for both current (2009) and potential (2030) vegetation quality using the following ratings:

1. Very Low Riparian vegetation is highly modified, predominantly comprising exotic species.
2. Low Riparian vegetation is highly modified, fragmented and meets social and amenity requirements
3. Medium Riparian zone consists of fragmented relevant EVC vegetation.
4. High Riparian vegetation is relatively intact with structural elements present with high connectivity.
5. Very High Riparian vegetation is intact with all structural components present and very high connectivity

There were significant gaps in the coverage (~80% of waterways) and accuracy of the data in the 2009 dataset. The 2009 expert elicited data is therefore not considered accurate enough to be used in the evaluation and as such will not be used to compare with the new data sets.

During the development of the HWS, some of these areas were filled using surveys and expert elicitation, however, there was not enough time to do this thoroughly. Following the release of the HWS, a more comprehensive update was carried out in 2018, known as VV18. This iteration significantly expanded the coverage (~51% of waterways) and included the addition of confidence ratings to the data. The high to very high certainty data is the most useful and comparable, as this equates to multiple site visits [High] or a systematic vegetation survey [Very High]).

This updated dataset has been used subsequently to expand the areas of known High or Very high quality vegetation and allow works in these areas to contribute to the performance objectives in the HWS that relate to protecting and maintaining high quality vegetation. Appendix D shows the extent to which high quality vegetation areas have increased from filling data gaps in the VV09 data.

Field-surveyed Vegetation Visions 2021: VV21

In recognition that the expert elicited data wasn't accurate enough to compare reaches over time, a new field-based method (Appendix B) was developed during the development of the HWS MERI. This involved an extensive review of existing methods and recent improvements in monitoring approaches and was peer reviewed (refer to Dell 2020).

The field method is based on a survey area of 20 m x 100 m (0.2 ha) in size, which is completed in a specified time period (5 - 15min) along one side of a waterway at selected sites. At each site the ecological vegetation class (EVC) was determined along with the vegetation type: forest and woodland, woody non-treed vegetation (e.g. scrubs and heath) or non-woody, non-treed vegetation (e.g. herbaceous and grassland). The method uses these broad vegetation categories as evaluation

against static historic benchmarks (e.g. EVCs), has implicit limitations, especially in the context of climate change.

Five components are scored (from 0-5) to make-up the VV score: structure, richness, connectivity and natural recruitment of terrestrial vegetation and instream vegetation. These 5 components are summed to give a score out of 25, and this is then divided by 5 to convert to a score ranging from 0 to 5. Both the total and divided score can be used, the division taking place to make it comparable to the historic use of the scoring system. Refer to Appendix E for an overview of these five components for the region.

The weediness of the site is also scored along with a separate score of highly invasive weed species. However, these weed scores are not used to construct the VV score, as weeds will already impact the structure, richness and natural recruitment scores. If weed scores were included, this would essentially double count their impact. The threats at the site, terrestrial vegetation structural forms and instream vegetation structural forms were also recorded. The scoring system and other information captured is shown in Appendix B. This VV21 assessment took place in late 2021 at 506 sites distributed across the Melbourne Water region.

The main differences between the VV21 data and the VV18 data are:

1. All VV21 scores are recorded from on-ground assessments whereas VV18 is a combination of on-ground and expert elicitation.
2. Data is recorded at the site scale (0.2 ha) based on a randomly selected GPS point for VV21 while it was recorded at the reach scale for the VV18 data (reach size varied depending on the waterways being assessed).
3. Weed scores were not incorporated into the VV21 final scores but they were in the VV18 scores.
4. VV21 scores were on a scale from 0-5 while VV18 data are on a scale from 1-5. However, VV18 was essentially the same, as non-native vegetation (e.g., 0) was not scored.

Despite differences in the methodology between the two datasets (VV18 and VV21), the high confidence data within the VV18 dataset can be used for comparative purposes with the VV21 data since multiple field surveys were undertaken in order to be assigned as high confidence. Data from VV18 which was assigned low to moderate confidence have not been used in the evaluation. The new VV21 data was also used in own right to look at spatial patterns across the region, and as it includes a number of sub-indicators, it allows us to look at different elements of vegetation conditions providing insights to the current state of key threats to vegetation.

Other vegetation monitoring methods

There are two monitoring methodologies that Melbourne Water uses that could be used to assess vegetation outcomes. These are the Restoration Outcomes Monitoring Protocol (ROMP) which has been used since 2021 to assess management intervention outcomes (revegetation, weed control and pest animal control) in comparison to existing remnant (target) areas. The other is the Index of Stream Condition monitoring which has been undertaken at 31 sites since 2010 to track vegetation change over time at sites where management interventions had been undertaken, comparing these sites to control sites where no management was implemented.

Index of Stream Condition (ISC2) monitoring

The primary aim of the ISC is to assess the environmental condition of Victoria's major rivers and streams and to provide statewide data for CMA regional waterway action planning and priority

setting. Over this time there have been three changes to the methodology in 1999, 2004 (ISC2) and 2010 (ISC3). The 2004 ISC methodology evolved significantly from 1999, especially in its refinement of the hydrology sub-index. Both the 1999 and 2004 ISC used field methods to assess environmental conditions in rivers and streams, whereas the 2010 method used aerial photography and LiDAR to assess these areas. The ISC2 method was maintained by Melbourne Water as it allowed the collection of floristic and lifeform level data.

The Index of Stream Condition (ISC2) streamside zone sub-index method was undertaken over a 14 year period (baseline surveys undertaken between 2006 and 2009) by one person (Jamie Kaye from Water Technology), who surveyed 31 sites (30 of which were assessed) selected by Melbourne Water prior to management interventions taking place, and then at one, three, six and ten years after the interventions. These interventions generally included revegetation activities and weed control. Works sites (where the interventions were undertaken) were monitored in conjunction with nearby upstream and downstream control sites (where there were no planned interventions). No remnant vegetation was monitored during this study, so does not directly relate to KEQ's in this report.

Similarly, It is very difficult to draw detailed conclusions from the electronically available ISC2 data. Firstly, this is because the ISC2's focus is on snapshot capture and summary reporting of river condition. The ISC2 index is itself constituted of five sub-indices. Each sub-index has further component metrics. The outputs of many of these metrics are scores which are actually compound constructs reported on an ordinal (e.g. 0-5) scale. Options for analysing and extracting further information from these ordinal scores are limited. As stated by Water Technology, 'without the assessor's interpretation and commentary, other reasons for a condition decline may be impossible to predict from the condition scores'. The ISC2 method was also designed to detect long-term changes in environmental condition, and as this study is relatively short-term (in comparison to the developmental stages of restored habitats) and seeks to assess the benefits of interventions such as revegetation, the results do not provide much detail on the earlier phases of revegetation intervention outcomes.The full report of the ISC2 method can be found in Jellinek *et al.* 2022a.

Restoration Outcomes Monitoring Protocol

The Restoration Outcomes Monitoring Protocol (ROMP) seeks to monitor areas where management interventions are undertaken to better understand how these areas grow and develop over time in comparison to target or reference habitats (Jellinek *et al.* 2022b).

While this method has the ability to track vegetation change over time, in sites that have had management interventions as well as at sites where remnant vegetation exists, these sites have only been assessed once since 2021/22 so no data is available to show how these areas are changing and are therefore not useful for this report.

This method has been used twice prior to it being implemented at the recent management intervention sites (see the A2 Factsheet):

- Eliza Foley-Congdon undertook at Masters of Science at the University of Melbourne which was completed in 2022 and used the ROMP method to assess 17 ISC2 sites and 10 remnant (target) sites to determine how revegetated areas compared to remnant habitat. As these sites only assessed remnant sites once, this data would not be useful to answer the KEQ's in this report. A report on this work can be found in the A2 Riparian Factsheet: MERI Riparian Revegetation – Assessing Restoration Outcomes and in Foley-Congdon *et al.* 2023.

- A study was undertaken to assess revegetation survival after 2 years in 2021/22. This study by Jellinek (see Jellinek 2022c) assessed only sites that had been revegetated in 2018/19 and were assessed once in 2021/22. This study did not include surveys of any remnant sites so is not able to inform the questions outlined in this report.

New and emerging methodologies

Some new and emerging methodologies are currently being developed and tested with the aim of applying them for end-of-strategy evaluation.

Satellite Vegetation Quality

Current research projects (refer to Research Fact Sheet attachment) are investigating the ability to develop predictive models of vegetation quality that will use our field data to train models to be applied to satellite data to provide regionwide reach scale vegetation quality data. The model currently has a 63% accuracy in assigning satellite imagery (Sentinel 2 - 10 x 10m pixels) to the vegetation vision scoring system (e.g., 0-5). The data from the 506 field base vegetation vision sites, will be used to further train the model and improve its predictive accuracy. If successful, this would provide condition data for almost all waterway reaches at a frequency of every couple of weeks. This will allow us to track the trajectory of the pixels over time, to help target locations for on-ground works and investigations. This will be an invaluable dataset going forward that will allow us to track to spatial and temporal changes at a fine resolution.

Artificial Intelligence – Vegetation Extent

Our current Vegetation Extent datasets are based on the processing of LiDAR data and so can only be generated every 4 years or so, when new LiDAR is flown. Melbourne Water are investigating the use of proprietary artificial intelligence software (from Nearmap), to determine vegetation extent from aerial imagery. This would significantly reduce the interval between datasets and would also significantly reduce the effort required to generate the dataset.

LiDAR Derived – Understorey Vegetation Density

Melbourne Water are currently working with the University of Melbourne to determine whether we can detect meaningful changes in understorey density in particular height bands. This would for instance, allow us to see whether deer (1-3m height) are significantly impacting on vegetation structure. (refer to the Research Fact Sheet attachment)

eDNA

Melbourne Water are also continuing discussions with EnviroDNA about the use of environmental DNA technology to detect flora species and communities. This is likely to be most useful for detecting specific species (e.g. Threatened Species or New and Emerging Weeds). It is also being trialled for aquatic plants as part of our Billabong monitoring program.

Index of Stream Condition 2

Melbourne Water has been monitoring riparian management interventions at sites across our region for over 15 years. These sites initially included a works site (n=30) and two control sites each (n=60). The number of control sites has diminished over time. These sites were monitored pre-works and 1, 3, 6, 10 and 15 years post-works, with the intention to keep monitoring them at 5 yearly intervals. This data will be used as part of mid-term evaluation for interventions and will be continued to provide a transition into the Restoration Outcomes Monitoring Protocol which will be used for end of strategy evaluation.

2. Summary of management actions and progress

The overarching strategy was to identify high priority threats to be addressed, to set explicit targets for doing so, via Performance Objectives, to devise and implement effective, decision-relevant monitoring initiatives, to commission research on critical decision-relevant knowledge gaps and to invest in scanning for important emerging threats and knowledge gaps.

This section provides a summary of the performance objectives which directly and indirectly relate to protecting or improving vegetation values across the 69 sub-catchments of the region.

Table 3 is an overview of performance objectives related to directly managing vegetation (e.g. revegetation and weed control) while *Table 4* are those which have a less direct relationship (e.g. stormwater management). It should be noted that the list is not exhaustive and a full list of RPOs and sub-catchment performance objectives can be found on the HWS website (https://healthywaterways.com.au/report-card) and in the Rivers MEP and the Regional MEP (Melbourne Water 2020).

Table 3. Performance objectives (sub-catchment and regional) which directly influence vegetation outcomes.

Threats	Sub-catchment Performance Objectives	Regional Performance Objectives
Weed cover, Pest animal and livestock density, land clearing, recreational access	Establish a continuous riparian vegetated buffer (XX km, XX ha) and maintain existing vegetation (XX km, XXX ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality) (indicator: Ha vegetation established) Maintain or achieve high and very high quality vegetation (Vegetation Quality level 4 and 5 - currently XX km) through effective monitoring and management of threats including protection of endangered EVCs in these reaches. Fill data gaps and ensure additional high quality reaches are also protected. (indicator ha vegetation managed)	RPO-31 A risk-based approach is adopted to prevent, eradicate and contain pest plants and animals (including deer) and protect waterway assets. (indicator: qualitative assessment in annual progress report)
Climate change	N/a	RPO-30 Climate change resilient revegetation management practices are understood and implemented by selecting plant species, provenances and vegetation communities that are suited to projected future climatic conditions. (indicator: qualitative assessment in annual progress report)

Table 4. Performance objectives (sub-catchment and regional) which indirectly influence vegetation outcomes

Threats	Sub-catchment Performance Objectives	Regional Performance Objectives
Water extraction, Urbanisation	Maintain critical flow components in refuge reaches along (e.g. Kororoit Creek) to protect instream environmental values. (indicator: qualitative assessment in annual progress report) Investigate options to increase environmental water reserve for the catchment is increased by xx GL /year by 2028 to meet ecological watering objectives and cover projected shortfalls. (indicator: GL water recovered) 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. (indicator: ML/y stormwater harvested and infiltrated)	RPO 12 Water for the Environment continues to be managed and delivered to the region's rivers and wetlands and recovery options continue to be investigated. RPO 13. Industry capacity for whole of water cycle and stormwater management is increased to enable collaboration, improved access to information and knowledge, and a skilful and capable industry with strong established networks. (Indicator: qualitative assessment in annual progress report)
Agricultural practices	Improve water quality for environmental values and receiving waters (eg Port Phillip Bay and Westernport) by reducing turbidity and nutrient run-off from rural land. This may include establishment of vegetated buffers in headwater streams. (indicator: ha rural land managed to best practice)	RPO 25. Programs, standards, tools and guidelines are in place to manage nutrients, sediments and other pollutants from rural land in priority areas. (indicator: qualitative assessment in annual progress report)

Progress of vegetation performance objectives

The HWS annual report tracks progress at multiple scales. It includes a high level summary (Box 1 and Box 2), regional scale reporting e.g. Regional Performance Objectives (RPOs) (*Table 5*) and reporting at the sub-catchment scale. The following section provides some insights into HWS progress at each of these scales for actions relating directly to achieving vegetation outcomes. Appendix F provides an overview of progress towards other less direct performance objectives (e.g. stormwater management).

High level summary of progress

Box 1 HWS annual summary 2020/21 Annual Summary 2021 | Healthy Waterways Strategy for Port Phillip and Westernport, Victoria

24 million plants by 2028 – that's a lot!

It is a great achievement to have **all 5 catchments on track for establishing vegetation in 2021**. Almost 500 ha of riparian vegetation was successfully established across the region in 2021, with 80 ha alone established along the upper reaches of Deep Creek in the Werribee Catchment. Other significant vegetation targets were achieved in the Little Yarra and Hoddles Creek subcatchment in the Yarra, creeks along the Mornington Peninsula and Kororoit Creek in the Werribee catchment. **Co-delivery has been an essential part of delivering these outcomes**, with contributions from land holders, friends groups and agencies including Melbourne Water, local government and Parks Victoria. For another excellent example of the power of co-delivery **see the Linking the Landscape case study**.

This is important because restoring vegetation along rivers and floodplains is one of the most important actions we can take to improve the health of our waterways. **The Strategy sets a bold target of establishing almost 8,000 ha of vegetation** over the life of the strategy. This will result in almost 2,000 kms of buffers and biolinks along waterways or around 24 million plants in the ground over 10 years.

Next we need to increase momentum. While a little over 1,200 ha has been achieved since the strategy began, we still have a long way to go to reach the 10 year target. **We need to significantly increase** the plantings delivered in 2022 to 800 ha to stay on-track. That's nearly double what was achieved in 2021.

Box 2 HWS annual summary for 2020/21 Annual Summary 2021 | Healthy Waterways Strategy for Port Phillip and Westernport, Victoria

Nibbling away at managing deer

Our knowledge of high quality vegetation is growing. We have mapped more than 5,600 kms of high quality vegetation (around 22,000 ha) along waterways, which is significantly greater than the estimated 1,700 kms (around 6,900 ha) of the Strategy

The Healthy Waterways Strategy target sets an ambitious target of managing all high quality riparian vegetation by 2028. In 20/21 **we managed 5,588 ha and are on-track**. Large areas were managed along Jacksons Creek, Lerderderg River, Werribee River, Upper Bunyip River, and the Upper Yarra river.

Despite being on track, deer are an increasing threat to high quality vegetation. Collaborative research identified specific ecological values at high risk from deer impact and the most cost-effective

management responses. To date, deer control has not been sufficiently implemented across the region, noting the good efforts of the Bunyip Recovery Deer Control Program - a partnership between Parks Victoria and Melbourne Water and the Tarago Deer Program run by DELWP and partners. **For more information see the Deer oh dear! case study.**

In 2020 the Victorian Government released the Victorian Deer Control Strategy and is in the process of developing a peri-urban Melbourne Deer Control Plan that aims to guide and coordinate deer control efforts across partner organisations.

This is important because **deer are an increasing threat to high quality vegetation because numbers are increasing**. They eat and trample vegetation, snap shrubs and young saplings, ring-bark trees by 'antler rubbing', and make large wallows in wet areas that impact unique vegetation and frog habitat. They also have negative impacts on agricultural areas, water supply reservoirs and road safety.

Next we need to update the high quality vegetation targets to include the additional areas of vegetation recently identified. We will **continue existing deer control** programs such as the Bunyip Recovery Deer Control Program. Once finalised, undertake actions highlighted in the peri-urban Melbourne Deer Control Plan and prioritise areas to **undertake additional deer control** with a coordinated program-level view.

Regional reporting

Reporting of the Regional Performance Objectives (RPOs) is via an annual progress report and presented on the HWS report card website. See *Table 5* for relevant RPOs for the 2020/21 annual report. A rubric is currently in development which will be used during the implementation enquiry to judge whether RPOs are on-track or not.

Table 5. Annual progress report for RPOs which are directly related to managing vegetation

RPO	2020/21 annual report
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	Given Melbourne Water's significant investment in revegetation along our waterways, wetlands and estuaries, it is important that the seed we use (to grow plants) is suitable for the climate we can expect in the future. There is concern that seeds currently used for growing plants for revegetation may not be able to tolerate future climate conditions leading to wide ranging failures in planted sites, resulting in increased revegetation costs and reduced ecosystem services provided by this vegetation. To help us work out where to collect seeds, Melbourne Water has teamed up with researchers from the University of Melbourne, Deakin University, Greening Australia and Cesar. For our most commonly used revegetation plants, they are developing models that show the impact of future climate scenarios on the state-wide distribution of these species. They are also using glasshouse trials looking at the growth and survival rates for seedlings through to mature plants under simulated future climatic conditions (e.g. hotter and drier). Six species ranging from sedges to trees have been selected for these glasshouse trials. The initial species selected for trials include: *Acacia implexa* (Lightwood), *Gahnia sieberiana* (Red-fruit Saw-sedge), *Allocasuarina verticillata* (Drooping She-oak), *Bursaria spinosa* (Sweet Bursaria), *Olearia lirata* (Snowy Daisy-bush) and *Eucalyptus camaldulensis* (River Red Gum). This research is being teamed with a behavioural science / policy project to ensure that Melbourne Water is able to adopt a proactive approach, which considers improved collection, management, distribution and supply of seed and plants, for climate resilient revegetation projects. During 2021, Melbourne Water has collaborated with Alluvium Consulting to review the background information and document current approaches to revegetation. We are identifying what needs to be done differently to ensure our investment in revegetation will have the best chances of success as climatic conditions change. Given the uncertainty associated with future climatic conditions, Melbourne Water are planning on using an adaptive pathways approach to implement the findings of the research. Outputs from this research program will be used to update work procedures and planting

RPO	2020/21 annual report
	guidelines to ensure Melbourne Water's revegetation projects along our waterways will be a lasting investment, and resilient to climate change.
RPO-31 A risk-based approach is adopted to prevent, eradicate and contain pest plants and animals (including deer) and protect waterway assets.	With our partners (including the community) we continue to carry out widespread, but targeted, works to reduce the impact of invasive species on our waterways. Over the past year we have continued to improve our understanding of invasive species across our region through research, modelling and surveys. We recently had an external review and refresh of our invasive species approach completed. This will inform an updated risk-based approach to invasive species control. In a collaboration comprising Melbourne Water, the Department of Environment, Land, Water and Planning (DELWP), Parks Victoria and the University of Melbourne's Waterway Ecosystems Research Group (WERG), a deer research project has built a model to predict where the impacts of deer on waterways are likely to be greatest. The deer modelling project has been running for three years. This year we have undertaken a range of activities to further refine the model to inform efficient targeting of deer impact mitigation and control activities. These include; use of LIDAR (a remote sensing technique) data to assess associations between deer density and changes in vegetation structure; field assessments of deer density and impacts to the west of Melbourne; and using the model to guide control programs.

Sub-catchment reporting

The sub-catchment performance objectives for establishing vegetation and protecting high quality vegetation are reported annually against a numeric target. To count a vegetation establishment target, the vegetation must generally be at least 2 years old. The protect / maintenance targets are based on areas of work (within priority areas) within the reporting year. If an area does not need on-ground intervention in that year, a polygon is still mapped to show the area has been assessed – and is counted towards the target.

It is important to note that there are some key limitations on the reporting of the maintenance targets. At present, reporting does not discern between management of pest plants or pest animals. This will be improved in future years (e.g. hectares deer-managed) and separate rubrics will be developed for key threats e.g. deer and pest plants. Informal or anecdotal evidence (*Paul Rees pers comm*) suggests that the threat of deer in particular, has not been adequately addressed. However, many new deer management projects are currently being developed. New information on deer extent is presented in the evaluation section of this report and further evaluation is proposed later in the year when KEQ2b is evaluated.

