Catchment management options for reducing agri-chemical impact on waterways

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Key Points

- Agri-chemicals are diffuse pollutants in agricultural catchments
- Catchment management actions such as sediment traps, buffer strips, swales and wetlands can reduce transport of agri-chemicals
- Based on a source-pathway-receptor model, a spatial mapping tool was developed to identify potential locations for management actions within the mid Yarra drinking water catchment

Abstract

Melbourne's bulk water supply system currently services over four million customers in Melbourne and the surrounding regions, supporting liveability, public health, economic growth and employment. Much of Melbourne's water is sourced from water supply catchments that occur in forested areas, are protected and closed to public access, and as a result the water requires minimal treatment. However, water harvested from the Yarra River at Yering Gorge (the 'mid-Yarra' catchment) and stored in Sugarloaf Reservoir comes from open, mixed-use catchments that support agricultural and recreation activities as well as some urban development. As a consequence of agricultural activities in the catchment, and urban land use, it is possible agri-chemicals may sometimes be present in low amounts in local waterways which supply the raw, untreated water to Sugarloaf Reservoir. It is important to note here that water from open catchments is fully treated and tested before supply to customers, so it meets the same quality requirements as water from protected catchments.

In this context, we explored how catchment management could be used to reduce possible runoff of agri-chemicals into local waterways throughout the mid-Yarra catchment. We used a source-pathway-receptor model to understand how agri-chemicals may be transported in the catchment and developed a profile for potential management actions using attributes which could be located spatially across the catchment. From this, a spatial mapping tool was developed to explore potential catchment management actions.

Keywords

Catchment management, agri-chemicals, water quality, diffuse pollution, Yarra River

Introduction

Melbourne's bulk water supply system currently services around four million customers in Melbourne and the surrounding regions, supporting liveability, public health, economic growth and employment. Much of Melbourne's water is sourced from water supply catchments that occur in forested areas, are protected and closed to public access, and as a result the water requires minimal treatment. However, water harvested from the Yarra River at Yering Gorge (the 'mid-Yarra' catchment) and stored in Sugarloaf Reservoir comes from open, mixed-use catchments that supports agricultural and recreation activities as well as some urban development. As a consequence of agricultural activities in the catchment, and urban land use, it is possible agri-chemicals may sometimes be present in low amounts in local waterways which supply the raw, untreated water to Sugarloaf Reservoir. Water from open catchments is fully treated and tested before supply to customers, so it meets the same quality requirements as water from protected catchments. Melbourne Water has a multi-barrier approach to drinking water management where it is important for agri-chemicals to be prevented from entering the drinking water supply as well as using treatment plant processes to remove them. In addition, the presence of agri-chemicals within local waterways which supply the drinking water reservoir could potentially have ecological impacts.

The aim of this study was to identify potential on-ground management actions which could be considered in the mid Yarra catchment to reduce agri-chemicals entering local waterways, and ultimately the drinking water supply. Fundamentally this study asked three questions:

1) **How** can catchment management be used to treat agri-chemicals?

2) **Where** in the catchment could management actions be implemented?

3) **What** agri-chemical form (dissolved or sediment-bound) will be treated by a management action at a particular location?

Agri-chemicals sources and transport pathways in the mid Yarra catchment

A source-pathway-receptor model was used to understand linkages between agri-chemicals in priority areas previously identified by Melbourne Water and local waterways, which in turn supply the drinking water reservoir, that could be targeted by catchment management actions. This involved firstly identifying sources of agrichemicals in the catchment, the main transport pathways and treatment options for different sources and pathways. This information was then incorporated with GIS mapping to identify locations for management action implementation.

Sources

The main sources of agri-chemicals in the mid-Yarra catchment were determined based on land use activities (e.g. intensive strawberry, pome fruit or vegetable production, mixed farming and grazing, vine yards), proximity of agriculture to waterways and topography. The agri-chemicals investigated included a range of herbicides, insecticides, miticides and soil fumigants. In total five possible target areas for management action were assessed (referred to as ‘sources’ in the analysis below).

Pathways

The main transport pathways through which agri-chemicals move through the catchment include spray drift, volatilization, dust, soil erosion, surface water run-off, subsurface drainage, groundwater and point source discharges (Reichenburger et al. 2007). The focus of this study was identifying locations where surface water could be intercepted and treated to reduce agri-chemical loads being transported from the farm (or other site of application, e.g. roadside verges) to local waterways.

