MID-TERM REVIEW

Healthy Waterways Strategy 2018-2028

Port Phillip & Westernport, Victoria

Threats

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

CMA	catchment management authority
CGRSWS	Central and Gippsland Regional Sustainable Water Strategy
DCI	directly connected imperviousness
DEECA	Department of energy, environment and climate action
DELWP	Department of environment, land, water and planning
DSS	Developer Services scheme
eDNA	environmental DNA
EPA	Environmental Protection Authority
GED	general environmental duty
HSM	habitat suitability mode
HWS	Healthy Waterways Strategy 2018
LWD	large woody debris
MW	Melbourne Water
NRM	natural resource management
PPB EMP	Port Phillip Bay Environmental Management Plan
PPWPCMA	Port Phillip and Westernport catchment management authority
PO	performance objective
PSP	Precinct Structure Plan
ROMP	restoration outcomes monitoring protocol
RPO	regional performance objective
SC	sub-catchment
SCPO	Sub-catchment Performance Objective
SOC	statement of compliance
SWPA	stormwater priority area
STP	sewage treatment plant
Strategy	refers in this instance as the Healthy Waterways Strategy 2018
UBG	urban growth boundary

Acknowledgement of Traditional Owners

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

1. Introduction

The conceptual models that underpin the Healthy Waterway Strategy (HWS) outline how waterway conditions support the environmental and social values. Threats are issues, activities or processes (e.g. urban development, dispersal of weeds, agricultural practices) which adversely impact conditions (e.g. flow regimes, water quality) and therefore the values. For example, farm dams can reduce baseflows which impacts platypus.

The status and trajectory of threats was assessed during the development of the HWS alongside the status and trajectory of condition and values. For instream values (e.g. platypus, fish and macroinvertebrates), habitat suitability models were used to predict impacts from some threats including urbanisation and climate change. For other values, threats were assessed in a more qualitative way.

Climate change and urbanisation were considered to be the two biggest threats facing our waterways as demonstrated using the Habitat suitability models. Priority areas were identified using the prioritisation software zonation which uses the outputs of the HSMs along with cost for different actions. It was assumed that all impacts of new urban development would be mitigated in these areas over the next 10 years and that over the long term there would be gradual improvements made in existing urban areas as the city redevelops. Climate change impacts were assumed to be particularly severe for Platypus. Through the HWS co-design process it was decided that attempts would be made to maintain baseflows to protect platypus populations from climate change.

For the first time the HWS made explicit the effort required to address threats and as such long term targets were sometimes about holding the line.

Threats to environmental values

For the purposes of this evaluation, threats have been categorised into 4 groups and 13 categories which largely reflect different activities or landuse types (see Table 1).

Climate change is one of the threat groupings but also recognised that it influences other threats. A separate HSM paper (Chee, Coleman, et al. 2022) summarises updated knowledge on climate change with respect to instream values. A high level summary of new knowledge around climate change on remaining values is presented below and is based on current research through the Waterways Research Practice Partnership.

The other threat groupings include **urban related threats** such as urban development, wastewater, litter and physical modifications to assets; **rural related threats** including agricultural practices and water use (both for agriculture and potable uses); and **habitat related threats** including pest plants, animals, instream barriers, recreational access and vegetation clearing.

The urbanisation threat has been separated into flow related and water quality related impacts because, while they are interrelated, flow impacts from impervious runoff have not been adequately represented in the past and require different management approaches.

Table 1. Threat groupings and description of each threat category

Threat category	Description
Climate change (can also influence other threats)	Water and air temperature increases, reduction in average rainfall and annual flow volumes, increased storm intensity and floods, increased bushfires, increased frequency of storms, increased urban heat island, sea level rise
Urban related threats	
Urbanisation (flow impacts)	Impervious surfaces increase runoff which can adversely impact flow regimes if not adequately managed. Urbanisation can also lead to elevated pollutant levels. The focus on flow impacts here is because the HWS has set targets for managing stormwater volumes in recognition of the impact excess runoff has on stream health. Historically management has focused on treating water quality to best practice standards with no clear guidance or regulation for managing the flow impacts. It is assumed that treatment systems to manage flow will also address typical water quality impacts from residential areas. The higher risk water quality impacts like toxicants which typically come from industrial areas, are separated into the Urbanisation (water quality) threat category discussed below.
Urbanisation (water quality)	Urban landuses typically lead to elevated pollutants including sediments, nutrients, toxicants and microplastics. Industrial landuses typically have higher risk profiles and require tailored interventions. This threat category also includes the threat of elevated pollutants during the construction phase of development.
Wastewater	Sewerage treatment plants, emergency relief structures, spills, untreated sewerage ingress, poor septic performance/maintenance. Recycled wateruse.
Physical modifications	Urban development waterway corridor encroachment leading to additional lighting, noise and litter along waterways. Piping or modification of headwater streams and building over wetlands, drains and levees, deepening for flood storage, LWD removal, illegal alteration of waterway (e.g. channelization) or creation of on-line wetlands.
Litter	Litter from urban areas, fishing equipment, opera house traps, grates (stormwater/water supply)
Rural related threats	
Water availability	Potable water supply dams, agricultural and other water demands e.g. surface water diversions, groundwater extractions, farm dams. Unregulated flows are closely related to the agricultural threat.
Agriculture	Agriculture practices with a focus on water quality impacts from runoff. Issues include intensification of farming, pesticide drift, vegetation clearing. Cattle impacts on headwater streams. Water use is closely linked to the water availability threat.
Habitat related threats	
Instream barriers	Gauging station weirs, dam walls, erosion control structures
Recreational access (in forested areas)	legal and illegal access e.g. use of the formal/designated road and track network as well as illegal off-road trail creation. Impacts can lead to noise, light, litter, excrement, dogs, erosion, and vegetation clearance.
Animals	Unfenced grazing land e.g. cattle, deer, rabbits and over abundant native wildlife (e.g. kangaroos). Issues include over grazing, trampling, pugging, introduction of weeds and bank erosion. Predators e.g. exotic fish, dogs and cats.
Pest plants	high risk weeds, over abundant native species e.g. common Reed, Typha
Vegetation clearing	Illegal tree removal and forestry practices.

Conceptual models

The HWS conceptual models include relationships between conditions and values. They are represented as diagrams (see Appendix 3) and also a database which contains more information and references. While the HWS conceptual models developed in 2018 include a description of threats in the database they are expressed as statements of undesirable condition and it was the management

lever which indicated what threat needed to be managed. In developing this paper we have reconciled the threats as articulated in the 2018 models to those expressed above. Table 2 summarises the moderate and strong value/condition relationships by condition groupings.

Given the importance of understanding what activities (and hence management actions) lead to undesirable conditions it would be worthwhile making the threats explicit in the conceptual model diagrams.

Table 2. Linkages between values, environmental conditions and threats. Dark green represents strong relationships, light green represents moderate relationships between conditions and threats.

Environmental condition	Threat (2018 conceptual models)	Threat 2022 (Threat category)	macros	Platypus	Birds	veg	Fish	Frogs
Abundance of macroinvertebrates	Degraded habitats (Loss of instream habitat (sedimentation))	Urbanisation (flow impacts and water quality), vegetation clearing, physical modification, agriculture, pest animals, wastewater, water availability						
Abundance of macroinvertebrates	Degraded habitats(Degraded riparian vegetation (large trees))	Vegetation clearing, pest animals, climate change, physical modification, wastewater, urbanisation (flow impacts and water quality), agriculture, water availability						
Abundance of macroinvertebrates	Invasive Flora and Fauna (Invasive Flora (Riparian (Trees)	Pest animals, pest plants, wastewater, urbanisation (flow impacts and water quality), agriculture, physical modification, water availability						
Abundance of macroinvertebrates	Poor water quality (Degraded water quality EC, turbidity, pH, P)	Vegetation clearing, pest animals, urbanisation (flow impacts and water quality), agriculture, physical modification, wastewater, water availability						

Environmental condition	Threat (2018 conceptual models)	Threat 2022 (Threat category)	macros	Platypus	Birds	veg	Fish	Frogs
Baseflows	Altered water regimes (Altered water regime (Increase in low flow magnitude)	Urbanisation (flow impacts), Urbanisation (WQ impacts), water availability, wastewater, instream barriers						
Freshes	Altered water regimes (Altered water regime (Reduction in high flow magnitude)	Instream barriers, water availability, urbanisation (flow impacts)						
Hydraulic environment	Altered water regimes (Changed water regime)	Instream barriers, water availability, urbanisation (flow), wastewater						
Overbank flows	Altered water regimes (Altered water regime (Reduction in high flow magnitude)	Instream barriers, water availability, urbanisation (flow impacts), climate change						
Wetland inundation extent	Altered physical form (Altered wetland form)	Physical modification, agriculture, climate change, vegetation clearing, water availability						
Wetland inundation extent	Altered physical form (Reduced estuary extent)	Physical modification, agriculture, climate change, vegetation clearing, water availability						
Wetland inundation extent	Altered physical form (Reduced wetland area)	Physical modification, agriculture, climate change, vegetation clearing, water availability						
Wetland inundation extent	Reduced connectivity (Reduced Floodplain and wetland connectivity)	Physical modification, agriculture, climate change, vegetation clearing, water availability, urbanisation (flows)						
Wetland inundation regime	Altered physical form (Altered wetland form)	Water availability, physical modification, climate change, urbanisation (flows), pest animals						
Wetland inundation regime	Altered physical form (Reduced wetland area)	Water availability, physical modification, climate change, urbanisation (flows), pest animals						
Wetland inundation regime	Reduced connectivity (Reduced Floodplain and wetland connectivity)	Water availability, physical modification, climate change, urbanisation (flows)						

Environmental condition	Threat (2018 conceptual models)	Threat 2022 (Threat category)	macros	Platypus	Birds	veg	Fish	Frogs
Bank composition	Altered physical form (Bank instability)	Pest animals, agriculture, physical modification, vegetation clearing, pest plants, urbanisation (flows)						
Bed composition	Altered physical form (Bed instability (Degradation)	Vegetation clearing, physical modification, , urbanisation (flows)						
Connectivity of habitat areas	Degraded habitats (Degraded buffer vegetation)	Vegetation clearing, pest animals, pest plants, climate change, physical modification, agriculture, , urbanisation (flows)						
Connectivity of habitat areas	Reduced connectivity (Barriers to fish migration)	Instream barriers						
Connectivity of habitat areas	Reduced connectivity (Reduced Floodplain and wetland connectivity)	Physical modification, vegetation clearing, pest animals, pest plants, climate change, urbanisation (flows), water availability						
Connectivity of habitat areas	Reduced connectivity (Reduced floodplain connectivity)	Vegetation clearing, pest animals, pest plants, physical modification, climate change, wastewater, water availability						
Connectivity of habitat areas	Reduced connectivity (Riparian connectivity (Longitudinal connectivity)	Vegetation clearing, pest animals, pest plants, physical modification, climate change, wastewater						
Connectivity of habitat areas	Reduced connectivity (Riparian connectivity (Vegetation width)	Vegetation clearing, pest animals, pest plants, physical modification, climate change, wastewater						
Large wood and coarse woody debris	Degraded habitats (Loss of instream habitat (large wood))	Physical modification, vegetation clearing						
Riparian rock habitat	Degraded habitats (Degraded buffer vegetation)	Vegetation clearing, physical modification						
Wetland habitat form	Altered physical form (Altered wetland form)	Instream barriers, water availability, physical modification, agriculture, vegetation clearing						

Environmental condition	Threat (2018 conceptual models)	Threat 2022 (Threat category)	macros	Platypus	Birds	veg	Fish	Frogs
Fringing non-woody vegetation	Degraded habitats (Degraded buffer vegetation)	Pest animals, agriculture, pest plants, vegetation clearing, physical modification, climate change						
Fringing woody vegetation	Degraded habitats(Degraded riparian vegetation (large trees))	Pest animals, agriculture, pest plants, vegetation clearing, physical modification, climate change						
Fringing woody vegetation	Reduced connectivity (Riparian connectivity (Longitudinal connectivity)	Pest animals, agriculture, pest plants, vegetation clearing, physical modification, climate change						
Fringing woody vegetation	Reduced connectivity (Riparian connectivity (Vegetation width)	Pest animals, agriculture, pest plants, vegetation clearing, physical modification, climate change						
Submerged vegetation	Altered water regimes (Changed water regime)	Water availability, climate change						
Submerged vegetation	Degraded habitats (Altered extent of aquatic macrophytes)	Physical Modification, Agriculture, Urbanisation (flows)						
Submerged vegetation	Degraded habitats (Degraded buffer vegetation)	Vegetation clearing, pest animals, physical modification						
Weeds	Invasive Flora and Fauna (Invasive Flora (Riparian (Ground Layer)	Pest animals, pest plants						
Weeds	Invasive Flora and Fauna (Invasive Flora (Riparian (Shrub Layer)	Pest animals, pest plants						
Weeds	Invasive Flora and Fauna (Invasive Flora (Riparian (Trees)	Pest animals, pest plants						
Invasive native bird species	Invasive Fauna (Terrestrial)	Pest animals						
Pest mammals	Invasive Fauna (Terrestrial)	Pest animals						
Chytridiomycosis infectious disease		Disease						
Pest fish species	Invasive Fauna (Aquatic)	Pest Animals						

Environmental condition	Threat (2018 conceptual models)	Threat 2022 (Threat category)	macros	Platypus	Birds	veg	Fish	Frogs
Dissolved oxygen	Poor water quality (Degraded water quality (Algal blooms, fish deaths)	Instream barriers, water availability, wastewater, urbanisation (WQ impacts)						
Dissolved oxygen	Poor water quality (Degraded water quality (DO, turbidity, pH, Chlorophyll a)	Instream barriers, water availability, wastewater, urbanisation (WQ impacts)						
Dissolved oxygen	Poor water quality (Degraded water quality EC, turbidity, pH, P)	Instream barriers, water availability, wastewater, urbanisation (WQ impacts)						
Litter and fishing equipment		Litter						
Nutrient concentration (Nitrogen, phosphorus)	Poor water quality (Changed water properties (Nutrients, Algal blooms, fish deaths)	Agriculture, pest animals, recreational access, urbanisation (flow impacts and water quality), wastewater, physical modification						
Nutrient concentration (Nitrogen, phosphorus)	Poor water quality (Degraded water quality (DO, turbidity, pH, Chlorophyll a)	Agriculture, pest animals, recreational access, urbanisation (flow impacts and water quality), wastewater, physical modification						
Nutrient concentration (Nitrogen, phosphorus)	Poor water quality (Degraded water quality EC, turbidity, pH, P)	Agriculture, pest animals, recreational access, urbanisation (flow impacts and water quality), wastewater, physical modification						
pH	Poor water quality (Degraded water quality EC, turbidity, pH, P)	Urbanisation (WQ), wastewater, agriculture, water availability						
Salinity	Poor water quality (Degraded water quality EC, turbidity, pH, P)	Instream barriers, water availability, wastewater, urbanisation (flow impacts and water quality), agriculture, physical modification						
Suspended sediment loads and turbidity	Altered physical form (Bed instability (Degradation)	Agriculture, pest animals, physical modification, recreational access, urbanisation (flow impacts), wastewater						
Suspended sediment loads and turbidity	Poor water quality (Degraded water quality EC, turbidity, pH, P)	Agriculture, pest animals, physical modification, recreational access, urbanisation (flow impacts and water quality), wastewater						
Toxicity and heavy metals	Poor water quality (Degraded water quality SIGNAL)	Urbanisation (flow impacts and water quality), wastewater, agriculture, water availability						
Water temperature	Poor water quality (Thermal water pollution)	Vegetation clearing, water availability, climate change, instream barriers						

Threats to social values

The conceptual models developed for the social values (Jacobs 2018) include a list of threats and the social values technical report (Macroinvertebrates: A Technical Report to Inform the Healthy Waterways Strategy Mid-term Evaluation) has updated information relating to threats. Given time and data limitations a comprehensive evaluation of where threats to social values are increasing was not possible. However as there is overlap between threats to social and environmental values some of the results in this paper are relevant to both social and environmental values. Table 3 provides a summary of threats to social values as they relate to social value conditions and whether these threats are also environmental value threats.

Table 3. Threats to social values and how they relate to the environmental threats

Social Value Condition	Social value threat category	Link to env threats
Physical form (corridor width, channel form)	**Urbanisation**: Inappropriate urban development reducing waterway corridor (width) through encroachment, overshadowing, views and vistas. Physical alterations: piping or modification of headwater streams and building over wetlands, drains and levees, deepening for	Physical modifications

Social Value Condition	Social value threat category	Link to env threats
	flood storage, LWD removal, illegal alteration of waterway (e.g. channelization) or creation of on-line wetlands.	
Vegetation	**Climate change**: reduction in average rainfall and annual flow volumes, increased storm intensity and floods, increased bushfires, increased frequency of storms, increased urban heat island, sea level rise, increased invasive species. **Vegetation clearing**: Illegal tree removal and forestry practices. **Access**: Poor or inappropriate access (i.e. into sensitive areas)	Climate change Vegetation clearing Not related
Water Quality	**Litter**: from urban areas, dumping, fishing equipment, opera house traps, grates (stormwater/water supply). **Wastewater**: Sewerage treatment plants, emergency relief structures, spills, untreated sewerage ingress, poor septic performance/maintenance. Recycled water use. **Urbanisation**: Urban land uses typically lead to elevated pollutants including sediments, nutrients, toxicants and micro plastics. Industrial land uses typically have higher risk profiles and require tailored interventions. This threat category also includes the threat of elevated pollutants during the construction phase of development. **Odours:** from chemical spills, stormwater run-off and septic tanks	Litter threat Wastewater threat Urban water quality threat
Water Regime	**Climate change:** reduced rainfall and runoff **Water use**: Potable water supply dams, agricultural and other water demands e.g. surface water diversions, groundwater extractions, farm dams. Unregulated flows are closely related to the agricultural threat.	Climate change Water use threat
Biodiversity (Native species)	**Access and recreation**: as a counter to increased human access and recreation from use of the formal/designated road and track network as well as illegal off-road trail creation. Impacts can lead to noise, light, litter, excrement (pollution), dogs (pests), erosion, and vegetation clearance which can impact biodiversity habitats, breeding and other behaviours. **Vegetation clearing**: Illegal tree removal and forestry practices. **Pest, plants and animals**: Unfenced grazing land (e.g. cattle, deer, rabbits etc.) over abundant native wildlife. Issues include over grazing, trampling, pugging, introduction of weeds and bank erosion. Predators e.g. exotic fish, dogs and cats disturbing native species. **Instream barriers**: restricting migration and movement, such as gauging station weirs, dam walls, erosion control structures, roads and other urban development infrastructure. **Access**: Poor or inappropriate access (i.e. into sensitive areas) **Light and noise**: introduced as parkland or urban infrastructure, increased human activities, events or urbanisation	Recreational access threat Vegetation clearing threat Pest plants and animals threat Instream barriers Recreational access threat Physical modifications threat
Facilities - Access	**Inappropriate maintenance:** unsightly or unsafe vegetation crossing/blocking paths. Path damaged caused by flooding and erosion. On-water access impacted by instream (high-value) habitat (e.g. snags). **Poor planning and collaboration**: Incomplete trails or located in inappropriate areas (e.g. trail or on-water ramps consistently impacted by flooding) **Safety**: Inappropriate/poor lighting, poor signage, low visitation (passive surveillance. **Urbanisation:** development, including private property or public infrastructure (e.g. roads, rail) that blocks continuous movement along a waterway corridor. **Climate Change**: paths and on-water access (e.g. boat ramps) impacted from rising sea levels (particularly in estuaries), increased flooding and bushfire.	Not related Not related Not related Not related Climate change

Social Value Condition	Social value threat category	Link to env threats
Organised events (social, recreational, cultural, sporting, art) and organised connections (e.g. citizen science, NRM groups, Caring for Country)	**Lack of appropriate facilities**: including assets for accessing, securely displaying (e.g. art) and which is available for a range of abilities. **Catastrophic events**: natural events such as flooding and bushfires may take facilities and spaces out of use temporarily or permanently. Human related issues such as pandemics have been seen to halt community events. **Climate change**: causing health or wellbeing issues may result in people not being able or wanting to visit waterways (e.g. urban heat)	Not related Climate change Climate change

KEQ purpose and scope

The following KEQ underpins the evaluation in this paper:

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

This evaluation is complementary to the HSM sub-catchment analysis which evaluated the updated climate projections and the impacts of urbanisation since 2018 (Chee, Coleman et al). As these models do not include all values or threats, supplementary data and evidence has been used.

The aims of this evaluation are to:

- Understand the implications of any changed assumptions and changes to the operating environment and to flag new or emerging trends which may be important for the next HWS.
- Prioritise broadscale threats which require a regional approach to management and flag any new and merging threats
- Determine whether the HWS has adequate performance objectives to address important threats
- Identify important knowledge gaps

As the social values framework is still under development and due to time and data constraints, threats relating solely to social values are not evaluated in this paper. As mentioned above many of the environmental threats are also relevant to social values and as such the evaluation results are applicable to social values as well.

2. Evaluation methodology

The process to summarise threats in the region and evaluate certain aspects of the threat is outlined in Table 4.

Table 4. Approach to capturing information and evaluative criteria for assessing threats

Step	Approach	Method
1	Describe each threat and document general information such as activities related to the threat, conditions and values that are impacted by the threat, whether it's a threat to rivers, wetlands or estuaries.	Input from Melbourne Water staff and existing HWS resource documents. Refer to Table 2 for relationship between values and threats.
2	Document data and assumptions made in 2018 including confidence in the assessment and how climate change was considered to influence the threat.	Input from Melbourne Water staff and existing HWS resource documents. Confidence rating based on: High = data driven Fair = combination of data and expert opinion Low = expert opinion
3	Summarise the types of performance objectives in the HWS that are aimed at addressing the various threats. Undertake an assessment of progress towards 10 yr targets for POs for rivers which have quantitative targets. Identify any gaps in the HWS ie where there are no POs for a particular threat.	Developed rubrics for quantitative performance objectives to assess if sub catchments were on-track, slightly off-track or significantly off-track. High level assessment of PO gaps.
4	Evaluate the threat trajectory for each sub-catchment using criteria drawing on a mix of data and expert elicitation. Document confidence in the assessment.	Assessed as increasing, stable or decreasing for each of the 69 sub-catchments. Confidence rating based on: High – data driven Moderate – mixture of data and expert opinion Low – anecdotal / expert opinion
5	Document any changed assumptions since 2018 or changes to the operating environment.	Input from Melbourne Water staff and existing HWS resource documents.
6	Summarise new and emerging information relating to each threat from the MW research programs and document new and emerging datasets.	MW Waterways Research fact sheets and input from Melbourne Water staff.
7	Summarise remaining priority knowledge gaps	MW Waterways Research fact sheets and input from Melbourne Water staff.

Threat trajectory and PO assessment methodology

An assessment of each individual threat at a sub-catchment scale was undertaken to determine whether the threat is increasing, decreasing or stable. A confidence rating was assigned to each threat class. Low confidence was typically assigned to threats where there was very limited or no data and expert elicitation was used. If a threat is increasing it implies that intervention is not mitigating the *increasing* threat (e.g. impacts of new urban development are not being addressed and as such the threat is increasing across the region). This is different to reducing an existing threat (e.g. removing fish barriers reduces the threat as no new barriers are being constructed and hence there is a net reduction in the threat). An example of a stable threat is STP discharges where they are not increasing their pollutant load discharges. Another example is a fully developed urban area.

In order to provide insights into the extent of management of these threats, an assessment of progress towards performance objectives at the sub-catchment scale was undertaken. This information will also be used in the synthesis analysis and the implementation enquiry.

The assessment does not consider the possible impacts of combined threats.

Table 5 below presents an overview of the different types of sub-catchment performance objectives for rivers and whether the targets are quantitative or not. For the quantitative performance objectives progress has been evaluated using criteria and standards set out in each threat section below. Progress reports are an annual written summary of activities which contribute towards achievement of the performance objective.