While the sub-catchment performance objectives are reported for each sub-catchment, progress is evaluated (ie on-track, slightly off-track and significantly off-track) at the major catchment scale (i.e. Yarra, Werribee, Maribyrnong, Dandenong and Westernport). This is designed to allow flexibility in delivery of targets.

The 10 year vegetation establishment targets are presented in *Figure 3*. Sub-catchments with large targets include, Lang Lang River and Lower Bunyip River in the Westernport catchment, Upper Deep Creek, Jacksons Creek in the Maribyrnong River catchment and Little River Upper in the Werribee catchment. Progress for these sub-catchments is lagging particularly in the Lang Lang and Little River sub-catchments. Both these sub-catchments are dominated by rural private frontages. The implementation enquiry will need to better understand the extent to which targets will be met by the end of the strategy.

The latest annual report available at the time of writing i.e. 2020/21 ***all 5 catchments were on-track*** to achieve the 10 year establishment and the protect/maintain targets (*Figure 4*). However, there is a very high chance that some catchments will be off-track this year (*pers comm* Paul Rees) – for the vegetation establishment targets. It is worth considering further whether two discrete target types (Vegetation Establishment & Vegetation Maintenance) are needed for the vegetation program, given the potential for perverse outcomes (e.g., driving target capture, rather than the most ecologically efficient outcomes). However, second order issues may also arise from having a single target. So any change to targets and the flow on implications of this need to be carefully thought through.

On a positive note, 2028 targets have been achieved in the Lower Yarra, Little Yarra and Hoddles Creek, Steele Creek (Maribyrnong River) and Corhanwarrabul, Ferny and Monbulk Creek sub-catchments. Revegetation works are funded primarily by Melbourne Water through a mix of incentives and capital and operational programs.

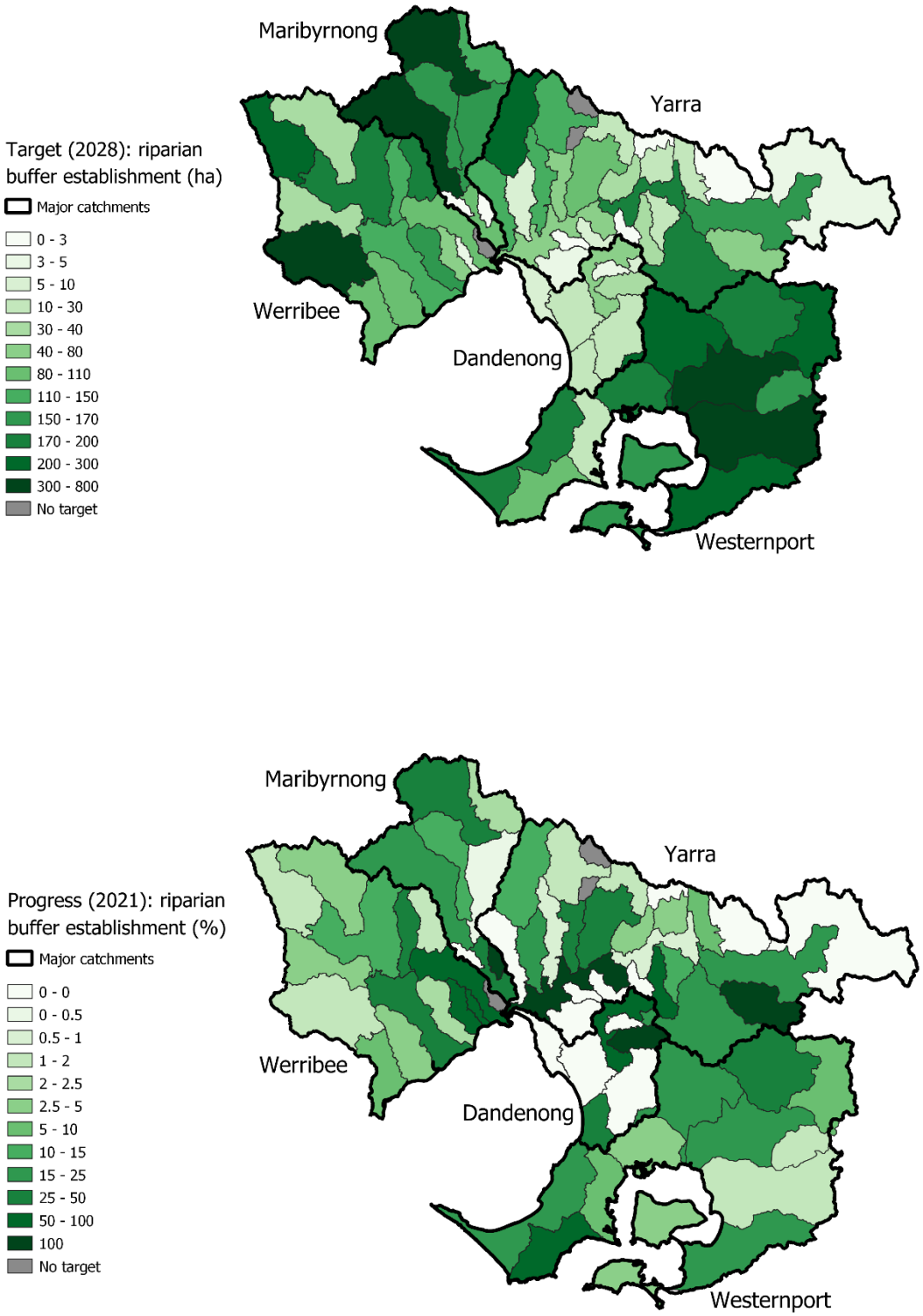
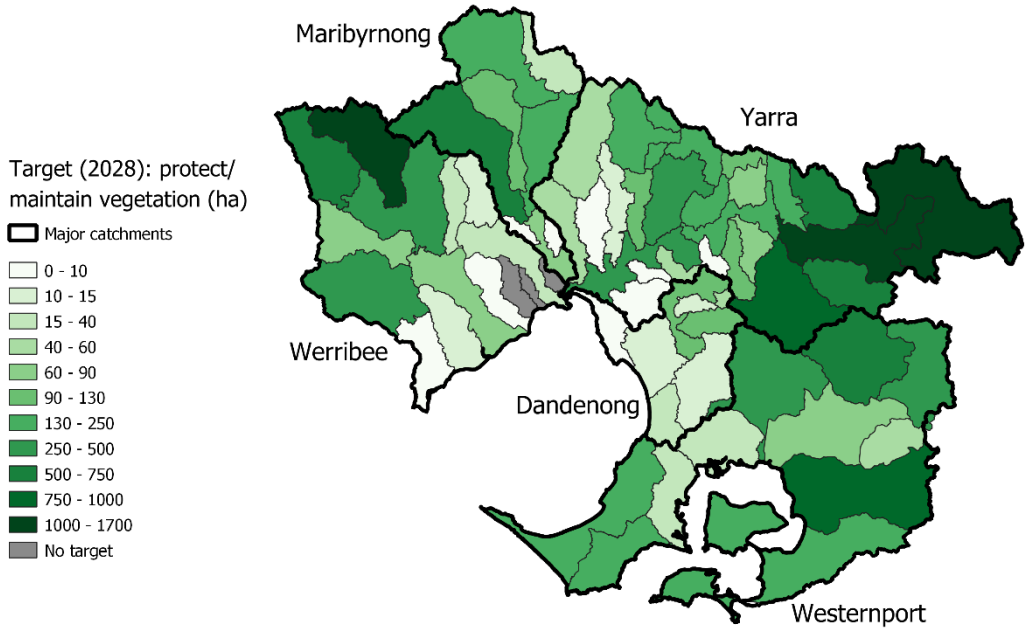


Figure 3. The top figure shows the sub-catchment performance objective targets (ha) for establishing vegetation along priority reaches (also referred to as Priority Areas). The bottom figure shows the percent progress towards the 10 year targets as of 2020/21 financial year.



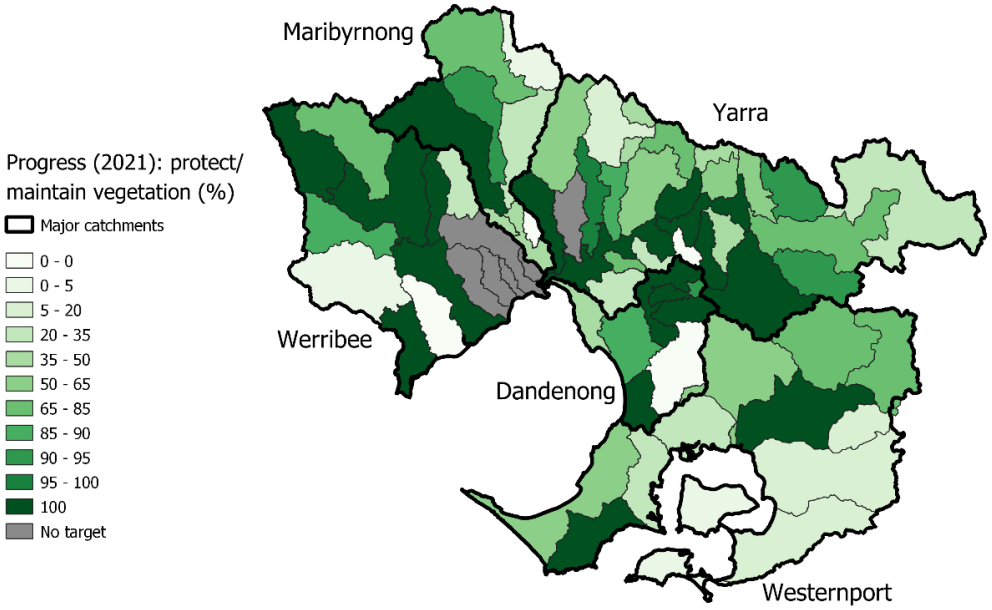


Figure 4. The bottom figure shows the sub-catchment performance objective targets (ha) for protecting and maintaining existing vegetation along priority reaches (also referred to as Priority Areas). The bottom figure shows the percent progress towards the 10 year targets as of 2020/21 financial year. Note that 100% means that the full target area was adequately managed in that year.

3. Evaluation questions and approach

Evaluation of the vegetation value is limited to an assessment of vegetation quality using the vegetation vision (VV) datasets. Data on vegetation extent is not expected until 2026 when remote sensing data will be available. The uniqueness aspect of the vegetation value metric is also not scheduled to be evaluated until 2026. This is consistent with the Rivers MEP (Melbourne Water, 2020).

While the Rivers MEP includes a rubric (evaluative criteria) for evaluating KEQ 3a, criteria for KEQ3b and 2a were developed for this paper in consultation with subject matter experts within Melbourne Water and The University of Melbourne. They centred around known important aspects on vegetation value (e.g. areas of high and very high quality and possible declines in condition) and conditions which support the value (e.g. natural regeneration rates, connectivity of vegetation, extent of highly invasive weeds and deer). The standards to determine what was significant for each of these criteria was also based on expert opinion and centred around the proportion of sites which fell above or below critical thresholds (e.g. >10% of high quality vegetation with no evidence of regeneration).

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

This evaluation question cannot be fully answered due to data limitations for both vegetation quality and extent. As discussed above, a new field-based assessment of vegetation quality has been developed and was collected in Spring 2021. It is not appropriate to answer this question with such limited data.

Some previous data may be able to inform the trajectory of vegetation, they include the Yarra River study, a study of Index of Stream condition data and a study using the ROMP methods:

Yarra River 2007 to 2013

Evaluation Methodology

Ecology Australia undertook vegetation monitoring along the Yarra River between 2007 and 2013 (Kershaw *et al.* 2013). While weed abundance monitoring was the main aim for this project, vegetation quality was also monitored on a scale of low to high (4 categories).

Evaluation Results and Discussion

The study found an overall increase in vegetation quality was recorded for the period between the 2007 and 2013 surveys, with High quality vegetation increasing by from 36 % to 44 %, Medium quality vegetation increasing 49 % to 54 %, and Low quality vegetation decreasing from 15 % to 2 % (Figure 5). This change in vegetation quality was not uniform across all river sections, with the majority of vegetation increase in quality occurring in only some sections. A critical assumption of Melbourne Water's Healthy Waterways Strategy is that vegetation quality can be improved through management and can step up from one vegetation quality category to another over time. Based on this study, this assumption is taken to be at least partially correct, though the extent to which positive change may occur is subject to a range of environmental factors, and may vary greatly between regions.

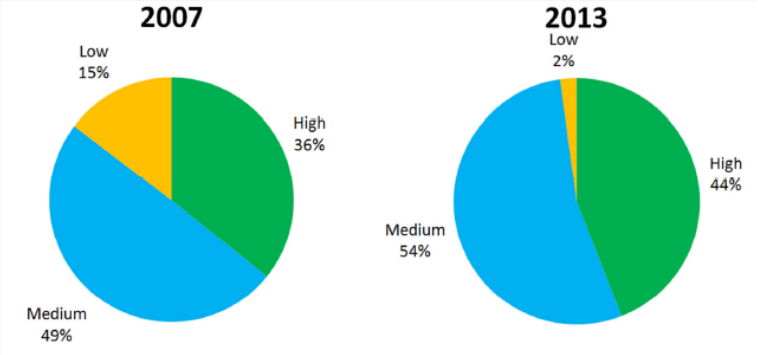


Figure 5. Relative extent of High, Medium and Low vegetation quality between 2007 and 2013 for all Sections of the Yarra River. See Kershaw et al 2013. Lower Yarra River Vegetation Review - comparative analysis of 2007 and 2013 weed and vegetation quality data for further information.

Masters study on revegetation effectiveness - 2021

Evaluation Methodology

As mentioned above, this study used the ROMP method to assess revegetated and nearby remnant areas (Jellinek *et al.* 2022b). It compared 10 to 14 year-old revegetation (17 sites) to remnant vegetation (10 sites) in Melbourne Water riparian areas to determine if species composition, vegetation structure and ecosystem function (plant recruitment) differed (Foley-Congdon *et al.* 2023). It also assessed if the amount of surrounding native vegetation, browsing animals, or soil characteristics influenced native woody plant recruitment in revegetated areas.

Evaluation Results and Discussion

It found that while native and exotic woody species richness did not differ, native woody plants were less abundant and exotic woody plants three times more abundant at revegetated sites than at paired remnant areas. The understory of revegetated sites was largely dominated by weeds, whereas that of remnant sites largely comprised native plants and leaf litter. While trees and tree canopy cover were similarly prevalent in revegetated and remnant areas, shrubs and ferns were lacking at revegetated sites. Native woody plant recruitment was lower at revegetated sites and was negatively associated with browser presence (Figure 6). The results suggest that while revegetated areas may have similar species richness and tree cover as remnant areas, weeds are often dominant and important structural components such as shrubs and ferns, and ecological processes such as plant recruitment, are lacking.

While this study does not directly show the trajectory of remnant habitats, it suggests that the remnants studied here were of higher quality than associated revegetated areas.

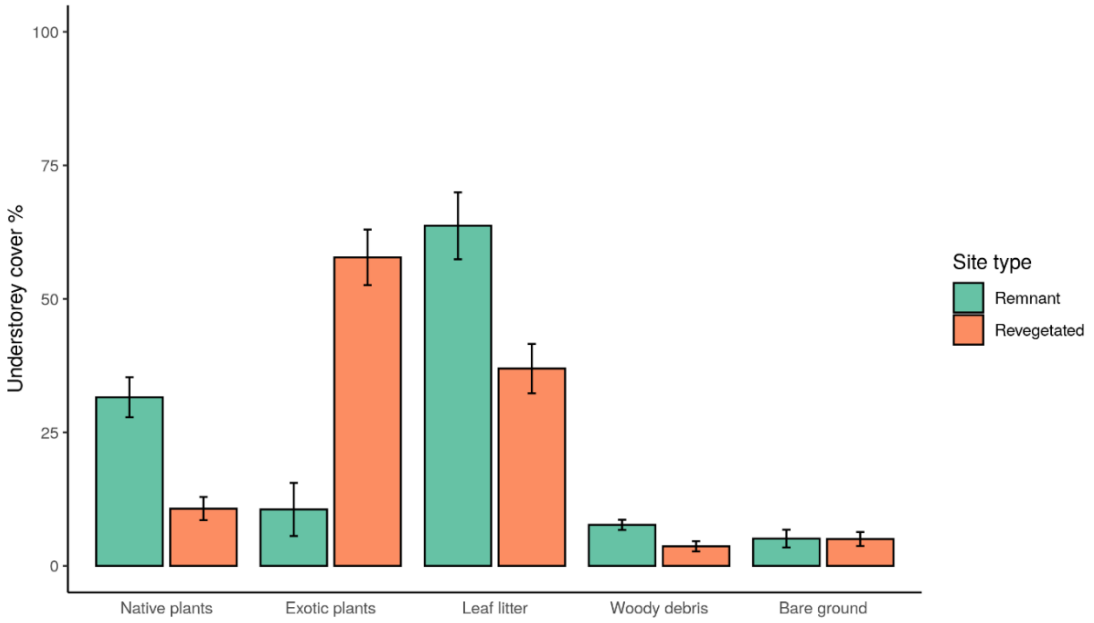


Figure 6. Understorey vegetation and ground layer components at remnant (green, n = 10) and revegetated (orange, n = 17) sites (bar plots indicate raw means ± SE).

Revegetation survival in the first 2 years since planting

Evaluation Methodology

ROMP survival monitoring was undertaken at 19 sites planted in 2018–2020 (Jellinek 2022c).

Evaluation Results and Discussion

This study showed that plant survival ranged from 72 – 91%, and two (Yarra and Werribee) out of the five catchments were below the expected 80% survival rate, while Maribyrnong was at 80% (Figure 7). Plant survival rates were substantially higher in the Dandenong and Westernport catchments and lower in the Maribyrnong, Yarra and Werribee catchments. The study also found that aridity was likely to be a major factor driving plant survival, with higher aridity catchments (Werribee, Maribyrnong and the western Yarra) having lower plant survival.

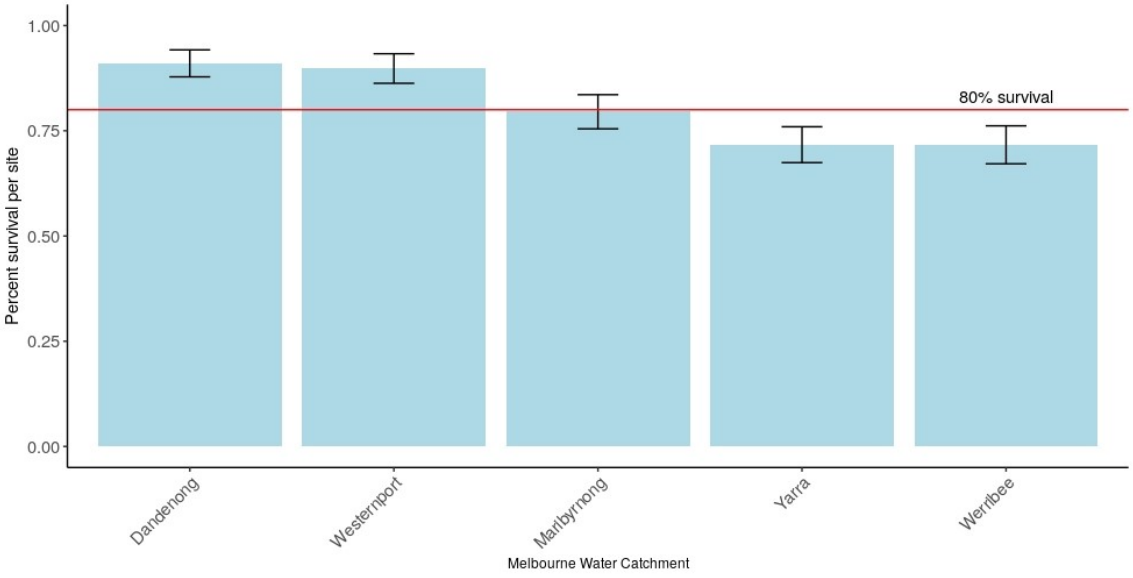


Figure 7. Survival rates of plantings at 2 or more years (at a total of 19 sites) across the five major catchments of the Melbourne Water region. Bars represent standard errors and the red line represents expected 80% survival rate.

ISC2 data assessing vegetation condition over 10 years

Evaluation Methodology

This study was undertaken over a 14 year period from 2010 and surveyed 31 sites (30 of which were assessed) selected by Melbourne Water prior to management interventions taking place, and then at one, three, six and ten years after the interventions. These interventions generally included revegetation activities and weed control. Works sites (where the interventions were undertaken) were monitored in conjunction with nearby upstream and downstream control sites (where there were no planned interventions).

Evaluation Results and Discussion

A review of Jellinek *et al.* (2022a) found that works sites did have a higher streamside zone score than control sites (
Figure 8), which was largely driven by understory vegetation, litter, canopy cover, recruitment and connectivity. It should be noted that as the scoring system was recorded and then grouped-up at an ordinal scale, and then had to be modified to a continuous scale, the analysis shown below is not scientifically robust. However, it does indicate that revegetated areas are likely to be increasing in vegetation quality, although it cannot directly indicate how remnant areas are tracking through time.

The outcomes and limitations of this study can be found in *Jellinek, S., Greet, J. & Chee, YE. (2022a) A Review of the Melbourne Water Riparian Vegetation Works Monitoring Method: Effectively monitoring interventions into the future*.