Within surface water run-off, agri-chemicals can be transported bound to sediments or within the dissolved phase depending upon the physicochemical properties of the agri-chemical. The phase within which an agri-chemical is transported is important as many management actions are more suited to either sediment-bound or dissolved contaminants. We assigned each of the agri-chemicals investigated to a ‘transport pathway’ (sediment-bound or dissolved phase) using physicochemical properties of the agri-chemicals. Of the twenty-two priority chemicals, twelve were likely to be sediment-bound during transport and fourteen were likely to be dissolved during transport.

Catchment management options for treating agri-chemical impacts

Potential catchment management actions at a range of scales (farm, local, catchment) were identified through a literature review. Of these management actions, five were assigned as preferentially treating sediment-bound contaminants, six were assigned as treating either sediment-bound or dissolved contaminants and one was assigned as preferentially treating dissolved contaminants (Table 1).

Table 1. Agri-chemical transport pathways treated by catchment management options

Sediment-bound	Dissolved phase	Sediment-bound or dissolved phase
• Edge of field buffer strip (narrow) • Riparian buffer strip (narrow) • Silt trap/ sand filter • Sedimentation basin (passive) • Sedimentation basin (active)	• Bioreactor	• Edge of field buffer strip (wide) • Riparian buffer strip (wide) • Vegetated drainage ditch (swale) • Constructed wetland + sedimentation basin • On-farm capture and re-use • On-farm best practice environmental management, e.g. timing and mode of application of agrichemicals or improved groundcover

Identifying locations where management actions could be implemented in the catchment

Location envelopes within which catchment management actions could be implemented were identified through combining the individual criteria for exclusion and locational metrics into two key datasets ("barcodes") and creating a composite GIS layer for the mid Yarra catchment as an iterative overlay.

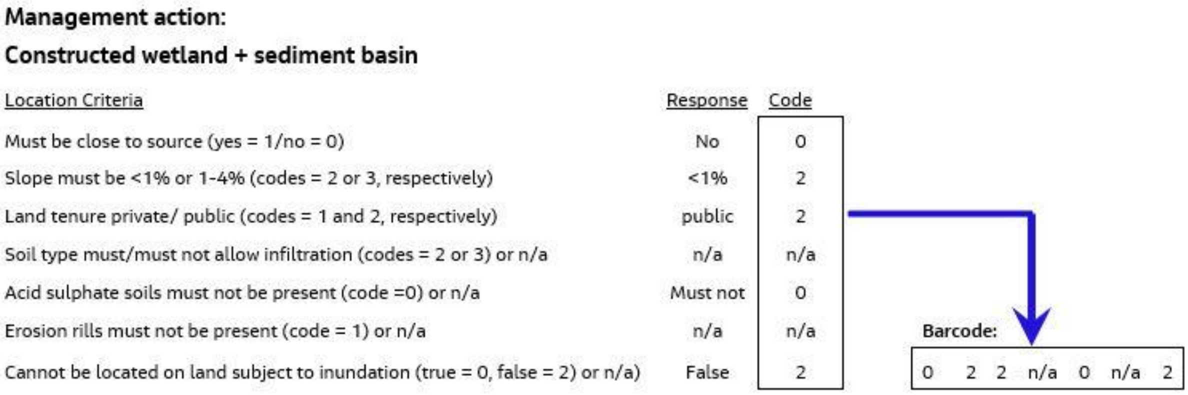
Developing the barcode

Two key questions were used in barcode development – where in the mid-Yarra catchment wouldn't you implement a management action and within the available land left, what criteria affect the effectiveness or implementation of the management action? From these questions a rule set with underpinning spatial datasets was compiled (Table 2). The outcome for each rule was associated with a numeric value that was used to develop a barcode that could be mapped spatially across the catchment (Figure 1).

Table 2. Exclusion and location criteria used to define rules for use in barcode development