Table 5. Overview of different types of sub-catchment performance objectives (for rivers) and how they are reported annually

SCPO group	Sub-catchment performance objectives theme/s	Tracking method
Habitat	Improve connectivity for fish Mitigate threats to physical form Protect specific values Re-engage floodplains	Quantitative target Progress report Progress report Progress report
Vegetation	Increase vegetation extent Maintain vegetation quality Protect high quality vegetation	Quantitative target Quantitative target Progress report
Pests	Implicit in vegetation SPCOs	See above
Water for the environment	Increase environmental water reserve in regulated systems Maintain or improve flow regimes in unregulated systems	Quantitative target Progress report
Water quality	Agricultural run-off Sewerage Treatment Plants discharges Septic tanks Industrial pollution Sediment run-off from construction activity	Quantitative target Quantitative target Progress report Progress report Progress report
Stormwater	Treat **new urban** development (maintain DCI at pre development levels) Treat new and **existing development** (reduce DCI)	Quantitative target Progress report

Limitations to the evaluation

There are a number of limitations to this review including:

- Some threats could not be assessed due to knowledge gaps
- There is low confidence in some threat trajectories due to data limitations or the use of expert elicitation (e.g. weed threat)
- Threats specific to social values could not be assessed due to data limitations
- Due to time limitations, a comprehensive analysis of changed assumptions and changes to the operating environment was not possible
- The assessment of climate change was limited to a few species and a restricted range of potential climate change impacts
- Progress towards some performance objectives could not be assessed as they do not have quantitative indicators or rubrics

- The evaluation focused on the extent to which threats are increasing across the region (e.g. new urban development). It did not assess whether existing threats (e.g. existing rural land) are leading to declines in conditions and values
- New and emerging data on threats and knowledge gaps was limited to information derived from the Melbourne Waterways Research program

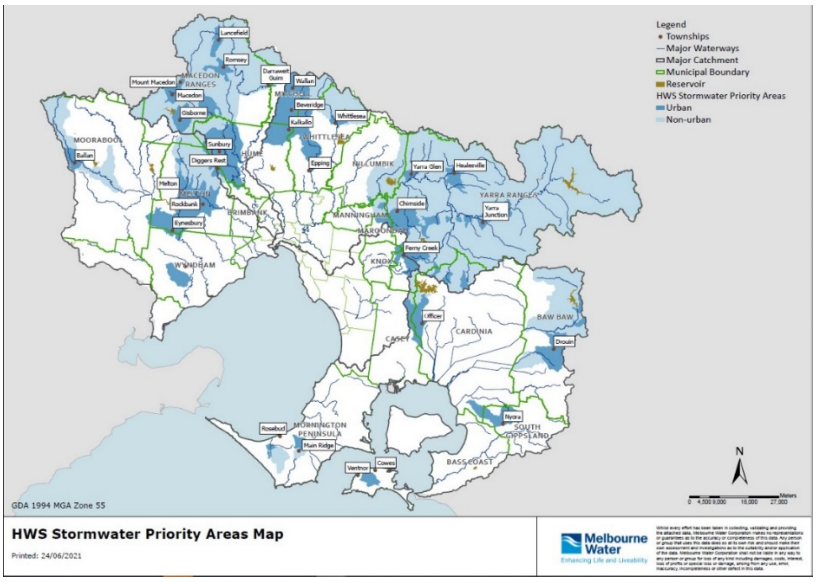
3. Results

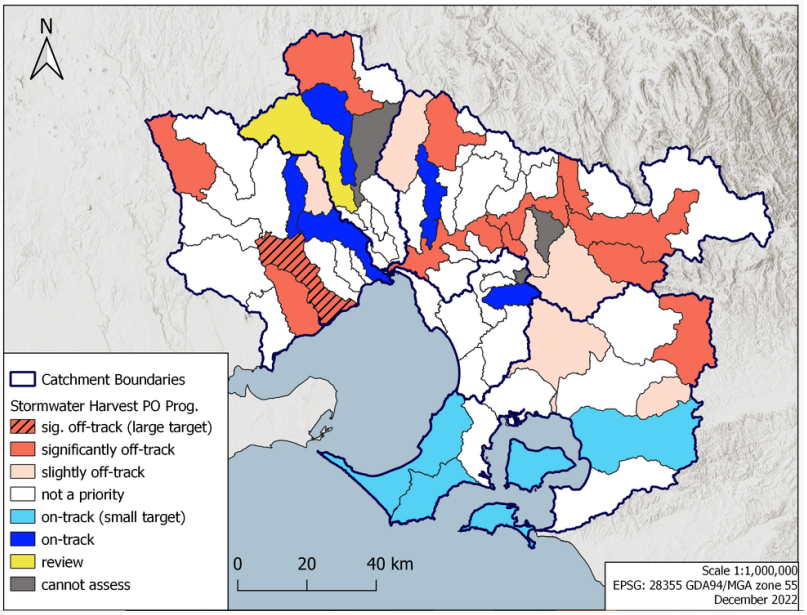
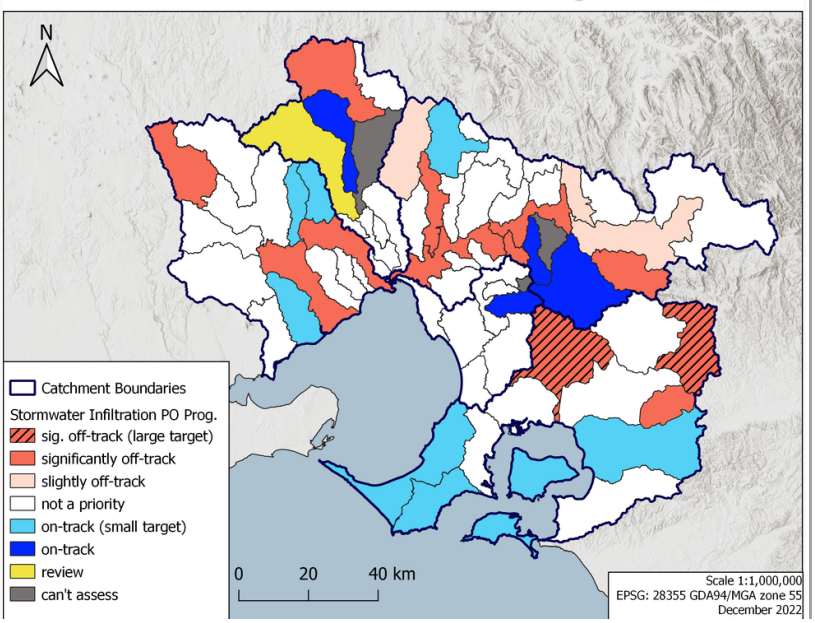
Results are summarised in a series of tables for each threat and grouped into urban related threats, rural related threats and habitat related threats.

URBAN RELATED THREATS

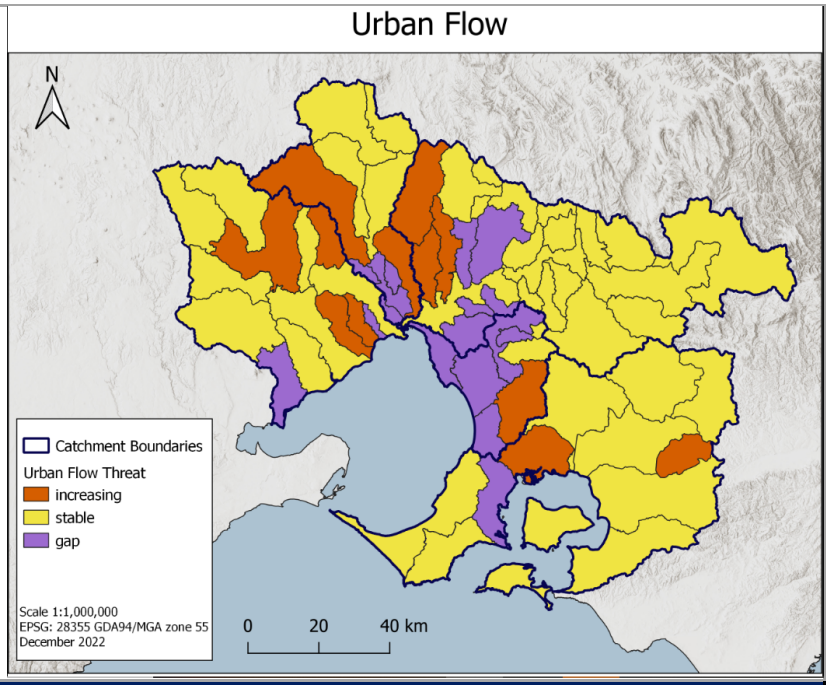
Urbanisation (flow impacts)

General Information	
Impervious surfaces increase runoff which can adversely impact flow regimes if not adequately managed. Urbanisation can also lead to elevated pollutant levels. The focus on flow impacts here is because the HWS has set targets for managing stormwater volumes in recognition of the impact excess runoff has on stream health. Historically management has focused on treating water quality to best practice standards with no clear guidance or regulation for managing the flow impacts. It is assumed that treatment systems to manage flow will also address typical water quality impacts from residential areas. The higher risk water quality impacts like toxicants which typically come from industrial areas, are separated into the Urbanisation (water quality) threat category discussed below.	
Activities related to the threat	Urban development leading to increased directly connected impervious (DCI) surfaces which changes flow regimes.
Conditions impacted by the threat Primary Secondary	 Stormwater (focus on changes to the flow regime) Physical form, Water quality, vegetation
Values impacted by the threat	Macroinvertebrates, platypus, fish, frogs, vegetation, birds
Asset impacted by the threat	Rivers, wetlands and estuaries
Data and assumptions made in 2018	
Datasets used in 2018	Impervious area mapping (used in HSMs) provided 2018 baseline. Future impervious estimates based on planning zone data (under Plan Melbourne) used to assess long term threat under a business as usual future (full development). Estimates made of expected development in 10 year HWS period based on best available data (Spatial Economics)
Confidence Key assumptions	Good - **Rivers** **Macros, platypus, fish:** Habitat Suitability Models use current and future DCI as a predictor variable. **Birds**: Experts forecast riparian bird condition ~20 years ahead given planned urban growth **Frogs**: Expert opinion / conceptual model used to give a broad assumption that changed flows from urbanisation will negatively impact frogs. **Vegetation**: Expert opinion / conceptual model used to give a broad assumption that changed flows from urbanisation will degrade vegetation.

	Good - **Wetlands** Discussion paper on wetlands based on SME considered urbanisation and climate change as biggest impacts on wetlands. Good - **Estuaries** **Birds**: Experts forecast riparian bird condition ~20 years ahead, when planned urban growth is in place and climate change effects will be apparent, assuming current policies and levels of investment in the management of our waterways.
How climate change was considered to influence the threat	Urbanisation and climate changes were assessed as a combined threat in the HSMs. The dynamics (e.g. storm intensity) of impacts of climate change on stormwater were not considered.
Performance objectives	
Existing regional performance objectives	Several RPOs focused around foundational activities e.g. improving capacity, policy, guidance e.g. RPO 13 Industry capacity for whole of water cycle and stormwater management is increased to enable collaboration, improved access to information and knowledge, and a skilful and capable industry with strong established networks. RPO 14 Standards, tools and guidelines are in place and implemented to enable re-use and infiltration of excess stormwater, and protect and/or restore urban waterways.
Sub-catchment performance objectives	Sub-catchment performance objectives were developed for priority areas using a combination of HSMs and zonation along with co-design workshops and areas where there was already commitments for significant IWM funding (e.g. Upper Merri Creek).  **Rivers example** - To prevent decline in stormwater condition, treat urban development in the upper reaches of Cherry Creek (e.g. Mambourin), so directly connected imperviousness (DCI) of Cherry Creek remains below 0.2% at Princes Freeway. For every hectare of new impervious area, this requires harvesting around 3.2 ML/y and infiltrating 0.5 ML/y. **Wetlands** – Implement urban stormwater treatment measures in the catchment to reduce the threat of poor water quality in Lilydale Lake.

	Estuaries - None – assumption that POs for rivers will benefit estuaries
Progress	Rivers sub-catchment (SC) performance objectives: Progress towards the stormwater performance objectives is based on completed and planned works. The 10 year volume target is based on an estimate of development in the life of the HWS. On-track = >40% of the 10 yr target Slightly off-track = 10-40% 10 yr target Significantly off-track = < 10% 10 yr target Large target = > 500ML/y (harvest), >150 ML/y (infiltrate) Small target = < 50 ML/y (harvest), < 25 ML/y (infiltrate) Stormwater Harvest PO Progress  Stormwater Infiltration PO Progress 

Gap / issue ?	Inclusion of planned stormwater treatment assets like constructed wetlands and raingardens, in annual progress reporting is a risk as it does not reflect the impact of unmitigated stormwater. Confidence in estimating 10 yr development forecasts in terms of impervious areas for each stormwater priority area is relatively low. For example development since 2018 has already exceeded the expected 10 year target for Jacksons Creek. A review of these estimates for the coming years is required and an improved dataset for setting the next HWS is also should also be a priority and should include areas outside SWPAs. Reporting of stormwater treatment outside of priority areas is not currently undertaken. It has been a significant undertaking to establish good reporting for priority areas. There is work underway with the IWM MERI working group which is investigating how reporting can be expanded to all areas across the region.
Threat trajectory	
Assessment of threat trajectory	Threat trajectory was based on a combination of updated DCI data and known areas of significant future development (e.g. PSPs). Appendix 1 outlines the methodology used to update DCI. This data is also used in the updated HSMs to assess HWS effectiveness. **Increasing**: In HWS SWPAs where DCI has increased by at least 0.1-2.5% from 2014 resulting from developments which occurred 2019-2022 as indicated by statements of compliance. For non- priority areas where with Precinct Structure Plans (PSPs) in place that are greater than 8ha. **Stable**: In HWS SWPAs where DCI increase is less than 0.1% from 2014 resulting from developments which occurred 2019-2022 as indicated by statements of compliance. For all predominately rural or forested sub-catchments. **Decreasing**: In HWS SWPAs where DCI has declined from 2014 resulting from interventions which are reducing the threat at a sub-catchment scale. DCI dataset indicates no decreasing threat in any SWPA. **Data gap**: Infill and other greenfield development outside stormwater priority areas – unless the sub-catchment has a PSP which is > 8h (indicating that there is going to be significant development in the sub-catchment in the future). Data outside priority areas is a current gap. Confidence in assessment – high Anecdotal evidence - Lot sizes are getting smaller making it harder to achieve stormwater objectives. For example Melton City council require all developments to include passively watered street trees. However with smaller lot sizes it is proving very difficult to fit all necessary services within the road reserve. (discussions with MW and council)
Where has the threat increased or decreased since 2018?	



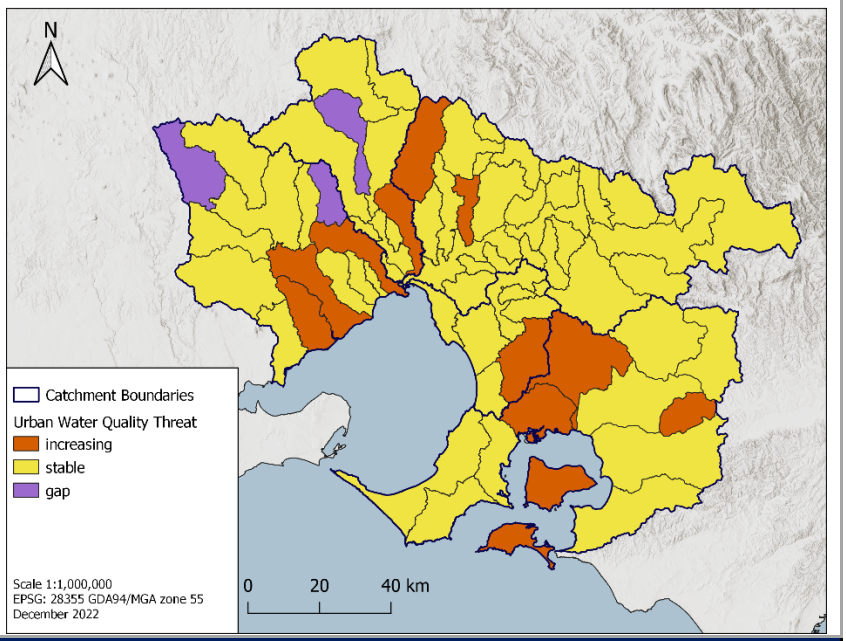
Changed assumptions and operating environment	
Have assumptions changed?	Long term assumptions on extent of urban development need to be updated to include new rezoning not accounted for in 2018. While there has not been any changes to the UGB, there has been some new PSP areas.
Has there been any policy changes since 2018 that influences the threat?	Assumptions around lot densities need reviewing given possible trends for smaller lot sizes. The assumption that all new development in SWPAs will be mitigated through achievement of HWS targets needs to be reviewed. The general environmental duty (GED) introduced under the Environment Protection Act 2017 is a new framework for environmental protection that focuses on threat prevention rather than management of impacts. Under the GED, industries have a responsibility to understand, manage and mitigate their impacts as much as is reasonably practicable in order to protect human health and the environment. The EPA, with input from Melbourne Water and others, developed new Stormwater Industry guidance that aligns with the HWS stormwater targets for priority areas. The new Central and Gippsland Sustainable Water Strategy (2021) supports the development of several strategies that in principle support the HWS stormwater harvesting and infiltration targets. Integrated Water Management catchment plans (led by DELWP – now known as DEECA)). At this stage Melbourne Water have not updated Developer Services Schemes to reflect the new flow objectives. Some councils (e.g. Melton) are requiring some compliance with flow objectives via their

	requirements on new developments to install passively watered street trees and rainwater tanks.
New and emerging	
Melbourne Water Waterways and Wetlands Research Program	A1. Spatial prioritization of management actions for biodiversity outcomes in streams & wetlands. (HSM updates and improvements, development of HSM's for wetlands) Long term research and intervention monitoring (e.g. Little Stringybark Ck, Dobsons Creek and Sunbury) provide good insights into how to manage the threat. D1 Understand the role of small headwater streams in urbanizing catchments for supporting waterway health. Focused on understanding the value of headwater streams, the impacts on local and downstream river health if they are lost from the landscape, and how they might be protected in the face of urban development.
New and emerging datasets	Near Map impervious surface mapping for the entire region for 2012, 2014, 2018 and 2022. Developer Services Scheme WSUD infrastructure timing and design effectiveness for stormwater priority areas.
Knowledge gaps	
What are the priority knowledge gaps for this threat?	Need to better understand how flow changes associated with climate change will influence the threat (e.g. increased storm intensity) and how interventions can mitigate these compounding threats (e.g. smart tanks). Implementation barriers e.g. policy, guidance, capacity and funding, sector willingness. To improve HSMs we need to improve predictions of future development including development densities for shorter time periods e.g. 10 years in addition to full development.

Urbanisation (water quality impacts)

General Information	
Activities related to the threat	Urban landuses that generate pollutants such as nutrients, sediment and toxicants. While current best practice adequately manages nutrients and sediments from residential areas toxicants from industrial areas and sediments from the construction phase of development are not well managed. This threat is related to the urbanisation (flow impacts) category – see Table 1 for more information.
Conditions impacted by the threat Primary Secondary	 Water Quality (env) Stormwater, Water regime, Vegetation
Values impacted by the threat	Macroinvertebrates, platypus, fish, frogs, vegetation, birds
Asset impacted by the threat	Rivers, wetlands and estuaries
Assumptions made in 2018	
Datasets used in 2018	Future urban landuse projections based on planning zone data. Landuse was used as a surrogate as there is good correlation between landuses and the ambient water quality monitoring data. A3P sediment quality data including risk ratings of toxicants. Includes 55 sites sampled annually. Same sites are sampled and cover 16 wetlands, 15 estuaries, 24 streams/rivers.
Confidence Key assumptions	Moderate Assumed that threat increases as urbanisation increases.
How climate change was considered to influence the threat	Was not considered. See the knowledge gap section below for future considerations.
Performance objectives	
Existing regional performance objectives	Several RPOs focused around foundational activities e.g. improving capacity, policy, guidance e.g. RPO-24 Risk-based programs are in place to mitigate sources of urban pollution (licenced and unlicensed discharges) to protect bays and waterways. RPO 13 Industry capacity for whole of water cycle and stormwater management is increased to enable collaboration, improved access to information and knowledge, and a skilful and capable industry with strong established networks. RPO 14 Standards, tools and guidelines are in place and implemented to enable re-use and infiltration of excess stormwater, and protect and/or restore urban waterways. RPO-17 Water quality in waterways and bays is improved by reducing inputs of sediment and other pollutants from urban construction and development.

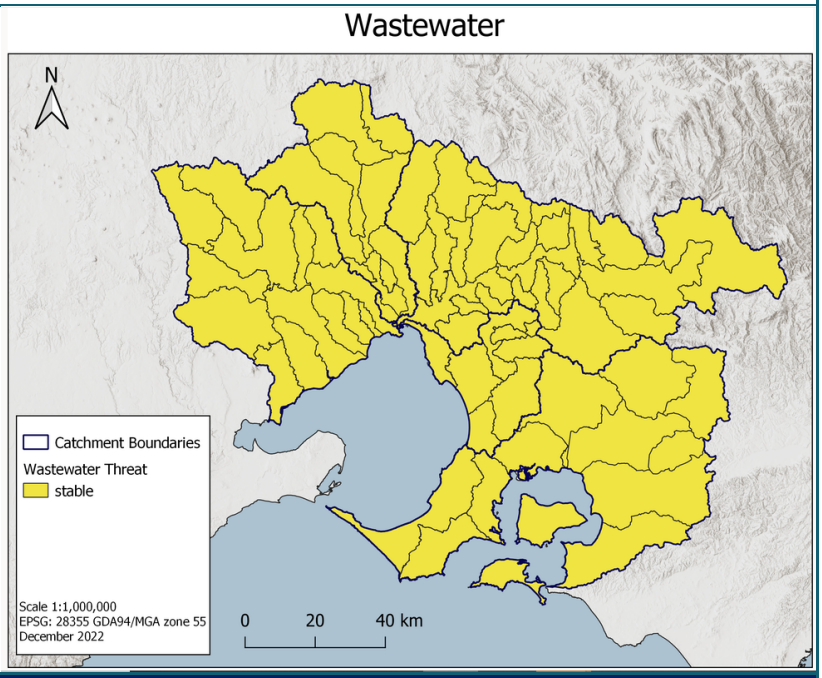
Sub-catchment performance objectives	**Rivers**: There are only 3 sub-catchment performance objectives aimed at managing industrial areas (Merri Ck Upper and Lower and Emu Creek). The reason for only including a few priority areas was based largely on a lack of 'buy-in' from agencies including Melbourne Water to implement appropriate programs that are aligned. The regional performance objective RPO 24 which is related to these performance objectives was intended to support improved policy and prioritisation of effort across agencies. *"Protect water quality of Port Phillip Bay and waterways from industrial activity by reducing industrial pollutant levels detected in waterways. Identify and mitigate sources of industrial pollution. This can be through education programs, enforcement actions or disconnections from the stormwater system"* The following SCPO is aimed at managing the construction phase of urban development was prioritised for urbanising sub-catchments entering Westernport. *"Protect water quality for environmental values and seagrass in Western Port by managing sediment loads from construction activities to ensure no pollutant or sediment laden run-off enters drains and waterways."* **Wetlands** - None – assumption that POs for rivers will benefit wetlands **Estuaries** - None – assumption that POs for rivers will benefit estuaries
Progress	Progress reports available on the HWS website. The reports for 21/22 for Merri Creek states: Officers for the Protection of the Local Environment (OPLEs) were working in the City of Hume and the City of Whittlesea in the southern section of the sub-catchment in 2021/22. OPLEs are Environment Protection Authority (EPA) officers, embedded in local councils who address key issues of concern, including reducing sedimentation from construction and industrial run-off.
Gap / issue ?	The industrial water quality performance objective for Emu Creek is being reviewed. It is not considered relevant as there is limited industrial development proposed in the catchment. As part of the review of the Emu Creek performance objective we will conduct an analysis to determine where new industrial areas are proposed in greenfield areas and whether appropriate performance objectives exist to address this new emerging threat have been included in relevant sub-catchment. Consultation with appropriate partners will need to be undertaken but it is possible new performance objectives could be recommended in a few areas.
Threat trajectory	
Assessment of threat trajectory	**Increasing**: For urbanising sub-catchments where toxicant monitoring data shows increased risk from 2018 as indicated by either metals, pesticides and ecotoxicology data. Or, if no data (e.g. Emu Ck) then if sub-catchment has > 8ha PSP area – ie significant future development. **Stable**: For sub-catchments which are predominately existing urban landuse and the toxicant risk is low to high. Or for urbanising sub-catchments where there was no change in risk from 2018 as indicated by metals, pesticides and ecotoxicology.