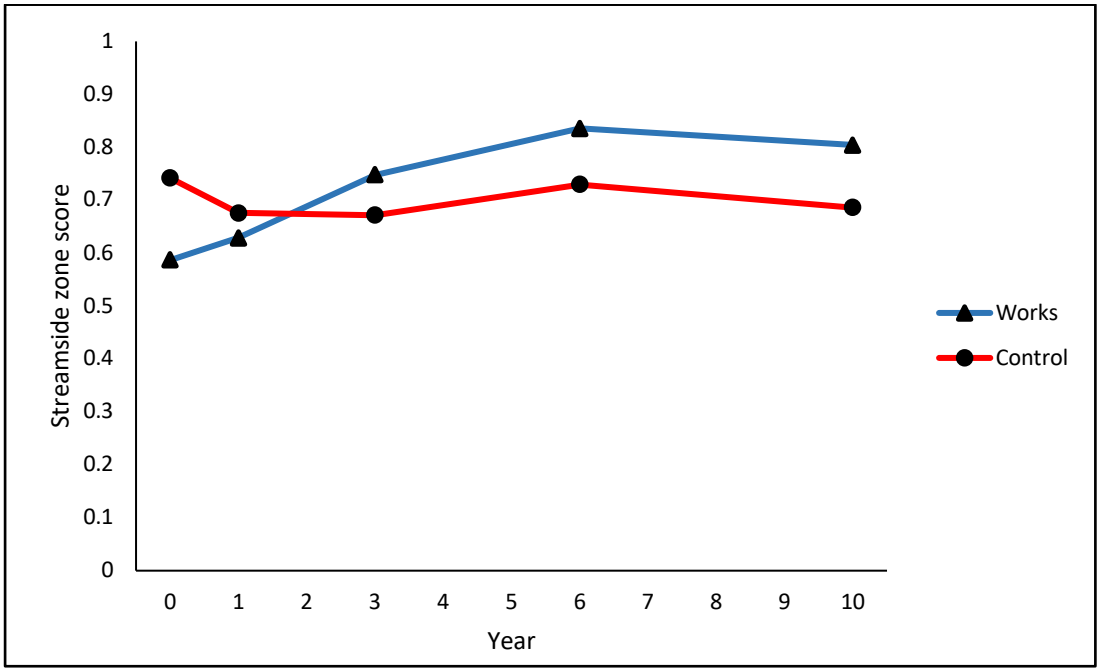


Figure 8. Mean weighted scores of the streamside zone sub-index comprising 9 metrics (understorey – 25%, weeds – 15%, longitudinal continuity – 12.5%, width – 12.5%, large trees – 10%, recruitment – 10%, tree canopy – 5%, organic litter – 5% and logs – 5%) at works (n = 22–25, see Appendix 1) and control sites (n = 17-19, see Appendix 1) over the 5 monitoring periods (labelled as 'Year').

The current rubric as outlined in the Rivers MEP is presented below (*Table 6*) for information purposes. It is likely that the rubric will be refined prior to the HWS final evaluation review, to account for new data and evaluation methods.

Table 6. Performance criteria for assessing vegetation quality targets at the sub-catchment and catchment scales (from Rivers MEP, Melbourne Water, 2020)

Performance	Criteria
On-track to achieving long term target	At least 90% of all sites within the sub-catchment / or catchment have same or increased vegetation vision score And 100% all level 4 and 5 remain at a 4 or 5 And 90% of all level 3s sites (within SCPO reaches) are at least a 3
Slightly off-track to achieving long term target	60-90% of all sites within the sub-catchment / or catchment have same or increased vegetation vision score Or 90% to <100% all level 4 and 5 remain at a 4 or 5 Or 60-90% of all level 3s sites (within SCPO reaches) are at least a 3
High chance that long-term targets will not be met	< 60% of all sites within the sub-catchment / or catchment have same or increased vegetation vision score Or <90% all level 4 and 5 remain at a 4 or 5 Or <60% of all level 3s sites (within SCPO reaches) are at least a 3

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

Evaluation Methodology

As discussed above, the data sources used for this evaluation are the VV18 and VV21. A subset of high to very high data certainty was used for the VV18 data. This equated to either multiple site visits (high) or a systematic vegetation surveys (very high). VV18 and the VV21 data were spatially matched and analysis was focused on areas which show high differences in scores (plus or minus 2 points or more), which indicate possible declines in vegetation quality or new areas of high or very high quality.

Analysis was also undertaken to determine if condition had changed significantly within the priority areas, and whether there were new areas which should potentially be included in the priority areas. In total, 151 VV21 sites overlapped with VV18 reaches that had high or very high certainty. These sites were used in the evaluation to compare trends in vegetation condition.

Evaluative criteria (*Table 7*) were developed to assess the significance of the findings with respect to implementation of the HWS. Recommendations have been developed for 'significant' findings.

Table 7. Criteria used to evaluate KEQ3b. The standards were applied at the regional scale

Sub KEQ	Criteria	Standards		
		Not significant for implementation	**Potentially significant for implementation**	**Significant for implementation**
3b. What trends and patterns for key values are of significance for implementation?	New areas of high quality vegetation	increases in category from 1 to 2 or 2 to 3 or 1 to 3	n/a	A VV21 monitoring site has high quality vegetation (4 or 5) that is not in Priority Areas or Protection Areas
	Decline in vegetation quality	Change of 1 or less between high confidence VV18 and VV21 score.	Decrease from a 4 to a 3 between high confidence VV18 and VV21 score.	Any site with a decrease of 2 or more categories between high confidence VV18 and VV21 score.

Limitations

A key limitation to robustly reporting on vegetation changes has been the lack of systematically documented, integrated, curated, retrievable and easily reusable vegetation data. This suggests that a dedicated database for vegetation data is urgently required. Similarly, a lack of a dedicated region-wide surveillance monitoring program for vegetation condition has limited our ability to evaluate progress towards long-term targets. This monitoring gap is being addressed and a long- term monitoring program has been established to evaluate vegetation condition and the influence of management interventions such as revegetation.

As outlined above, previous methods were not similar enough to allow robust comparisons to report on vegetation changes and associated key evaluation question since the implementation of the strategy. It is expected that, in the future, using Vegetation Visions data (i.e. VV21) as well as the Restoration Outcomes Monitoring Protocol (ROMP, to assess management interventions such as revegetation), vegetation measures should be more reliable and robust. Other vegetation assessment methods are also being developed, such as remote sensing of vegetation quality, aerial imagery and artificial intelligence data to track vegetation extent, which will help to answer some of the key evaluation questions in the future.

Further, the VV18 and VV21 datasets are not directly comparable as they have different constitutive elements and are scored differently, were undertaken at different scales (waterway reaches for VV18 data and discrete sites for VV21 data) and were assessed differently (expert elicitation for VV18 data and field assessments for VV21 data). So, caution needs to be taken when comparing the two. Future assessments using the VV21 method will provide more accurate data on changes in vegetation condition.

Evaluation Results and Discussion

New areas of high quality - Vegetation Visions data (VV21)

Overall the VV21 surveys found that a 42% of the 506 surveyed sites were of high quality (*Table 8*) and the catchment with the highest percentage of high quality sites was the Yarra (53%) followed by

Dandenong (43%) (Figure 9). As expected 88% of high quality sites were found in the previously identified **Priority Areas** (performance objective reaches), while lower quality sites were located in more fragmented, urbanised and cleared habitats, such as in the eastern part of the Westernport catchment and the lower reaches of the Werribee catchment (Figure 9 and *Table 8*,*Table 9* and *Table 10*).

Of the 213 high quality sites across the region, 120 (56%) did not correspond with **Protection Areas** (i.e. reaches with previously identified VV18 vegetation condition score 4 or 5, high or very high quality) (refer to *Figure 10*). A list of these sites is provided in Appendix G. These differences are most likely due to condition assessment methods, rather than an improvement in condition. Of particular interest is Werribee and Dandenong which both only had a small proportion of high quality VV21 sites in **Protection Areas.** While this percentage is high, only 12% (25 sites) of high quality VV21 sites did not sit within the broader **Priority Areas** and therefore have no performance objectives related to these reaches (*Table 10*, *Figure 11*).

This suggests that these high quality vegetation reaches need to be investigated and potentially designated as new HWS vegetation Protection Areas with associated Performance Objectives.

Table 8. Number of high quality VV21 sites in the MW region by catchment

Catchment	Number of high quality VV21 sites	Percentage of total VV21 sites
Yarra	94	53%
Westernport	50	39%
Werribee	31	31%
Maribyrnong	23	37%
Dandenong	15	43%
Total sites	213	42%

Table 9. VV21 sites (with a high quality) corresponding with HWS Priority Areas and HWS Protection Areas. Note Priority Areas are areas/reaches where performance objectives for establishing and maintaining vegetation exist and Protection Areas are reaches where vegetation was rated as high quality (4-5 in VV18 data).

Catchment	% VV21 sites (4's & 5's) corresponding with HWS Priority Areas	% VV21 sites (4's & 5's) corresponding with HWS High Quality Areas
Yarra	95%	60%
Maribyrnong	84%	32%
Westernport	77%	35%
Dandenong	91%	26%
Werribee	73%	20%
Total	88%	43%

Table 10. High quality sites (25) outside of Priority Areas (ie areas/reaches where performance objectives for establishing and maintaining vegetation exist)

Site ID	Catchment	Sub-catchment	VV21 quality score
443	Yarra	Brushy Creek	5
368	Yarra	Diamond Creek (Rural)	4
473	Yarra	Merri Creek Lower	4
477	Yarra	Gardiners Creek	4
380	Yarra	Diamond Creek (Rural)	4

Site ID	Catchment	Sub-catchment	VV21 quality score
416	Westernport	Mornington Peninsula North-Eastern Creeks	5
505	Westernport	Mornington Peninsula South-Eastern Creeks	5
420	Westernport	French and Phillip Islands	5
451	Westernport	Mornington Peninsula Western Creeks	4
417	Westernport	Mornington Peninsula North-Eastern Creeks	4
506	Westernport	Mornington Peninsula South-Eastern Creeks	4
478	Westernport	Dalmore Outfalls	4
454	Werribee	Werribee River Lower	4
422	Werribee	Cherry Creek	4
455	Werribee	Skeleton Creek	4
428	Werribee	Little River Lower	4
435	Werribee	Little River Upper	4
438	Werribee	Little River Upper	4
491	Werribee	Lollypop Creek	4
383	Maribyrnong	Deep Creek Upper	4
449	Maribyrnong	Deep Creek Lower	4
441	Dandenong	Blind Creek	5
419	Dandenong	Eumemmerring Creek	4
400	Dandenong	Dandenong Creek Middle	4
426	Dandenong	Kananook Creek	4

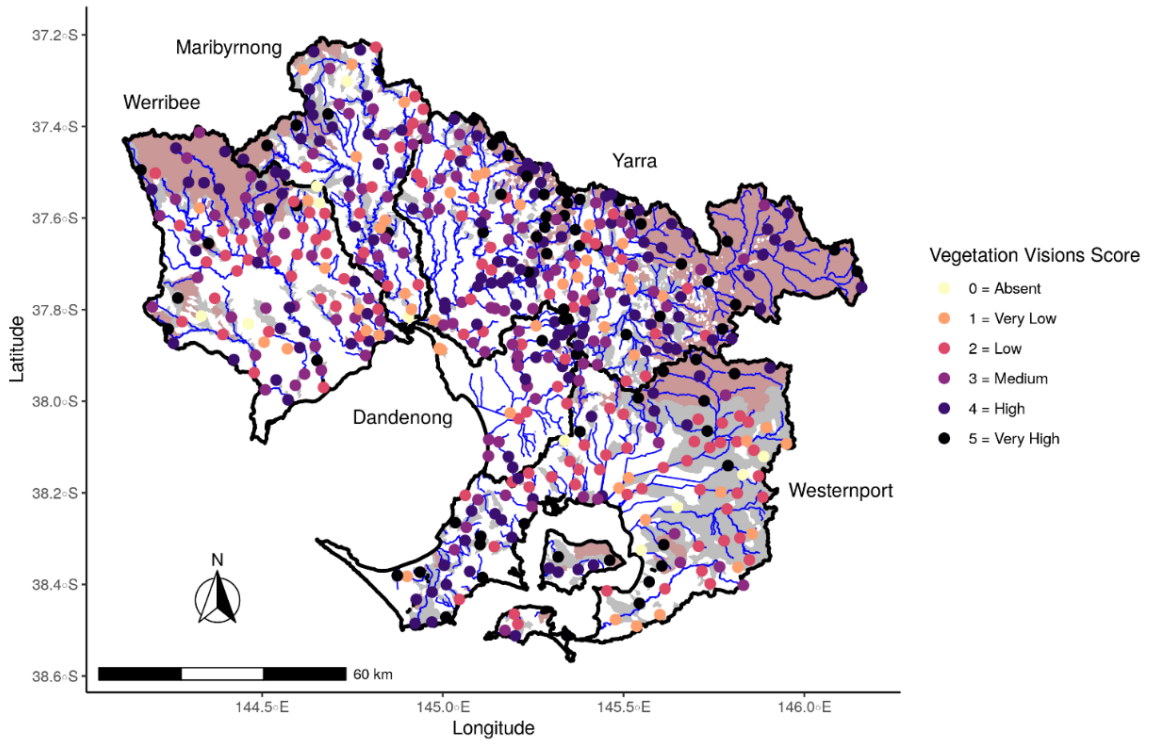


Figure 9. VV21 scores in the Melbourne Water region. Light red polygon areas are Protection Areas (ie where vegetation was rated as high quality (4-5 in VV18 data). Light grey polygon areas represent Priority Areas (ie where performance objectives for establishing and maintaining vegetation exist). Priority Areas contain Protection Areas.

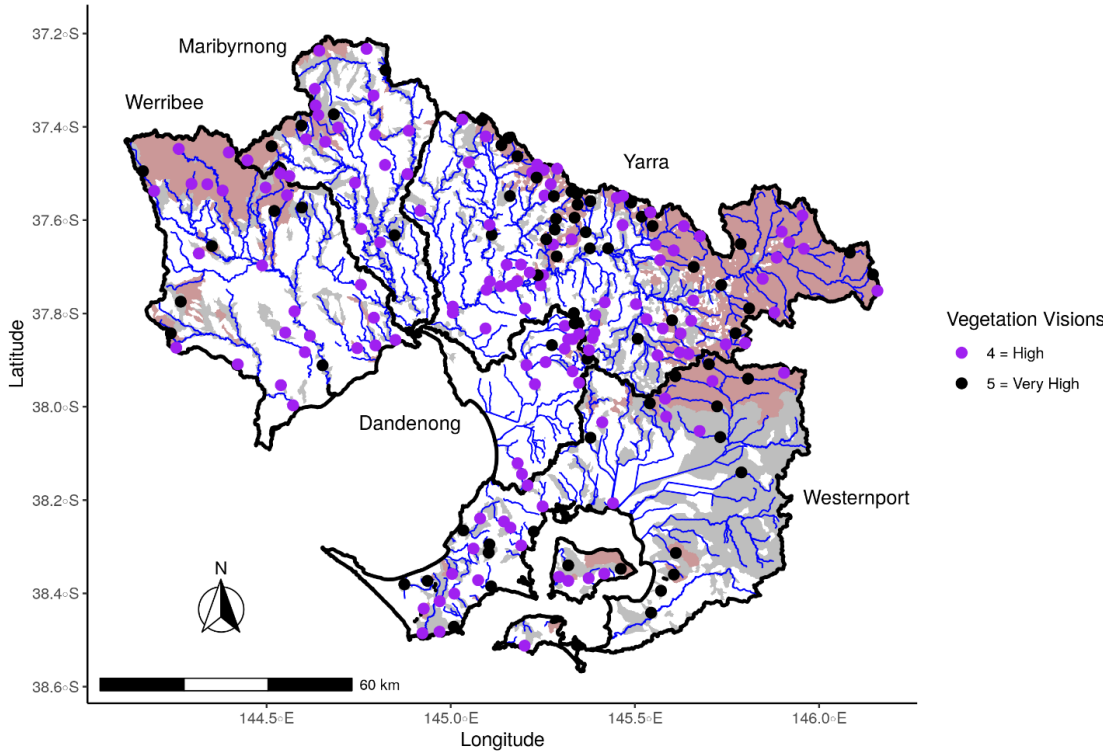


Figure 10. High to very high quality VV21 scores in the Melbourne Water region. Light red polygon areas are Protection Areas (i.e., where vegetation was rated as Protection areas (4-5 in VV18 data). Light grey polygon areas represent Priority Areas (i.e., where performance objectives for establishing and maintaining vegetation exist). Priority Areas contain Protection Areas.

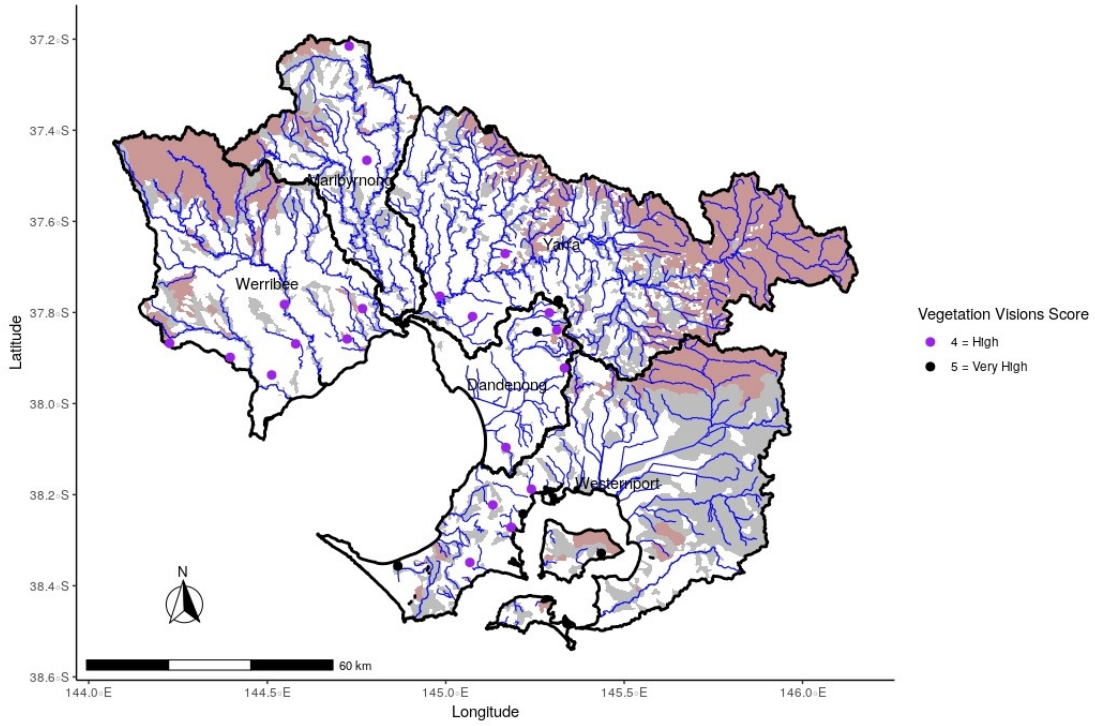


Figure 11. VV21 scores in the Melbourne Water region for high and very high quality vegetation that are outside where performance objectives exist. The Light red and grey polygons are where vegetation performance objectives exist (light red = protect high quality and light grey = establish and maintain) This illustrates where areas of high quality vegetation may not be adequately managed or protected in the HWS.

Comparison of the VV21 site data with the VV18 reach scale data revealed 15 locations where the VV21 data is significantly higher (ie 2 or more categories) than the VV18 data (*Table 11*). These areas have been included in the evaluation results above.

Table 11. VV21 sites which higher than the VV18 reach data by 2 or more categories.

Catchment	Sub-catchment	VV21 Site ID	Reach	VV21 score	VV18 score	Difference
Dandenong	Blind Creek	441	Blind crk	5	2	3
Dandenong	Dandenong Creek Middle	403	Fussel rd drain	5	3	2
Dandenong	Eumemmerring Creek	419	Eumemmerring crk (up)	4	2	2
Maribyrnong	Deep Creek Upper	383	Trib Deep crk	4	1	3
Werribee	Kororoit Creek Lower	76	Kororoit crk	4	2	2
Werribee	Laverton Creek	99	Laverton M.D.	4	2	2
Werribee	Little River Lower	437	Little River (lwr)	4	2	2
Werribee	Toolern Creek	195	Trib Toolern crk	5	2	3
Werribee	Werribee River Lower	466	Werribee river (lwr)	5	3	2
Westernport	Bass River	8	Trib of 3307	5	2	3
Westernport	Dalmore Outfalls	478	Langwarrin crk	4	2	2
Westernport	Mornington Peninsula South-Eastern Creeks	173	Merricks crk	5	3	2
Westernport	Mornington Peninsula Western Creeks	164	Balcombe crk	5	3	2
Yarra	Merri Creek Lower	473	Merri crk lwr	4	2	2
Yarra	Yarra River Middle	302	Yarra river (5600)	5	3	2

Decline in Vegetation quality

The information in this section should be treated with caution as the data is comparing site (point) information (VV21 data) with river reach information (VV18 data), which isn't strictly valid scientifically. As noted above, the scoring system as also slightly different.

For the 151 spatially-matched sites where field-based VV21 scores can be compared to high or very high confidence VV18 scores, score differences across the majority of sites are not substantial (between –1 to 1 as shown by the oranges, tan and dull green points, *Figure 12*). Desktop and potentially on-ground assessments need to be undertaken in areas where VV21 scores lower (by 2 points or more) than VV18 data, as this may indicate a decline in vegetation quality.