Rule	Data source
Exclusion criteria (where not to implement a management action)	
Areas more than 300m from a waterway	MW asset management framework
Slope >5%	Slope derived from Vicmap Elevation DEM 10m[1]
Avoid areas of sensitive land use	Classified using descriptions from Victorian Land Use Mapping 2016 and planning overlays from Vicmap[1]
Avoid areas of significant biodiversity	MW sites of significant biodiversity
Avoid built up areas	Classified using Victorian Land Use Mapping 2016[1]
Location criteria (must be present for catchment management action to be effective)	
Must be close to source (yes/no)	Source classified using MW DCI sub catchments
Slope must be <1% or 1-4%	Slope derived from Vicmap Elevation DEM 10m[1]
Land tenure public/ private	Public Land Management (PLM25), VPA Open Space[1]
Soil type allows infiltration (yes/no)	Hydrologic soils group classified using Victorian Soil Type Mapping[1]
Acid sulphate soils must not be present (or n/a)	ASRIS Atlas of Australian Acid Sulphate Soils and classified using geology from Seamless Geology of Victoria, Geological Units 250K[1]
Erosion rills must not be present (or n/a)	Geomorphology of Victoria (GMU250)[1]
Cannot be located on land subject to inundation (yes/ no/ n/a)	MW 1 in 100-year flood overlays

Notes:
1. From data.vic.gov.au



Management action:
Constructed wetland + sediment basin

Location Criteria	Response	Code
Must be close to source (yes = 1/no = 0)	No	0
Slope must be <1% or 1-4% (codes = 2 or 3, respectively)	<1%	2
Land tenure private/ public (codes = 1 and 2, respectively)	public	2
Soil type must/must not allow infiltration (codes = 2 or 3) or n/a	n/a	n/a
Acid sulphate soils must not be present (code =0) or n/a	Must not	0
Erosion rills must not be present (code = 1) or n/a	n/a	n/a
Cannot be located on land subject to inundation (true = 0, false = 2) or n/a)	False	2

Barcode: 0 2 2 n/a 0 n/a 2

Figure 1. Example of how a barcode was generated for the constructed wetland and sediment basin a management action from location criteria.

Mapping exclusion and location criteria

Figure 2 shows the extent of land available in the mid Yarra catchment which met the exclusion criteria set out in Table (i.e. land available for management actions). The requirements for a management action to be within 300 m of a waterway and avoiding high slopes limits the amount of land available in the catchment.

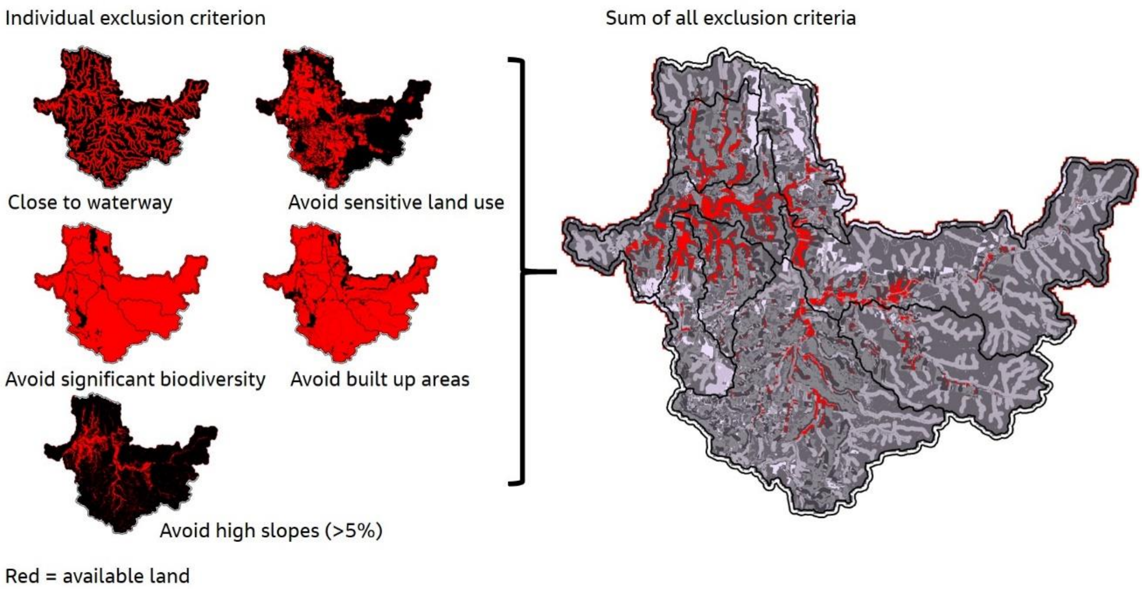


Figure 2. Exclusion criteria mapped individually (left) and combined (right) across the mid Yarra catchment. The areas shown in red are those which do meet the exclusion criteria, i.e. are available for implementation of catchment management options.

