CRC for
Water Sensitive Cities

RESTORE Tool evaluation
Scrubby Creek pilot application

February 2020

Australian Government
Department of Industry, Innovation and Science

Business
Cooperative Research Centres Programme

RESTORE Tool Evaluation
Scrubby Creek Pilot Application

Authors

Stephanie Brown, Sally Boer, Shaw Abrey, Ben Walker

Publisher

Cooperative Research Centre for Water Sensitive Cities

Level 1, 8 Scenic Blvd, Clayton Campus
Monash University
Clayton, VIC 3800

p. +61 3 9902 4985
e. admin@crcwsc.org.au
w. www.watersensitivecities.org.au

Date of publication: February 2020

An appropriate citation for this document is:

Brown, S., Boer, S., Abrey, S. and Walker, B. (2020), RESTORE Tool evaluation - Scrubby Creek pilot application. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities

Disclaimer

Contents

List of figures

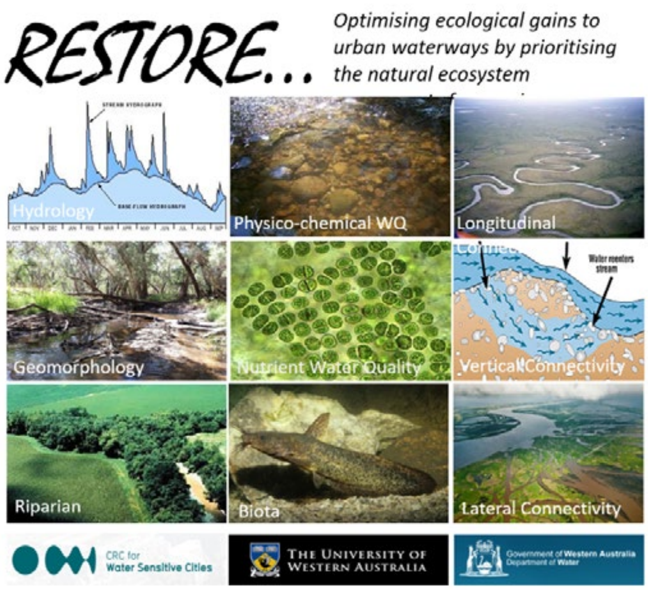
List of tables

1. Background to the RESTORE Tool pilot application

E2DesignLab was commissioned by the CRC for Water Sensitive Cities (CRCWSC) to conduct an independent review of its newly developed RESTORE Tool. As a new tool, testing and evaluating its implementation is important for helping with industry uptake, and for refining the tool so it's easier to apply.

This paper presents the outcomes of E2DesignLab's pilot application of the RESTORE Tool to four sites along Scrubby Creek located in the City of Logan, south-east Queensland. It explains how the E2DesignLab team applied the tool, and identifies opportunities for improvement.

RESTORE is a decision-support tool that was developed to support the holistic repair of urban waterways. It is a product of the CRCWSC, developed by Leah Beesley[1], Belinda Quinton[2], Timothy Storer[2], Daniel C Gwinn[3] and Peter M. Davies[1]. Developing the tool involved a thorough and rigorous literature review and input by waterway specialists.



The RESTORE Tool is supported by a compendium of 13 factsheets: *Improving the ecological function of urban waterways* (https://watersensitivecities.org.au/content/improving-the-ecological-function-of-urban-waterways-a-compendium-of-factsheets/), which identify site-scale and catchment-scale strategies for restoring waterways.

RESTORE allows waterway managers to incorporate local and regional attributes into their restoration decision process. The tool asks practitioners a range of questions about the environmental and urban setting of their restoration site and identifies the ecosystem components likely to be most relevant. The ecosystem components considered are hydrology, geomorphology, connectivity, riparian, water quality and biota. The tool ranks the components according to three criteria to improve the efficacy of on-ground management interventions. The criteria include: (i) importance to ecosystem function at the site, (ii) severity of stress (i.e., departure from reference), and (iii) potential to be repaired or protected into the future. The premise of these criteria is that management effort will yield the largest ecological return when it targets ecosystem drivers that: (i) exert significant influence on the ecosystem function of the site, (ii) are highly altered, and (iii) have a good capacity for recovery.