	Decreasing: Not considered. **Data gap**: Urban or urbanising sub-catchments with no monitoring data. **Confidence** - medium Anecdotal evidence - Increased use of bifenthrin for termite control in new developments and retrofits – believed that 1 out of 3 properties now use it either as a membrane or in a liquid form with regular replenishment. New industrial areas establishing without treatment beyond sediment and nutrients. Detection of new chemical contaminants, including pesticides not registered for use (Atrazine) and new fungicides associated with treated wood and paint.
Where has the threat increased or decreased?	Urban Water Quality 
Changed assumptions and operating environment	
Have assumptions changed? Has there been any policy changes since 2018 that influences the threat?	General Environmental Duty including the new Urban Stormwater Management Guidelines which outline nutrient and sediment load targets. (note these are the same as the existing BPEM standards which are required under the Victorian Planning Provisions. Sediment load target for Westernport in the Environmental Reference Standards. The 2018 Marine and Coastal Act and subsequent policy which requires the preparation of the Port Phillip Bay Environmental Management Plan (PPB EMP).
New and emerging	
Melbourne Water Waterways and Wetlands Research Program	A1. 1 Synopsis of the sources and impacts of pollutants B2 Major sources and fate of sediments in streams, wetlands, estuaries and bays to inform management opportunities. Focused on sediment generated during construction of urban developments. A2. 4 Impacts of sediments from urban and rural stormwater on stream health. Focused on toxicants attached to the sediments that are generated

	during urban construction. Main chemical is Bifenthrin attached to sediment. B1.1 Identifying and managing emerging contaminants of concern. Project is about what chemicals we should be concerned about but don't have local information about presence or impact on environmental values. B2. 6 Understanding the risk of contaminants in environmentally sensitive areas. Is aimed at refining the key criteria for assessing contaminant risk at high value sites.
New and emerging datasets	Increasing dataset around sediment runoff from new developments. Additional contaminate monitoring data. Knowledge of new toxicants in system – Bifenthrin, fungicides, pharmaceuticals, fragrances New survey work (111 wetlands) correlating pesticides with land-use (roads, DCI, turf, football ovals, golf courses. Simazine, Atrazine.) Improved understanding of background PFAS levels
Knowledge gaps	
What are the priority knowledge gaps for this threat?	Potential impacts to water quality from residential use of recycled water. Improve understanding of climate change implications with respect to contaminants.

Wastewater

General Information	
Activities related to the threat	Sewage treatment plant (STP) discharges, sewage spills (including emergency relief structures), untreated sewerage ingress, poor septic tank performance/maintenance, recycled water use.
Conditions impacted by the threat Primary Secondary	 Water Quality Water regime
Values impacted by the threat	Macroinvertebrates, platypus, fish, frogs, birds, vegetation
Asset impacted by the threat	Rivers, wetlands and estuaries
Assumptions made in 2018	
Datasets used in 2018	Quantified loads from existing STPs. Did not quantify ERS or septic tank data. Local septic impacts derived from HWS workshops.
Confidence Key assumptions	Good It was assumed that the threat was not increasing significantly as loads from STPs are highly regulated and are required to meet license discharges. It was also assumed there would be no new STP's.
How climate change was considered to influence the threat	Was not considered.
Performance objectives	
Existing regional performance objectives (RPO)	RPO 24 Risk-based programs are in place to mitigate sources of urban pollution (licenced and unlicensed discharges) to protect bays and waterways.
Sub-catchment performance objectives	**Rivers** – Performance objectives exist in sub-catchments where there is a STP that discharges to Port Phillip Bay. This is to provide alignment with the Port Phillip Bay Environmental Management Plan priority action *3.2 Prevent increases in nutrient loads from wastewater systems and where practicable reduce loads of other pollutants.* There are 8 performance objectives across the region. Example of the wording is provided below: *"Protect water quality for Port Phillip Bay and waterways by maintaining the current quality of discharges from sewage treatment plants (and reducing volumes where possible) ensuring they are released in a manner that ensures environmental values are supported in the waterway."* Performance objectives for septics were included in several POs which included a range water quality related threats eg: "*Improve water quality for environmental values and Port Phillip Bay by reducing turbidity impacts from rural land, urban growth and unsealed roads as well as nutrient inputs from rural land and septic tanks in Monbulk creek between Birdsland and Lysterfield Rd."* **Wetlands** - None - assumed RPO and rivers SCPOs would be adequate **Estuaries** - None - assumed RPO and rivers SCPOs would be adequate

Gap / issue ?	The RPO does not report against this threat specifically and focuses more on unlicensed and industrial pollution management. This is not a significant issue as the SCPOs report on STP loads.
Threat trajectory	
Assessment of threat trajectory	**Increasing**: current loads are greater than the 2018 baseline **Stable**: current loads are same as the baseline **Decreasing**: current loads are less than the 2018 baseline Confidence in assessment = mod (doesn't assess septics or sewer spills) Anecdotal evidence - STPs are well-regulated and monitored, and a number of STPs will go offline in the life of the HWS. ERS spills have generally been declining over the long term across the region. A septic backlog program (connecting septic users to reticulated sewer network) is continuing. Septics have localised impact, and do not pose a wide-spread threat.
Where has the threat increased?	
Changed assumptions and operating environment	
Have assumptions changed? Has there been any policy changes since 2018 that influences the threat?	The Environmental Reference Standard (ERS) was recently (1st July 2021) introduced under the new Environment Protection Act 2017 that replaces the Environment Protection Act 1970 and the State Environment Protection Policy (Waters). The ERS is an environmental benchmark that describes environmental values and the relevant indicators and objectives in different waterways/regions that need to be maintained to ensure environmental and human health outcomes are achieved. The general environmental duty (GED) is a new framework for environmental protection that focuses on pollution prevention rather than management of pollution impacts.
New and emerging	
Melbourne Water Waterways and Wetlands Research Program	B1.2 Understanding the ecological impacts of treated and untreated sewage inputs in waterways has found that micro pollutants are present in waterways receiving sewage inputs, some of which may be useful as chemical indicators of sewage pollution.

	Based on findings from extensive field sampling, a list of priority chemicals that may be suitable indicators of sewage pollution will be more thoroughly investigated (~10 compounds). For each of these chemicals, a risk assessment will be done to establish if any are likely to have impacts on environmental values. This approach will enable chemicals of concern to be prioritised, that can then be more thoroughly investigated through targeted chemical testing as well as Eco toxicological testing (if necessary). Suitable indicators that can identify specific sources of wastewater e.g. septics vs treatment plant discharges. Other research programs are investigating the impacts of waste water on in-water recreation but because this threat analysis is focussed on environmental values this is not summarised here.
New and emerging datasets	A3P contaminate datasets for stormwater wetlands and areas with known wastewater contamination issues.
Knowledge gaps	
What are the priority knowledge gaps for this threat?	Validate relevant chemical indicators of sewage pollution. Refine passive sampling methods - move from semi-quantitative (presence/absence) to quantitative assessments (to report data as a concentration). Quantify risks to key environmental values associated with chemicals associated with wastewater. Understanding the risks of treated and untreated wastewater into waterway under a changing climate. Including wet and dry weather risks. Understand risk to waterways from increased use of recycled water for environmental flow purposes and use in residential and agricultural areas. Based on new and emerging research, additional priority areas for management may need to be developed. Quantification sewage overflows from ERSs from both MW and water retailer assets to assess with the threat quantification.

Physical modifications

General Information	
Urban development waterway corridor encroachment leading to additional lighting, noise and litter along waterways. Piping or modification of headwater streams and building over wetlands, drains and levees, deepening for flood storage, LWD removal, illegal alteration of waterway (e.g. channelization) or creation of on-line wetlands.	
Threats assessed	Piping or modification of streams, including headwater/first order streams and building over wetlands.
Other related threats	Urban development waterway corridor encroachment leading to additional lighting, noise and litter along waterways. Creation of drains, levees and other floodplain modifications e.g. for increased flood storage. Large Woody Debris (LWD) removal, illegal alteration of waterway (e.g. channelization, dams), sediment extraction or creation of on-line stormwater wetlands. Artificial estuary openings.
Conditions impacted by the threat Primary Secondary	 Physical form Vegetation, Instream connectivity
Values impacted by the threat	Macroinvertebrates, platypus, fish, frogs, birds, vegetation
Asset impacted by the threat	Rivers, wetlands and estuaries
Assumptions made in 2018	
Datasets used in 2018	High level erosion sensitivity assessment for each sub-catchment which was largely related to urban threats which increase erosion and other known legacy erosion issues outside of urban areas.
Confidence Key assumptions	Fair Expert opinion focused on erosion impacts. Assumed other activities mentioned above like alteration to waterways and LWD removal were a low threat. It was also assumed natural wetlands would be retained in the landscape and not built over during urban development.
How climate change was considered to influence the threat	Was not considered. However it is likely that erosion impacts will increase in the future with predicted increased storm intensities.
Performance objectives	
Existing regional performance objectives (RPO)	RPO 16 Protection mechanisms are in place for headwaters to ensure that they are retained as features in the landscape for environmental, social, cultural and economic benefits. RPO 28 Seasonal Herbaceous Wetland vegetation communities are identified and a management program is in place to protect them on public and private land. RPO 15 Victoria's planning system is used effectively to protect and enhance waterway values.
Sub-catchment performance objectives	**Rivers** – Performance objectives were set for 35 sub-catchments and were worded along the lines of:

	"Investigate and mitigate threats to physical form (e.g. erosion) and other high values (including impacts of urbanisation)." **Wetlands** – There is only one example of a performance objective aimed at protecting the wetland form from urban development i.e.: *"Ensure that use of Cunningham's Swamp as a stormwater retarding basin is not at the expense of the natural wetland form and Obligations of managing a Seasonally Herbaceous Wetland."* **Estuaries** - None
Gap / issue ?	The performance objective for rivers is focused purely on erosion control. There are no explicit performance objectives aimed at protecting wetlands from being built over.
Threat trajectory	
Assessment of threat trajectory	Level of threat and loss of wetlands and headwater streams in urban areas reported in HWS annual report using spatial datasets e.g. PSP, DSS, development stage. Table below shows lengths (kms) of headwater streams where there are plans for the streams to be modified or piped as a result of urban development.

Stream Type	Dandenong	Maribyrnong	Werribee	Western Port	Yarra	Total
modified	0	16	17	46	130	209
piped	1	6	5	4	34	51

Table below shows the status (ha) of natural wetlands with respect to urban development threat. This assessment is repeated each year for the annual report.

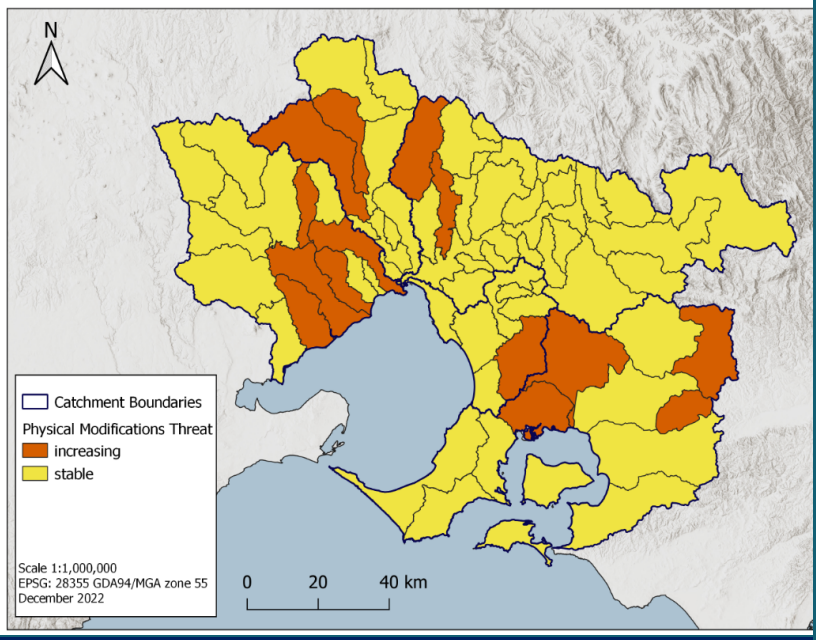
Wetlands	Period	Protected	Future threat	Imminent risk	Effectively lost	Other	Total
Priority Wetlands (*n*)	2019						
	2020	101	2	15	3	129	250
	2021	104	1	14	4	131	254
	2022	102	3	14	4	131	254
Natural wetlands (ha)	2019						
	2020	2,081.6	82.2	573.5	71.7	3,444.0	6,253.0
	2021	2,136.8	163.2	663.4	113.7	3,175.9	6,253.0
	2022	1,994.5	104.7	415.0	117.7	3,621.1	6,253.0

Anecdotal evidence - Loss of wetlands and headwater streams were not explicitly recognised in HWS development, and the loss of wetlands and headwater streams since 2018 has been noted and is to be modelled in future.

LWD work is static – have wood, but little community support given flooding concerns. Want to target key areas for platypus and fish, but need access via private land.

Illegal works on waterways by public has been detrimental in some areas (e.g. use of excavators, covering culverts etc.). No compliance activity have occurred around these.

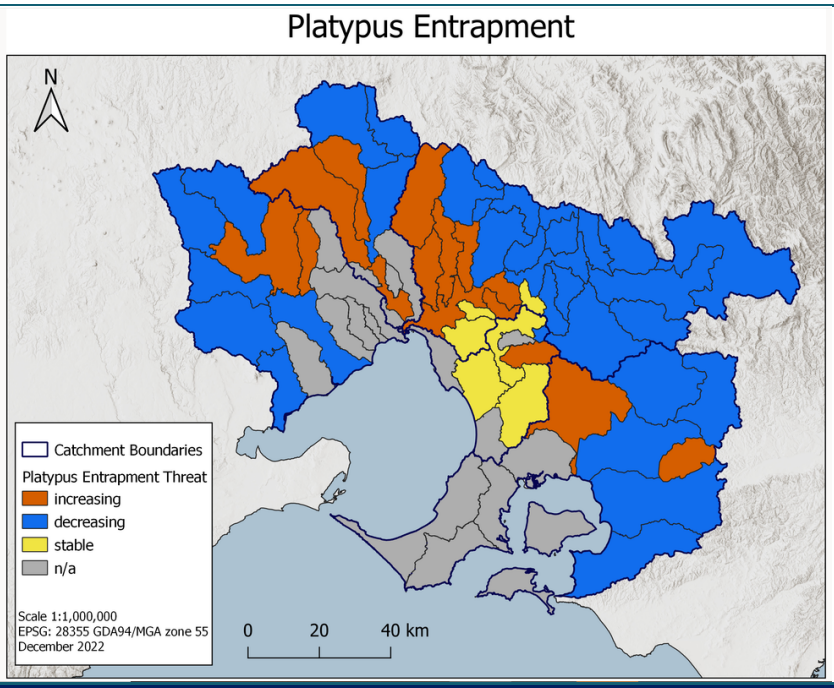
Seeing more growth than was expected outside the urban growth boundary. Development is currently happening up to the 100 yr flood

	line, not the vegetation buffer. Unable to fully vegetate corridors due to flood constraints. Competition for space vs path, sewer pipes and other infrastructure.
Where has the threat increased or decreased?	Based on data presented above. **Increasing** – where 1 or more natural wetlands within a sub-catchment are at imminent threat from urban development or there are plans to pipe a headwater stream. **Decreasing** – no criteria developed. **Stable** – where there is no proposed piping or threat to natural wetland form. Or threat to wetland loss is rated as future and not imminent. Confidence in assessment = moderate Refer to Appendix 2 for separate maps for headwater and wetland threat Physical Modifications 
Changed assumptions and operating environment	
Have assumptions changed? Has there been any policy changes since 2018 that influences the threat?	Updated stream network and waterbodies layer has become the designated waterways layer.
New and emerging	
Melbourne Water Waterways and Wetlands Research Program	Project A3. Geomorphic change and disturbance thresholds for the protection or recovery of stream form in urban catchments. D1 – headwater streams. Current generic corridor widths are inadequate if we want to retain floodplain functioning in urban areas, which requires preservation of adequate floodplain space, near-natural hydrologic regimes, lateral and vertical connectivity and vegetation. Modelling work is helping to better understand floodplain dynamics in Melbourne's growth areas.

New and emerging datasets	New physical form data sets (e.g. width, depth, slope, sinuosity) are in development including remote sensing techniques (e.g. liar) and a new on-ground physical form assessment which will be included in the waterways condition monitoring program. Flow and water quality monitoring data of headwater streams. A new designated waterways layer includes headwater streams. New waterbodies layer. Potential to use Nearmap images to track trajectory of urban encroachment Updated stream network, including headwater streams Data on lost wetlands and headwater streams Potential information/data in Iris, Maximo and MW Call Centre complaints records – currently not searchable
Knowledge gaps	
What are the priority knowledge gaps for this threat?	Development of site specific waterway setbacks that protect floodplain functioning. Implementation barriers for headwater stream and wetland protection. Case studies for 'how to protect' streams from urbanisation. (e.g. Aitken Ck).

Litter

General Information	
Threat assessed	Litter from urban areas, fishing equipment, opera house traps, grates (stormwater/water supply)
Other related threats	All other litter e.g. microplastics
Conditions impacted by the threat Primary Secondary	Water Quality (includes litter because of its importance mainly to social values)
Values impacted by the threat	Platypus, birds
Asset impacted by the threat	Rivers, wetlands, estuaries
Assumptions made in 2018	
Datasets used in 2018	Not assessed
Confidence Key assumptions	Fair Without additional effort to change urban drainage design and littering behaviour, it was assumed that litter in waterways will increase as urban population increases.
How climate change was considered to influence the threat	Not considered
Performance objectives	
Existing regional performance objectives (RPO)	RPO 26 Methods are in place to assess volume and source of litter to inform and promote litter reduction programs. RPO 27 Incidence of littering and illegal dumping is reduced through raised community awareness and knowledge, infrastructure and enforcement.
Sub-catchment performance objectives	**Rivers** None **Wetlands** None **Estuaries** None
Gap / issue ?	No performance objectives specific for platypus
Threat trajectory	
Assessment of threat trajectory	**Increasing:** Urbanising sub-catchments based on assumption of increasing litter in waterways relative to previous land use rural **Stable**: Existing urban areas based on assumptions that litter threat is stable. **Decreasing**: Predominately rural and forested sub-catchment. Based on banning of Opera house traps. Since the ban on opera house nets in 2019, drowning deaths of platypus, rakali and freshwater turtles are thought to have significantly declined (Severns 2020) **n/a** where no platypus targets or where the target was very low and text stated that they are not expected in the sub-catchment.

	Confidence in the assessment = moderate (low for stable rating as it's likely that litter could increase in existing urban areas as densification occurs.) Anecdotal evidence – Banning of yabby nets (opera house traps) is likely leading to a reduction in entrapment. COVID19 likely slowed litter generation during lockdowns, but litter is expected to return to pre-COVID19 levels in the long-term.
Where has the threat increased?	
Changed assumptions and operating environment	
Have assumptions changed? Has there been any policy changes since 2018 that influences the threat?	No Banning of opera house nets.
New and emerging	
Melbourne Water Waterways and Wetlands Research Program	F5.1 Understand the impact of litter, including microplastics, on the social and ecological values of waterways and bays.
New and emerging datasets	New knowledge of baseline litter data on six sub-catchments as well as propose litter condition metric and associated ratings. Masters project investigation into litter threat directly relating to platypus.
Knowledge gaps	
What are the priority knowledge gaps for this threat?	Knowledge gaps around entrapment for other values e.g. birds and fish.

RURAL RELATED THREATS

Water Use

General Information	
Activities related to the threat	Potable water supply dams, agricultural and other water demands e.g. surface water diversions, groundwater extractions, farm dams. Is related to the agricultural threat.
Conditions impacted by the threat Primary Secondary	 Water regime Water quality
Values impacted by the threat	Macroinvertebrates, platypus, birds, vegetation, fish, frogs
Asset impacted by the threat	Rivers, wetlands, estuaries
Assumptions made in 2018	
Datasets used in 2018	Flow stress ranking and FLOW compliance. Farm dam data not used – implicit in the flow stress ranking metric. For mostly urban catchments DCI was used to rate flow condition.
Confidence Key assumptions	Good (gap for farm dams) Assumed additional demand for rural and urban water supply from the catchments for domestic, stock and agricultural uses. There is a gap around impacts of farm dams and in quantifying the increase in farm dams over time.
How climate change was considered to influence the threat	Reduction in gauge flows by 44.3% in line with DELWP 2065 dry climate predictions (representing a worst case climate change outcome) (DELWP, 2016)
Performance objectives	
Existing regional performance objectives (RPO)	There are a number of regional and sub-catchment specific performance objectives for priority rivers, wetlands and estuaries that span both regulated and unregulated catchments. 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 11 Understanding of groundwater dependent ecosystems is improved and opportunities to maintain or improve these continue to be investigated.
Sub-catchment performance objectives	**Rivers** Regulated rivers - '*Investigate options to increase environmental water reserve by 5 GL/year by 2028 to meet ecological watering objectives and cover projected shortfalls. This will benefit Jacksons Creek and the lower Maribyrnong River. Any water recovery will be considered through the sustainable water strategies, markets and use of alternative water.* Unregulated rivers - *Identify and implement opportunities to reduce the key threat of flow stress on waterways by addressing causal factors such as water for domestic and stock use, climate change, diversions or urbanisation'.*

Wetlands *'Investigate opportunities to improve wetland water regime to meet ecological watering objectives, improve ecosystem services, cultural and social value'.*

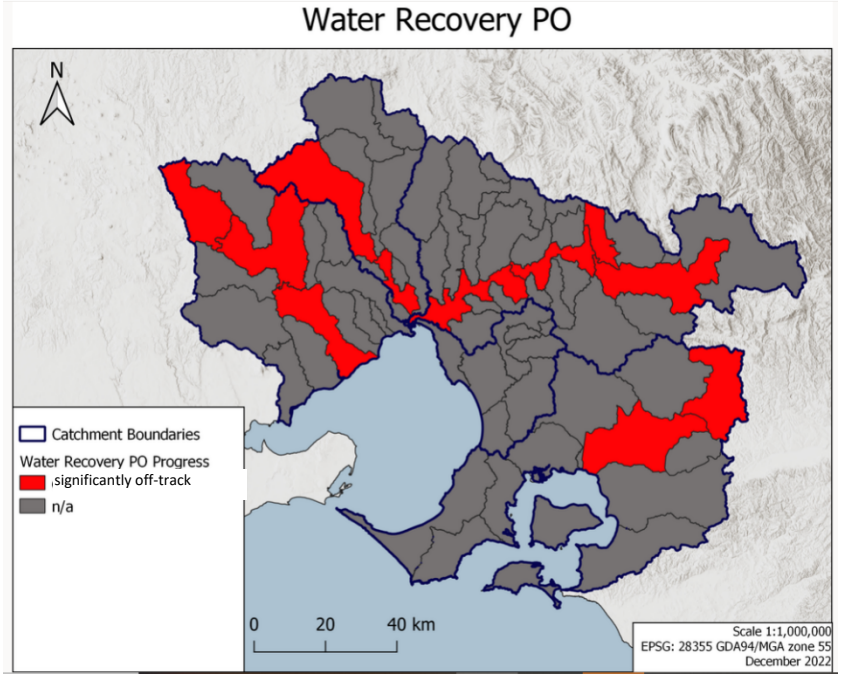
Estuaries '*Maintain critical flow components in refuge reaches to protect instream environmental values*'.