When the various combinations of location criteria were combined there were 75 unique combinations mapped across the catchment (Figure 3). Although we included tenure as a location criterion (Table) it was not used in later analysis as there was essentially no publicly owned land within 300 m of a waterway/ avoiding high slopes in the catchment (compare Figures 2 and 3)

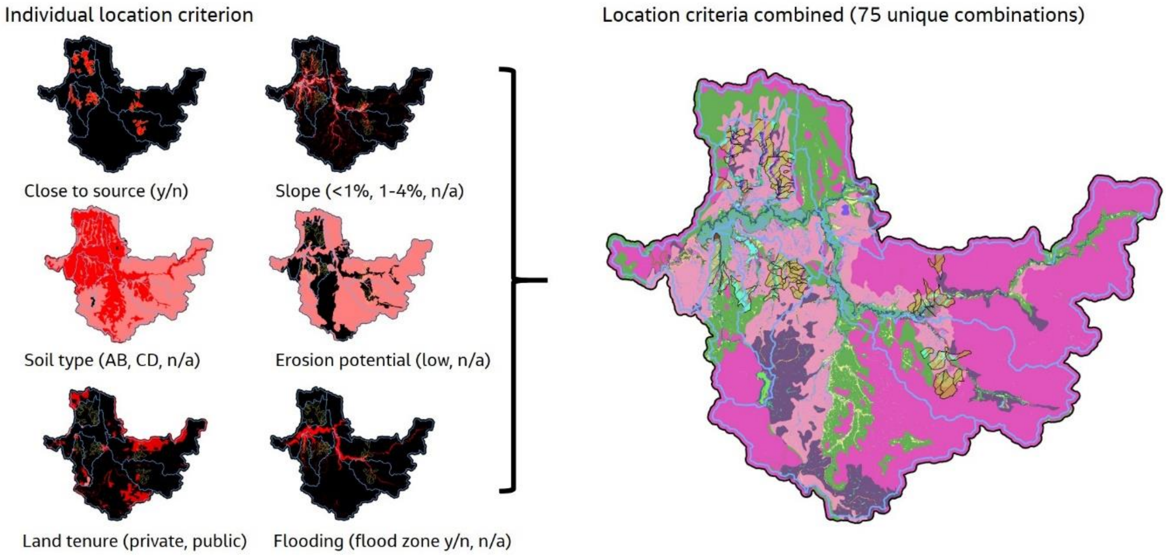


Figure 3. Location criteria mapped individually (left) and combined (right) across the mid Yarra catchment. The colour of shading represents a location condition (left) or combination of location conditions (right) which matches the requirements of the assessed treatment options.

Potential locations for catchment management options to reduce agrichemical impacts to waterways in the mid Yarra catchment

The composite overlay of exclusion and location criteria are shown in Figures 4 to 6. Figure 4 shows catchment management actions colored by the transport pathway targeted (i.e. sediment-bound or dissolved), Figure 5 shows the number of management actions that could be implemented across the catchment and Figure 6 shows where some of the individual management actions included in the assessment could be implemented.