There were 8 VV21 sites across the region which had significantly (difference of 2 or more between VV21 and V18 data) lower condition scores than HWS VV18 data (*Table 12*). Of potential concern are Stony Creek (Werribee River) and the tributary of the Yankee Creek (Lerderderg River) in the Werribee catchment, and Cement Creek and tributary of Hansen Creek (Woori Yallock) in the Yarra catchment, as these reaches were high or very high quality in the VV18 data. These reaches are in Protection Areas but their VV21 score is substantially lower than their VV18 (Figure 13). These reaches should be investigated further to ascertain if the changes are actual on-ground declines or are instead only paper changes as a result of the new methodology.

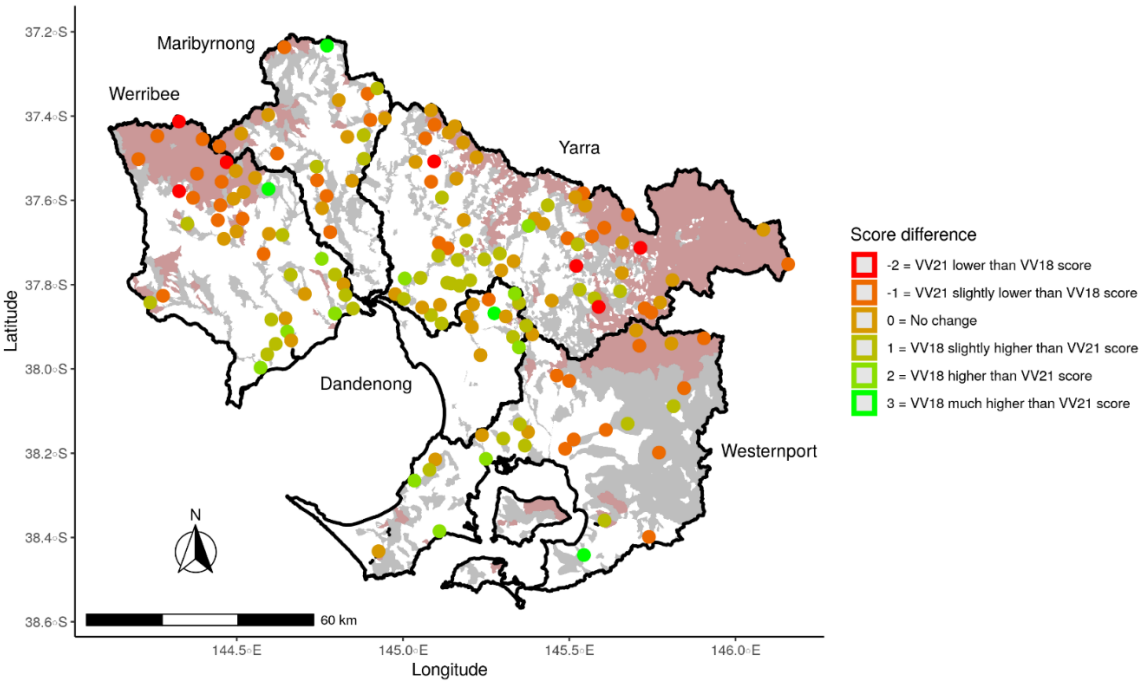


Figure 12. Differences in VV scores for the 151 spatially-matched VV21 sites and VV18 reaches (dot points). Scores are negative where VV18 scores were higher than VV21 scores and vice versa. Light red polygon areas are Protection area where vegetation was rated as high quality (4-5 in VV18 data). Light grey polygon areas represent priority areas. All Protection areas are within the priority areas.

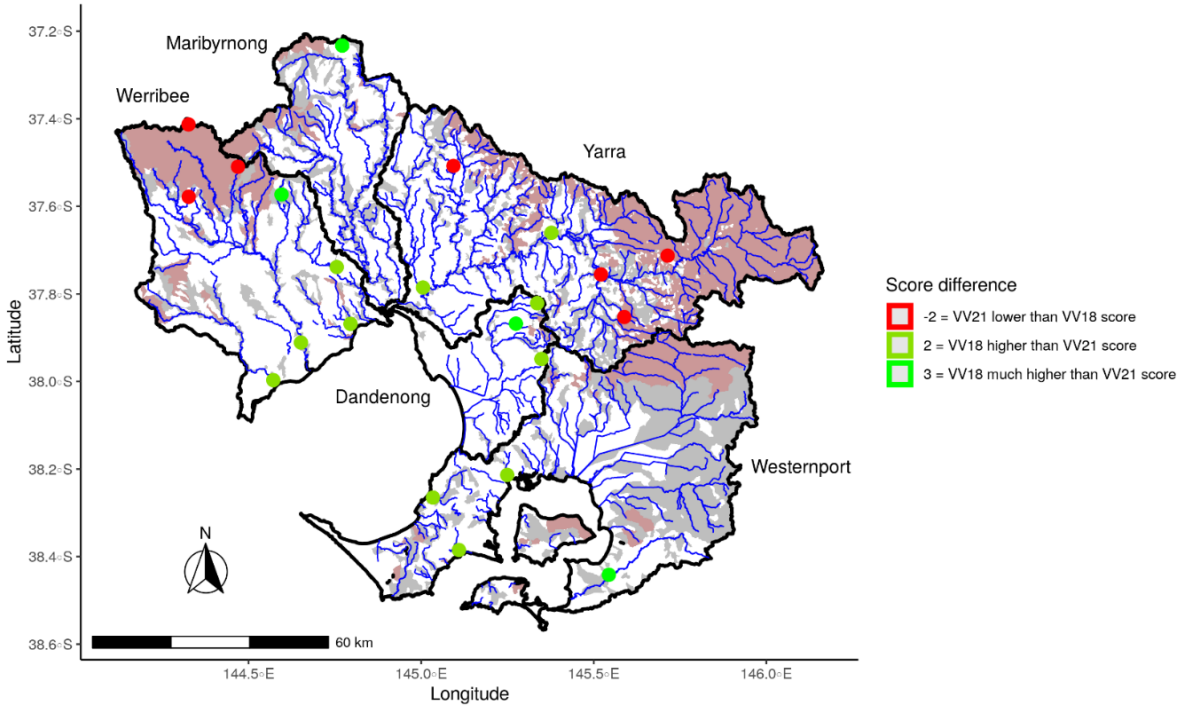


Figure 13. Reaches that had the highest differences in scores between VV21 and VV18 data (see Table 1). Negative scores meant that EE scores were higher than VV scores, and positive scores meant the opposite. Light grey are priority MW areas, while light red are areas that had very high scores (4's and 5's) based on VV18 data.

Table 12. The river reaches in the MW area that had the highest score differences (diff) between VV21 and VV18 data. Highlighted text depicts VV21 scores lower than VV18 scores by 2 categories.

Catchment	Sub-catchment	VV21 Site ID	Reach	VV21 score	VV18 score	Difference
Werribee	Lerderderg River	184	Scotties gully	3	5	-2
Werribee	Lerderderg River	492	Trib Yankee crk	3	5	-2
Werribee	Werribee River Upper	193	Stony hut crk	1	3	-2
Yarra	Plenty River Upper	390	Barbers crk upper	1	3	-2
Yarra	Woori Yallock Creek	363	Trib Hansen crk	2	4	-2
Yarra	Yarra River Middle	302	Yarra river (5600)	5	3	2
Yarra	Yarra River Upper (Rural)	337	Yarra river (5700)	1	3	-2
Yarra	Yarra River Upper (Rural)	342	Cement crk	3	5	-2

Conclusions

KEQ3b results - New areas of high quality

There were 25 sites from the VV21 high quality data that were not in the HWS Priority Areas or Protection Areas. The majority fell within the Werribee (7 sites) and Westernport catchments (7 sites).

These sites were considered significant for implementation as the HWS has performance objectives around protecting all high-quality reaches.

Recommendation: Determine the extent and connectivity of the area which should be included in the HWS Protection Areas.

KEQ3b - Possible decline in condition

A comparison of high confidence data from 2018 was compared with the new field data revealed a possible decline in condition in 8 sites, 5 in the Yarra and 3 in Werribee.

These sites were considered significant for implementation as it is important to understand if this decline is real or methodological and if real then it is also important to understand what may be causing the decline.

Recommendation: Investigate and if necessary, prioritise management intervention for these reaches in priority areas to prevent further decline in condition.

Table 13. Summary of evaluation results for KEQ3b.

Criteria	Significant for implementation	Summary of results
Decline in vegetation quality	Any site where the VV21 score is 2 or more points less than its VV18 score	7 VV21 sites Yarra - 4 sites Werribee - 3 sites (1 Yarra site is not in a HWS priority area)
New areas of high-quality vegetation	A VV21 monitoring site has high quality vegetation (4 or 5) that is not in HWS Priority Areas or Protection Areas	25 VV21 sites Dandenong - 4 sites Maribyrnong - 2 sites Werribee - 7 sites Westernport - 7 sites Yarra - 5

KEQ 2a. What environmental conditions (e.g. Water quality) and external factors (e.g. policy) help explain current key value trends?

Evaluation Methodology

The sub indicators of the VV21 data were used in this evaluation to assess some key factors that contribute to the condition of vegetation. These sub indicators included regeneration, connectivity, weeds and deer. Evaluative criteria used to assess how condition and threat data explains current key value trends is shown in *Table 14* and analysis is carried out at a catchment scale. The thresholds for the evaluative criteria was based on expert opinion and detailed understanding of these attributes of condition. Attention was focused on sites of high quality due to the underlying principle of 'protecting the best' in the HWS.

Table 14. Evaluative criteria used to assess how condition and threat data explains current key value trends.

Sub KEQ	Criteria	Categories		
		Not significant for implementation	**Potentially significant for implementation**	**Significant for implementation**
What environmental conditions (e.g. water quality) and external factors (e.g. policy) help explain current key value trends?	Natural regeneration of vegetation	<5% of VV21 high quality vegetation sites within a catchment with no evidence of regeneration	5-10 % of VV21 high quality vegetation sites within a catchment with no evidence of regeneration	>10% of VV21 high quality vegetation sites within a catchment with no evidence of regeneration
	Low connectivity	<5 % of VV21 high quality sites within a catchment that have low connectivity (i.e. <3)	5-10 % of VV21 high quality sites within a catchment have low connectivity (i.e. <3)	>10 % of VV21 high quality sites within a catchment have low connectivity (i.e. <3)
	Spatial extent of highly invasive weeds	<10% high quality VV21 sites within a catchment that have high 'highly invasive' weed loads in HWS priority areas	10-20 % VV21 high quality sites within a catchment have high 'highly invasive' weed loads in HWS priority areas	>20% of VV21 high quality sites within a catchment have high weed loads in HWS priority areas
	Spatial extent of deer	N/a	Any detection of deer in high quality sites and modelled deer density is moderate	Any detection of deer in high quality sites and modelled deer density is high

Limitations

Given only one round of data (i.e. 2021 was used in this evaluation), these preliminary results need to be reviewed with caution and reassessed in future years.

Tthe connectivity score for the VV21 data is limited to a visual assessment at the site and does not take into account of broader landscape analysis. A spatial analysis as a component of the VV21 could improve the method.

Evaluation Results and Discussion

Regeneration and connectivity

The results suggest that only ten sites in the MW region have a high VV21 score and low (<3) regeneration score (*Table 15*). These are spread evenly between the major catchments, except for

Dandenong where no low regeneration sites were recorded in Protection areas. Maribyrnong was the only catchment where there were significant implications for implementation as 13% of these high quality sites had low regeneration (3 sites). Similarly, Werribee also had 3 high quality sites with low regeneration (*Table 15*, *Figure 14*).

When regeneration was assessed in Protection areas (VV18), most of the sites with low recruitment occurred in the Werribee catchment (8 sites or 62% of sites), with 4 occurring in the Yarra and one in Westernport.

While the field-based data is somewhat limited in its ability to quantify connectivity, we applied a criteria to find potential sites with high quality that had low connectivity scores, indicating these sites may be vulnerable in the future. Only two sites in the Melbourne Water area had low connectivity but VV21 high quality scores.

Table 15. Low regeneration sites in the VV21 high quality sites

Site ID	Catchment	VV21 low regeneration scores	VV21 vegetation quality score
389	Maribyrnong	1	4
122	Maribyrnong	2	4
150	Maribyrnong	2	4
188	Werribee	2	4
100	Werribee	2	4
428	Werribee	2	4
114	Westernport	2	4
468	Westernport	2	4
336	Yarra	2	4
324	Yarra	2	4

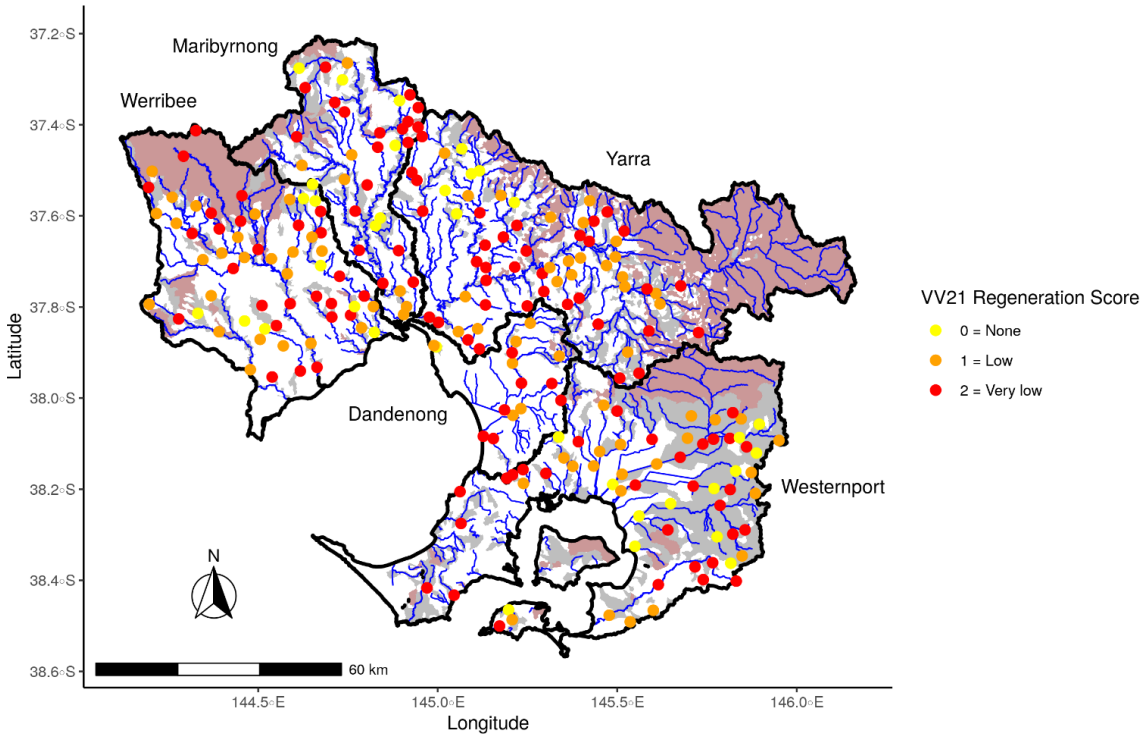


Figure 14. Sites with low (below 3) VV21 regeneration scores in the MW region.

Weeds

The data suggests that 99 sites (47%) with high to very high VV21 scores had high to very high general weed loads, whereas only 41 (19%) of these sites had high to very high scores for highly invasive weeds (Figure 15 and Figure 16, *Table 16*). The highest weed loads, both for weeds generally and highly invasive weeds, were recorded in the Dandenong region, probably due to its greater % cover of urban areas in the catchment. Westernport also had a high proportion of highly invasive weeds (24%) but a lower overall weed score. Yarra had generally low weeds in high quality areas (*Table 16*).

Woody weed control is a large-scale and costly management intervention action undertaken by MW, and generally overlaps with sites with highly invasive weed loads in the Westernport and Maribyrnong catchments (*Table 16*).

Table 16. The proportion of VV21 high quality (4's & 5's) sites which had high (4) to very high (5) weed and highly invasive weed scores.

Catchment	Proportion of high quality sites with high to very high weed scores	# sites	Proportion of high quality sites with high to very high highly invasive weed scores	# sites
Yarra	34%	32	17%	16
Westernport	51%	25	24%	12
Werribee	55%	17	13%	4
Maribyrnong	61%	14	13%	3
Dandenong	73%	11	40%	6

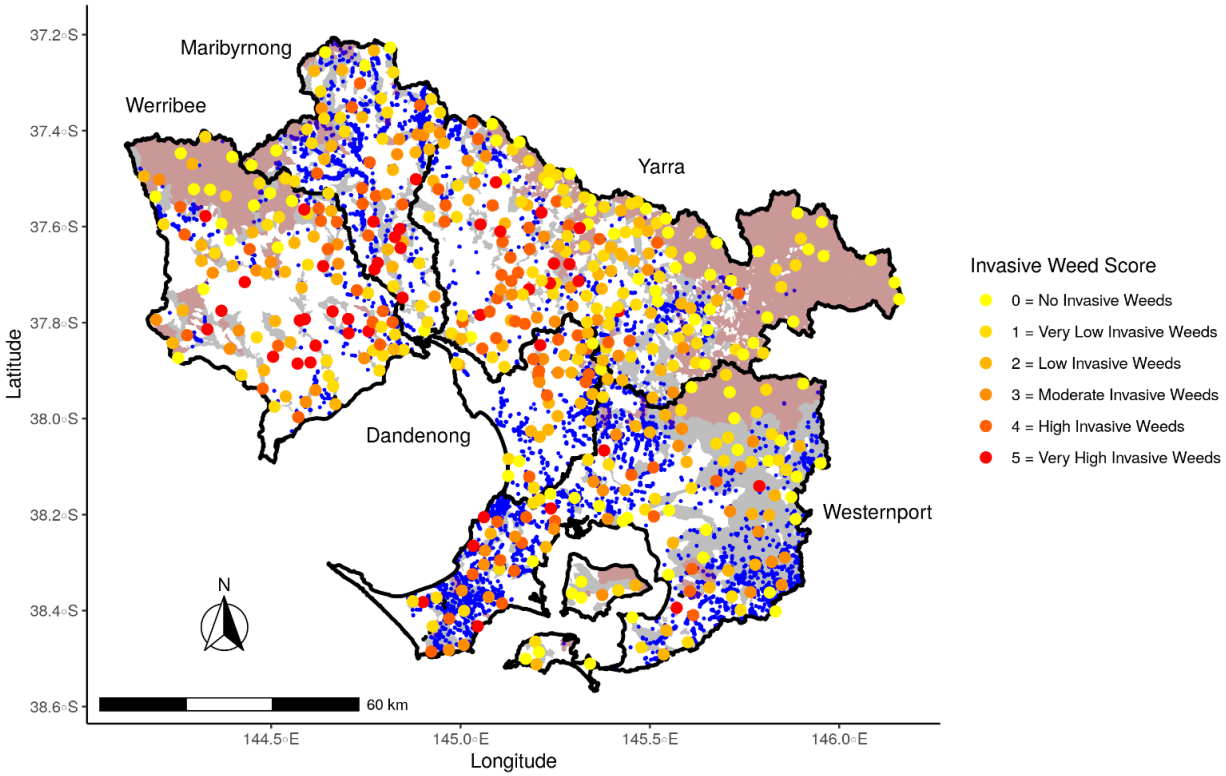


Figure 15. Invasive weed score for the VV21 sites. Blue areas represent sites where woody weed control has been carried out.

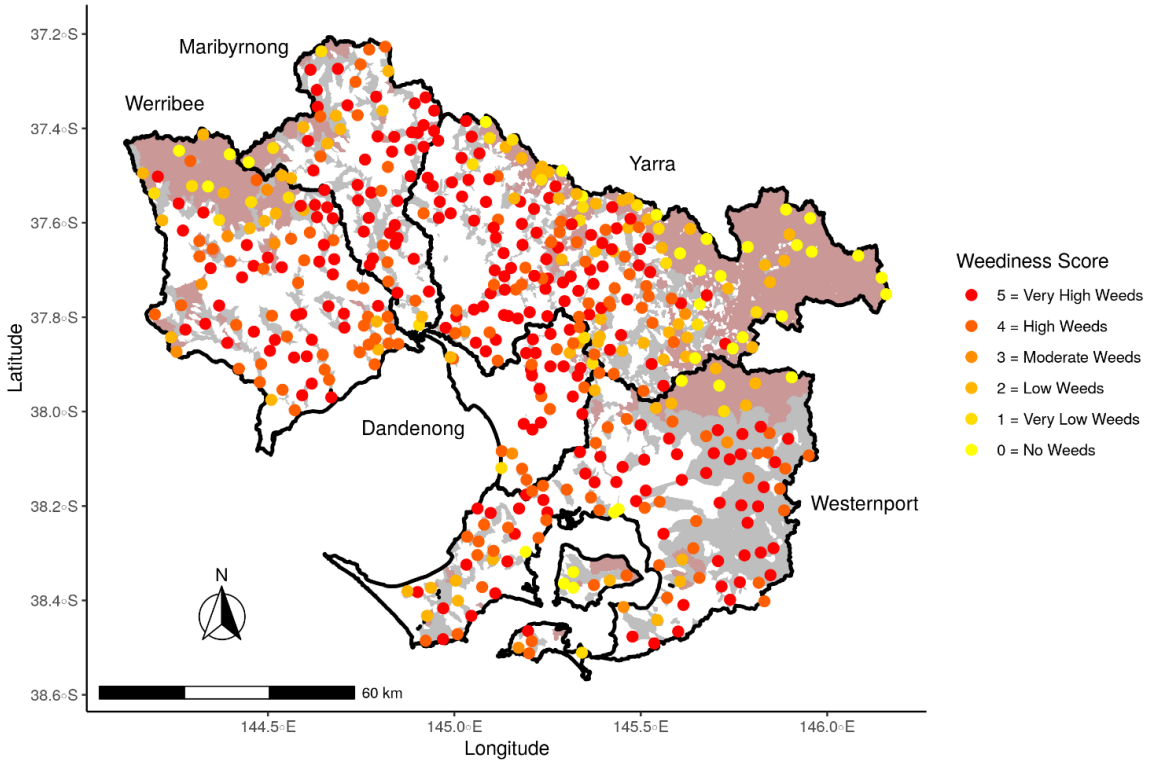


Figure 16. General weediness score for VV21 sites

Deer and rabbits

The VV21 data showed that deer were likely to be present at 63 of the 506 sites that were surveyed, and most of these recordings were in the Yarra catchment (59%) followed by Westernport (27%). Signs of deer presence was recorded as wallows, browsing and scats/prints (Appendix B), with the highest presence likely where all of these signs were recorded. On average, deer were more likely to be found at sites that were of high quality (4 or 5). Of particular note, when the VV21 data were compared to modelled deer density (refer to Research Fact Sheet attachment), 19 of the 63 sites (30%) were predicted to have high (above 0.6 average pixel score) deer densities (*Table 17*, Figure 17).