Regulated rivers:

On-track – >95% of shortfall volumes recovered

Slightly off-track – 50-90% of shortfall volumes recovered

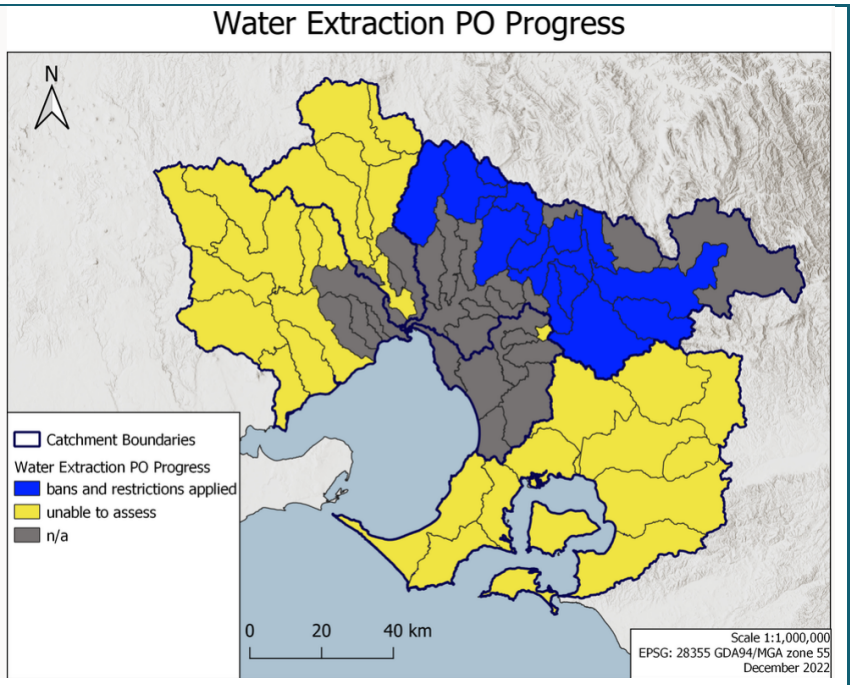
Significantly off-track – <50% of shortfall volumes recovered

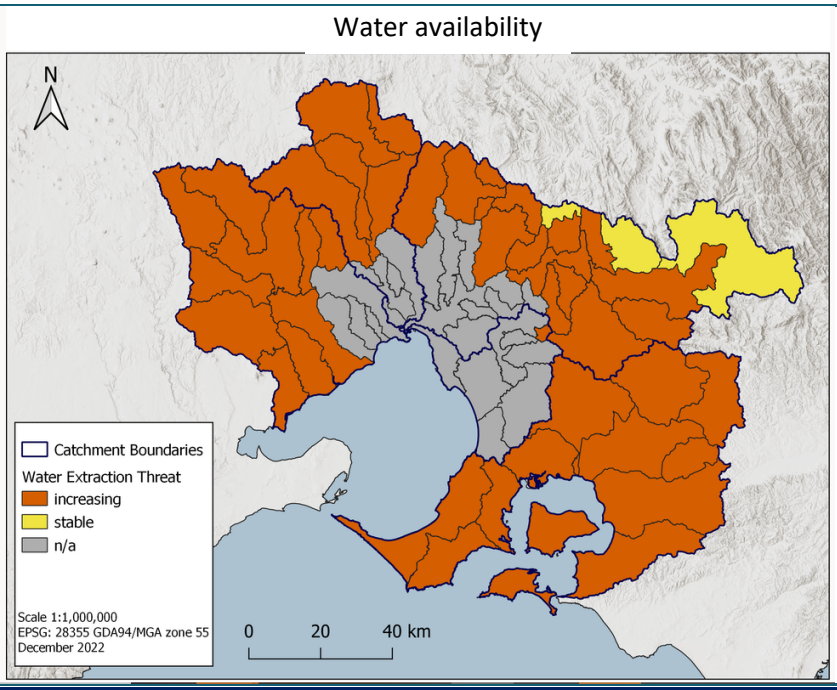


Unregulated rivers:

There is good evidence of bans and restrictions applied within the Yarra catchment. Data is not available for other catchments.

Unregulated flow PO progress

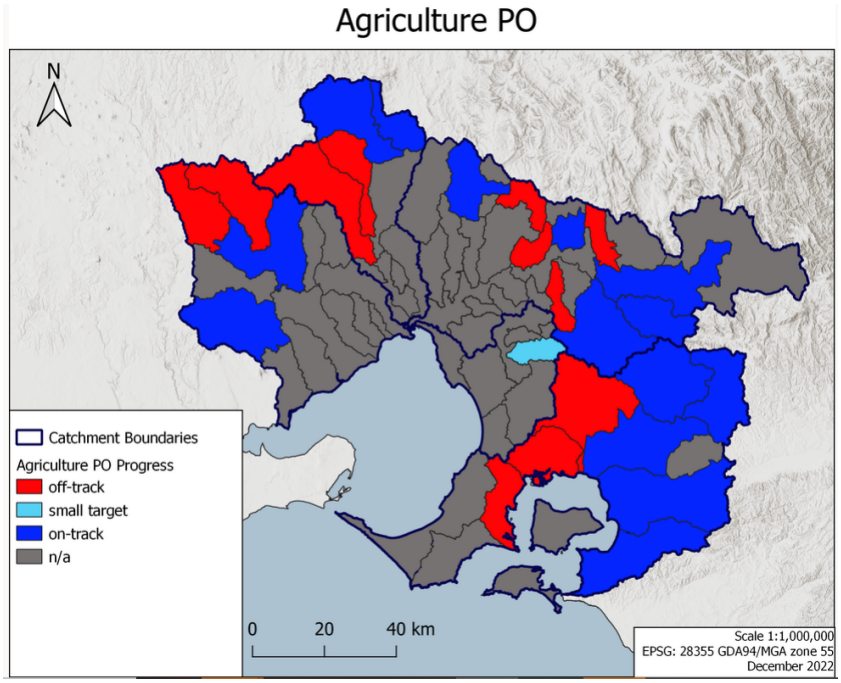
	
Gap / issue ?	Tracking progress is qualitative.
Threat trajectory	
Assessment of threat trajectory	**Increasing**: Long term water resources assessments for each catchment indicates significant declines in water availability. Based on this the threat was considered increasing in all rural sub-catchments. **Stable**: Protected water supply catchments. Urban sub-catchments n/a due to it being a separate flow related threat. **Decreasing**: Evidence that flow stress has been reduced. **Data gap:** Data similar to the LTWR assessments is needed at the sub-catchment level (in development) Confidence in assessment = moderate Anecdotal evidence – MW diversions staff believe there has been a reduction in extraction with some licenses turning into sleeper licenses (surface water and groundwater) or being reduced when traded or consolidated – it is noted however, that the weather has been wet for the past few years and the sleeping licences may be reactivated in dry conditions. There is no buyback program for sleeper licences. Some landholders have expressed interest in obtaining new/additional licenses (licenses are currently capped) Some landholders are looking to expand and or use sleeper licenses Note: 2020-2022 have been wet years, with likely reduced demand for extractions. SWS was signed in 2022 – may take time to see any impact. MW can only comment on water extraction threat severity where MW is the diversion manager. MW are waiting upon external strategies for an external regulator perspective

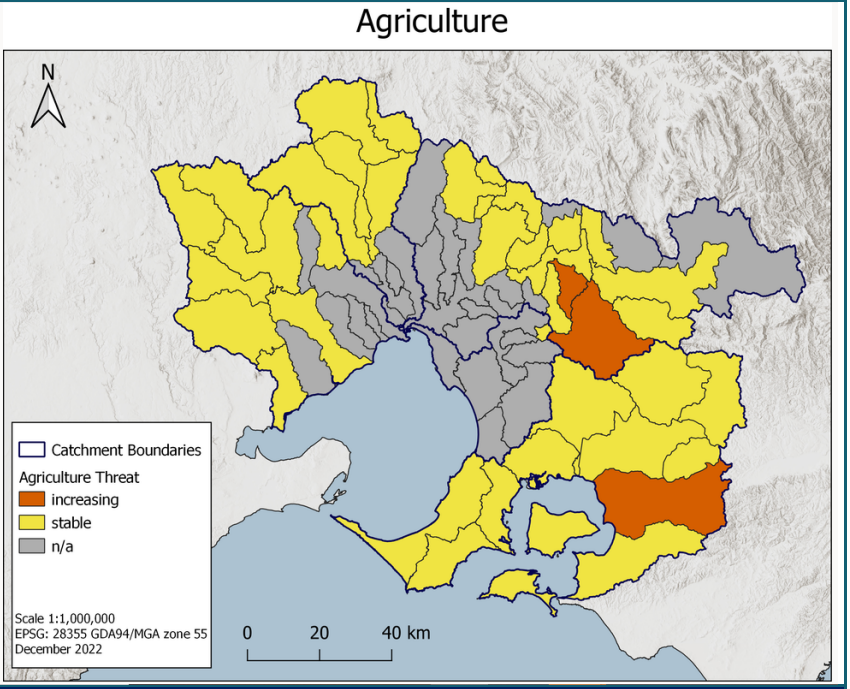
	Dams for stock and domestic use do not require a license, therefore very few new dams are licensed by MW – SMEs estimate that for every MW licensed dam, 300 dams are built with Council permits. The number of farm dams is increasing rapidly with water security a concern for agriculture. The increase in farm dams could be linked to the lack of availability of water under capped licensing arrangements. More dams are being built in peri-urban areas undergoing subdivision (Yarra Valley, Macedon, Nillumbik, Mornington Peninsula etc.).
Where has the threat increased?	
Changed assumptions and operating environment	
Have assumptions changed? Has there been any policy changes since 2018 that influences the threat?	Yes 1. Central and Gippsland Region Sustainable Water Strategy (CGRSWS) updated in 2022 -Provides supportive policy which will rely on manufactured and other water sources driven by government. Funding sources are as yet unknown. 2. Long term Water Resource assessment in 2020 - shows declines across the region which informs the CGRSWS 4. New Groundwater Management (2032) policy with DELWP 5. Water Is Life policy and greater Traditional Owner involvement in water planning and management - This could change the way environmental entitlements are delivered 6. EPA policy work on 'substitution' of environmental water with recycled water - new guidelines for use of recycled water are in development which aim to facilitate net benefits for environmental water recovery and improved environmental flows and water quality.
New and emerging	
Melbourne Water Waterways and Wetlands Research Program	New climate change projections input into HSM's has shown that the benefit of performance objectives (actions in the HWS) is likely to be constrained unless we can protect stream flows.

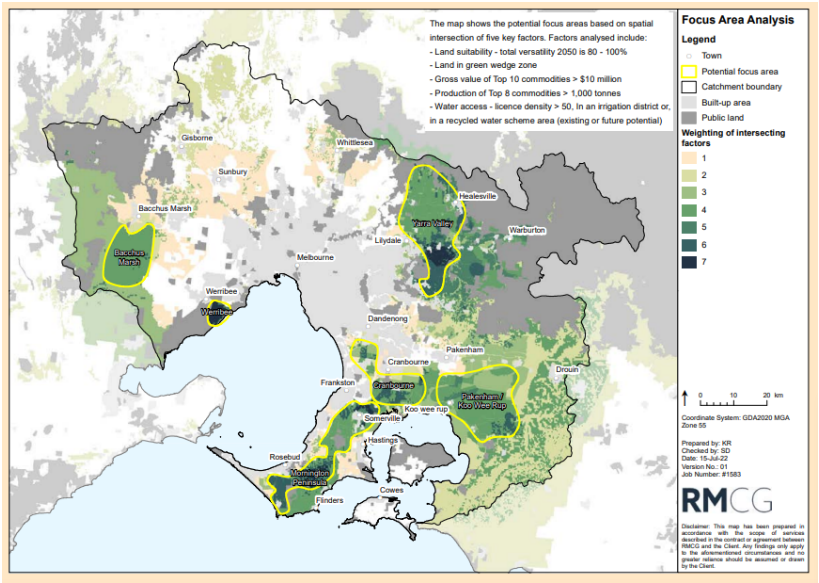
	On-going monitoring and research on groundwater inputs to streams and wetlands (e.g. Yellingbo).
New and emerging datasets	1. Reach scale flow stress ranking (developed for use in habitat suitability models) 2. Updated predictions of climate impacts on water availability 3. Data on frog, fish and vegetation responses to watering (billabong watering) 4. Information from Councils regarding the issuance of permits and licences for farm dams 5. Project A1. Long term satellite imagery of waterbody inundation 6. Satellite data for farm dams and waterbodies
Knowledge gaps	
What are the priority knowledge gaps for this threat?	Given climate change we are not sure about the political will to tackle the impact of irrigation licenses (ground and surface water) on waterway health in a drying climate. Monitoring data on flow extractions in unregulated systems. Understanding management levers and policy options for managing flows in unregulated systems. The ability to provide "manufactured" water to irrigation areas and potentially reduce flow stress from extraction is dependent on government direction which is still unclear. The Sustainable Diversion Limits (SDL) have not been updated for several years and in light of the CGRSWS.

Agriculture

General Information	
Activities related to the threat	Agriculture practices, intensification of farming, pesticide drift, vegetation clearing. Livestock impacts on headwater streams. This threat driver focuses on water quality impacts. Water use impacts are described in the water availability threat.
Conditions impacted by the threat Primary Secondary	Water quality (sediment and nutrient and pesticide runoff/drift) Vegetation, Water Regime
Values impacted by the threat	Macroinvertebrates, Platypus, Fish, Frogs, Vegetation
Asset impacted by the threat	Rivers, wetlands and estuaries
Assumptions made in 2018	
Datasets used in 2018	Ambient WQ monitoring data, A3P data (e.g. toxicants), estimate of proportional landuse per subcatchment.
Confidence Key assumptions	Fair Long term water quality targets set based on assumption that threat from ag land would decrease based on a 25% improvement in land practices over 50 years (based on current programs). Ag landuses were not split based on relative threat to water quality. Rural land priority areas in the HWS were selected where high value macroinvertebrate habitat intersected with rural land use under the assumption that rural land use would be a priority threat to macroinvertebrate health due to contaminated run-off and reduced vegetated buffer width.
How climate change was considered to influence the threat	Was not considered.
Performance objectives	
Existing regional performance objectives (RPO)	RPO 25 Programs, standards, tools and guidelines are in place to manage nutrients, sediments and other pollutants from rural land in priority areas.
Sub-catchment performance objectives	**Rivers** *Protect water quality for environmental values and seagrass in Western Port by reducing sediment run-off from rural land. Increase support for improved water stewardship.* *Improve water quality for environmental values and Port Phillip Bay by reducing sediment run-off from rural land, urban growth and unsealed roads as well as nutrient inputs from rural land and septic tanks. This may include establishment of vegetated buffers in headwater streams.* **Wetlands** *Implement rural land management program to reduce nutrient and sediment inflow to the wetlands as identified for each sub-catchment.* **Estuaries** *Implement rural land program in catchment to minimise sediment and nutrient loads to the estuary.* **On-track** = >10 ha improved land management in a sub-catchment **Off-track** = < 10 ha improved land management in a sub-catchment

	Small target = <10 ha overall (only Dandenong catchment is in this category with a small target applying in one sub-catchment) 
Gap / issue ?	There are 2 additional sub-catchments which need to be included as priorities for the rural land program. This will not impact the overall target but will improve the flexibility of where the rural land program can be implemented. PPWPCMA programs (now MW) such as the Westernport Landcare network Smart Farming in Westernport program and other programs such as the Water Stewardship Program currently don't contribute to the hectare targets set in the HWS. This is because these programs don't currently track the areas of land improved through the programs. This should be followed up to see if alignment can be developed so that the contributions from these programs can be acknowledged more fully. Currently they only contribute to participation targets.
Threat trajectory	
Assessment of threat trajectory	**Increasing**: Areas where agricultural landuse has changed to a use that poses a greater threat to water quality or runoff (e.g. intensification from grazing to horticulture). Based on subject matter experts involved in rural land management programs. **Stable**: Areas where agricultural landuse has not changed. Based on subject matter experts involved in rural land management programs. n/a urban and forested sub-catchments. **Decreasing**: Based on subject matter expert opinion. Confidence in assessment: low (as based on local knowledge not explicit data) Anecdotal evidence – There has been a decline in potato farmers in the Cockatoo catchment as evidenced by a reduction in irrigation licenses. Agriculture in the Lang Lang shifting from dairy to potatoes and peas and

	other? veggies, Woori Yallock and Stringybark = change from grazing to strawberries which means greater imperviousness. There is a shift to more poly tunnels and with high rainfall in last few years, which has significantly increased erosion and sediment run-off.
Where has the threat increased?	
Changed assumptions and operating environment	
Have assumptions changed? Has there been any policy changes since 2018 that influences the threat?	Policy on landuse planning to secure agricultural land in the region. Plan Melbourne Action 17 - Support strategic planning for agriculture Improve planning decision-making to support sustainable agriculture by identifying areas of strategic agricultural land in Melbourne's green wedges and peri-urban areas. This will give consideration to climate change, soils and landscape, access to water, integration with industry and significant government investment in agricultural infrastructure. It will also protect the right to farm in key locations within green wedges and peri-urban areas. NRM action plan includes a section on agriculture as part of the new Regional Catchment Strategy. There is a new statewide Agriculture Strategy - Strong-Innovative-Sustainable-a-new-strategy-for-Agriculture-in-Victoria. The focus is on low emissions, climate change, markets and resilience.
New and emerging	
Melbourne Water Waterways and Wetlands Research Program	C3.3 Developing methods to increase the efficiency and effectiveness of waterway health assessment within streams, wetlands and estuaries. Using the Little Yarra River as a case study of a rural catchment, a range of new waterway health indicators have been tested. The intention is that these indicators will allow us to understand major stressors in a river system that could explain observed trends in environmental values and id management actions most likely to benefit waterway health.

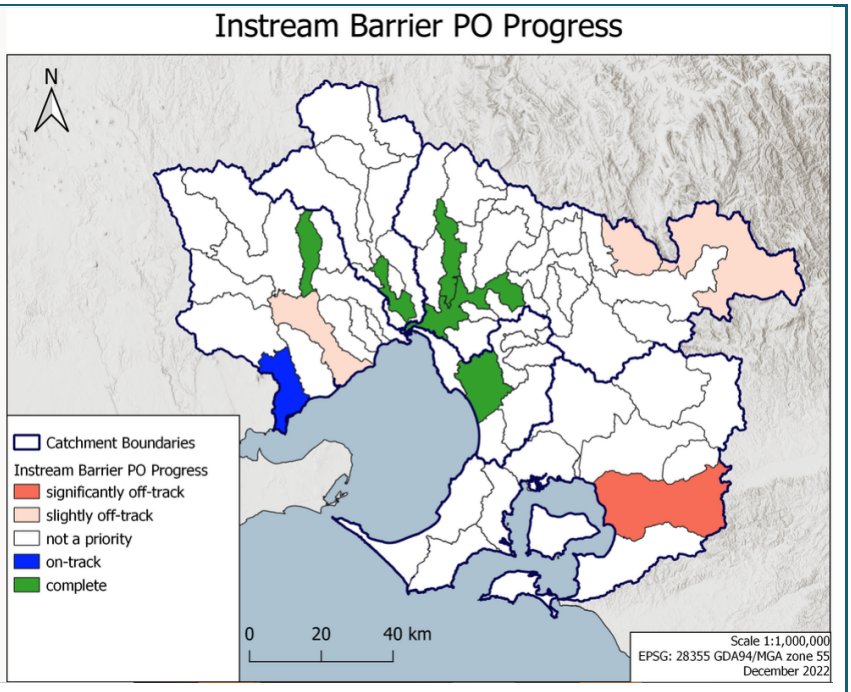
	In comparison to other catchments it appears that the Little Yarra has high values and an agriculture threat has shown a low risk based on ecotoxicology and other pesticide and water quality monitoring data. Research project in the Tarago water supply catchment demonstrated that large, well vegetated buffers are required around headwater streams to provide optimal water treatment (microbial) and that understory and ground cover is fundamental to the protection of downstream waterways. Fencing was also important to keep livestock and animals out of vegetated areas. There is new and emerging concerns around antimicrobial resistance (AMR), which could be an emerging threat emanating from within the agricultural sector. Climate change analysis as part of the NRM plan for the Regional Catchment Strategy has highlighted potential focus areas for agriculture in the future. (see figure below) 
New and emerging datasets	A3P MERI framework and a growing toxicant dataset. Improved understanding of the risks of different agricultural crops and practices.
Knowledge gaps	
What are the priority knowledge gaps for this threat?	Though conceptually sound, the effectiveness of site scale agricultural interventions to reduce sediment and nutrient run-off and protect waterway health is very difficult to measure. Consequently many assumptions are made about the benefits of works for waterway benefits. The current rural land metric calculator used in the MW Rural Land Program to estimate sediment and nutrient improvements from projects does not currently estimate benefits in pesticide reduction. Improvements in the metric calculator to include more region specific information as well as estimated benefits from pesticide reduction would be helpful. Whilst ambient water quality data is available, little data on threats from pesticides, sediment contaminants and ecotoxicology is available for waterways where high values (e.g. macroinvertebrates, platypus) intersect

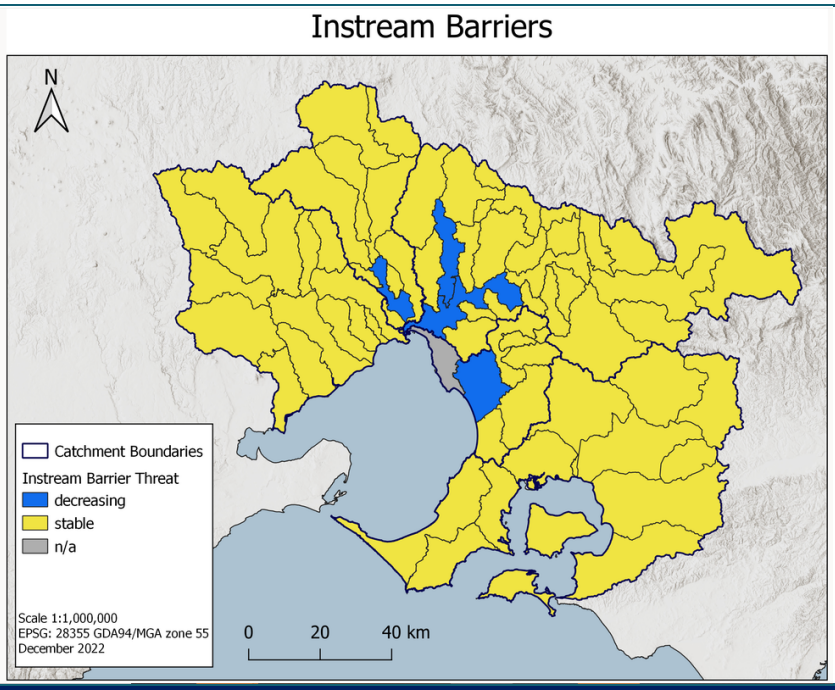
	with rural land use. Additional A3P investigations in such areas would help to better understand and characterise the risks of agriculture on waterway values. With respect to knowledge gaps around water use refer to the water availability threat section.