The tool facilitates a decision process that considers all aspects of the waterway and its catchment. This enables restoration plans to be tailored, and to prioritise investments that will provide greatest return in terms of waterway repair. The question-based approach of the tool enables waterway managers to tap into existing knowledge and expertise without needing quantitative data inputs. In this regard, it is particularly useful in facilitating stakeholder input to shape waterway restoration plans.

[1] From The University of Western Australia.
[2] From the WA Department of Water and Environmental Regulation.
[3] From Biometric Research, Perth.

2. How we applied the tool

To evaluate the RESTORE Tool, we applied it to four waterway sites identified during development of Logan City Council's *Scrubby Creek Recovery Plan*. This approach allowed us to test the tool's application and to compare the results with the findings from the Logan City Council project. Both projects were run concurrently, which also allowed the results of the RESTORE Tool pilot to influence the priorities and actions included in the *Scrubby Creek Recovery Plan*.

2.1 Process

For the pilot application of the RESTORE Tool, we selected four waterway sites that differed in their site characteristics, their location within the catchment and their perceived potential for restoration. A description of these sites is in Section 3 for reference.

We applied the tool in steps:

1. Sole application of the tool—an individual team member applied the tool using available desktop information and knowledge gained through the Scrubby Creek Recovery Plan project to answer the questions to the best of her ability.
2. Team based application of the tool—we held a team workshop, involving four additional team members, to work through the questionnaire and improve the rigour of the results.
3. Analysis—we reviewed the results of the RESTORE Tool to confirm priority ecological components for each of the sites.
4. Identification of actions—we used the *Improving the ecological function of urban waterways: a compendium of factsheets*, to identify potential actions at each site.
5. Comparison—we compared the priorities and actions identified using the RESTORE Tool and accompanying factsheets to those developed during the *Scrubby Creek Recovery Plan* project, to test the tool's validity.

2.2 Input data used

To answer the questions within the RESTORE Tool, we referred to the following information and data sources for guidance and justification on the answers we selected:

- Aerial images—current and historical
- Water quality monitoring data (single sample)
- Observations from site visits
- Fish survey and fish passage assessment
- Rainfall characteristics
- GIS data:
    - Land use zoning
    - Piped network
    - Vegetation management
    - Infrastructure (stormwater, water, sewer)
    - Roads
    - Waterway/streams
- Climate Change Australia website
- EPBC search
- *Logan water body asset management report 2014: a review of waterbodies across Logan City Council to assess their condition and identify management actions.* The report included two sites used in this pilot application (Gould Adams Park and JJ Smith Park Lakes) and several other waterbodies within the Scrubby Creek catchment
- Scrubby Creek Recovery Plan Condition Assessment Report—the consultants involved in the Scrubby Creek Recovery Plan developed a condition assessment report, which was extremely valuable to us in answering the questions within the tool. The report consolidated input data used for this tool, making it more efficient to respond to RESTORE Tool questions. But more importantly, it provided insights on a range of topics with expertise from the relevant disciplines. It covered:
    - catchment land use
    - ecological condition
    - fish passage and assemblage
    - catchment modelling and water quality management
    - water balance and flooding
    - community connections
    - community survey.

2.2.1 Missing information

Our team did not have enough information, expertise or site knowledge of some topics to provide an informed response, which resulted in some questions receiving the score associated with an 'unknown' response.

Information that would have improved our ability to answer the questions and provide a higher level of confidence includes:

- Site soils information
    - Sediments currently and historically
    - Nutrient levels of soil
    - Prior agricultural influences on soils/catchment
    - Acid sulfate soils
- Groundwater data/summary information
    - Water table
    - Groundwater quality (nutrients/pollutants)
    - Importance of groundwater historical to site's flow patterns
- Geomorphology
    - Site based and historical knowledge.

3. Case study sites

This section provides an overview of the sites we assessed using the RESTORE Tool, for contextual reference.