The modelled deer data suggests that 23% of VV21 sites were likely to have high deer densities (above 0.6), with the majority of these sites occurring in the Westernport (55%) and the Yarra (37%) catchments. On average the sites where modelled deer densities were high had moderate (3) VV21 scores.

Table 17. The VV21 scores at each site where deer signs were present, including the number of deer signs detected and the modelled deer density. Modelled deer data 0.6 and higher represented high deer densities.

Site ID	Catchment	VV21 score	Number of signs	Modelled deer density
376	Yarra	5	3	0.49
269	Yarra	5	2	0.89
343	Yarra	5	2	0.44
275	Yarra	5	2	0.28
240	Yarra	5	2	0.17
311	Yarra	5	2	0.04
330	Yarra	5	1	1.18

Site ID	Catchment	VV21 score	Number of signs	Modelled deer density
369	Yarra	5	1	1.09
354	Yarra	5	1	0.53
377	Yarra	5	1	0.38
262	Yarra	5	1	0.35
276	Yarra	5	1	0.28
302	Yarra	5	1	0.19
308	Yarra	5	1	0.17
245	Yarra	5	1	0.05
260	Yarra	5	1	0.02
378	Yarra	5	1	0.00
453	Yarra	5	1	0.00
371	Yarra	4	2	0.79
304	Yarra	4	2	0.77
463	Yarra	4	2	0.40
241	Yarra	4	1	0.78
239	Yarra	4	1	0.73
345	Yarra	4	1	0.49
235	Yarra	4	1	0.48
279	Yarra	4	1	0.44
362	Yarra	4	1	0.38
423	Yarra	4	1	0.32
482	Yarra	4	1	0.28
290	Yarra	4	1	0.08
271	Yarra	4	1	0.05
391	Yarra	4	1	0.04
273	Yarra	4	1	0.00
306	Yarra	3	1	0.55
339	Yarra	3	1	0.55
313	Yarra	3	1	0.42
270	Yarra	1	1	0.76
37	Westernport	5	3	0.73
31	Westernport	5	2	0.93
179	Westernport	5	2	0.85
11	Westernport	5	2	0.19
8	Westernport	5	2	0.15
43	Westernport	5	1	0.78
416	Westernport	5	1	0.35
23	Westernport	5	1	0.26
487	Westernport	5	1	0.16
66	Westernport	4	2	0.12
36	Westernport	4	1	0.89
27	Westernport	4	1	0.55
65	Westernport	4	1	0.18
38	Westernport	3	3	0.86
39	Westernport	3	2	0.40

Site ID	Catchment	VV21 score	Number of signs	Modelled deer density
33	Westernport	3	1	0.72
61	Westernport	2	1	0.36
129	Maribyrnong	5	2	0.00
150	Maribyrnong	4	2	0.07
135	Maribyrnong	4	2	0.03
130	Maribyrnong	4	1	0.00
137	Maribyrnong	3	1	0.03
386	Maribyrnong	2	1	0.25
141	Maribyrnong	2	1	0.17
45	Dandenong	5	2	0.15
490	Dandenong	4	2	1.07

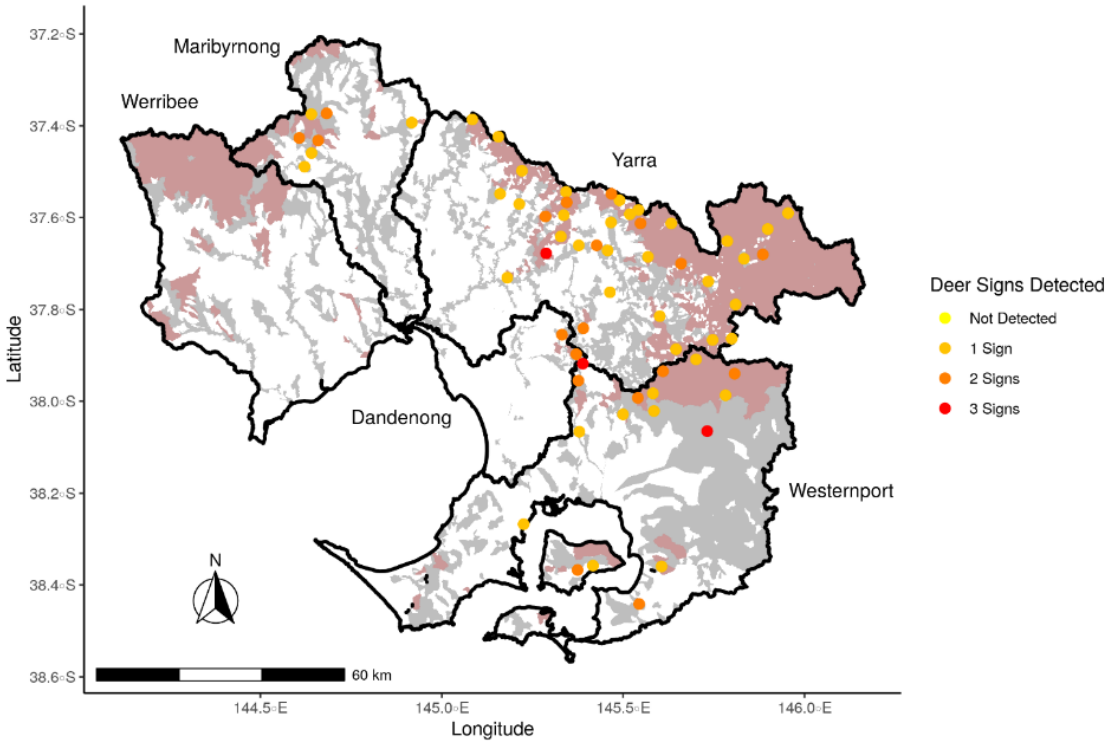


Figure 17 VV21 sites where deer was detected

Rabbits were mostly found in Werribee and Maribyrnong as well as the Yarra (Figure 18). Signs of rabbit presence were warrens and pellets/scats (Appendix B). Interestingly they were found to occur in areas that were largely different to the deer. This is not surprising as deer generally prefer areas that provide cover, such as forest areas adjacent to more open grazing habitats. Rabbits are generally found in more cleared, agricultural landscapes.

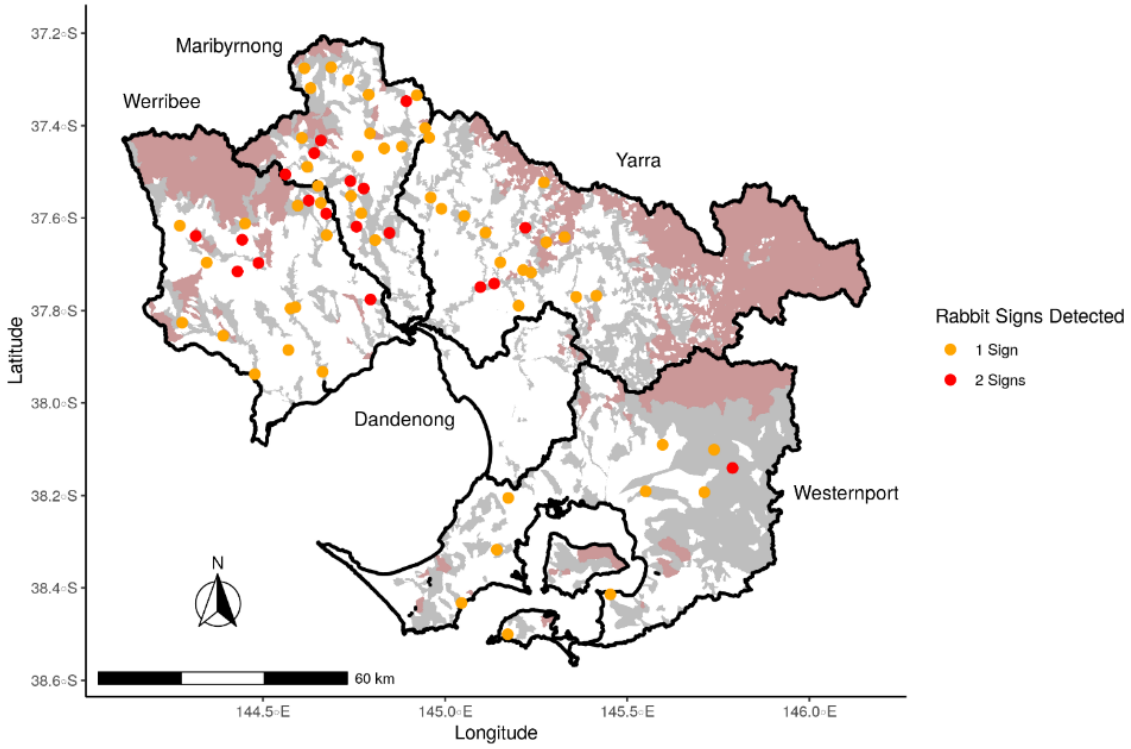


Figure 18. VV21 sites where rabbits were detected

Conclusions

KEQ2a – Potential low natural regeneration rates

The new field data confirmed our assumption that low quality sites have low natural regeneration rates due to the degree of disturbance and pressures at these sites. However, we were interested to see whether any high-quality sites also had low regeneration rates, as this may indicate a possible future decline in condition. Our threshold for significance was if more than 10% of high-quality sites within a catchment had low natural regeneration rates. There were 10 sites across the region, in all catchments except Dandenong.

Recommendation: Investigate the 10 sites to better understand the extent of low regeneration. Understand what could be driving this and intervene if required. Continue to monitor regeneration levels.

KEQ2a - Low connectivity in Protection areas

While the field-based data is somewhat limited in its ability to quantify connectivity, we applied a criteria to find potential sites with high quality that had low connectivity scores, indicating these sites are likely to be vulnerable.

Recommendation: Investigate the 2 sites which showed low connectivity but high scores to confirm there are no methodological issues.

KEQ2a –Highly invasive weeds in Protection areas

While data shows that there are high weed loads across most sites, it's the highly invasive weeds, in high quality sites which are of most concern. We focused our attention on high quality sites where more than 20% of the high-quality sites had high levels of highly invasive weeds. There was a total of 41 sites across the region with the most in the Yarra (16) and the least in the Maribyrnong (3).

Recommendation: Investigate the current level of management for these sites and ensure they are prioritised for on-ground works.

KEQ2a – Protection areas threatened by deer

Deer are a growing concern across the region. The new field-based condition data and a predictive model of reach scale distribution across the region, which has only just been finalised is helping to identify hot spots for deer. We found that 83% of sites where deer were detected were at high quality VV21 sites. Of these 27% had a high modelled deer density.

Recommendation: Prioritise efforts for deer management across the region using latest modelling and field data.

The outcome of the evaluation for each of the criteria is summarised below (*Table 18*).

Table 18. summary of evaluation results for KEQ2a.

KEQ	Criteria	Significant for implementation	Summary of results
2a	Natural regeneration of vegetation	>10% of VV21 high quality vegetation within a catchment with no evidence of regeneration	10 VV21 sites 3 - Maribyrnong 3 - Werribee 2 - Yarra 2 - Westernport
2a	Low connectivity	>10 % of VV21 high quality sites within a catchment have low connectivity (ie <3)	No sites
2a	Spatial extent of highly invasive weeds	>20% VV21 high quality sites within a catchment have high weed loads in Priority areas	41 VV21 sites 16 -Yarra 12 - Westernport 4 - Werribee 3 - Maribyrnong 6 - Dandenong
2a	Spatial extent of deer	Any detection of deer in high quality sites and modelled deer density is high	83% of sites where deer were detected were at high quality VV21 sites. Of these 27% had a high modelled deer density.

Recommendations for consideration

Recommendations relating to KEQ 3b and 2a for the Science Inquiry to consider have been developed for results that were evaluated as being significant for implementation. These are outlined in *Table 19*.

Table 19. Summary of results for significant criteria and proposed draft recommendations

KEQ	Criteria	Significant for implementation	Summary of results	Recommendation for consideration of Science Inquiry
3a	Long term targets are significantly off-track	< 60% of all sites within the sub-catchment / or catchment have same or increased vegetation vision score Or <90% all level 4 and 5 remain at a 4 or 5 Or <60% of all level 3s sites (within SCPO reaches) are at least a 3	Not possible due to insufficient data	Continue to invest in data, technology and research that allows vegetation value (condition and extent) to be evaluated frequently over large scales and over time (and back casting)
3b	Decline in vegetation quality	Any site where the VV21 score is 2 or more points less than its VV18 score	7 VV21 sites Yarra – 4 sites Werribee - 3 sites (1 Yarra site is not in a HWS priority area)	Investigate and if necessary, prioritise management interventions for these reaches in priority areas to prevent further decline in condition.
3b	New areas of high quality vegetation	A VV21 monitoring site has high quality vegetation (4 or 5) that is not in HWS Priority areas or Protection areas	25 VV21 sites Dandenong – 4 sites Maribyrnong – 2 sites Werribee - 7 sites Westernport- 7 sites Yarra – 5 sites	Determine the extent and connectivity of the area which should be included in the HWS High Quality vegetation priority areas.
2a	Natural regeneration of vegetation	>10% of high quality vegetation with no evidence of regeneration	10 VV21 sites Maribyrnong – 3 sites Werribee – 3 sites Yarra – 2 sites Westernport – 2 sites	Investigate the 10 sites to better understand the cause and extent of low regeneration, intervene if required. Continue to monitor regeneration levels.
2a	Low connectivity	>10 % high quality sites have low connectivity (ie <3)	No sites	Investigate the 2 sites which showed low connectivity but high scores to confirm there are no methodological issues.
2a	Spatial extent of highly invasive weeds	>20% high quality sites have high weed loads in HWS priority areas	41 VV21 sites Yarra – 16 sites Westernport – 12 sites Werribee – 4 sites Maribyrnong – 3 sites Dandenong – 6 sites	Investigate the current level of management for these sites and ensure they are prioritised for on-ground works.
2a	Spatial extent of deer	Any detection of deer in high quality sites and deer modelling density is high	83% of sites where deer were detected were at high quality VV21 sites. Of these 27% had a high modelled deer density.	Prioritise efforts for deer management across the region using latest modelling and field data

Overarching Recommendations for consideration:

1. Update Melbourne Water's revegetation guidelines and develop broader vegetation management guidelines (for rivers, wetlands and estuaries) to include climate change mitigation actions, new information on chemical use, bird habitat design and amenity outcomes.
2. Invest in long-term data sets to enable the evaluation of vegetation extent and quality.
3. Ensure Melbourne Water have staff who are knowledgeable of the various vegetation databases and data collection methods, who have a background in ecology.
4. Invest in a database to manage previous and ongoing vegetation and intervention monitoring. Ensure this is able to link to other databases for faunal and social values.
5. Assess how faunal species such as birds and macroinvertebrates are influenced by changes in vegetation condition and extent, including in revegetated areas.
6. Assess how climate change is likely to influence vegetation condition and extent, including species used in revegetation activities.
7. Investigate the use of new remote sensing technologies (LiDAR, high resolution satellite imagery) to monitor the quality and extent of restored and remnant habitats over time.
8. Prioritise sites across the region that could be used for direct seeding.
9. Collaborate with Traditional Owner groups to better understand the vegetation communities being planted from a TO perspective, how climate adapted seed can be included in revegetation actions, and how to monitor vegetation communities more effectively.

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 coming months.

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

A project has been initiated to look at 'what's changed' since the HWS was released. The results of this project will feed into KEQ2b and be presented in the Science Inquiry Report (Melbourne Water, 2023a). The project will also provide useful data for the implementation enquiry which evaluates the extent to which performance objectives have been achieved along with the effectiveness of collaboration.

The project will focus on:

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

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

The project will consider the impacts of these changes through a SWOT analysis to identify what's significant for future implementation of the HWS.

A complete list of threats for environmental values is being refined as each Key Value paper is prepared and conceptual models are updated. Refer to *Table 20* below for a draft summary of threats to environmental values which are further investigated, along with social values in the Threats Technical paper (Melbourne Water 2023b).

Table 20. Draft list of threats to waterways, examples, the Environmental Conditions and Key Values as outlined in the HWS which are impacted by the threat and whether they are relevant to Rivers (R), Wetlands (W) and/or Estuaries (E).

Threat	Examples	Environmental conditions	Key values	Asset type
Urbanisation (DCI)	Directly connected impervious surfaces change flow regime and degrade water quality	Water quality, Water Regime, Stormwater, Physical Form	all values	R,W,E
Urbanisation (toxicants/contaminants/microplastics/pathogens)	Industry, untreated sewerage ingress, construction phase of development	Water quality	all values	R,W,E
Litter	Commercial areas, fishing equipment	Litter	Platypus	R,W,E

Threat	Examples	Environmental conditions	Key values	Asset type
Physical modifications	Piping of headwater streams, channelisation of waterways, building over wetlands, LWD removal, illegal alteration of waterway	Physical Form, Vegetation	all values	R,W,E
STPs and ERSs and septic tanks	STPs discharges, ERS spills, poor septic performance/maintenance	Water quality	Macroinvertebrates	R,W,E
Recreational access	Motor bikes, noise, light, tracks,	Water quality, Vegetation	Birds, Vegetation	R,W,E
Fish barriers	Gauging station weirs, dam walls, erosion control structures	Instream connectivity	Fish	R, E
Pest plants (inc biosecurity)	High risk weeds	Vegetation	Vegetation	R,W,E
Pest animals (inc biosecurity)	Deer, rabbits, over abundant wildlife, exotic fish	Vegetation	Vegetation	R,W,E
Stock access	Unfenced grazing land	Vegetation	Vegetation	R,W,E
Vegetation clearing	Illegal tree removal, forestry, recreation e.g. mountain bike tracks, 4WD tracks	Vegetation	Vegetation	R,W,E
Farm dams	On-line and off-line dams, licensed and unlicensed	Water Regime	all values	R,W,E
Water extraction	Water supply dams, surface water diversions, groundwater extractions	Water Regime	all values	R,W,E
Agriculture	Agriculture, intensification of agriculture, pesticide drift	Water Quality, Water Regime	all values	R,W,E
Artificial estuary openings	Dredging for recreation	Physical Form	Fish	E
Disturbances	Bushfires, floods, storms, wind	Water Quality, Water Regime, Physical Form, Vegetation	all values	R,W,E
Climate change	Water temperature increases, reduction in flow, increased storm intensity, increased urban heat, sea level rise	Water Quality, Water Regime, Physical Form, Vegetation	All values	R,W,E

Climate change

Climate change is of considerable concern for vegetation as a value and a condition. Some initial findings from the research - modelling risk to climate change for revegetation species project (refer to the Draft Research Fact Sheet attachment) - suggests that many of the sub-catchments in the Westernport and Yarra catchments are predicted to become substantially more arid by 2050 compared to baseline data. This suggests that the high quality sites (*Figure 19*) in these areas may be

at risk. Monitoring these at risk sites using the Detailed monitoring sites (black dots in the figure) will help ensure these sites aren't declining in quality over time.