HABITAT RELATED THREATS

Barriers

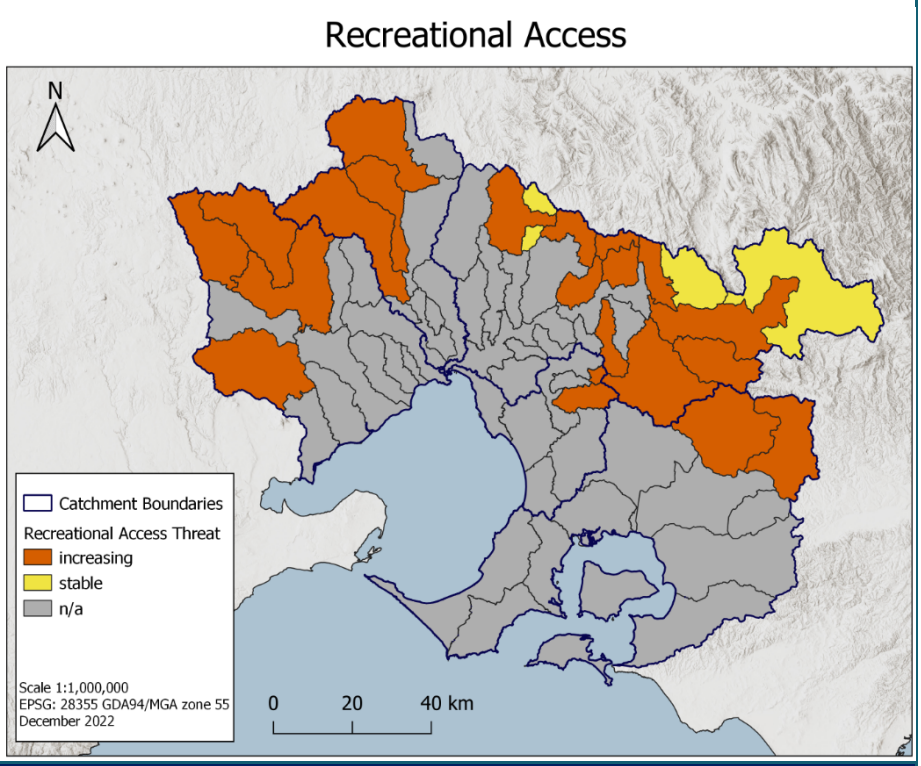
General Information	
Activities related to the threat	Gauging station weirs, dam walls, erosion control structures, crossings and fords
Conditions impacted by the threat Primary Secondary	Instream connectivity
Values impacted by the threat	Fish, platypus
Asset impacted by the threat	Rivers, Estuaries, wetlands
Assumptions made in 2018	
Datasets used in 2018	Fish barrier database
Confidence Key assumptions	Fair Barrier database used for current threat. It is assumed new barriers are minimal across the region as all new waterway structures (such as erosion control and weirs) are required to be fish friendly. The extent and increase of Illegal on-line dams or other structures is currently unknown.
How climate change was considered to influence the threat	Was not considered.
Performance objectives	
Existing regional performance objectives (RPO)	RPO 18 Critical waterway health assets including stormwater treatment systems, fishways and erosion control structures, are maintained for their designed purpose or the same outcomes are delivered by alternative means.
Sub-catchment performance objectives	**Rivers '***Increase instream connectivity provide fish (kuwiyn) passage along the Little River (Worrin-yaloke) from the mouth to Geelong-Bacchus Marsh Rd, by removing five fish barriers in the lower reaches'*. **Wetlands** None **Estuaries** '*Improve longitudinal connectivity and tidal exchange by removing barrier at Racecourse Road'*. **On-track:** Planning is underway and on-ground works are scheduled **Slightly off-track:** Commitment to barrier removal is there but unsure if it will be delivered in the HWS time frame **Significantly off-track:** There is no commitment to delivery in the HWS time frame OR project is fully scoped but is currently on-hold and uncertainty is high as to whether it will be delivered (e.g. Lang Lang, Heads Road). **Complete**: fishway has been constructed and handed over to maintenance

	
Gap / issue ?	No performance objectives around barrier threat to platypus and other values.
Threat trajectory	
Assessment of threat trajectory	**Increasing:** Evidence of new in-stream barriers or lack of maintenance of existing fishways. **Decreasing:** sub-catchments where fishways have been installed since 2018 **Stable:** all other sub catchments. Confidence in assessment = moderate (barriers formed by flood debris are not considered) Anecdotal evidence – No new barriers have been identified. New (or modified) barriers (e.g. gauging weirs) take fish passage into consideration. Partial barriers may become greater barriers under a future dry climate scenario.

Where has the threat increased?	
Changed assumptions and operating environment	
Have assumptions changed? Has there been any policy changes since 2018 that influences the threat?	The GED will influence the way dams and water supply weirs or large in-stream structures are managed and may require greater consideration of fish access upstream.
New and emerging	
Melbourne Water Waterways and Wetlands Research Program	None
New and emerging datasets	Surveillance of additional barrier up and downstream undertaken as part of any fishway capital investigations.
Knowledge gaps	
What are the priority knowledge gaps for this threat?	Understanding how climate change could impact the function of fishways. Understanding of other barriers such as roads to other values e.g. frogs, birds. Understanding of chemical barriers e.g. areas of low DO which act as a barrier to fish movement. Additional barriers. LIDAR data could potentially help to ID new barriers. Better understanding of fragmentation and population health due to barriers, particularly under climate change scenarios. Better understanding of partial versus full barriers. Genetic studies could help understand population fragmentation and help improve business cases for barrier removal.

Recreational access (in forested areas)

General Information	
Threats assessed	Motor bikes/cars, mountain bikes leading to increased tracks and vegetation disturbance. Covers both illegal recreational activities such as off-road access as well as endorsed visitor activities/experiences. Leads to fragmentation and erosion.
Other related threats	Recreation along urban and rural waterways leading to noise, light, litter, excrement, dogs, tracks, vegetation clearance
Conditions impacted by the threat Primary Secondary	 **Water quality** Vegetation
Values impacted by the threat	Macroinvertebrates, Platypus, Birds**,** Fish, Frogs, Vegetation
Asset impacted by the threat	Rivers, wetlands and estuaries
Assumptions made in 2018	
Datasets used in 2018	No data Some issues raised through HWS threats workshops
Confidence Key assumptions	Gap Impacts on birds considered through a survey. Broadly considered as a threat to vegetation which fed into the broad assumption that vegetation quality will decline under the business as usual future.
How climate change was considered to influence the threat	Climate change is considered to have a low influence on recreational access. Influence considered transient e.g., bushfire disturbance, extreme rainfall events, intensified runoff . In fact it reduce the threat as there will be less people outdoors due to extreme weather events.
Performance objectives	
Existing regional performance objectives (RPO)	RPO 43 The social values framework, information and methods used to develop values assessments, targets and performance objectives are further developed and improved during the life of the Strategy. RPO 21 The multiple benefits of waterways investment are tracked and understood.
Sub-catchment performance objectives	There are no performance objectives for rivers, wetlands or estuaries which specifically address this threat.
Gap / issue ?	No performance objectives are aimed at managing the impact of recreational access in forested areas. No data, no agency for updates on access. Insufficient resourcing at agencies for enforcement.
Threat trajectory	
Assessment of threat trajectory	**Increasing:** significant areas of state forest within a sub-catchment **Stable**: Closed water supply catchments

	Decreasing: Significant proportion of sub-catchment has changed land tenure e.g. state forest to a national park **n/a:** Predominately urban or rural (not forested) sub-catchments Confidence in assessment = low Anecdotal evidence – An increase in 4WD tracks and the creation of new mountain bike trails have occurred in some areas. In the Lerderderg SP pathways 5-6m wide in places have been created as 4WDs follow the clearance made by bikes etc. All new trails generate fragmentation and erosion/WQ risk around waterways. The change of status of some areas from State Forest to State Park has altered recreational activity (e.g., reduced 4WD use) in some areas because such activity is not allowed and enforcement is significant enough to be a deterrent.
Where has the threat increased?	
Changed assumptions and operating environment	
Have assumptions changed? Has there been any policy changes since 2018 that influences the threat?	No. Assume increasing impact if increasing threat Some conversion of state forest to state park. Some planning of new recreation mountain bike tracks.
New and emerging	
Melbourne Water Waterways and Wetlands Research Program	Human movement data (mobile phone data, Strava heat maps, mobile phone pings) Forestry road/track mapping (DELWP) eDNA studies investigating detection of humans in water supply catchments.

New and emerging datasets	Human movement data (mobile phone data, Strava heat maps, mobile phone pings) Forestry road/track mapping (DELWP) Parks Victoria's state of the parks assessment
Knowledge gaps	
What are the priority knowledge gaps for this threat?	Better understanding on the impact of this threat on values.

Pest animals (deer)

General Information	
Threats assessed	Deer
Other related threats	Other herbivores e.g. rabbits and over abundant wildlife e.g. kangaroos leading to trampling, pugging, introduction of weeds and bank erosion. Predators e.g. exotic fish, dogs and cats are a different form of pest animals which impact different values e.g. birds and fish. These have not been assessed. Illegal clearing of vegetation clearing is captured as a separate threat in the next section.
Conditions impacted by the threat Primary Secondary	Vegetation Physical form, Water quality
Values impacted by the threat	Macroinvertebrates, platypus, fish, birds, frogs, vegetation
Asset impacted by the threat	Rivers, wetlands and estuaries
Assumptions made in 2018	
Datasets used in 2018	none
Confidence Key assumptions	Gap (deer, rabbits, cats, exotic fish) Expert opinion. Broad assumptions that vegetation quality will decline due to threat of pest animals – particularly deer for rivers. Evidence from deer fencing revegetation trials suggests that even three and four year old vegetation is impacted when deer fencing is removed Fair (stock access) Assumed the threat exists on rural frontages where there have not been previous incentives provided to landowners. Assumed level of threat was relatively stable
How climate change was considered to influence the threat	Was not considered
Performance objectives	
Existing regional performance objectives (RPO)	RPO 13 A risk-based approach is adopted to prevent, eradicate and contain pest plants and animals (including deer) and protect waterway assets.
Sub-catchment performance objectives	**Rivers:** *Establish a continuous riparian vegetated buffer (2 km, 6 ha) and maintain existing vegetation (1 km, 2 ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality).* *Maintain or achieve high and very high quality vegetation (level 4 and 5 vegetation quality is currently 14 km) along Emu Creek and tributaries through effective monitoring and management of threats including protection of endangered EVCs. Fill data gaps in mapping of high quality vegetation.*

Wetlands *'Reduce threat to native birds from foxes, cats and dogs to moderate'.*

Estuaries '*Protect estuary roosting sites from excessive disturbance from humans, vehicles, dogs, foxes and cats'*.

Progress towards the above performance objectives is qualitative or semi-quantitative. At present the rivers performance objectives are tracked by ha of vegetation maintained, which could include weed control or pest animal control. Data capture improvements are underway which will allow the ability to evaluate management effectiveness in the future.

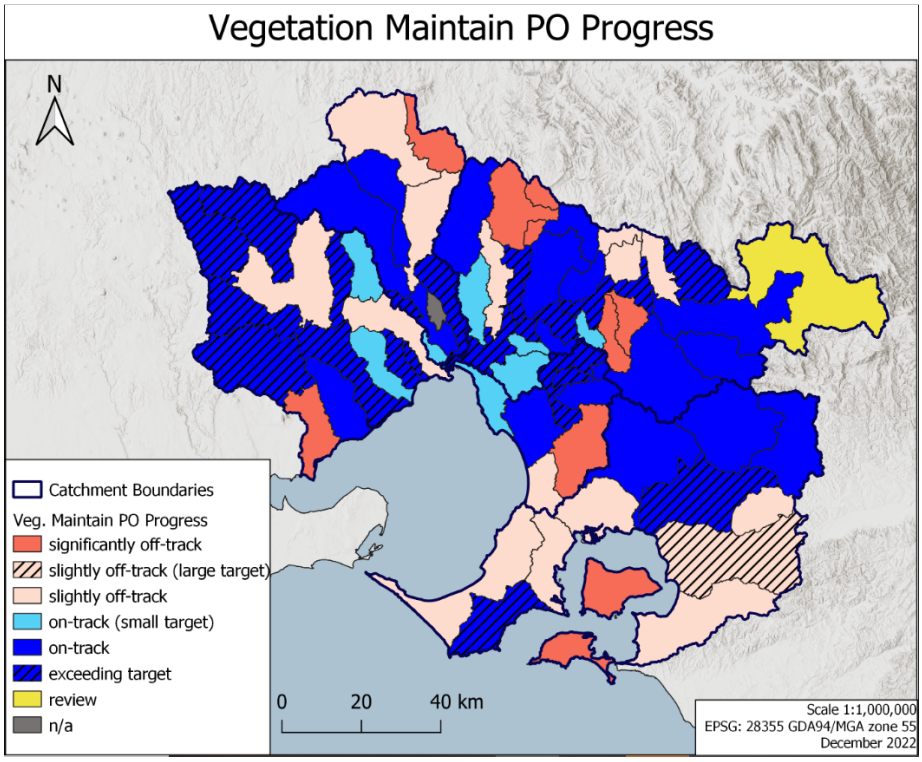
On-track = > 40% 10 yr ha target

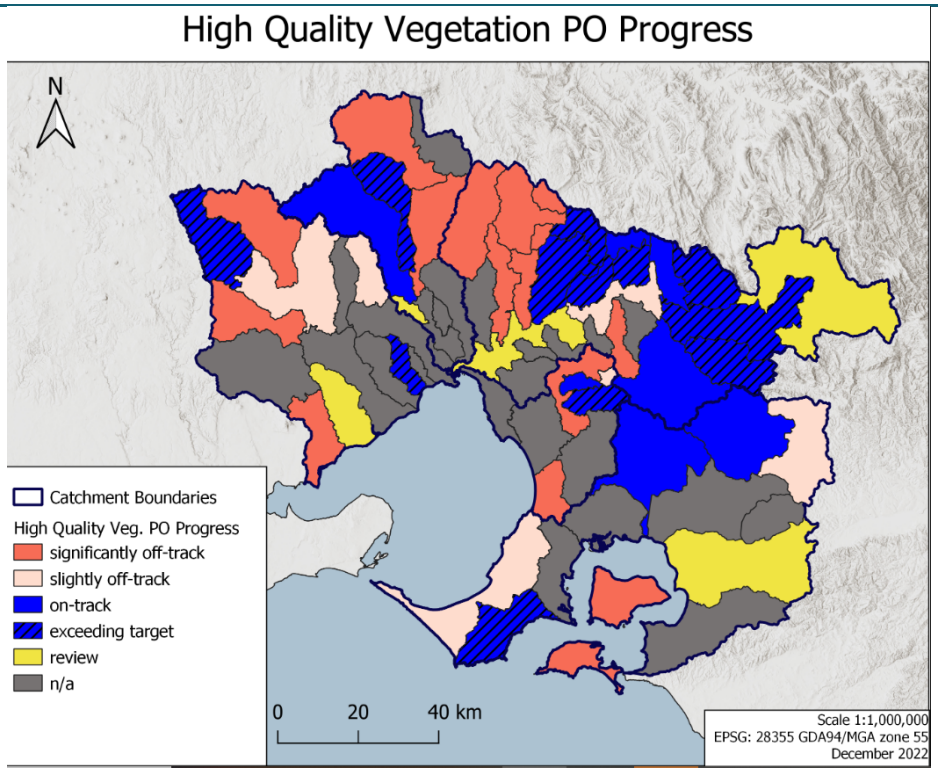
Slightly off-track = 10-40% ha target

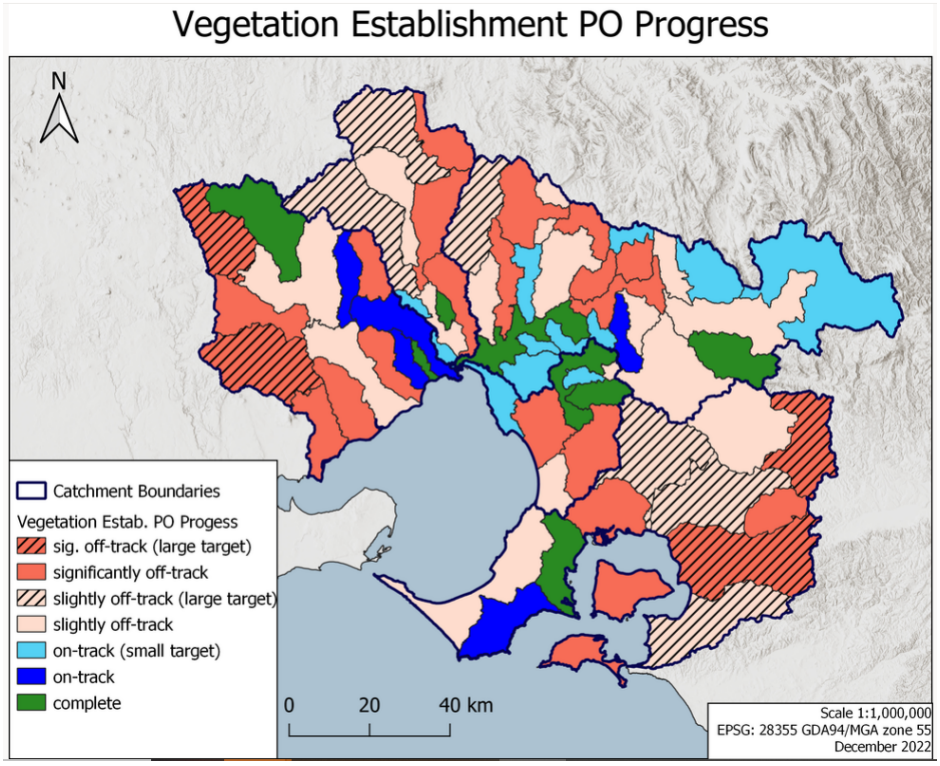
Significantly off-track = < 10% 10 yr target

Large target = > 500 ha (maintain vegetation) and > 200 ha (establish vegetation)
Small target = < 10 ha (maintain and establish vegetation)

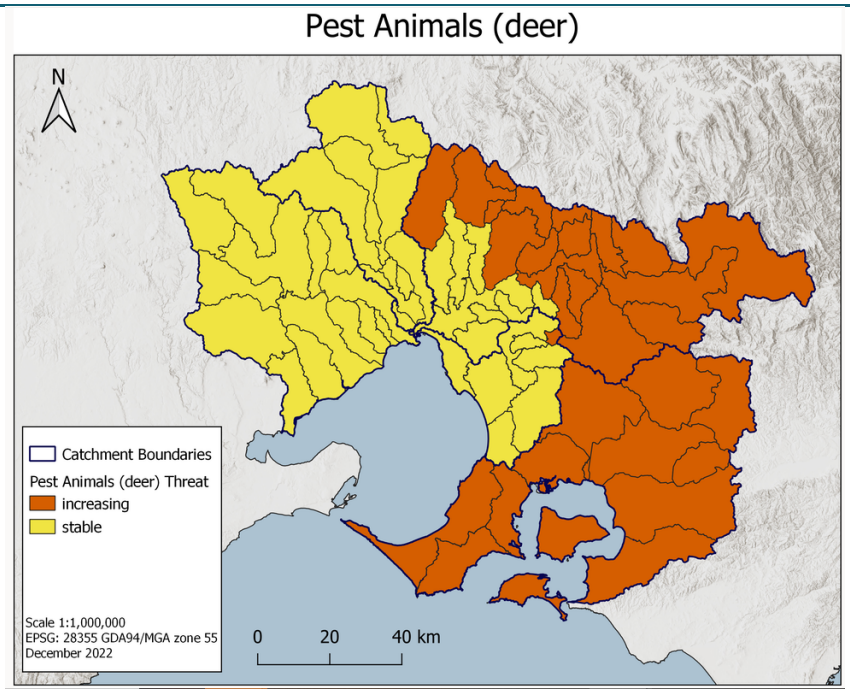
Review = where the results need to be checked or in the case of high quality vegetation there are areas of work assigned to high quality vegetation but the vegetation vision data does not indicate there is any high quality vegetation in the sub-catchment.

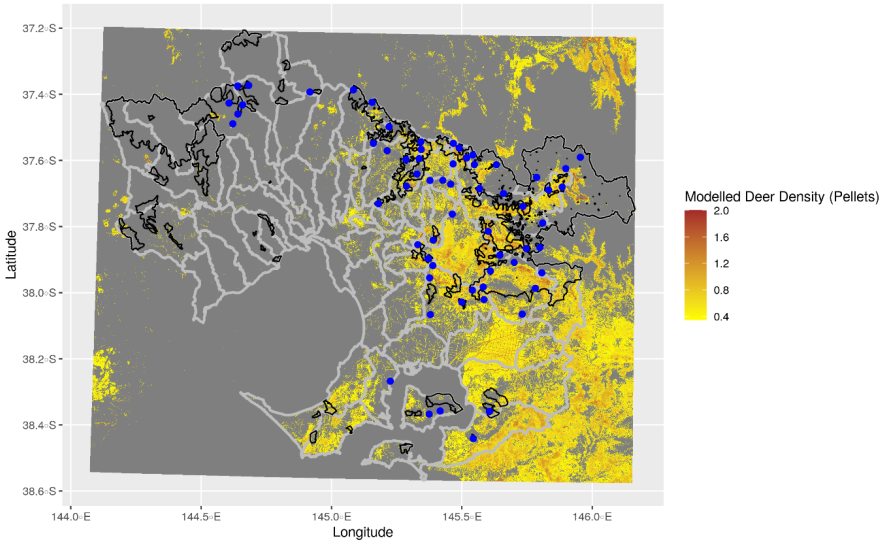






Gap / issue ?	Managing the deer threat for rivers is implicit in the performance objective at present reporting does not consider pest animals separate to pest plants. It is assumed that new vegetation that is established will be maintained. However the maintenance targets were set around existing vegetation.
Threat trajectory	

Assessment of threat trajectory	**Increasing** = Sub-catchment where modelled deer pellet density is greater than 0.35. It is assumed that the level of effort of deer control in these high density areas is not extensive enough. **Stable** = Sub-catchment where modelled deer pellet density is less than 0.35. **Declining** = not considered. Confidence in assessment: high Deer was considered the most important threat. Other pest animals were not considered. <u>Anecdotal evidence</u> - Deer was not explicitly recognised as a threat in the HWS. Deer management has not kept pace with the threat. Projects in Warburton and upstream require fencing because of the deer threat even 3 years of fencing is not sufficient to establish vegetation in the presence of deer. The pest (deer, kangaroos and wallabies) threat to vegetation establishment is increasing. The threat to vegetation is related to grazing pressure, rather than a pugging threat. Deer threat is often framed as 'total grazing pressure' and therefore indistinguishable from stock access. Material costs (fencing) have dramatically increased, impacting budgets and the number and types of projects that can be funded in the future. Stock access is not being tracked overall. MW track where vegetation has been established and fencing is installed if required. Assume investment has resulted in stock threat itself decreasing.
Where has the threat increased?	

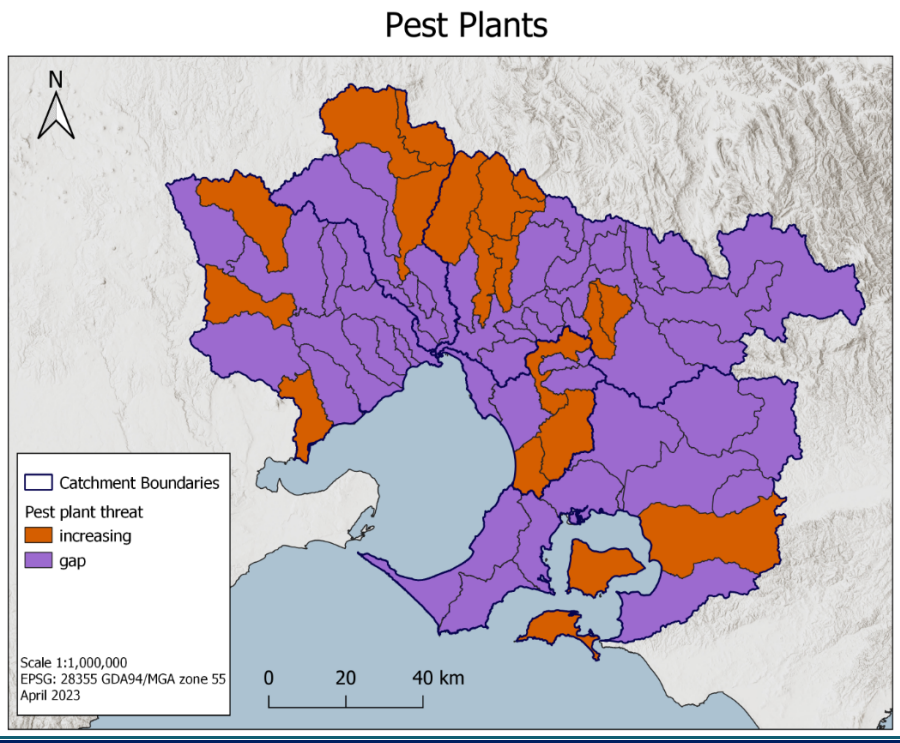


Modelled deer density from 0.35 (moderate deer pellet density to 2 (high) deer pellet density. The blue dots are where deer were recorded in VV21. The black lines represent the protection areas from VV18 and the grey lines are the subcatchments.