The Scrubby Creek catchment covers over 57 km2 and drains from Park Ridge and Regents Parks, through Browns Plains, Heritage Park, Berrinba, Marsden and Loganlea before entering Slacks Creek at Meadowbrook (figure 1). The catchment is mostly located in Logan City Council area with some tributaries to the north located within Brisbane City Council.

Historically, the catchment was forested with pockets of rural and rural residential land uses (figure 2). Today, it is highly urbanised with a mix of land uses including residential, industry, commercial, open space, rural residential and conservation. The waterway corridor primarily falls within the open space network, providing a good level of protection from development. Some main roads, including the Logan Motorway and the Mount Lindsay Highway, dissect the catchment.

The waterway corridor itself is a mix of urbanised channels, natural waterways and large open waterbodies. There are also some natural wetlands across the catchment. The Berrinba wetlands are in the heart of the catchment and provide a key destination for community recreation, despite being in an industrial area.

The majority of the Scrubby Creek riparian corridor is vegetated, providing links between conservation areas including Boronia Bushland Reserve, Rosia Road and Slacks Creek Conservation Park. The vegetated waterway corridor also helps to connect regional landscapes including Greenbank, Karawatha Forest and Daisy Hill. The waterway channel form is varied between concrete and grassed channels, large waterbodies, natural channels and wetlands. The banks are relatively stable and there are some sand slugs moving through the catchment as a result of past land use impacts.

Native and pest fish species exist in the catchment. Native abundances were much higher than pest fish abundances in the two downstream sites in the catchment. As sampling continued upstream, we observed fewer natives than pest species, as we didn't identify any native species at the furthest upstream site. The native fish we observed in the upstream sites were large in size, indicating that juveniles are unable to reach these upstream sites, likely because of the increasing number of fish barriers in the waterway progressing upstream.

Figure 1. 2017 aerial photo of catchment showing the location of the four case study sites (the Scrubby Creek catchment boundary is indicated, excluding parts of the catchment within the Brisbane City Council local government area)