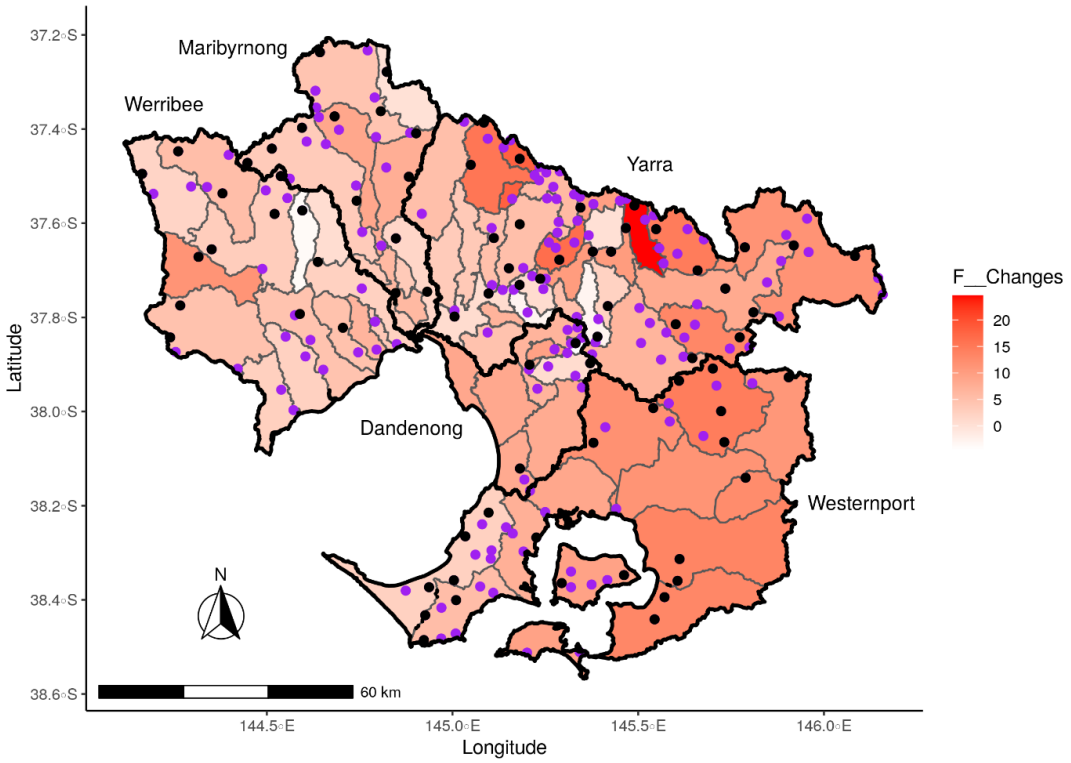


Figure 19. Aridity change to 2050 in the Melbourne Water sub catchments, including high quality VV21 scores (purple dots) and VV21 Detailed monitoring sites (black dots). F_Changes represents the amount of aridity change from the baseline (1986 – 2005), with higher numbers representing greater changes

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

Across research literature, various definitions exist for the term intervention. 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 review, 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 to ultimately support a key value (e.g. platypus) to meet the expectations of stakeholders and the community to achieve the targets outlined in the HWS. Interventions typically fall into two categories;

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

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

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

This section includes a summary of interventions that directly protect or improve vegetation quality. It does not include other interventions which can influence vegetation outcomes e.g. stormwater management or provision of environmental water. The evaluation of interventions is outlined in the Intervention Technical Report (Melbourne Water, 2023c). This section provides some insights into the information used in the evaluation.

Overview of vegetation interventions

There are many different types of interventions for vegetation currently applied for the Healthy Waterways Strategy (*Table 21*). Many of these have been used widely in the region over the years with mid 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.

The confidence in the effectiveness of different interventions is variable in the region. Those interventions with low confidence but require high investment will be of particular focus during the evaluation (Figure 20) as some of these are interventions that Melbourne Water monitors through the Melbourne Waterways Research Partnership and other research initiatives.

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 21. Vegetation on ground interventions used in relation to Healthy Waterways Strategy

Intervention type	Specifics	Confidence	Adoption Stage
Revegetation	Tube stock (including long stemming)	High	Part of BAU
	Direct seeding	Low - High	Early adoption
Fencing riparian zones	Stock exclusion fencing	High	Part of BAU
	Flexible fencing	High	Early adoption
Climate adaptation	Species selection	Low	Research is underway
	Altering Species Mixes	Low	Research is underway
Deer control	Fencing	High	Early adoption
	Lethal	Low	Early adoption
	Noise	Low	Research is underway
	Landscape of Fear	Low	Research is underway
Rabbit control	Baiting	High	Part of BAU
	Ripping	High	Part of BAU
	Fencing	High	Part of BAU
	Implosion	High	Part of BAU
Weed control general	Herbicide	High	Part of BAU
	Alt. Chemical treatment	Low to High	Research is underway
	Hand removal	High	Part of BAU
	Heat treatment	Low	Research is underway
	Livestock (goats)	Low	Research is underway
	Mowing / Brush Cutting	High	Part of BAU
	Burning	Low - High	Early adoption
	Biocontrol	Low to High	Early adoption

Woody weed control	Grooming Physical Removal Cut and paint Drill and fill	High High Low – High Low - High	Part of BAU Part of BAU Part of BAU Part of BAU	
Cultural practices	Burning		Low - High	Early adoption
Water licensing and flow release	Flow releases Bans and restrictions Physical modification	Low to High (species dependent)	Part of BAU Part of BAU Early adoption	

Table 22 summarises the interventions and associated intervention monitoring research projects. The approach to evaluating these interventions is outlined in the Intervention Technical report (Melbourne Water, 2023c).

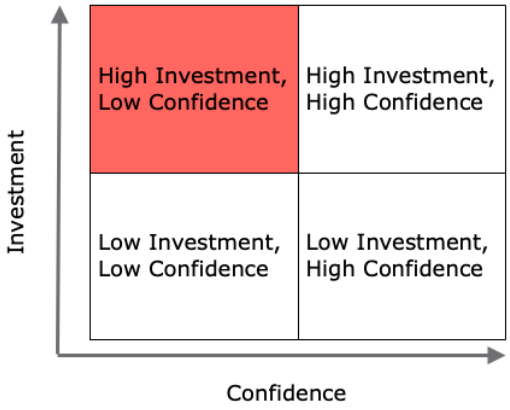


Figure 20. Focus of evaluation of interventions through the Waterways and Wetlands Research Program

Table 22. Summary of vegetation intervention research projects to be included in mid-term evaluation

Intervention Group	Intervention type	Specifics	Current extent of use in region	Relevant research project
Establish	Revegetation	Tube stock planting Direct seeding	High Low	A2 sub. Monitoring, Evaluation, Reporting and Improvement (MERI) for Riparian Revegetation (ISC2 & ROMP) Evaluating direct seeding as a cost effective technique for riparian vegetation
Establish	Climate Adaptation	Species selection	Low	D5 Modelling the risk of climate change to key revegetation species
Maintain/protect	Deer control	Fencing Lethal Noise Landscape of fear	Low	D2 Managing the impacts of deer on riparian vegetation
Maintain/protect	Weed control general	Alternative chemical treatment	Low	E2.4 What are the effects of chemicals frequently used by Melbourne Water near waterways

Intervention Group	Intervention type	Specifics	Current extent of use in region	Relevant research project
		Heat treatment		Research projects on Alligator weed, Spartina, Phragmites and Tradescantia control
Maintain/protect	Woody weed control	Cut and paint Drill and fill	Low	Desert Ash control trials along waterways
Maintain/protect	Water licensing and flow release	Flow releases Physical modification	High Low	A2-sub Birrarung's billabongs: vegetation response to environmental watering D4 Yellingbo hydrology works MERI program

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?

This question is addressed in Section F of the Science Inquiry report (Melbourne Water, 2023a).

Table 23 outlines a list of current research projects that relate to vegetation that are also outlined in science factsheets.

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

Research Project name
A2- 1 MERI Riparian Revegetation - Monitoring Management Interventions (MWRPP) (placeholder)
D2 Managing the impacts of deer on riparian vegetation
D5 Modelling the risk of climate change to key revegetation species
B1 Urban flow ecology: Investigating relationships between flow, channel form, instream vegetation and ecosystem function
D4 - Yellingbo hydrology works MERI program
Birrarung's billabongs - vegetation response to environmental watering
Landsat vegetation monitoring
B1 Urban flow ecology: Investigating relationships between flow, channel form, instream vegetation and ecosystem function
Evaluating direct seeding as a cost effective technique for riparian vegetation
What are the effects of chemicals frequently used by Melbourne Water on or near waterways on aquatic ecosystems and human health? (A3P)
Restoring instream resources to complement riparian works (ARC Linkage, UoM) (placeholder)
Propagation of native sedges for riparian revegetation programs (placeholder)

5. Summary of the evaluation method and results

Evaluative criteria were developed to answer KEQ 3a and 2a. The criteria were developed in consultation with subject matter experts within Melbourne Water and The University of Melbourne. They centred around known important aspects on vegetation value (e.g., areas of high and very high quality and possible declines in condition) and conditions which support the value (e.g., natural regeneration rates, connectivity of vegetation, extent of highly invasive weeds and deer. The standards to determine what was significant for each of these criteria was also based on expert opinion and centred around the proportion of sites which fell above or below critical thresholds (e.g. >10% of high quality vegetation with no evidence of regeneration). A summary of the findings and recommendations for consideration in the Science inquiry (Melbourne Water, 2023a) are provided below.

KEQ3a – data gaps require filling

This evaluation question cannot be answered in full due to data gaps relating to vegetation quality and extent. Some previous studies on riparian health and management interventions suggest that remnant habitats are maintaining or possibly improving in quality. Revegetated areas are increasing in quality.

Recommendation for consideration: Continue to invest in data, technology and research that allows vegetation value (condition and extent) to be evaluated frequently over large scales and over time (including back casting).

KEQ3b results - New areas of high quality

There were 25 sites from the new field based vegetation condition data that were not previously identified as high quality. The majority fell within the Werribee (7 sites) and Westernport catchments (7 sites).

These sites were considered significant for implementation as the HWS has performance objectives around protecting all high quality reaches.

Recommendation for consideration: Determine the extent and connectivity of the area which should be included in the HWS Protection areas.

KEQ3b - Possible decline in condition

A comparison of high confidence data from 2018 compared with the new field data revealed a possible decline in condition in 7 sites, 4 in the Yarra and 3 in Werribee.

These sites were considered significant for implementation as it is important to understand if this decline is real or methodological and if real then it is also important to understand what may be causing the decline.

Recommendation for consideration: Investigate and if necessary, prioritise management interventions for these reaches in priority areas to prevent further decline in condition.

KEQ2a – Potential low natural regeneration rates

The new field data confirmed our assumption that low quality sites have low natural regeneration rates due to the degree of disturbance and pressures at these sites. However, we were interested to see whether any high quality vegetation sites also had low regeneration rates, as this may indicate a possible future decline in condition and resilience. Our threshold for significance was if more than 10% of high quality sites (i.e. protection areas) within a catchment had low natural regeneration rates. There were 10 sites across the region, in all catchments except Dandenong.

Recommendation for consideration: Investigate the 10 sites to better understand the extent of low regeneration. Understand what could be driving this and intervene if required. Continue to monitor regeneration levels.

KEQ2a - Low connectivity in high quality areas

While the field-based data is somewhat limited in its ability to quantify connectivity, we applied a criteria to find potential sites with high quality that had low connectivity scores, indicating these sites are likely to be vulnerable in the future.

Recommendation for consideration: Investigate the 2 sites which showed low connectivity but high quality scores to confirm there are no methodological issues.

KEQ2a –Highly invasive weeds in Protection areas

While data shows that there are high weed loads across most sites, it's the highly invasive weeds, in high quality sites which are of most concern. We focused our attention on high quality sites where more than 20% of the high quality sites had high levels of highly invasive weeds. There were a total of 41 sites across the region with the most in the Yarra (16) and the least in the Maribyrnong (3).

Recommendation for consideration: Investigate the current level of management for these sites and ensure they are prioritised for on-ground works.

KEQ2a – Protection areas threatened by deer

Deer are a growing concern across the region. The new field based condition data and a predictive model of reach scale distribution across the region, which has only just been finalised is helping to identify hot spots for deer. We found that 83% of sites where deer were detected were at high quality VV21 sites (Protection areas). Of these, 27% had a high modelled deer density.

Recommendation for consideration: Prioritise efforts for deer management across the region using latest modelling and field data.

This is an interim evaluation for vegetation and the recommendations will be prioritised alongside all other recommendations from the technical papers in the Science Inquiry Report (Melbourne Water, 2023a).

Overarching Recommendations:

- Update Melbourne Water's revegetation guidelines and develop broader vegetation management guidelines (for rivers, wetlands and estuaries) to include climate change mitigation actions, new information on chemical use, bird habitat design and amenity outcomes.
- Invest in long-term data sets to enable the evaluation of vegetation extent and quality.
- Ensure Melbourne Water have staff who are knowledgeable of the various vegetation databases and data collection methods, who have a background in ecology.
- Invest in a database to manage previous and ongoing vegetation and intervention monitoring. Ensure this is able to link to other databases for faunal and social values.
- Assess how faunal species such as birds and macroinvertebrates are influenced by changes in vegetation condition and extent, including in revegetated areas.
- Assess how climate change is likely to influence vegetation condition and extent, including species used in revegetation activities.
- Investigate the use of new remote sensing technologies (LiDAR, high resolution satellite imagery) to monitor the quality and extent of restored and remnant habitats over time.
- Prioritise sites across the region that could be used for direct seeding.
- Collaborate with Traditional Owner groups to better understand the vegetation communities being planted from a TO perspective, how climate adapted seed can be included in revegetation actions, and how to monitor vegetation communities more effectively.

6. References

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Melbourne Water (2023b) Threats: A technical report to inform the Healthy Waterways Strategy mid-term review, Melbourne Water, Docklands, Victoria, Australia.

Melbourne Water (2023c) Interventions: A technical report to inform the Healthy Waterways Strategy mid-term review, Melbourne Water, Docklands, Victoria, Australia.

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Appendix A HWS vegetation value metrics

The criteria for determining uniqueness is displayed in Table 24. A maximum score of 5 can be achieved if all 3 categories are triggered within the reach. Table 25 then assigns a value measure to the cumulative score.

Table 24. Uniqueness criteria for vegetation value scoring.

Score	Uniqueness criteria (based on 200m buffer)
2	Bioregional conservation status endangered or vulnerable
2	Listed species EPBC or FFG
1	BCS depleted or low

Table 25. Uniqueness value scoring and categorisation

Uniqueness Value category	Cumulative score
Very low	1
Low	2
Medium	3
High	4
Very High	5

Statewide datasets (eg VBA) were used to determine the uniqueness scores for each reach based on a 200m buffer along the waterways.

Naturalness was defined by a combination of vegetation quality and extent. Data was generated for these two indicators at the reach scale. The reaches were based on the Melbourne Water reach asset dataset. Reaches vary in length but are on average about 1km.

Vegetation Quality: Melbourne Water's vegetation 2009 vegetation visions (expert elicited data) was the main source of data used to describe vegetation quality. Essentially it provides a score based on vegetation structure, species composition and weediness.

Vegetation extent: Ideally this metric would be based around the extent of cover of remaining native vegetation – using EVCs as a benchmark. However due to data limitations a simple canopy cover assessment was undertaken using existing data. This data was used to determine the percentage of the reach which contained canopy cover within the 200m buffer. The following categories were used (see Table 26):

Table 26. Vegetation extent scoring

Amount of tree canopy cover within a 200m buffer from the centreline	Category	Score
80-100%	Very High	5

Amount of tree canopy cover within a 200m buffer from the centreline	Category	Score
60-80%	High	4
40-60%	Medium	3
20-40%	Low	2
0-20%	Very Low	1

Naturalness ratings were then calculated by combining the vegetation quality and vegetation extent ratings using a lookup table that rated naturalness of vegetation from very low to very high (Table 27).

Table 27. Vegetation naturalness rating

Naturalness		Vegetation Extent					
		Very Low	Low	Medium	High	Very High	No Data
Vegetation Quality	Very Low	Very Low	Very Low	Very Low	Very Low	Low	Very Low
	Low	Very Low	Low	Low	Low	Medium	Low
	Medium	Low	Medium	Medium	Medium	High	Medium
	High	Medium	High	High	High	High	High
	Very High	High	Very High	Very High	Very High	Very High	Very High
	No Data	Very Low	Low	Medium	High	Very High	

Uniqueness and Naturalness ratings were combined using a look up table to determine the overall Vegetation value state (Table 28) .

Table 28. Look-up table for calculating vegetation value based on naturalness and uniqueness scores

Vegetation Value		Uniqueness					
		Very Low	Low	Medium	High	Very High	No Data
Naturalness	Very Low	Very Low	Low	Low	Medium	High	Very Low
	Low	Low	Low	Low	Medium	High	Low
	Medium	Medium	Medium	Medium	Medium	High	Medium
	High	Medium	Medium	High	High	Very High	High
	Very High	High	High	High	Very High	Very High	Very High
	No Data	Very Low	Very Low	Low	Medium	High	

Appendix B Vegetation Visions (VV21) field based assessment methodology

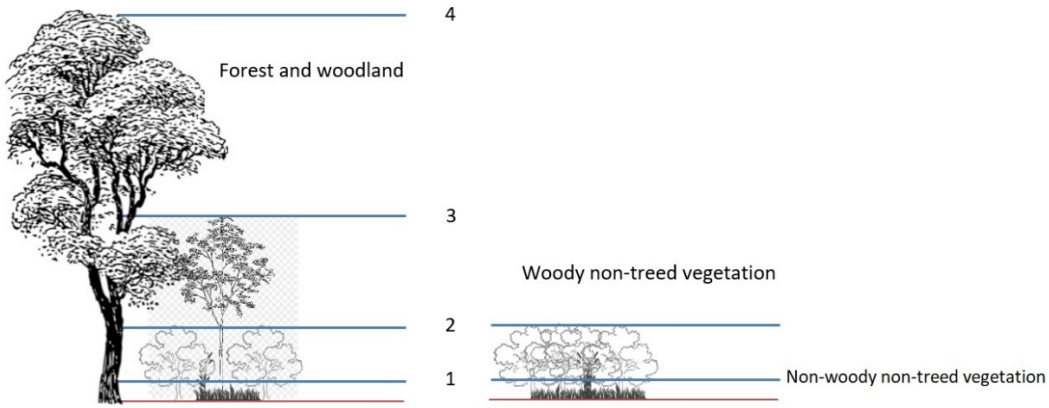


Figure 21. The different vegetation strata, from ground layer (1) and understory (2), to midstory (3) and overstory (4) vegetation. Similarly the different vegetation types, from non-woody non-treed vegetation (1 to 2), woody non-treed vegetation (2 to 3) and forest and woodland (3 to 4).

Table 29. Scoring system for the structural components of a site (component A).

% Native cover	1 strata	2 strata	3 + strata	Score
No native species				Absent
<10%				Very low
11-30%				Low
31-50%				Medium
51-100%				High
				Very high

Table 30. Assessment of the different components at a site and their relative score.

Date:	**Site Name:**	**Assessor Name:**	**EVC name/number:**
Survey area (e.g. 0.2 ha)**:**	**Notes:**		
Upstream Easting:	**Upstream Northing:**	**Downstream Easting:**	**Downstream Northing:**

Components	**Quality** **Absent = 0**	**Very low = 1**	**Low = 2**	**Medium = 3**	**High = 4**	**Very high = 5**	**Score (0-5)**
A1 Structure **Forest and woodland**	Non-indigenous vegetation	Estimated combined native cover ≤10%	One to two strata with estimated combined native cover 11–30%. One stratum with estimated combined native cover 31–50%.	One stratum with estimated native cover >50%. Two strata with estimated native cover 31–50%. Three or more strata with estimated combined native cover 11–30%.	Two strata with estimated combined native cover >50%. Three or more strata with estimated combined native cover 31–50%.	Three or more strata with estimated combined native cover >50%.	
A2 Structure **Woody non-treed vegetation e.g. scrubs, heaths**	Non-indigenous vegetation	Estimated combined native cover ≤10%	Estimated combined native cover 11–25%	Estimated combined native cover 26–50%	Estimated combined native cover >50%, single stratum	Estimated combined native cover >50%, two or more strata	
A3 Structure **Non-woody non-treed vegetation e.g. grassland**	Non-indigenous vegetation	Estimated combined native cover ≤10%	Estimated combined native cover 11–25%	Estimated combined native cover 26–50%	Estimated combined native cover 51–75%	Estimated combined native cover 76–100%,	
B1 Richness **Forest and Woodland**	Non-indigenous vegetation	Very low species richness (1–3 species)	Low species richness (4–8 species)	Medium species richness (9–15 species)	High species richness (16+ species in less than 8 lifeforms)	Very high species richness (16+ species in at least 8 lifeforms)	
B2 Richness **Woody non-treed vegetation diversity e.g. scrubs, heaths**	Non-indigenous vegetation	Very low species richness (1 species)	Low species richness (2–6 species)	Medium species richness (7–13 species)	High species richness (13+ species in less than 7 lifeforms)	Very high species richness (13+ species in at least 7 lifeforms)	
B3 Richness **Non-woody non-treed vegetation e.g. grassland**	Non-indigenous vegetation	Very low species richness (1 species)	Low species richness (2–6 species)	Medium species richness (7–13 species)	High species richness (13+ species in less than 5 lifeforms)	Very high species richness (13+ species in at least 5 lifeforms)	
C **Instream vegetation composition**	None or non-indigenous vegetation	Instream vegetation of 1 species.	Instream vegetation of 2 species or lifeforms	Instream vegetation of 3 species or lifeforms	Instream vegetation of 4 species or lifeforms	Instream vegetation of 5+ species or lifeforms	

Date:	Site Name:	Assessor Name:	EVC name/number:
Survey area (e.g. 0.2 ha)**:**	**Notes:**		
Upstream Easting:	**Upstream Northing:**	**Downstream Easting:**	**Downstream Northing:**

Components	Quality Absent = 0	Very low = 1	Low = 2	Medium = 3	High = 4	Very high = 5	Score (0-5)
D **Patch shape and fragmentation**	Non-indigenous vegetation	Native vegetation confined to 20 m from waterway on one side only, not longitudinally contiguous.	Native vegetation confined to 20 m from waterway on both sides of waterway, not longitudinally contiguous.	Native vegetation either longitudinally or laterally contiguous with native vegetation outside of assessment area, to within 100 m from boundary.	Native vegetation longitudinally and laterally contiguous with native vegetation outside of assessment area, >100 m from boundary in one direction.	Native vegetation longitudinally and laterally contiguous with native vegetation outside of assessment area, >100 m from boundary in both directions.	
E **Regeneration**	Non-indigenous vegetation	No evidence of recruitment.	Little evidence of recruitment, few recruits present with restricted distribution.	Little evidence of recruitment, few recruits present with scattered distribution.	Recruitment clearly evident with more than a few recruits in less than half of lifeforms present. No evidence of canopy species recruitment in forests and woodlands.	Recruitment clearly evident with more than a few recruits in more than half of lifeforms present. May or may not include evidence of canopy species recruitment in forests and woodlands. ***OR*** If Recruitment clearly evident with more than a few recruits in less than half of lifeforms present, then evidence of canopy species recruitment required in forests and woodlands.	
						Overall Score	
Weediness	No weeds detected	Weed species <10% relative cover without highly invasive species.	Weed species <10% relative cover including highly invasive species.	Weed species 10–50% relative cover without highly invasive species.	Weed species >50% relative cover without highly invasive species ***OR*** Weed species 10–50% relative cover including highly invasive species.	Weed species >50% relative cover including highly invasive species.	
Weediness (Highly Invasive Species)	No highly invasive weeds.	<10% relative cover of highly invasive species	10-25% relative cover of highly invasive species	26%-50% relative cover of highly invasive species	51-75% relative cover of highly invasive species	76-100% relative cover of highly invasive species	

Table 31. Calculation of the Overall Score to the Relative Score.