Changed assumptions and operating environment	
Have assumptions changed? Has there been any policy changes since 2018 that influences the threat?	Victorian deer control strategy and a peri-urban Melbourne Deer Control Plan for Melbourne
New and emerging	
Melbourne Water Waterways and Wetlands Research Program	D2 Prediction tool for deer abundance across the region, including likely impacts on vegetation.
New and emerging datasets	Increased knowledge of deer habitat preferences and impacts and maps of predicted deer density and impact for entire MW region. MW Guidelines on managing pest plants, animals and pathogens. 2021. In the future, eDNA monitoring data will be a useful complementary dataset on the distribution of pest animals. ROMP intervention monitoring will help to better understand the effectiveness of vegetation management interventions and should provide good understanding of key threats to vegetation such as rabbits and deer.
Knowledge gaps	
What are the priority knowledge gaps for this threat?	Extent and impact of animal threats other than deer e.g. invasive fish, rabbits, dogs and cats and over abundant wildlife e.g. kangaroos.

Pest plants

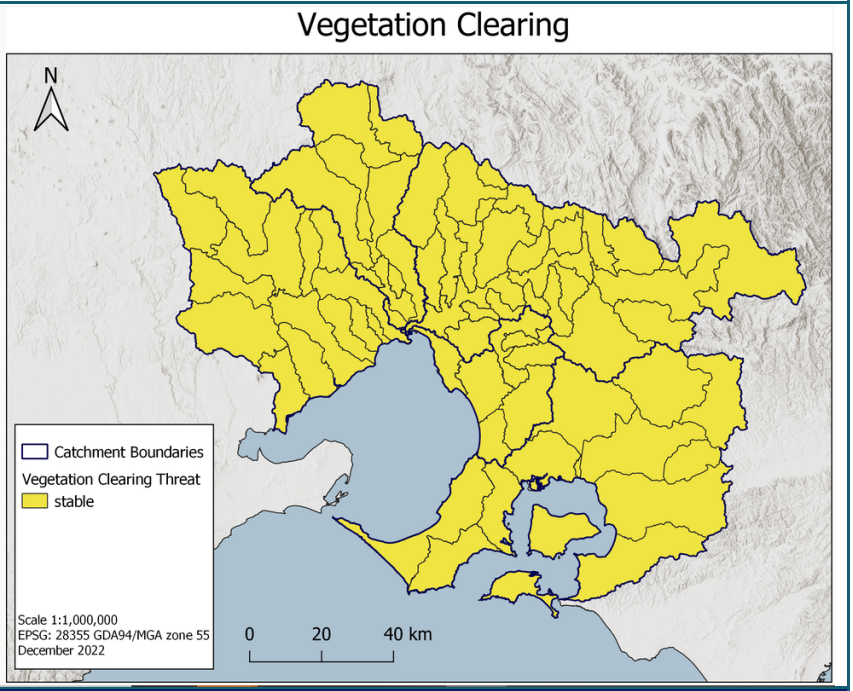
General Information	
Activities related to the threat	High risk weeds, over abundant native species e.g. common Reed, Typha
Conditions impacted by the threat Primary Secondary	 Vegetation Water quality, physical form, flow
Values impacted by the threat	Vegetation, birds and other values to a lesser extent
Asset impacted by the threat	Rivers, wetlands and estuaries
Assumptions made in 2018	
Datasets used in 2018	Vegetation visions expert elicitation data
Key assumptions Confidence	Gap Expert opinion. Broad assumptions that vegetation quality will decline due to threat of pest plants.
How climate change was considered to influence the threat	Was not considered
Performance objectives	
Existing regional performance objectives (RPO)	RPO 13 A risk-based approach is adopted to prevent, eradicate and contain pest plants and animals (including deer) and protect waterway assets.
Sub-catchment performance objectives	**Rivers** Establish a continuous riparian vegetated buffer (2 km, 6 ha) and maintain existing vegetation (1 km, 2 ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality). Maintain or achieve high and very high quality vegetation (level 4 and 5 vegetation quality is currently 14 km) along Emu Creek and tributaries through effective monitoring and management of threats including protection of endangered EVCs. Fill data gaps in mapping of high quality vegetation. **Wetlands** Reduce invasive flora threat to low focussing on salt tolerant weeds in saltmarsh communities. **Estuaries** Protect remnant estuarine vegetation communities, particularly coastal saltmarsh, through targeting key invasive plant species. Refer to pest animal table for progress towards the rivers performance objectives.
Gap / issue ?	Managing pest plant threat for rivers is implicit in the performance objective at present reporting does not consider pest animals separate to pest plants.
Threat trajectory	
Assessment of threat trajectory	Without long term surveillance data is difficult to assess the trajectory of weeds. The threat is likely to be increasing where maintenance efforts are significantly off-track and as such the performance objective status was used as a surrogate.

	Increasing – where the protect/maintain vegetation performance objectives are significantly off-track. Stable – unable to assess Decreasing – unable to assess Gap – remaining areas Confidence in assessment = low Anecdotal evidence – There is evidence at works monitoring sites that pest plants are decreasing however it is difficult to assess at a regional level.
Where has the threat increased?	
Changed assumptions and operating environment	
Have assumptions changed? Has there been any policy changes since 2018 that influences the threat?	Given the merger with the CMA, Melbourne Water will have a stronger role in weed management given new responsibilities under the CALP act. e.g. the Minister can ask a CMA to prepare a pest plan that provides for the control and/or eradication of declared weeds and includes measures to protect biodiversity. Biosecurity provisions are currently being reviewed by the Victorian Government. Current laws dealing with animals, pests and plants are spread across multiple Acts. Reforming Victoria's biosecurity legislation | Strengthening Victoria's Biosecurity System Program | Protecting Victoria | Biosecurity | Agriculture Victoria Biosecurity provisions of the Fisheries Act, Catchment and Land Protection Act, Plant Biosecurity Act or Livestock Disease Control Act, depending on the type of organism involved.
New and emerging	
Melbourne Water Waterways and Wetlands Research Program	A3P Project E2.4: What are the effects of chemicals frequently used by Melbourne Water on or near waterways on aquatic ecosystems and public health? Alternative control methods.

New and emerging datasets	Vegetation vision assessments at over 500 riparian and estuarine sites across MW region, including identification of problem weeds. Estuarine vegetation condition monitoring and weed threat has been initiated in 2023 along most estuaries in the region. Detailed vegetation condition monitoring along rivers and estuaries will assess impacts of climate change. eDNA monitoring data has potential to target invasive weeds. ROMP surveys of restored areas and sites of management intervention. Ie knowledge of weeds before and after intervention. Inventory of values and threats (including weeds) for several streams of significance. Agriculture Victoria distribution mapping of 20 weeds. DELWP's NatureKit. This identifies/maps Biodiversity 2037 priority areas and Strategic Management Prospects (including threat, benefit and cost ranking) for a range of control actions such as pest plant and animal control (by species e.g. deer, pig, goat, fox, cat).
Knowledge gaps	
What are the priority knowledge gaps for this threat?	Changes to weed distributions from climate change.

Vegetation clearing

General Information	
Activities related to the threat	Illegal tree removal and forestry practices.
Other related threats	Building over of wetlands will lead to vegetation loss. Covered in the physical modification threat section.
Conditions impacted by the threat Primary Secondary	Vegetation
Values impacted by the threat	Macroinvertebrates, platypus, birds, vegetation, fish, frogs
Asset impacted by the threat	Rivers, wetlands, estuaries
Assumptions made in 2018	
Datasets used in 2018	Not quantified; assumed to be a low threat
Key assumptions Confidence: Good, fair, gap	Gap Not considered
How climate change was considered to influence the threat	Climate change was not considered
Performance objectives	
Existing regional performance objectives (RPO)	RPO 29 Programs, standards, tools and guidelines are in place to protect wetland vegetation communities from urban and rural threats, including adequate planning controls.
Sub-catchment performance objectives	While there are no specific performance objectives aimed at managing illegal vegetation clearing in priority areas, the establishing vegetation SCPOs are in-directly related. **Rivers** *Establish a continuous riparian vegetated buffer (2 km, 6 ha) and maintain existing vegetation (1 km, 2 ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality).* **Wetlands** *Improve the wetland buffer to cover 50% of the wetland perimeter.* **Estuaries** There are no establish vegetation performance objectives for estuaries. They are focused on climate change adaptation. Ie *Enable lateral and longitudinal migration of estuarine vegetation communities on the floodplain to allow adaptation to climate change risks.*
Gap / issue ?	No specific Performance Objectives.
Threat trajectory	
Assessment of threat trajectory	Assumed stable in all sub-catchment. Subject matter experts judged this threat to be relatively stable as levels of illegal clearing along waterways are likely to be low. Confidence in assessment – low

	Anecdotal evidence – Noted that vegetation offsetting is largely ineffective
Where has the threat increased?	
Changed assumptions and operating environment	
Have assumptions changed? Has there been any policy changes since 2018 that influences the threat?	No Logging is being phased out by 2030
New and emerging	
Melbourne Water Waterways and Wetlands Research Program	Partnership with RMIT - using remote sensing data to track vegetation condition.
New and emerging datasets	Remote sensing data (RMIT research). LiDAR and Near map data – with the potential for identifying areas of cleared vegetation and detecting impacts on vegetation strata. RMIT may have an offsets database. Councils may have data on vegetation clearing e.g. permits.
Knowledge gaps	
What are the priority knowledge gaps for this threat?	Understanding the extent and likely impacts of vegetation clearing. If significant it will be an important input to HSMs. Loss of vegetation can be tracked by aerial/satellite imaging, but imaging does not inform the cause of vegetation loss.

Climate change

The HWS considered climate change as one of the key threats in the development process. The best available projections were used at the time to help set long term targets for key values. The mid-term evaluation of the HWS was an opportunity to reassess assumptions around climate change and incorporate any new knowledge. This section:

- summarises the HWS performance objectives that relate to climate change
- summarises an unpublished review paper on the increasing threat of forest fires for the world's aquatic ecosystems
- references Melbourne Waterways Research Practice Partnership research projects which has informed the HWS mid-term review

HWS climate change Performance Objectives

There are a number of performance objectives in the HWS which consider climate change. These include:

RPO 10 - An adaptive pathways approach is adopted to understand and manage the risks of climate change on waterways.

RPO 22 - Cooler, greener and more liveable urban environments are created through revegetation and as part of managing excess stormwater.

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.

Examples of performance objectives at the sub-catchment scale are:

Rivers - Performance objectives in the theme of 'unregulated flows' typically included a statement around climate change *e.g. "Reduce threat of summer low flow stress by addressing causal factors such as water for domestic and stock use, diversions and climate change".*

Wetlands – Ramsar sites include the following performance objective *"Identify opportunities for habitat creation and migration with the adjacent to Ramsar to mitigate habitat loss due to climate change risks."*

Estuaries – Some estuaries included the following performance objective *"Climate change adaptation plans in place for social and environmental values associated with the estuary."*

Climate change threatens Melbourne's forested ecosystems

Climate change represents a large threat to the conditions and values existing in Melbourne's most highly valued managed areas: forest ecosystems in protected and un-protected catchments. By almost all measures, these forested ecosystems in the upper parts of Melbourne's catchments (e.g. Lerderderg State Park, Macedon Regional Park, Yarra Ranges National Park, Bunyip State Park, Dandenong Ranges National Park) harbour relatively natural ecological conditions and processes and support communities of threatened and significant species.

However, climate change is the leading factor driving a global increase in wildfire extent and severity in forested areas (Halofsky et al. 2020, Mansoor et al. 2022) and represents an increasing threat to Melbourne's terrestrial and aquatic ecosystems. For example, in temperate eastern Australia, declines in winter-spring rainfall from the late 1990s to the 2019/20 summer together with

increased incidence of extremely high temperatures in summer manifest as drought and heatwaves directly contributed to an increase in wildfire severity and extent across many forested catchments (Adams et al. 2020, Nolan et al. 2020; Abram et al. 2021) resulting in the "Black Summer" fire season of 2019-20. These Black Summer fires are estimated to have directly impacted 487,600 km of stream network through widespread changes in vegetative cover, substantive erosion, and the mass delivery of solutes and particulate matter into streams from the terrestrial zone (Cox et al., unpublished).

High-severity forest fires will occur again in the Melbourne region and their frequency and extent will increase due to climate change. Melbourne's streams and rivers in high-value forested catchments are, therefore, particularly vulnerable to changing fire regimes and particularly high-severity wildfires in the face of ongoing climate change.

Melbourne Water Waterways Research

The Melbourne Waterways Research-Partnership has 2 projects related to climate change.

Project A1. Spatial prioritization of management actions for biodiversity outcomes in streams & wetlands. The aims of this project with respect to the mid-term review and climate change are:

1. Use habitat suitability models (HSMs) of instream values (fish, platypus and macroinvertebrates) to assess the latest climate change projections and compare to predictions made in 2018. E.g. are predictions using more sophisticated and detailed climate change data different?
2. Assess whether priority actions developed for the HWS are robust under a range of plausible climate futures

A summary of findings can be found in Chee, Coleman et al (2023).

Project D5 - Modelling the risk of climate change to key revegetation species. The aims of this collaborative project are to:

1. investigate how key riparian revegetation species used by Melbourne Water are likely to be influenced by a changing climate,
2. identify which key revegetation species are at greatest risk as a result of climate change,
3. investigate important mechanisms at critical life-history stages such as germination and seedling establishment that influence species responses to climate change,
4. investigate if provenance selection may ameliorate the risk of climate change on a key revegetation species River Red Gum Eucalyptus camaldulensis ssp. camaldulensis; and,
5. explore how climate-matching methods could support climate-adapted seed-sourcing to build genetic resilience and adaptation to projected future climatic conditions

A region wide assessment of climate change impacts on estuaries is underway. The project is aiming to assess the predicted impact of sea level rise on estuary vegetation and connectivity to floodplains and impacts on social infrastructure to inform the development of climate change adaptation plans.

4. Key findings and recommendations

Below is an overall summary of key findings from the threats stocktake with more detail provided in each of the threat groupings. These sections include recommendations that are focused on implementation while knowledge gaps identified in the report have fed into 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?

- Many threats are still increasing across the region.
- Climate change remains a significant threat to the region
- Urbanisation, water availability and pest animals (largely deer) are the top 3 threats that have increased since 2018.
- Wastewater, instream barriers and streamside vegetation clearance (low confidence) are the only threats ranked as stable or decreasing in all sub-catchments.
- Many sub-catchments have multiple increasing threats which can often interact with each other.
- Forested sub-catchments have the fewest threats, although climate change is considered a significant threat, particularly forest fires.

Urban related threats

Stormwater (flow, water quality), wastewater, physical modifications, litter

Urban development is one of the biggest threats to environmental values in our region and for the first time targets to reduce stormwater runoff volumes have been set. However, given the fast pace of development and the effort required to shift focus from business as usual water quality management the flow impact threat has continued to increase. Using updated directly connected imperviousness (DCI) data the urban flow threat is considered to be still increasing in 12 sub-catchments. While best practice guidelines for managing water quality from urbanisation are in place, these do not adequately manage industrial areas that produce toxicants, heavy metals and other emerging contaminates. Using sediment quality data the urban water quality threat has been rated as increasing in 11 sub-catchments, largely due to the presence of industrial areas. The construction phase of urban development which generates large sediment loads is also a concern in many sub-catchments, particularly in areas of sodic soils (typically the north and west) and areas that threatened sea grasses in Westernport Bay.

In addition to flow and water quality impacts headwater streams and natural wetlands are also directly threatened by urban development. There are 14 natural wetlands which are at threat from being built over and around 50 kms of headwater streams proposed to be piped.

Litter is a threat to social values and some environmental values like platypus. With respect to platypus, the litter threat is considered to be declining in rural areas where opera house nets have recently been banned however, there are 14 urbanising sub-catchments where platypus are likely to be exposed to an increasing litter threat.

The threat from wastewater discharges on environmental values has been rated as stable across the region, based on the fact that pollutant load discharges from STPs are not increasing. STPs are regulated and a number will go offline in the life of the HWS. Septic tank impacts are declining as areas are connected to the reticulated sewer network. Emergency Relief Structure spills are also regulated and have been generally declining over the long term across the region.

In terms of performance objectives targets for STPs are on-track. While stormwater harvesting performance objectives are on-track for the Werribee and Maribyrnong catchments the status is largely based on works that are planned and yet to be constructed. Infiltration targets are significantly off-track in all major catchments except Maribyrnong where infiltration objectives are planned to be met through the Sunbury IWM project. Performance objectives focused on industrial pollution are limited to 3 sub-catchments and progress is difficult to assess. The assessment has highlighted the need to potentially consider additional performance objectives in sub-catchments where the threat is increasing. Performance objectives for protecting natural wetlands and headwater streams are regional and qualitative making progress difficult to assess. There are also no sub-catchment specific performance objectives for managing litter to protect platypus in priority areas.

Table 6 provides a summary of each threat including the number of sub-catchments where the threat is increasing, the coverage of performance objectives in the region and key changes to the operating environment.

Table 6. Urban related threats summary

Threat category	# SCs with increasing threat	Performance objective coverage	Significant operating environment changes
Urban flow (DCI)	12	Priority areas in 31 sub-catchments	GED supports HWS targets
Urban WQ (toxicants)	11	3 sub-catchments	GED supports HWS targets
Wastewater (STPs)	0	7 sub-catchments Missing PO in Werribee River	GED supports HWS targets
Physical modifications (natural wetlands and headwater streams)	15	2 regional POs	Designated waterways layer includes headwater streams and natural wetlands
Litter (platypus)	14	1 regional PO No sub-catchment PO focused on platypus	Banning of Opera House nets

Recommendations (implementation focus) for consideration in the Science Inquiry:

- Prioritise protection of headwater streams from urban development
- Prioritise protection of natural wetlands from urban development
- Increase efforts to reduce sediment run-off during the construction phase of urban development in priority areas such as sub-catchments in the north and west and those close to Westernport Bay.
- Improve understanding of implementation for managing industrial areas and develop more quantitative ways to assess progress. Consider adding additional performance objectives for new priority areas or focus reporting RPO 24 around management in priority sub-catchments identified during the science inquiry.

Rural related threats

Water availability and agricultural land

There is a growing body of evidence of the significance of flow stress in the region particularly in unregulated catchments. Decreasing water availability has been identified as an increasing threat in most rural sub-catchments as evidenced by the Long term water resources assessment (DEPI 20conducted as part of the CGRSWS. Water recovery targets for regulated flows identified in the last HWS have not been achieved. Qualitative targets for non-regulated sub-catchments are difficult to assess. There is a need to better understand the causes of flow stress (e.g. climate change and/or water use) and options for more targeted performance objectives to improve management, reporting and evaluation in the future.

Agricultural land has been identified as an increasing threat to values in 3 sub-catchments due to observed intensification of farming practices. Progress towards improved land management is on-track in 2 of these sub-catchments (Lang Lang River and Woori Yallock Creek) while the third (Stringybark Creek) is not currently a priority area due to low macroinvertebrate values. With respect to water quality impacts from agricultural practices, further pesticide, sediment and ecotoxicology studies are needed to improve understanding of the threat in key areas and inform the development of appropriate interventions beyond nutrient and sediment management.

Table provides a summary of each threat including the number of sub-catchments where the threat is increasing, the coverage of performance objectives in the region and key changes to the operating environment.

Table 7. Rural related threats summary

Threat category	# SCs with increasing threat	Performance objective coverage	Significant operating environment changes
Water availability	42	43 sub-catchments in unregulated rivers 11 sub-catchments in regulated rivers	Central and Gippsland region sustainable water strategy (CGRSWS) aligns with HWS targets
Agriculture	3	26 sub-catchments	Plan Melbourne identifies areas of strategic agricultural land

Recommendations (implementation focus) for consideration in the Science Inquiry:

- Investigate the drivers of flow stress across the region including climate change and water extraction and develop an implementation plan to improve climate resilience and reduce flow stress. Consider actions such as on-line dam removal, riparian sponges and floodplain re-engagement, updates to the sustainable diversion limits, increased / improved regulated flows that consider transfer of organic and inorganic matter downstream of barriers.
- Develop a more quantitative approach to annual reporting for the water for environment performance objectives.
- Focus investigations of pesticide, sediment and other contaminants from agriculture land through ecotoxicology studies in high value areas and where needed development appropriate interventions (e.g. that go beyond nutrient and sediment run-off).

Habitat related threats

Pest plants, animals, recreational access, barriers and vegetation clearing.

Herbivores such as deer, rabbits, livestock and over abundant wildlife impact vegetation through grazing, trampling, pugging and dispersal of weeds. Other animals can be predators such as exotic fish, dogs and cats. The threat from livestock is generally thought to be decreasing as more riparian land is appropriately managed. Deer however is an emerging threat and is rated as increasing in almost half the sub-catchments in the region, particularly those in the south and east. There was not enough data to assess exotic fish, dogs or cats.

Weeds continue to threaten vegetation along waterways and regular on-going management is often required. In time regional surveillance monitoring will provide better evidence of the weed threat trajectory across the region. As a surrogate the threat trajectory was assessed as increasing in sub-catchments where vegetation maintenance targets are off-track. Based on this there are 18 sub-catchments where the weed threat is likely to be increasing.

Motor bikes, cars and mountain bikes can increase tracks and vegetation disturbance leading to fragmentation and erosion. Recreational access in forested catchments was flagged as a potentially increasing threat however further data and analysis is required to quantify the extent of the impact. There are currently no specific performance objectives in the HWS aimed at managing this threat.

Instream barriers can threaten fish movement and migration. As new waterway structures such as weirs are designed to be fish friendly, the threat is considered largely stable across the region and declining in several sub-catchments (Dandenong Creek lower, Yarra River lower, Darebin Creek and Maribyrnong River) where fishways have been constructed.

Illegal clearing of riparian vegetation is not considered to be a widespread threat in our region however confirmation of this is required. New aerial imagery datasets will enable this assessment to be made in the future.

Disease can also be a threat and in our region and chytrid fungus is present and impacting on frogs. The degree to which the threat is increasing is not known. Table 8 provides a summary of each threat including the number of sub-catchments where the threat is increasing, the coverage of performance objectives in the region and key changes to the operating environment.

Table 8. Habitat related threats summary

Threat category	# SCs with increasing threat	Performance objective coverage	Significant operating environment changes
Weeds	18	Implicit in the establishing or maintaining vegetation which are included in all 69 sub-catchments	MW/CMA merger has given MW a stronger role in weed management under the CALP Act.
Animals (deer)	30	Implicit in the establishing or maintaining vegetation which are included in all 69 sub-catchments	Deer control strategy and peri-urban deer control plan.
Recreational access	21	No specific performance objectives	
Vegetation clearing	0	No specific performance objectives	
Instream barriers	0	Performance objectives in 10 sub-catchments	GED supports HWS targets

Recommendations (implementation focus) for consideration in the Science Inquiry:

- Prioritise efforts to manage deer in high value vegetation areas
- Develop quantitative ways to report progress towards pest animal control with a focus on deer management
- Consideration should be given to developing performance objectives for managing the threat of litter on platypus in priority locations.

Climate change

Climate change is a large looming threat to the conditions and values of the region. It is likely to (and may already be) lead to water and air temperature increases, reduction in average rainfall and annual flow volumes, increased storm intensity and floods, increased bushfire extent and severity, increased frequency of storms (e.g. wind storms), increased urban heat island and sea level rise.

Using the latest climate change projections, impacts of climate change on several instream values including fish, macroinvertebrates and platypus were assessed using habitat suitability models. Results showed a number of sub-catchments where species are predicted to contract and decline in a warmer and drier climate. While there are several limitations to the modelling, these results are important considerations in how we respond to climate change (Chee, Coleman 2023).

Climate change can also amplify other threats e.g. threats from erosion may increase in due to increased storm intensities, changed flow regimes may impact the performance on fishways and certain weeds and pest animals may proliferate.

Many knowledge gaps remain with respect to climate change and there are a number of research projects underway aimed at improving understanding of the risks of climate change and adaptation pathways.

Recommendations (implementation focus) for consideration in the Science Inquiry:

- Refer to the report - HWS Mid-term Values Synthesis Results (2023)
- Refer to the report – Chee, Colememan et al (2023)

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Appendix 1 -Directly Connected Imperviousness mapping

Recalculation of imperviousness for HWS mid-term review.

Statement of compliance (SoC) data from 2019 to 2022 for the stormwater priority areas (Figure 1 A) were used to estimate growth in directly connected imperviousness since the 2014 estimate used by the HWS habitat suitability models. Areas of new development identified in the SoC data in each subcatchment were divided by 0.5 to estimate new connected impervious areas.