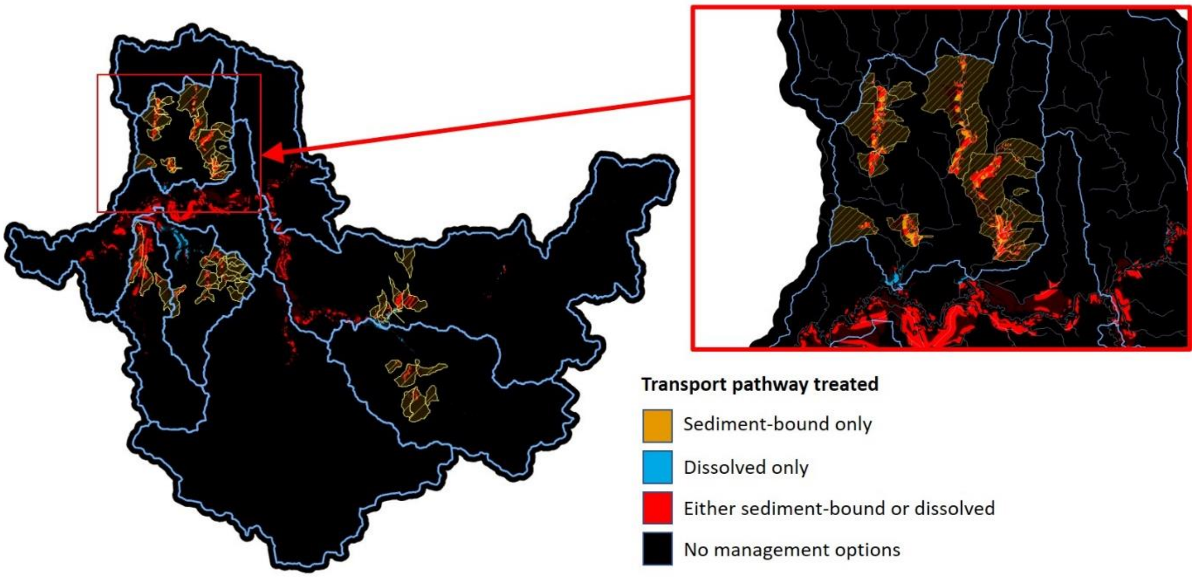


Figure 4. Map of the mid Yarra catchment showing location envelopes were catchment management could be used to treat sediment-bound and/or dissolved agri-chemicals. The yellow hatched areas are sub catchments containing the target areas identified during the previous assessment.

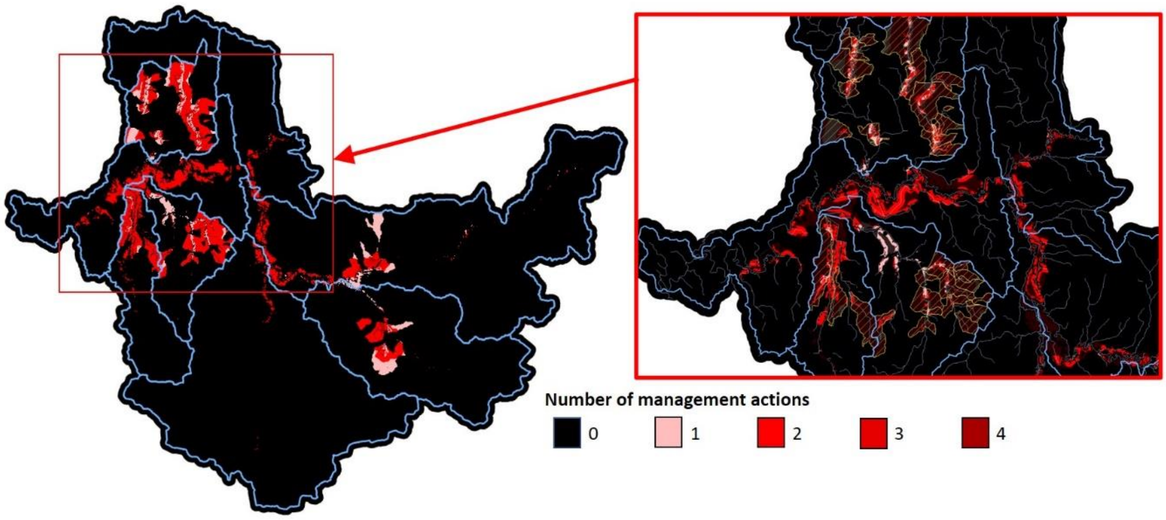


Figure 5. Map of the mid Yarra catchment showing location envelopes were multiple catchment management options could be used to treat agri-chemicals. The yellow hatched areas are sub catchments containing the target areas identified during the previous assessment.