																										Score
Overall Score	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Relative Score	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	4	4	4	4	4	5	5	5	5	5	

Table 32. Calculation of the Overall Score to the Relative Score.

																										Score
Overall Score	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Relative Score	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	4	4	4	4	4	5	5	5	5	5	

Table 33. Assessment of the lifeforms present at the site.

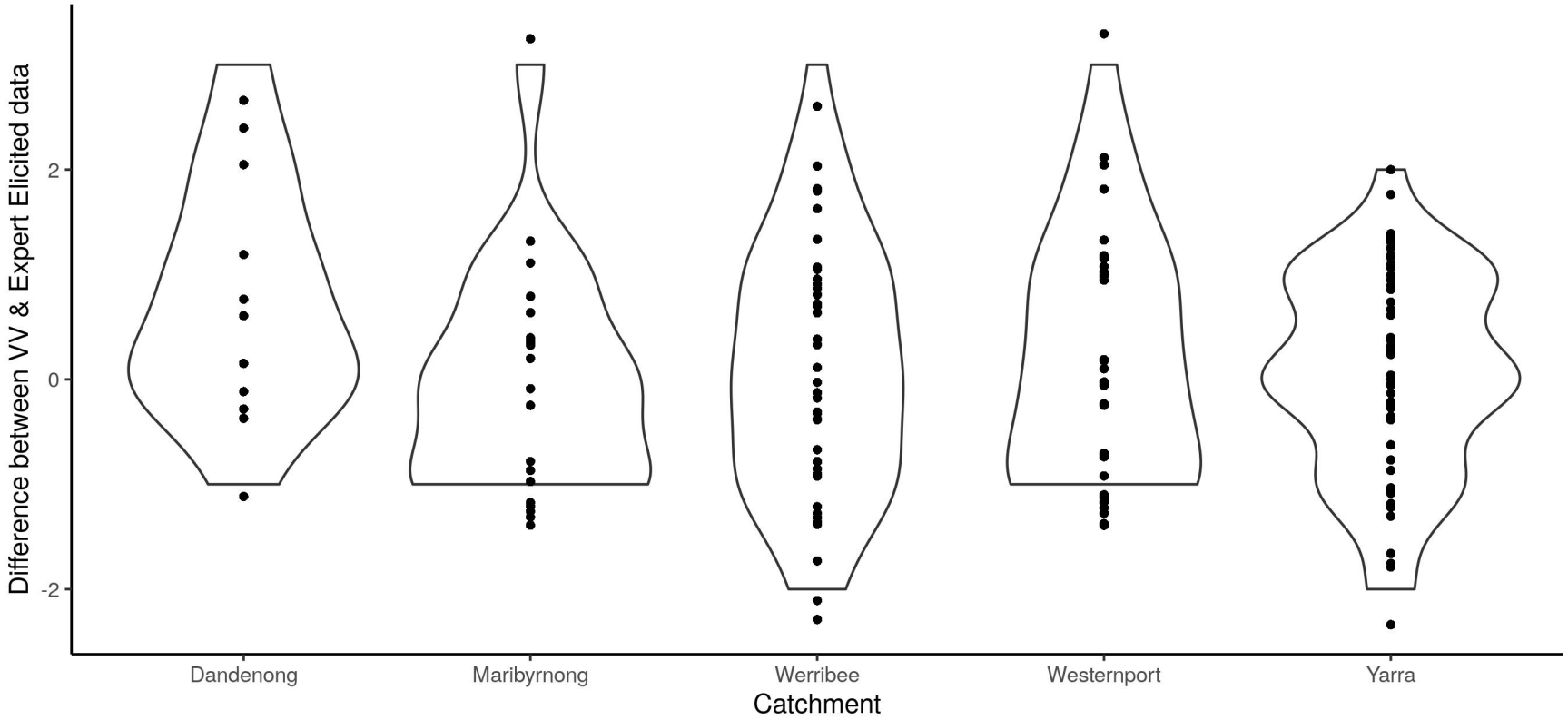
Date:	**Site Name:**	**Assessor:**
Terrestrial Lifeforms		**Presence**
Angiosperm Tree	Flowering woody plant with one main stem/trunk	
Gymnosperm tree	Conifer with one main stem/trunk	
Narrow-leaved upright Shrub*	Woody plant with multiple upright stems, leaves > 4 times longer than width or with leaves reduced and photosynthetic branches	
Broad-leaved upright shrub*	Woody plant with multiple upright stems, leaves < 4 times longer than wide	
Narrow-leaved prostrate shrub*	Woody plant with multiple stems +/- horizontally spreading, leaves > 4 times longer than width or with leaves reduced and photosynthetic branches	
Broad-leaved prostrate shrub*	Woody plant with multiple stems +/- horizontally spreading, leaves < 4 times longer than wide	
Narrow-leaved herb*	Herbaceous plant that is not a grass, sedge or rush, leaves > 4 times longer than width or without visible leaves	
Broad-leaved herb*	Herbaceous plant that is not a grass, sedge or rush, leaves < 4 times longer than wide	
Herb without leaves*	Herbaceous plant with no obvious leaves e.g. some saprophytes.	
Tufted grass, sedge or rush	Graminoid with three or more leaves arising from a common base	
Spreading grass, sedge or rush	Graminoid with no obvious tufted groups of leaves	
Climber, vine or twining plan	Any climbing, trailing or twining plant which when advanced grows on other plants/structures for vertical support	
Bryophytes or lichens	Mosses, liverworts, hornworts and lichens combined	
Tree fern	Fern with single trunk with a crown of fronds at the top	
Ground fern or fern-ally	Fern with fronds arising individually or in clumps from the ground.	
Epiphytic fern or fern-ally	Fern with fronds growing on the body of another plant (often a tree or tree fern)	
Mistletoe	Parasitic shrub often on the branches of eucalypts or wattles	
Instream plant lifeforms (for riparian applications)		**Presence**
Floating grass or grass-like plant	Free floating (but not necessarily at the surface), not attached to substrate	
Floating forb	Free floating (but not necessarily at the surface), not attached to substrate	
Emergent grass or grass-like plant	Attached to substrate with leaves or flowering stem +/- upright at or above the waterline	
Emergent forb	Attached to substrate with leaves or flowering stem +/- upright at or above the water surface	
Submergent grass or grass-like plant	Attached to substrate with leaves below water surface	
Submergent forb	Attached to substrate with leaves below water surface	
Submergent or emergent bryophytes (mosses, liverworts or hornworts combined)	Attached to substrate with leaves below, at or above water surface	
Submergent of emergent macro algae	Attached to substrate with body below, at or above water Surface	
Floating macro algae	Free floating, not attached to substrate	

Table 34. Table of threats for Vegetation Visions sites

Date:	**Site Name:**		**Assessor:**		
Threat	**Observed**	**Not Observed**	**Threat**	**Observed**	**Not Observed**
Rabbit pellets			Evidence of Phytophthora		
Rabbit warrens			Evidence of acid sulphate soils impacts		
Deer pellets			Native vegetation clearing		
Deer browsing			Stock access		
Deer wallows			Recent understory fire*		
Fox scats			Recent canopy fire*		
Encroachment			Land slip or stream bank collapse		
Storm water/grey water discharge			Soil surface erosion		

*Estimated or known in <3 years. ** Conspicuous rill or gully erosion by exposed soil/clay or associated sediments.

Appendix C Violin plot of the number of sites with differences between Vegetation Visions data Expert Elicited data in the different MW Catchments



Appendix D Difference in high quality vegetation between VV09 and VV18

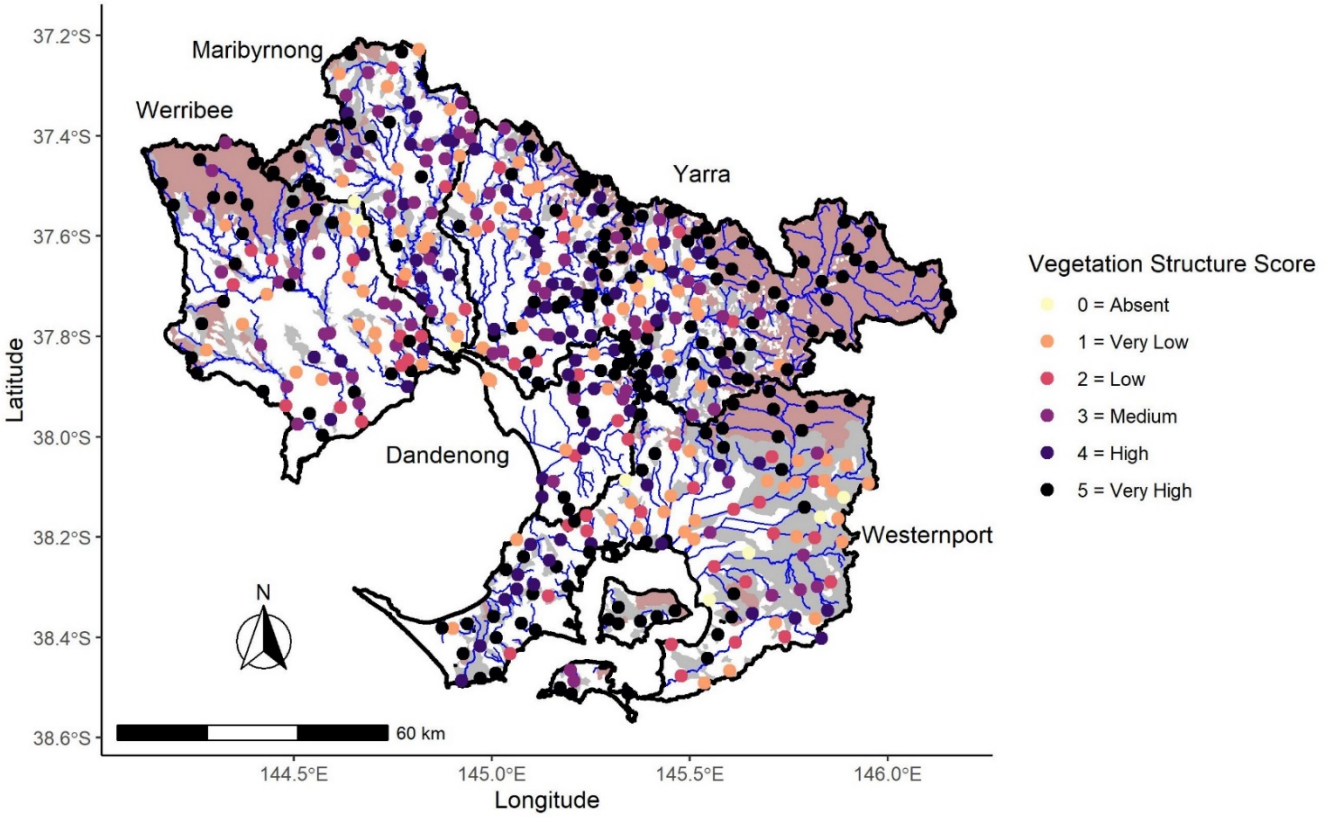
Table 35. Sub-catchments where the extent of high quality vegetation has increased from that reported in the HWS baseline. I.e. the difference between the 2009 vegetation visions expert elicited data and the 2018 data capture.

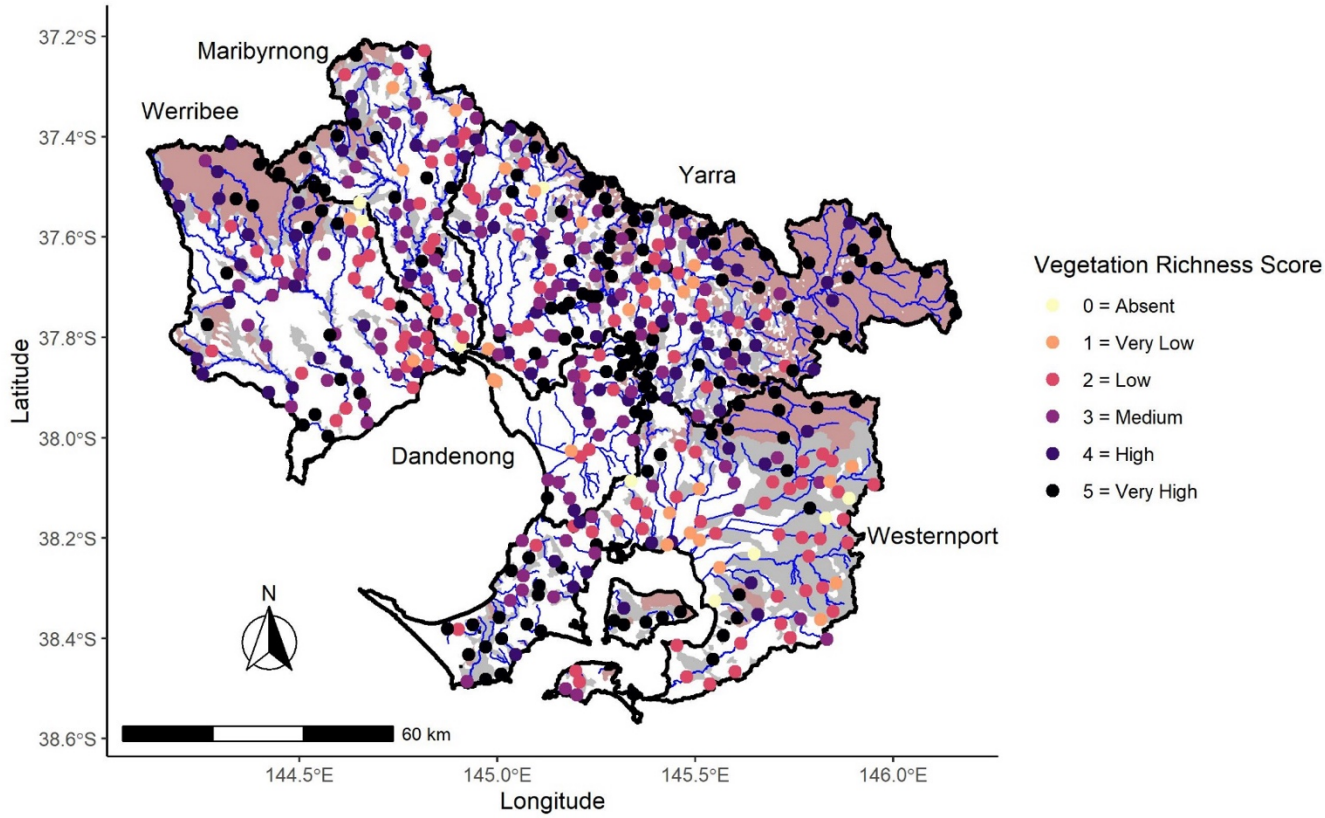
CATCHMENT	SUBCATCHMENT	VV09 HWS baseline (ha)	VV18 (ha)	increased high quality (ha)
Yarra	Yarra River Upper (Source)	824	8,781	7,957
Yarra	Yarra River Upper (Rural)	432	1,987	1,555
Westernport	Bunyip River Middle and Upper	400	1,742	1,342
Werribee	Lerderderg River	1112	2,373	1,261
Yarra	Watts River (Source)	232	1,454	1,222
Werribee	Werribee River Middle	444	984	540
Yarra	Plenty River (Source)	108	551	443
Westernport	Tarago River	644	995	351
Yarra	Little Yarra River and Hoddles Creek	188	465	277
Yarra	Diamond Creek (Source)	88	324	236
Yarra	Steels and Pauls Creek (Source)	68	268	200
Werribee	Werribee River Upper	368	547	179
Yarra	Watsons Creek	104	267	163
Westernport	French and Phillip Islands	8	116	108
Westernport	Lang Lang River	0	73	73
Werribee	Little River Upper	112	155	43
Yarra	Plenty River Upper	140	181	41
Werribee	Parwan Creek	0	39	39
Yarra	Watts River (Rural)	76	103	27
Maribyrnong	Boyd Creek	0	25	25
Yarra	Diamond Creek (Rural)	16	34	18
Yarra	Yarra River Lower	0	16	16
Maribyrnong	Emu Creek	56	63	7
Dandenong	Corhanwarrabul, Monbulk and Ferny Creeks	28	34	6
Westernport	Bass River	0	4	4
Yarra	Steels and Pauls Creek (Rural)	8	12	4

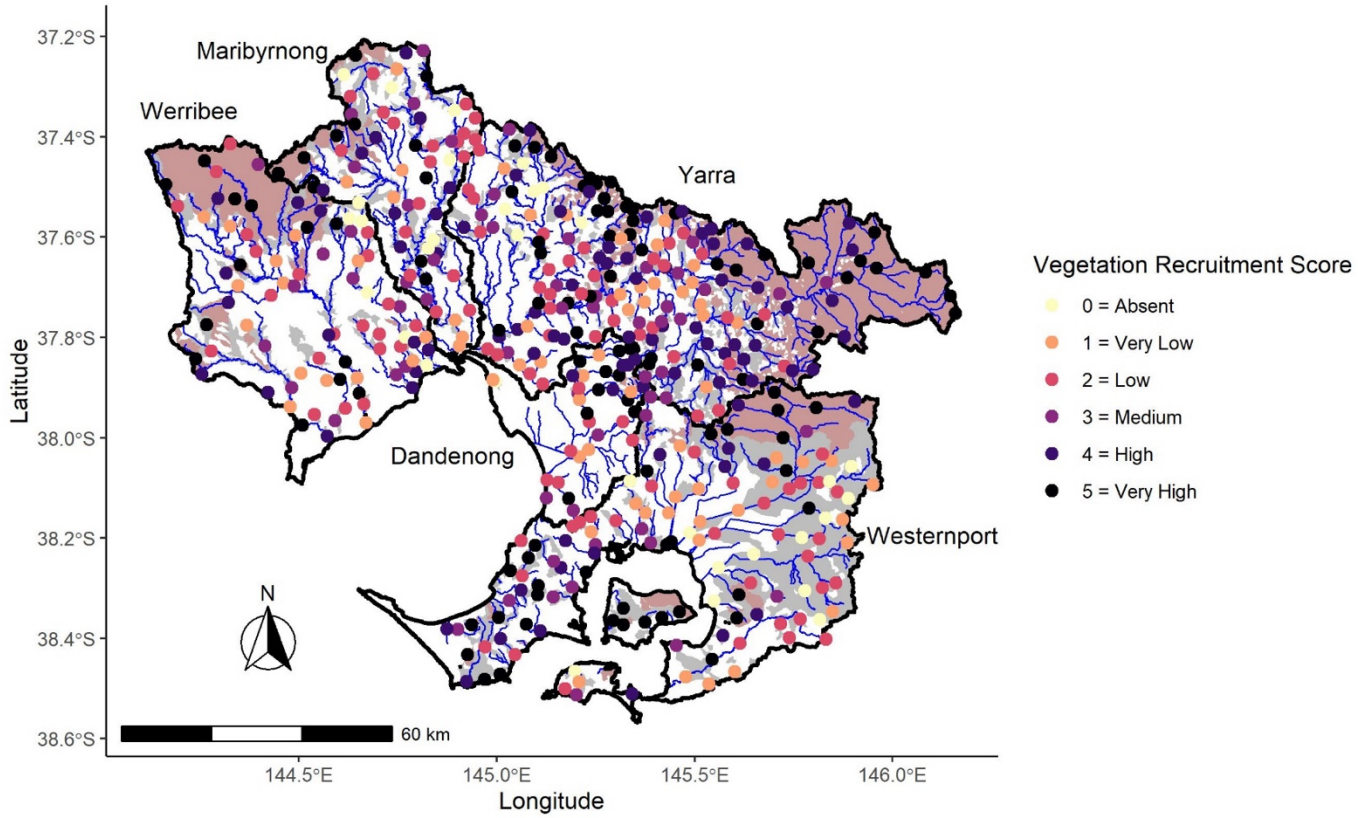
Table 36. Sub-catchments where the extent of high quality vegetation has decreased from that reported in the HWS baseline. Ie the difference between the VV09 data and the VV18 data capture.