A multiplier of 0.5 was used assuming an impervious fraction of new developments between 0.5 and 0.65, accounting for a small reduction in effective imperviousness resulting from stormwater control measures designed to meet the urban stormwater guidelines of Victorian Stormwater Committee (1999) (see above). We currently lack data on developments (greenfield and infill) that were built between 2015 and 2019 (i.e. after the 2014 DCI area estimate and before the available SoC data), so the estimate of the growth of stormwater impacts in this analysis is a likely conservative underestimate of true urban growth in many of these areas.

The new subcatchment DCI area estimates of all upstream subcatchments were summed for each subcatchment (and divided by catchment area) to estimate catchment DCI in 2022. These recalculations were applied only to streams flowing through the stormwater priority areas (Figure 1 B).

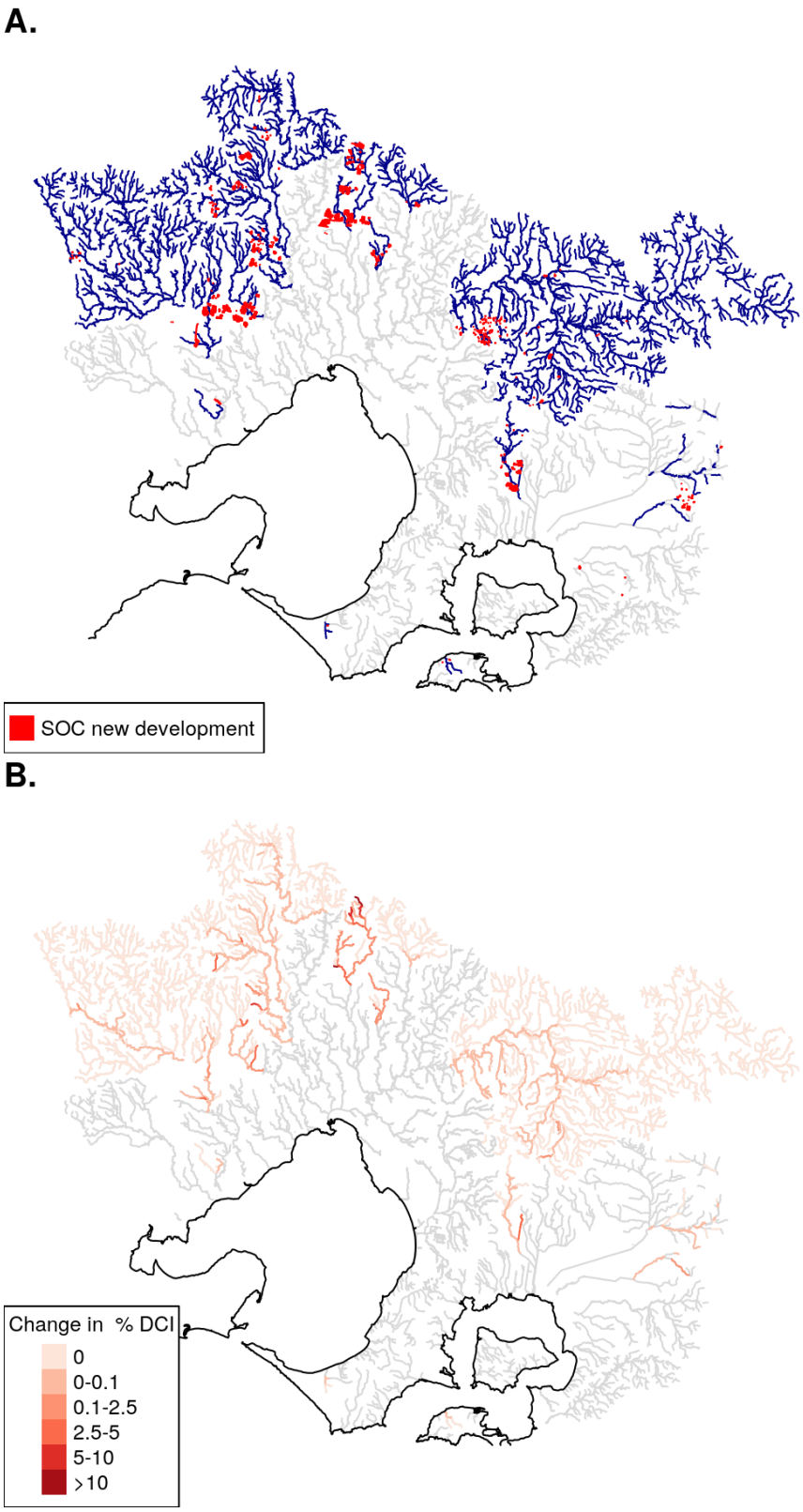


Figure 1 A. Locations of 'State of compliance' new development polygons. B. Percentage change in DCI from 2014 resulting from developments covered by 2019-2022 statements of compliance for the HWS stormwater priority areas, represented by shades of red. In both plots, reaches outside the priority areas are coloured grey.

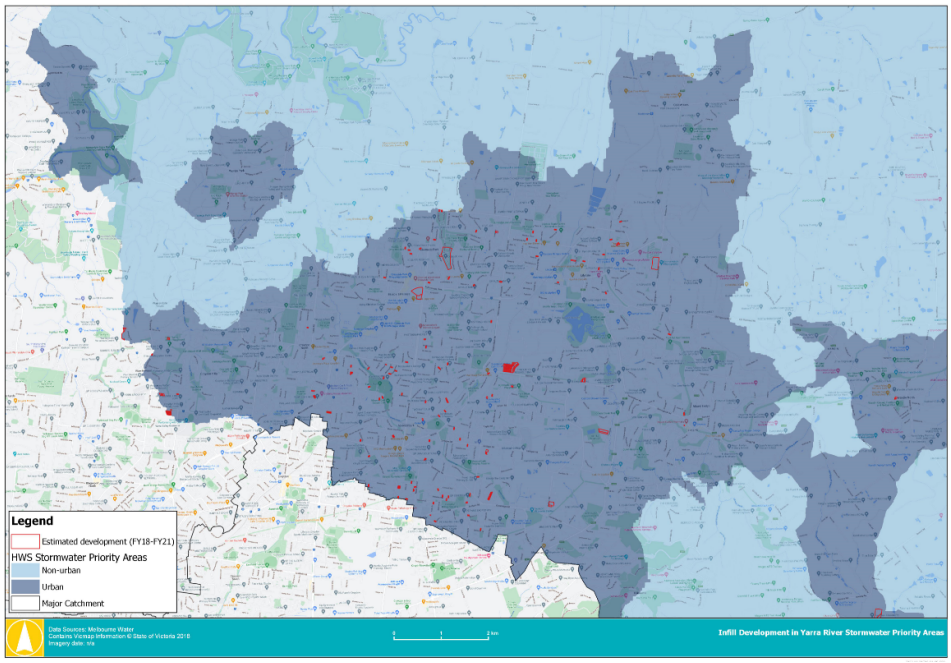


Figure 1B Example of infill development in the middle Yarra sub-catchment as indicated by statement of compliance data (red polygons)

Appendix 2 -headwater streams and natural wetlands threat maps

Sub-catchments where headwaters and wetlands are at threat from being built over by urban development.

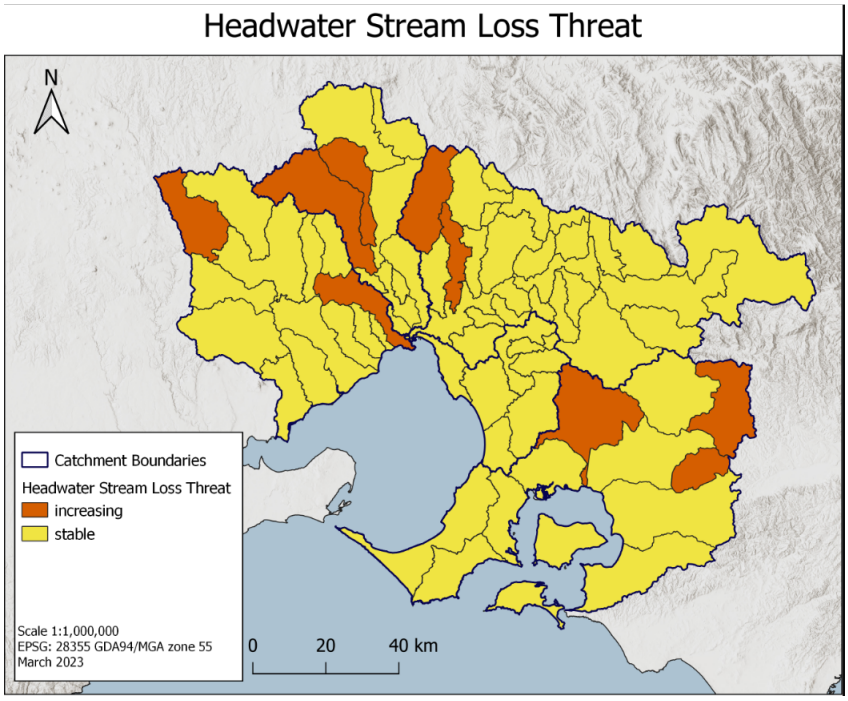


Figure 2 Sub-catchments where headwater stream losses are predicted

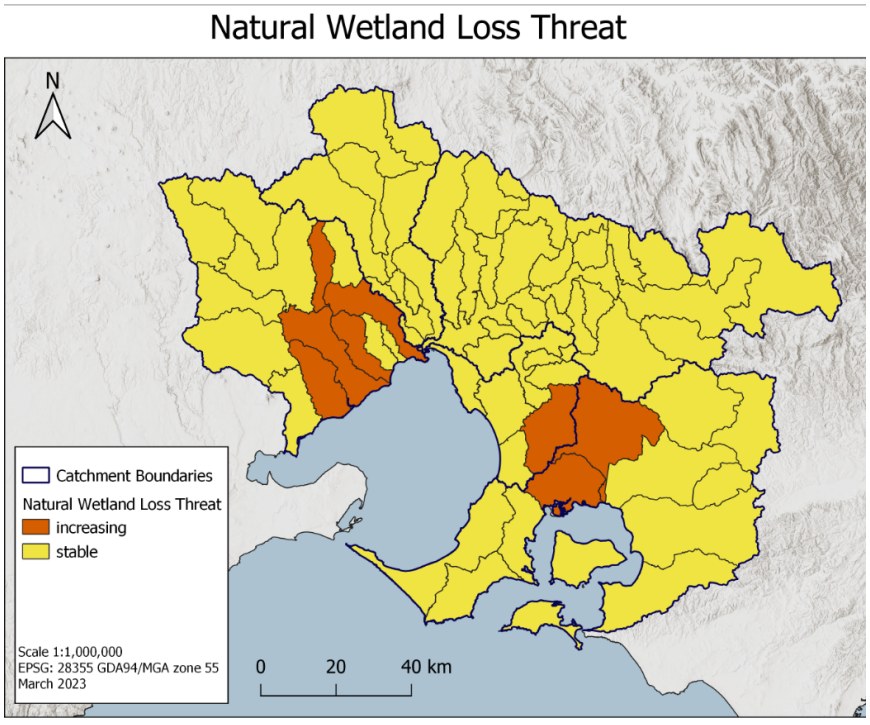
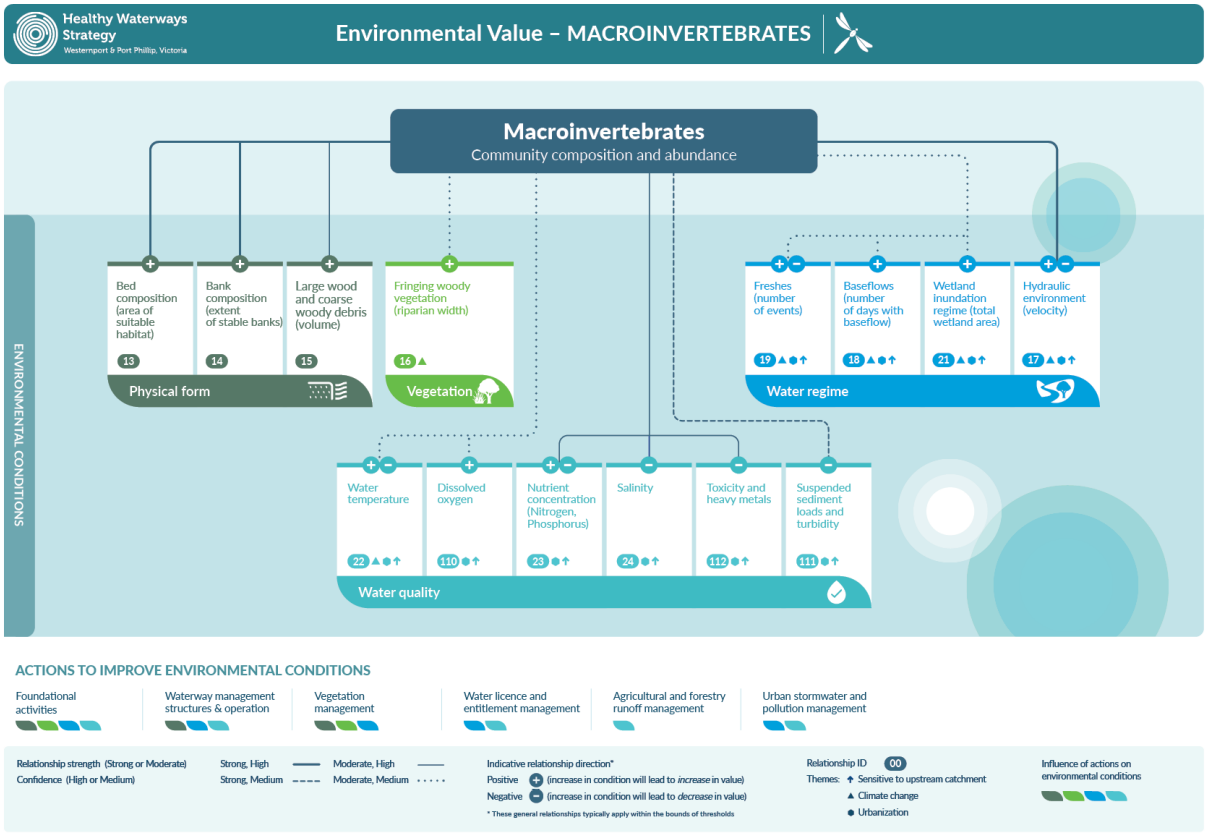


Figure 3 Sub-catchments where natural wetland loss is predicted

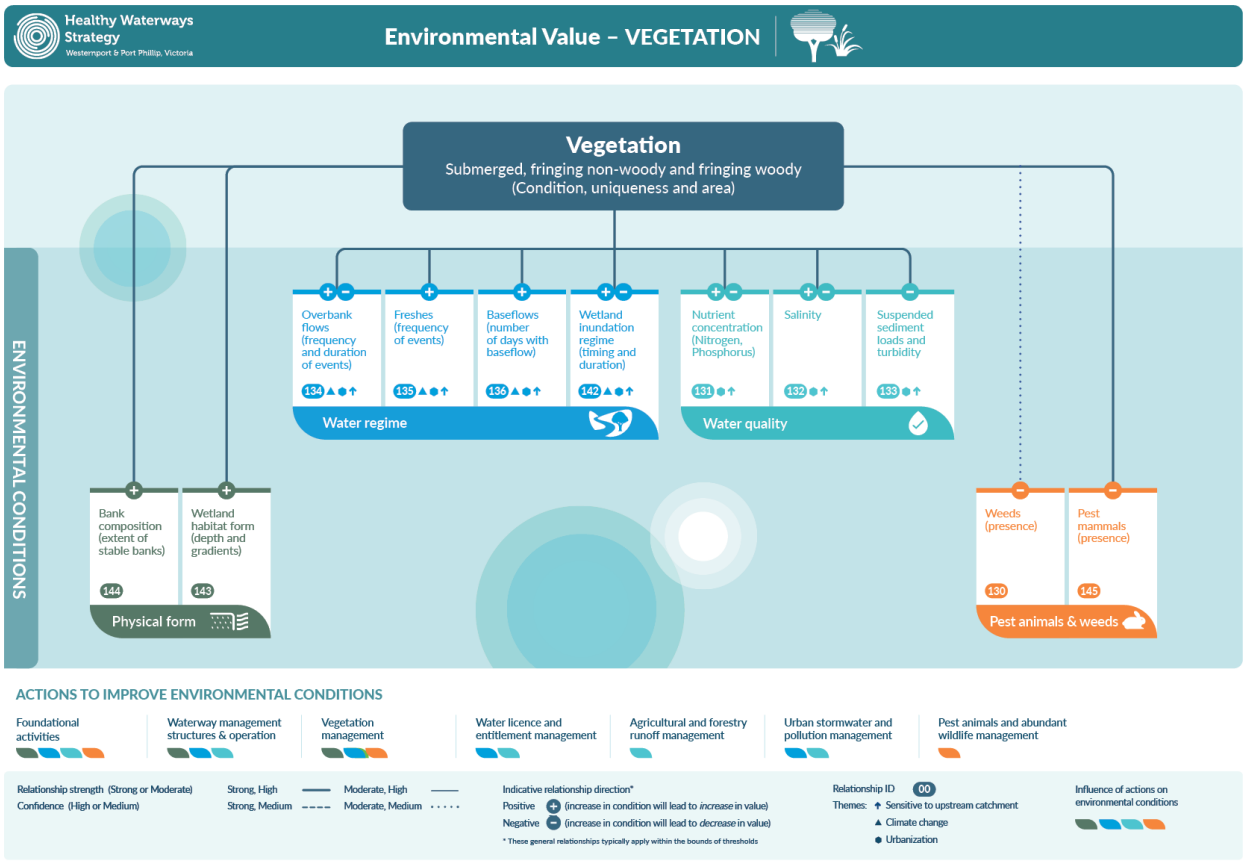
Appendix 3 – Conceptual models

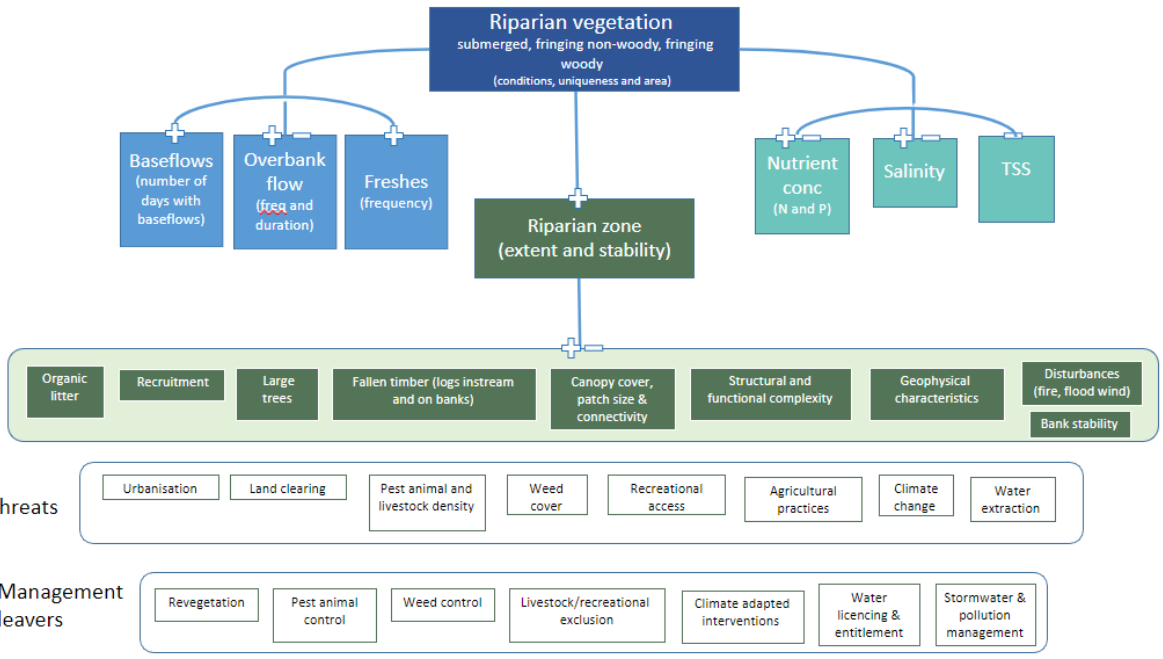
The HWS conceptual models are presented below to provide a quick reference guide to the conditions which influence key values. It is proposed that these models be updated following the mid-term review to include relevant threats.