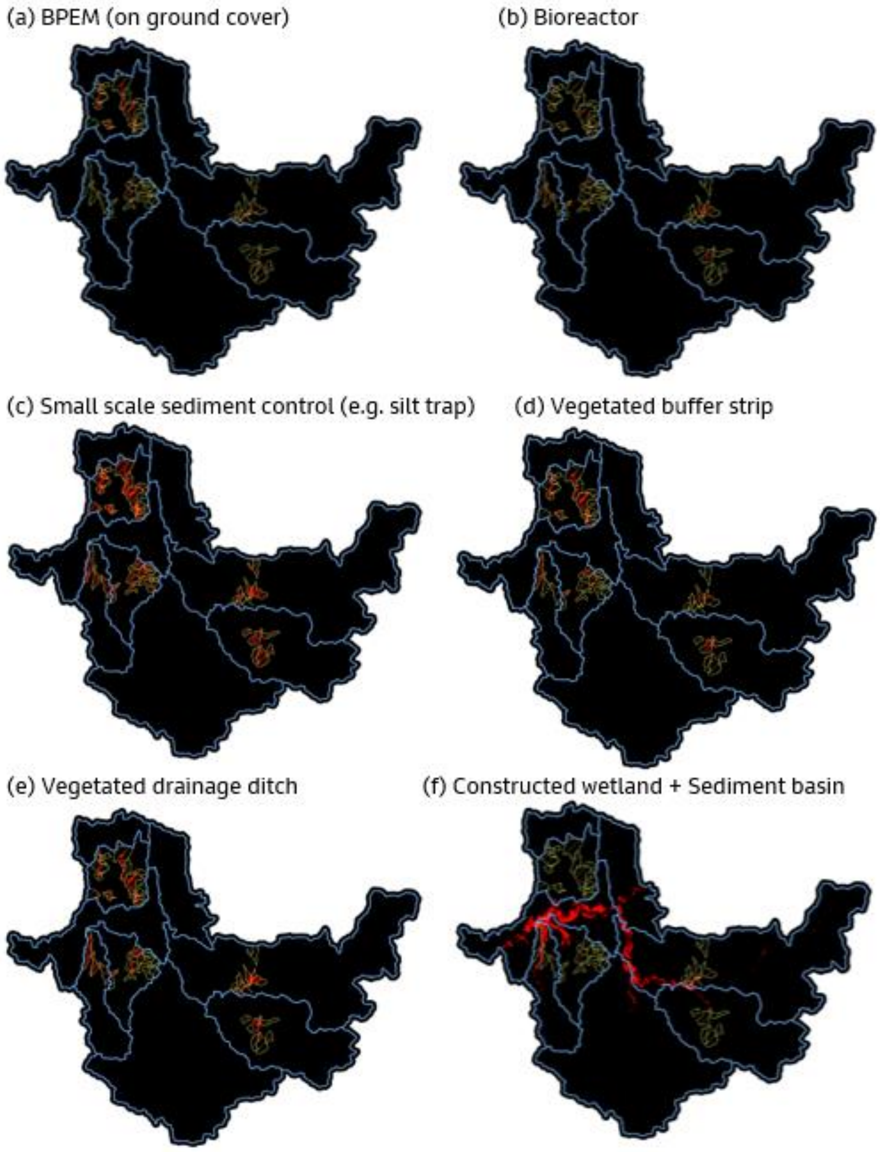


Figure 6. Maps of the mid Yarra catchment showing location envelopes (red shading) where the following catchment management options could be implemented: (a) improving ground cover, (b) bioreactor, (c) small scale sediment control (e.g. a silt trap), (d) vegetated buffer strip, (e) vegetated drainage ditch (swale) and (f) (passive) sedimentation basin and constructed wetland. The yellow hatched areas are sub catchments containing the target areas identified during the previous assessment.

Future directions

The above analysis was captured in a spatial mapping tool which enables Melbourne Water to further explore potential changes to the rule sets, for example the requirement for slopes <5% can be switched off. Melbourne Water are able to use the tool to explore where potential catchment management activities for agri-chemical mitigation could overlap with other environmental benefits including bank stabilization, nutrient attenuation, stormwater management, flood mitigation, protecting habitat for wildlife and creating or enhancing social and recreational amenity.

Before any catchment management actions to target agri-chemical impacts to local waterways are considered further, site-specific assessments will need to be undertaken, including engagement of stakeholders, to 'ground-truth' the results of the catchment-scale spatial analysis.

Conclusions

Spatial assessment of potential locations for agri-chemical interventions in the mid Yarra catchment identified 'location envelopes' for many different management actions ranging from farm-scale changes in environmental management through to sub-catchment interventions such as sediment basins and constructed wetlands.

Within the mid-Yarra catchment, the majority of land is private tenure, especially land in the vicinity of the target areas. Implementation of catchment management actions may require a partnership or incentives approach, with the objective of achieving mutually beneficial outcomes.

There are however 'location envelopes' suitable for a range of management actions explored in this spatial assessment. Locations with conditions suitable for siting farm-to-local scale management options such as silt traps, vegetated buffer strips or vegetated drainage ditches were generally located away from the Yarra River as according to the rule set, these treatments must be located close to the agri-chemical source. For these treatments to be effective, the origin(s) of the agrichemicals (i.e. the individual farm(s) or waterways impacted) will need to be identified. Multiple locations along the Yarra River floodplain were identified as meeting the conditions for siting management options such as sediment basins and constructed wetlands. As these assets treat a larger portion of the catchment, the exact source of the agri-chemicals does not need to be identified. Implementation of such management options are far more expensive than farm or local-scale options, however because they treat a larger catchment additional benefits to waterway health could potentially be realised.

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