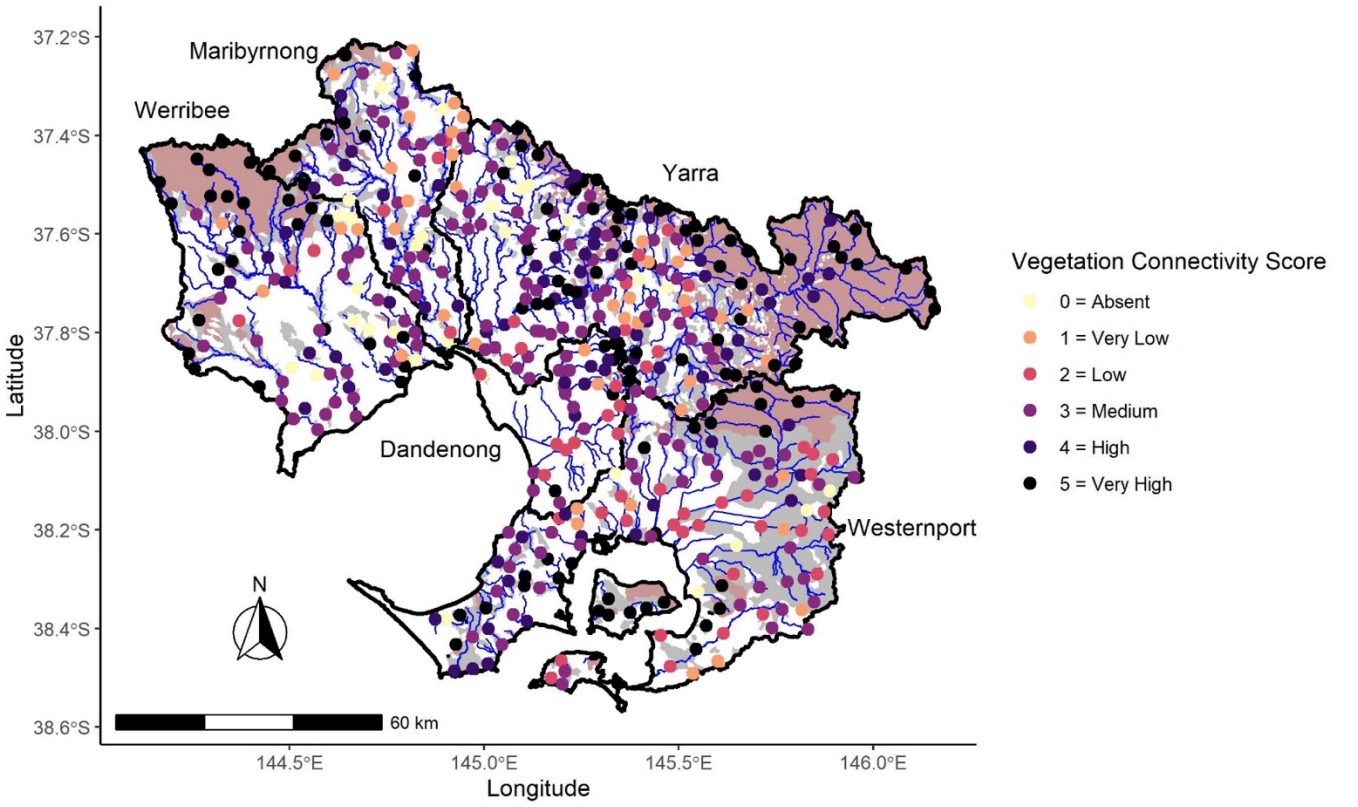
CATCHMENT	SUBCATCHMENT	HWS baseline ie VV09 (ha)	post HWS ie VV18 (ha)	Decreases in high quality (ha)
Yarra	Plenty River Lower	176	-	- 176
Yarra	Woori Yallock Creek	336	201	- 135
Maribyrnong	Jacksons Creek	412	326	- 86
Yarra	Merri Creek Upper	40	-	- 40
Westernport	Cardinia, Toomuc, Deep and Ararat Creeks	152	112	- 40
Maribyrnong	Deep Creek Lower	36	-	- 36
Westernport	Mornington Peninsula Western Creeks	44	14	- 30
Yarra	Darebin Creek	24	-	- 24
Maribyrnong	Deep Creek Upper	112	88	- 24
Yarra	Olinda Creek	40	19	- 21
Yarra	Yarra River Middle	32	14	- 18
Werribee	Little River Lower	16	-	- 16
Westernport	Mornington Peninsula South-Eastern Creeks	36	24	- 12
Werribee	Skeleton Creek	24	12	- 12
Dandenong	Dandenong Creek Upper	16	5	- 11
Dandenong	Dandenong Creek Middle	4	-	- 4
Dandenong	Kananook Creek	4	-	- 4
Dandenong	Blind Creek	4	2	- 2
Werribee	Laverton Creek	8	7	- 1

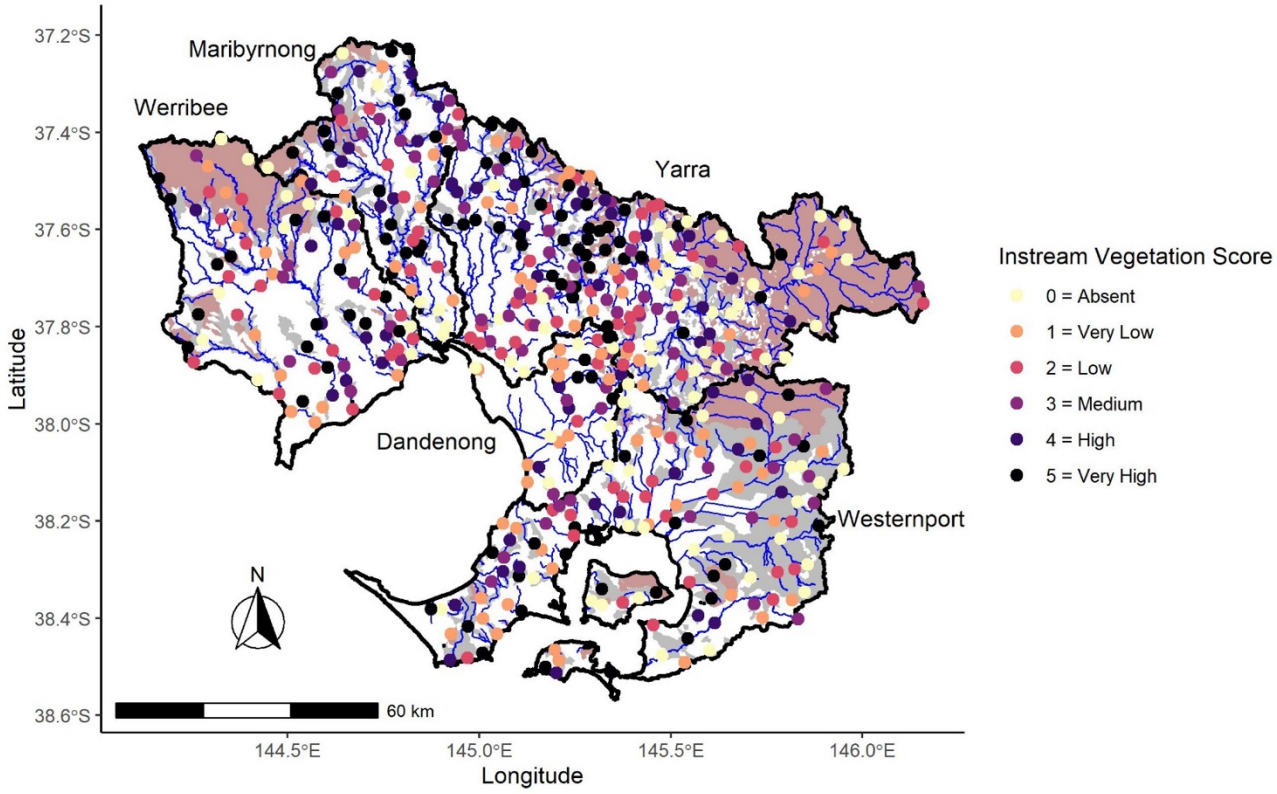
Appendix E The five components that make-up the VV21 scores.






Maribyrnong
Werribee
Yarra
Dandenong
Westernport
N
60 km
37.2°S
37.4°S
37.6°S
37.8°S
38.0°S
38.2°S
38.4°S
38.6°S
Latitude
144.5°E
145.0°E
145.5°E
146.0°E
Longitude
Vegetation Recruitment Score
0 = Absent
1 = Very Low
2 = Low
3 = Medium
4 = High
5 = Very High


Maribyrnong
Werribee
Yarra
Dandenong
Westernport
N
60 km
37.2°S
37.4°S
37.6°S
37.8°S
38.0°S
38.2°S
38.4°S
38.6°S
Latitude
144.5°E
145.0°E
145.5°E
146.0°E
Longitude
Vegetation Connectivity Score
0 = Absent
1 = Very Low
2 = Low
3 = Medium
4 = High
5 = Very High


Maribyrnong
Werribee
Yarra
Dandenong
Westernport
N
60 km
37.2°S
37.4°S
37.6°S
37.8°S
38.0°S
38.2°S
38.4°S
38.6°S
Latitude
144.5°E
145.0°E
145.5°E
146.0°E
Longitude
Instream Vegetation Score
0 = Absent
1 = Very Low
2 = Low
3 = Medium
4 = High
5 = Very High

Appendix F Progress towards vegetation value related RPOs

RPO	20/21 annual report
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.	Clearwater and Department of Environment, Land, Water and Planning have launched the Online Navigator Tool Resource Portal to assist planning system users identify stormwater management requirements set out in the Victoria Planning Provisions to protect the health of waterways from stormwater runoff. The Portal provides step-by-step guidance and advice, providing users with the knowledge and resources they need to ensure their subdivision or buildings and works development meets Victoria's stormwater planning requirements. Clearwater helped deliver integrated water management (IWM) capacity building in 2020-21 by presenting 11 events (including training on the constructed waterway design manual and construction hold points for constructed wetlands), connecting with 565 participants from 152 organisations, and fully funding two and partially funding one water leadership program scholarships (one of which is dedicated to emerging Indigenous water leaders).
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.	Melbourne Water has adaptively managed Environmental Entitlements in the Werribee, Yarra and Tarago systems. It has delivered flows on behalf of VEWH in accordance with the Seasonal Watering Plan for water dependent values in these systems, including several billabongs in the Yarra system. Melbourne Water are participating in the Victorian Government's Sustainable Water Strategy for the Central Region and Gippsland (CRGSWS). Department of Environment, Land, Water and Planning convened a number or working groups that were theme based which raised issues associated with the sustainable use of water resources in this region. Meetings for some of the working groups were held in September 2020, with representatives from various parts of Melbourne Water. Water Recovery for the Environment was discussed in the Environment Water SWS working Group (October, 2020). To date, nine meetings have been held for the Environment Working Group between Jun 2020 and April 2021. The discussion draft CRGSWS is currently being finalised and the environmental water shortfalls for the Werribee, Maribyrnong, Yarra and Tarago have been provided for consideration in the strategy. Melbourne Water, Southern Rural Water, Greater Western Water and DELWP are investigating opportunities to recover water for the environment by exploring options which range from transferring entitlements and use of stormwater and recycled water. The Werribee Irrigation District (WID) Modernisation Project has reduced losses through upgrades to channel infrastructure through the district. This recovered water is to be shared between the environment and WID users. The final volumes are yet to be determined (by SRW & Department of Environment, Land, Water and Planning), but is likely to be in the order of 2GL returned to the environment. The Greater Melbourne Urban Water System Strategy is also currently being drafted and will consider the options available for improving environmental water shortfalls in the Yarra catchment. Melbourne Water has maintained 7 Streamflow Management Plans in the Yarra catchment balancing the needs of surface water extractions and stream values in unregulated streams. Melbourne Water has investigated predicted impacts of climate change to determine the threats and intervention options available to minimise or mitigate future climate change pressures on stream values.

Stormwater

Several big initiatives occurred for stormwater this past year. **EPA flow guidance** was released setting out development standards for impervious run-off volumes in alignment with the Healthy Waterways Strategy stormwater targets. For more information **see Regional report, Stormwater RPO 14**.

Melbourne Water received $98M in stormwater funding to implement large scale stormwater treatment systems. This includes the Sunbury, Upper Merri Creek and Regional Stormwater Harvesting Schemes. These projects will be significant contributors to the stormwater targets, but contributions from co-delivery partners are also critical.

This is important because achieving the stormwater targets will require strong commitment and collaboration across local and state governments, water authorities and the development industry. Including the targets in industry guidance is a critical way to support their achievement.

Next we need to collectively act on the recommendations of the Regional Leadership Group and clarify roles and responsibilities around stormwater asset management and embed the new standards into the planning framework. Melbourne Water will deliver stormwater management over the next 5 years that maximises the benefits of the funding allocation.

The Healthy Waterways Strategy set out ambitious but critical targets for harvesting and infiltrating stormwater. These targets have been set in response to the Melbourne community's strong support for stormwater harvesting and infiltration to halt further degradation to waterways. While there are some inroads being made towards harvesting, the **infiltration targets are significantly off-track** (see Stormwater in the Report Card). **Key enablers have been discussed by the Regional Leadership Group (RLG)**.

This is important because we know urban development dramatically changes the way water moves through the landscape and is one of the biggest threats to the health of our waterways. **Infiltrating water into soils will protect base flows in waterways**, which we know is critical in a drier climate with more intensive storms. Retaining water in the landscape is also **important for urban cooling** and there are **multiple benefits** to be made through achieving the infiltration targets.

Next we need to ensure all new development designs-in infiltration measures. **Melton City Council are leading the way** by requiring runoff from all new roads to be directed into tree pits which will passively water street trees whenever it rains. The council have also mandated rainwater tanks on new lots (greater than 300 square meters) for toilet flushing and irrigation. For more information **see the Shading, cooling and greening Melbourne's public spaces case study**.

Environmental water

The Healthy Waterways Strategy targets for additional environmental water for Maribyrnong, Werribee, Yarra and Westernport catchments are **significantly off-track** because **shortfalls identified in 2006**, that were in the last Central and Gippsland Region Sustainable Water Strategy, **have not yet been recovered**.

Environmental water entitlements are volumes of water held by the Victorian Environmental Water Holder to ensure water is released from supply dams in a way which benefits the downstream waterway.

The **Discussion Draft of the Central and Gippsland Region Sustainable Water Strategy has been released for public consultation** and the environmental water shortfalls for our region have been provided for consideration in the strategy.

This is important because with climate change and population growth, water needs are becoming a critical concern for both people and the environment. Modelling during the development of the Healthy Waterways Strategy showed projections for platypus in particular are set to decline in a warmer and drier climate.

Next we need to ensure that these shortfalls are formally recognized in the final Central and Gippsland Region Sustainable Water Strategy and solutions are found to secure additional water. It is promising to see work is already well underway across agencies to consider options that will increase our supply by utilising all sources of water. The use of **manufactured water such as desalinised and fit-for-purpose recycled water as well as stormwater will be an important part of the solution**. It is also a relief that flow conditions have been quite good over the last year given good rainfall across the catchments.

Appendix G High quality vegetation sites outside of the HWS Protection areas.

Site ID	Catchment	Sub-catchment	VV21 quality score
360	Yarra	Woori Yallock Creek	5
302	Yarra	Yarra River Middle	5
343	Yarra	Yarra River Middle	5
286	Yarra	Plenty River Lower	5
354	Yarra	Little Yarra River and Hoddles Creek	5
283	Yarra	Diamond Creek (Rural)	5
443	Yarra	Brushy Creek	5
265	Yarra	Diamond Creek (Source)	4
209	Yarra	Olinda Creek	4
293	Yarra	Woori Yallock Creek	4
288	Yarra	Woori Yallock Creek	4
244	Yarra	Merri Creek Upper	4
252	Yarra	Diamond Creek (Source)	4
380	Yarra	Diamond Creek (Rural)	4
282	Yarra	Plenty River Lower	4
320	Yarra	Diamond Creek (Rural)	4
477	Yarra	Gardiners Creek	4
346	Yarra	Stringybark Creek	4
345	Yarra	Yarra River Lower	4
338	Yarra	Yarra River Lower	4
333	Yarra	Yarra River Lower	4
272	Yarra	Merri Creek Upper	4
463	Yarra	Olinda Creek	4
355	Yarra	Little Yarra River and Hoddles Creek	4
356	Yarra	Little Yarra River and Hoddles Creek	4
357	Yarra	Woori Yallock Creek	4
352	Yarra	Woori Yallock Creek	4
241	Yarra	Yarra River Middle	4
331	Yarra	Plenty River Lower	4
473	Yarra	Merri Creek Lower	4
347	Yarra	Mullum Mullum Creek	4
234	Yarra	Yarra River Lower	4
474	Yarra	Woori Yallock Creek	4
254	Yarra	Plenty River Upper	4
368	Yarra	Diamond Creek (Rural)	4
334	Yarra	Mullum Mullum Creek	4
336	Yarra	Yarra River Lower	4
323	Yarra	Yarra River Middle	4
68	Westernport	French and Phillip Islands	5

Site ID	Catchment	Sub-catchment	VV21 quality score
159	Westernport	Mornington Peninsula Western Creeks	5
505	Westernport	Mornington Peninsula South-Eastern Creeks	5
43	Westernport	Cardinia, Toomuc, Deep and Ararat Creeks	5
416	Westernport	Mornington Peninsula North-Eastern Creeks	5
225	Westernport	King Parrot and Musk Creeks	5
173	Westernport	Mornington Peninsula South-Eastern Creeks	5
37	Westernport	Bunyip River Middle and Upper	5
4	Westernport	Bass River	5
420	Westernport	French and Phillip Islands	5
162	Westernport	Mornington Peninsula Western Creeks	5
164	Westernport	Mornington Peninsula Western Creeks	5
157	Westernport	Mornington Peninsula Western Creeks	5
478	Westernport	Dalmore Outfalls	4
65	Westernport	French and Phillip Islands	4
66	Westernport	French and Phillip Islands	4
29	Westernport	Bunyip River Middle and Upper	4
67	Westernport	French and Phillip Islands	4
36	Westernport	Cardinia, Toomuc, Deep and Ararat Creeks	4
44	Westernport	Cardinia, Toomuc, Deep and Ararat Creeks	4
115	Westernport	Mornington Peninsula South-Eastern Creeks	4
464	Westernport	Mornington Peninsula Western Creeks	4
158	Westernport	Mornington Peninsula Western Creeks	4
506	Westernport	Mornington Peninsula South-Eastern Creeks	4
114	Westernport	Mornington Peninsula South-Eastern Creeks	4
468	Westernport	Dalmore Outfalls	4
430	Westernport	French and Phillip Islands	4
451	Westernport	Mornington Peninsula Western Creeks	4
439	Westernport	Cardinia, Toomuc, Deep and Ararat Creeks	4
417	Westernport	Mornington Peninsula North-Eastern Creeks	4
167	Westernport	Mornington Peninsula North-Eastern Creeks	4
172	Westernport	Mornington Peninsula South-Eastern Creeks	4
113	Westernport	Mornington Peninsula South-Eastern Creeks	4
195	Werribee	Toolern Creek	5
103	Werribee	Little River Upper	5
466	Werribee	Werribee River Lower	5
454	Werribee	Werribee River Lower	4
435	Werribee	Little River Upper	4
100	Werribee	Lollypop Creek	4
428	Werribee	Little River Lower	4
491	Werribee	Lollypop Creek	4
210	Werribee	Werribee River Lower	4
455	Werribee	Skeleton Creek	4

Site ID	Catchment	Sub-catchment	VV21 quality score
437	Werribee	Little River Lower	4
407	Werribee	Kororoit Creek Lower	4
201	Werribee	Parwan Creek	4
188	Werribee	Werribee River Upper	4
99	Werribee	Laverton Creek	4
76	Werribee	Kororoit Creek Lower	4
422	Werribee	Cherry Creek	4
438	Werribee	Little River Upper	4
187	Werribee	Werribee River Middle	4
205	Werribee	Werribee River Middle	4
298	Maribyrnong	Moonee Ponds Creek	5
152	Maribyrnong	Boyd Creek	5
449	Maribyrnong	Deep Creek Lower	4
125	Maribyrnong	Deep Creek Upper	4
135	Maribyrnong	Jacksons Creek	4
153	Maribyrnong	Deep Creek Lower	4
389	Maribyrnong	Jacksons Creek	4
143	Maribyrnong	Jacksons Creek	4
132	Maribyrnong	Deep Creek Upper	4
133	Maribyrnong	Deep Creek Upper	4
383	Maribyrnong	Deep Creek Upper	4
122	Maribyrnong	Deep Creek Upper	4
123	Maribyrnong	Deep Creek Upper	4
149	Maribyrnong	Jacksons Creek	4
140	Maribyrnong	Deep Creek Lower	4
150	Maribyrnong	Jacksons Creek	4
131	Maribyrnong	Emu Creek	4
441	Dandenong	Blind Creek	5
403	Dandenong	Dandenong Creek Middle	5
59	Dandenong	Corhanwarrabul, Monbulk and Ferny Creeks	4
419	Dandenong	Eumemmerring Creek	4
52	Dandenong	Dandenong Creek Upper	4
426	Dandenong	Kananook Creek	4
50	Dandenong	Corhanwarrabul, Monbulk and Ferny Creeks	4
411	Dandenong	Dandenong Creek Middle	4
71	Dandenong	Kananook Creek	4
413	Dandenong	Dandenong Creek Middle	4
400	Dandenong	Dandenong Creek Middle	4
51	Dandenong	Dandenong Creek Upper	4

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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 >>

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