Macroinvertebrates

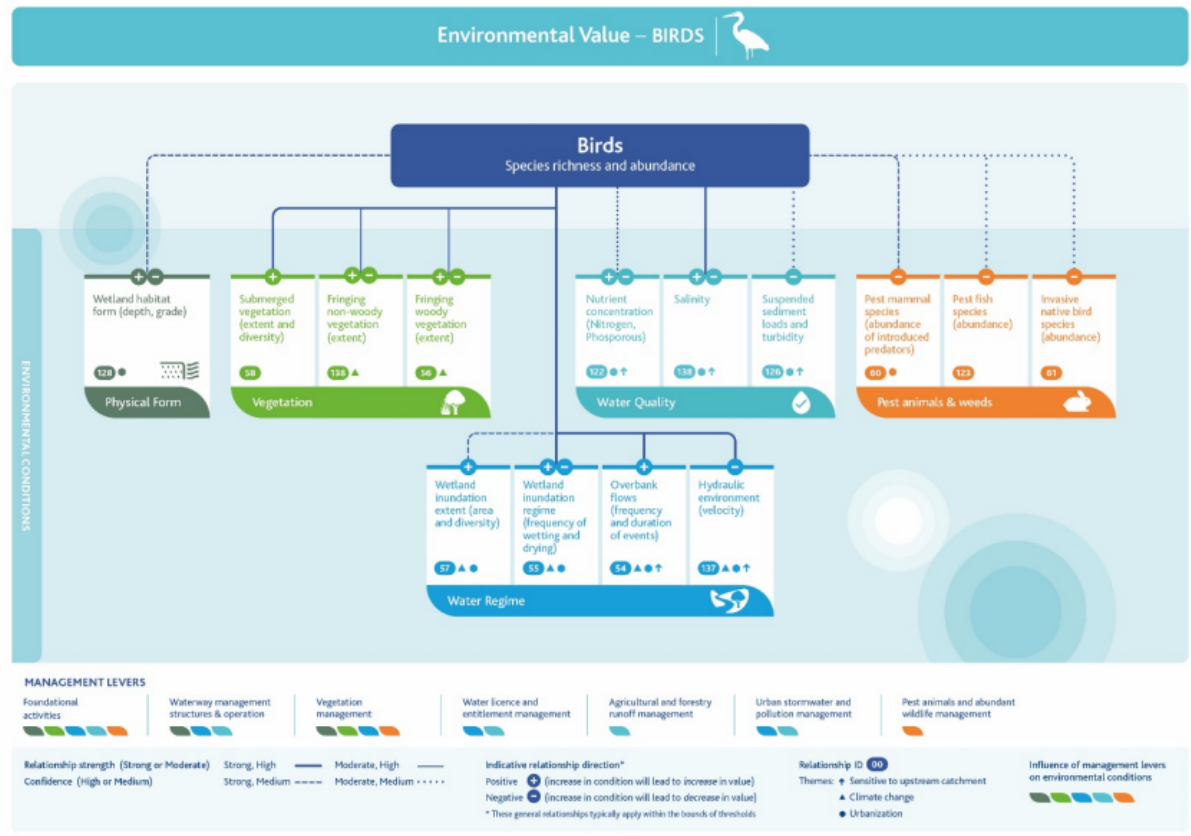


Vegetation

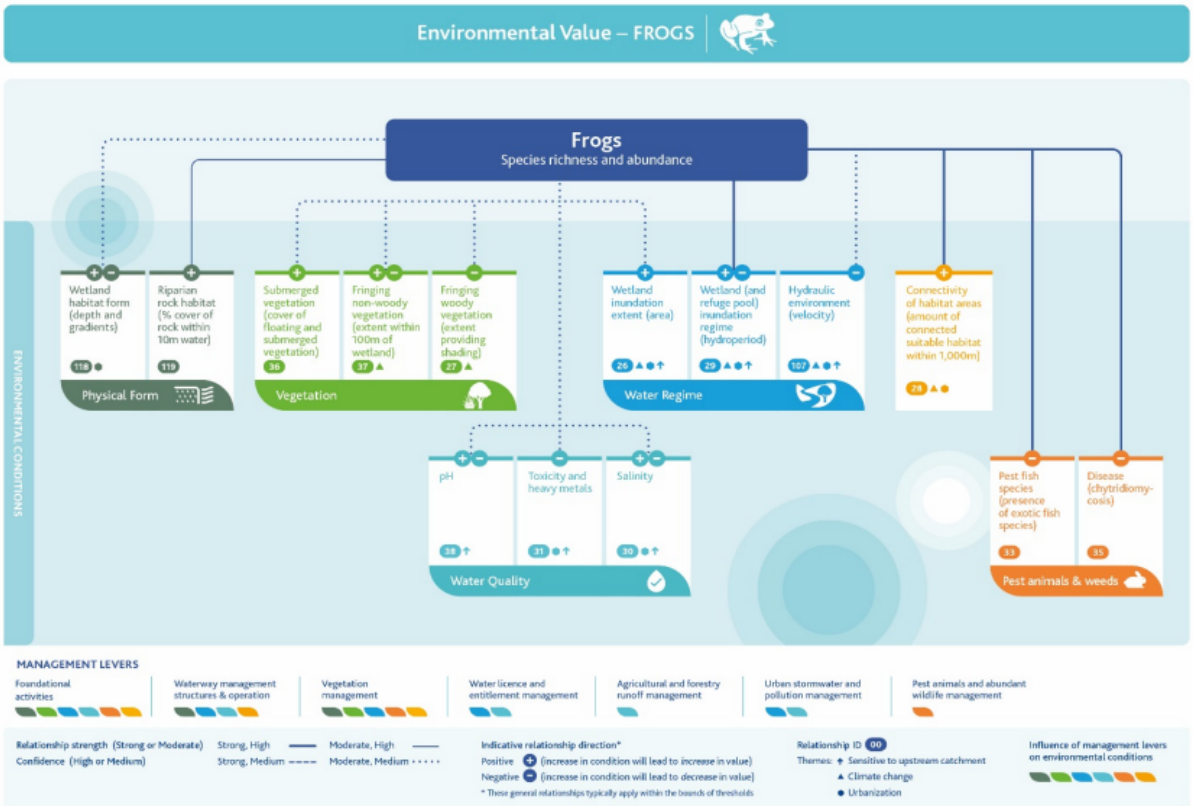

Healthy Waterways Strategy
Westernport & Port Phillip, Victoria
Environmental Value – VEGETATION
Vegetation
Submerged, fringing non-woody and fringing woody
(Condition, uniqueness and area)
ENVIRONMENTAL CONDITIONS
Overbank flows (frequency and duration of events)
134
Freshes (frequency of events)
135
Baseflows (number of days with baseflow)
136
Wetland inundation regime (timing and duration)
142
Water regime
Nutrient concentration (Nitrogen, Phosphorus)
131
Salinity
132
Suspended sediment loads and turbidity
133
Water quality
Bank composition (extent of stable banks)
144
Wetland habitat form (depth and gradients)
143
Physical form
Weeds (presence)
130
Pest mammals (presence)
145
Pest animals & weeds
ACTIONS TO IMPROVE ENVIRONMENTAL CONDITIONS
Foundational activities
Waterway management structures & operation
Vegetation management
Water licence and entitlement management
Agricultural and forestry runoff management
Urban stormwater and pollution management
Pest animals and abundant wildlife management
Relationship strength (Strong or Moderate)
Confidence (High or Medium)
Strong, High
Strong, Medium
Moderate, High
Moderate, Medium
Indicative relationship direction*
Positive (increase in condition will lead to increase in value)
Negative (increase in condition will lead to decrease in value)
* These general relationships typically apply within the bounds of thresholds
Relationship ID 00
Themes: Sensitive to upstream catchment
Climate change
Urbanization
Influence of actions on environmental conditions


Riparian vegetation
submerged, fringing non-woody, fringing woody
(conditions, uniqueness and area)
Baseflows (number of days with baseflows)
Overbank flow (freq and duration)
Freshes (frequency)
Riparian zone (extent and stability)
Nutrient conc (N and P)
Salinity
TSS
Organic litter
Recruitment
Large trees
Fallen timber (logs instream and on banks)
Canopy cover, patch size & connectivity
Structural and functional complexity
Geophysical characteristics
Disturbances (fire, flood wind)
Bank stability
Threats
Urbanisation
Land clearing
Pest animal and livestock density
Weed cover
Recreational access
Agricultural practices
Climate change
Water extraction
Management leavers
Revegetation
Pest animal control
Weed control
Livestock/recreational exclusion
Climate adapted interventions
Water licencing & entitlement
Stormwater & pollution management

Birds


Environmental Value – BIRDS
Birds
Species richness and abundance
ENVIRONMENTAL CONDITIONS
Wetland habitat form (depth, grade)
Physical Form
Submerged vegetation (extent and diversity)
Fringing non-woody vegetation (extent)
Fringing woody vegetation (extent)
Vegetation
Nutrient concentration (Nitrogen, Phosporous)
Salinity
Suspended sediment loads and turbidity
Water Quality
Pest mammal species (abundance of introduced predators)
Pest fish species (abundance)
Invasive native bird species (abundance)
Pest animals & weeds
Wetland inundation extent (area and diversity)
Wetland inundation regime (frequency of wetting and drying)
Overbank flows (frequency and duration of events)
Hydraulic environment (velocity)
Water Regime
MANAGEMENT LEVERS
Foundational activities
Waterway management structures & operation
Vegetation management
Water licence and entitlement management
Agricultural and forestry runoff management
Urban stormwater and pollution management
Pest animals and abundant wildlife management
Relationship strength (Strong or Moderate)
Confidence (High or Medium)
Strong, High
Strong, Medium
Moderate, High
Moderate, Medium
Indicative relationship direction*
Positive (increase in condition will lead to increase in value)
Negative (increase in condition will lead to decrease in value)
* These general relationships typically apply within the bounds of thresholds
Relationship ID
Themes: Sensitive to upstream catchment
Climate change
Urbanization
Influence of management levers on environmental conditions

Frogs


Environmental Value – FROGS
Frogs
Species richness and abundance
ENVIRONMENTAL CONDITIONS
Wetland habitat form (depth and gradients)
Riparian rock habitat (% cover of rock within 10m water)
Physical Form
Submerged vegetation (cover of floating and submerged vegetation)
Fringing non-woody vegetation (extent within 100m of wetland)
Fringing woody vegetation (extent providing shading)
Vegetation
Wetland inundation extent (area)
Wetland (and refuge pool) inundation regime (hydroperiod)
Hydraulic environment (velocity)
Water Regime
Connectivity of habitat areas (amount of connected suitable habitat within 1,000m)
pH
Toxicity and heavy metals
Salinity
Water Quality
Pest fish species (presence of exotic fish species)
Disease (chytridiomy-cosis)
Pest animals & weeds
MANAGEMENT LEVERS
Foundational activities
Waterway management structures & operation
Vegetation management
Water licence and entitlement management
Agricultural and forestry runoff management
Urban stormwater and pollution management
Pest animals and abundant wildlife management
Relationship strength (Strong or Moderate)
Confidence (High or Medium)
Strong, High
Strong, Medium
Moderate, High
Moderate, Medium
Indicative relationship direction*
Positive (increase in condition will lead to increase in value)
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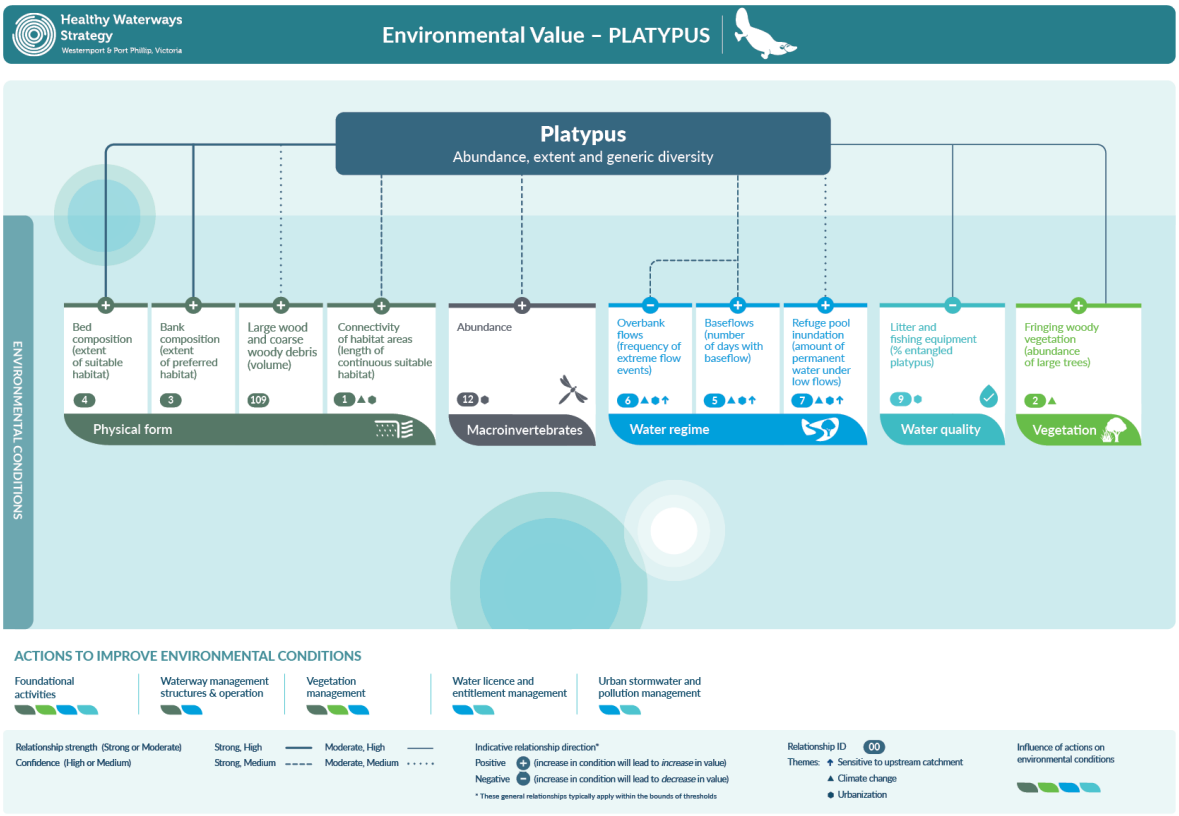
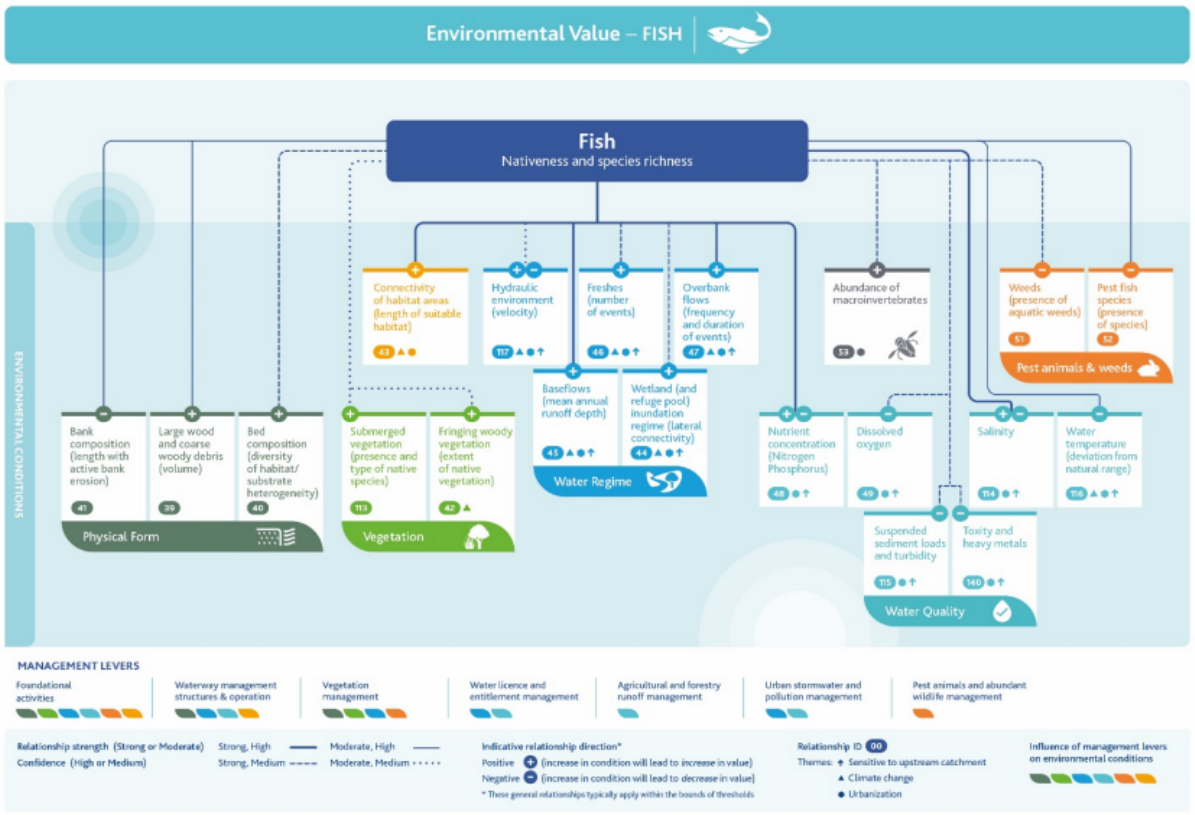
Relationship ID
Themes: Sensitive to upstream catchment
Climate change
Urbanization
Influence of management levers on environmental conditions

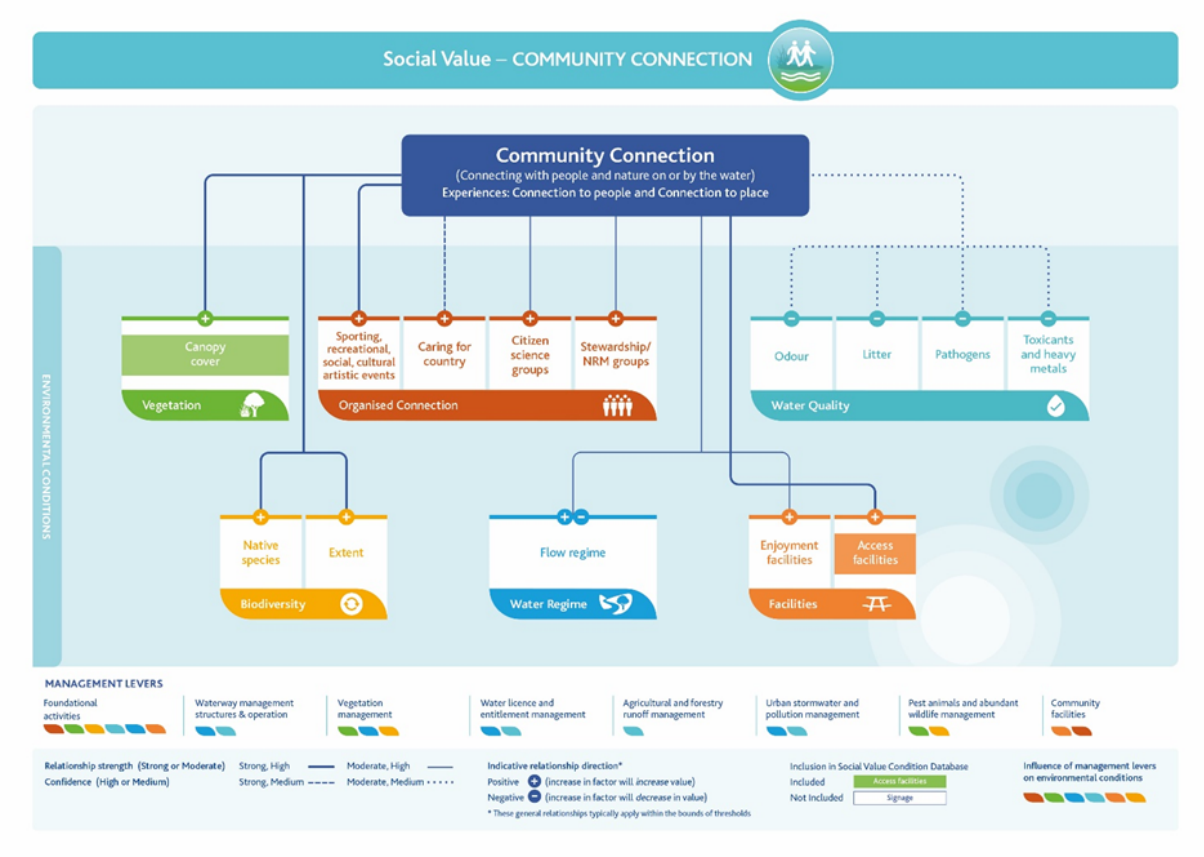
Platypus



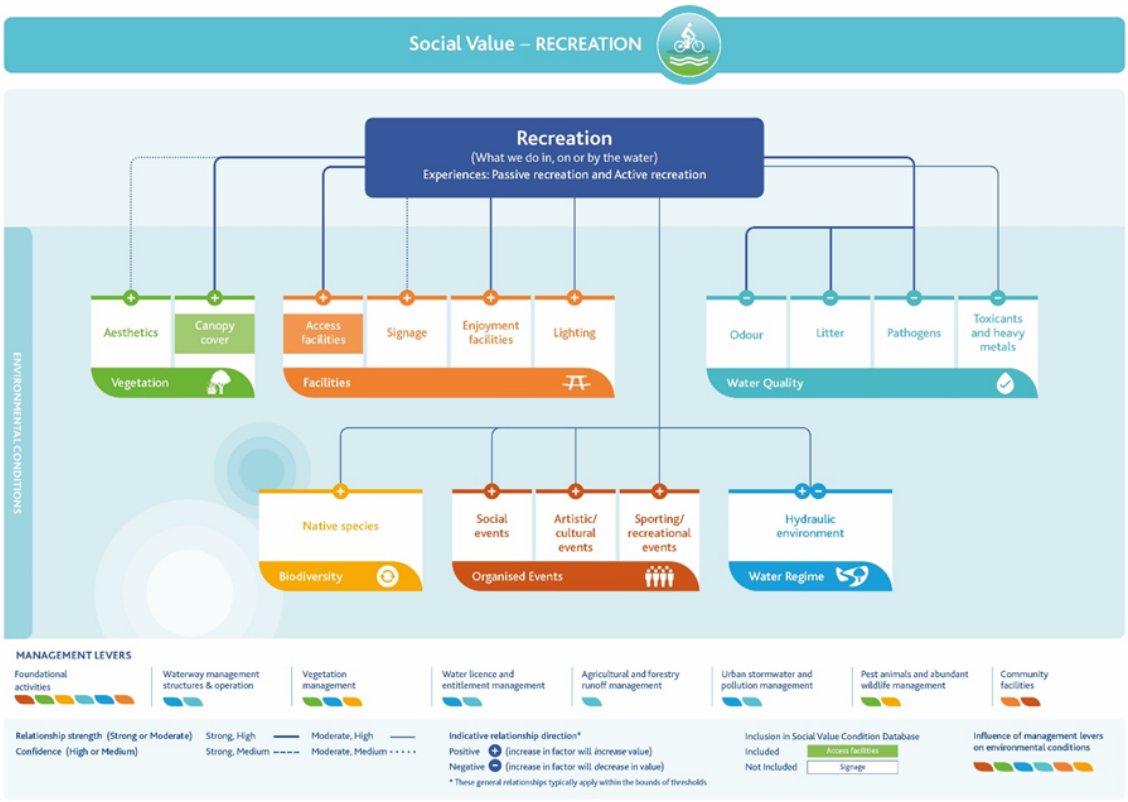
Fish



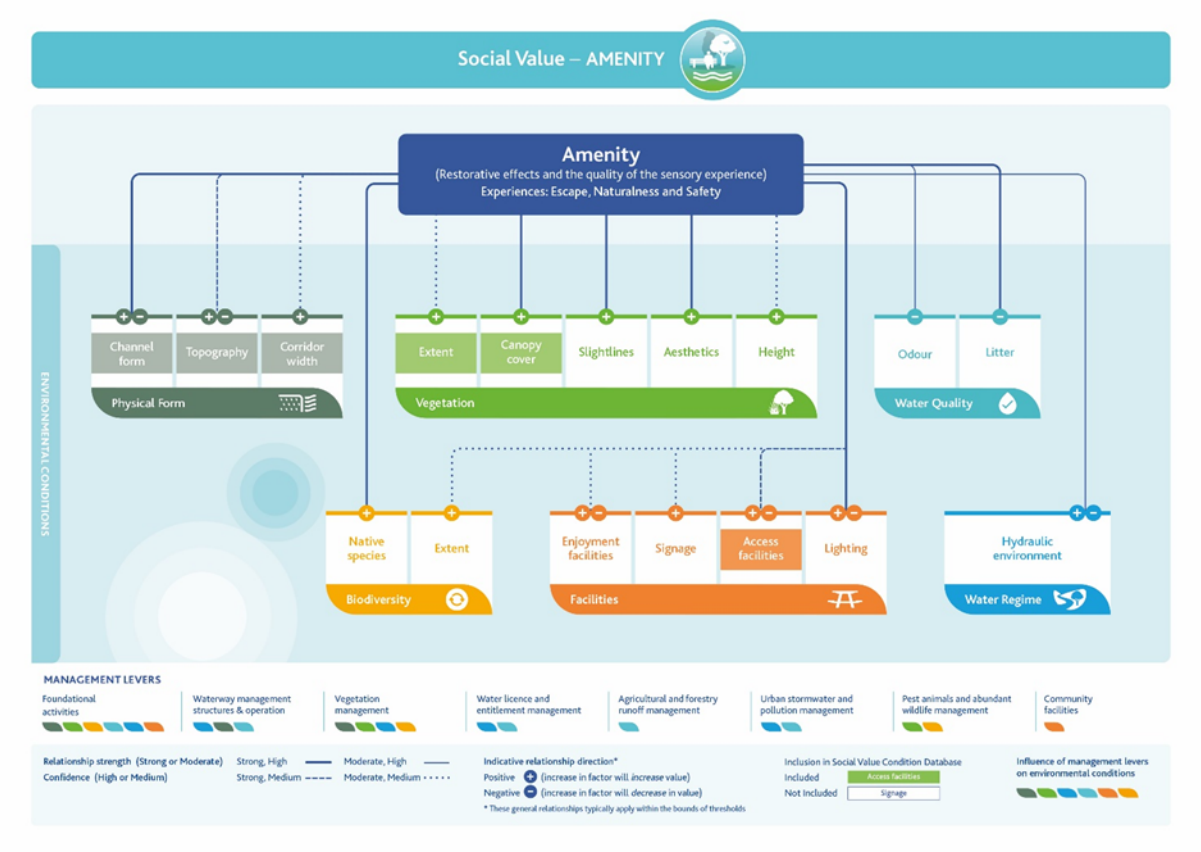
Community Connection



Recreation



Amenity


Social Value – AMENITY
Amenity
(Restorative effects and the quality of the sensory experience)
Experiences: Escape, Naturalness and Safety
ENVIRONMENTAL CONDITIONS
Channel form
Topography
Corridor width
Physical Form
Extent
Canopy cover
Slightlines
Aesthetics
Height
Vegetation
Odour
Litter
Water Quality
Native species
Extent
Biodiversity
Enjoyment facilities
Signage
Access facilities
Lighting
Facilities
Hydraulic environment
Water Regime
MANAGEMENT LEVERS
Foundational activities
Waterway management structures & operation
Vegetation management
Water licence and entitlement management
Agricultural and forestry runoff management
Urban stormwater and pollution management
Pest animals and abundant wildlife management
Community facilities
Relationship strength (Strong or Moderate)
Confidence (High or Medium)
Strong, High
Moderate, High
Strong, Medium
Moderate, Medium
Indicative relationship direction*
Positive (increase in factor will increase value)
Negative (increase in factor will decrease in value)
* These general relationships typically apply within the bounds of thresholds
Inclusion in Social Value Condition Database
Included
Access facilities
Not Included
Signage
Influence of management levers on environmental conditions

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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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