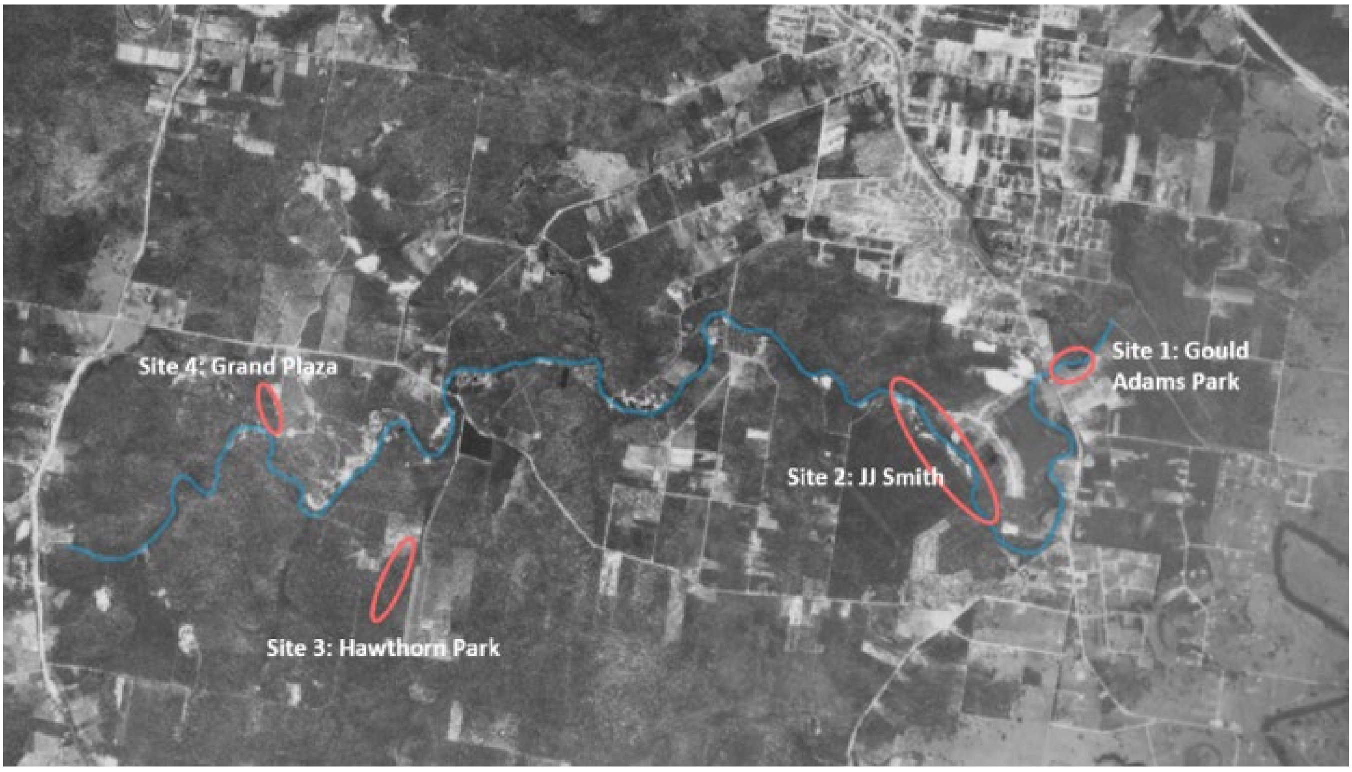


Figure 2. 1969 aerial photo of catchment showing the location of the four case study sites (the Scrubby Creek centreline is shown in blue for geographic context)

We further describe the four sites we selected for the pilot application of the RESTORE Tool here:

3.1 Gould Adams Park

Gould Adams Park (figures 3 and 4) is a site in the lower reaches of the Scrubby Creek catchment. It is a naturalised online waterbody thought to have been created about 70 years ago when a weir was constructed to enable the Kingston Butter Factory to extract water from Scrubby Creek. While water extraction for the butter factory ceased some time ago, a permit is in place that allows a contractor to extract water for landscape watering. Council also uses this location for water extraction from time to time. Gould Adams Park is located on the northern side of the waterbody. In the context of the public park, the waterbody provides visual amenity, passive recreation and recreational fishing opportunities. Mid-level planting has mostly been removed within 30 m of the north side of the waterbody, under a management strategy to improve passive surveillance of the space.

Gould Adams Park's key ecological characteristics are:

- Large deep pool created by concrete weir (approx. 10–20 m wide channel)
- Moderate in-stream habitat but lacking complexity
- Native and pest fish present
- Mature riparian trees with habitat boxes and retained dead trees, but sparse groundcovers and streamside vegetation
- Para grass dominant on upstream and southern edges
- Low lying floodplain area, inundating adjacent sports fields during high flows (10 per cent AEP and above).

Figure 3. Aerial photo of Gould Adams Park (stormwater pipe network shown in blue-purple lines)

Figure 4. Gould Adams Park site photos—top left: historic weir; top right: grass banks adjacent to main waterbody; bottom left: main waterbody with bare bank edges; bottom right: main waterbody with para grass on edges

3.2 JJ Smith Park Lakes

JJ Smith Park Lakes (figures 5 and 6) were created several decades ago, although the reason for their construction is uncertain. Council believes they were constructed for a combination of sand mining and flood mitigation. There are four waterbodies within the waterway channel, which are all online. Three of the four waterbodies have islands in their centre.

Access to the lower lying waterbodies is restricted by steep vegetated batters. There are areas of flatter floodplain surrounding some of the waterbodies which experience periodic inundation.

The creek upstream from the waterbodies is small and channelised with steep banks leading to the elevated park and walking area. The riparian buffer is relatively narrow and in varying condition, although there is generally an intact riparian edge surrounding the waterbodies and good macrophyte growth in the shallow waterway channels between the waterbodies. In most sections, revegetation would improve the condition and function of the riparian zone by increasing the complexity and structure of the buffer, providing shade, bank stability and potential for improved nutrient filtering.

Figure 5. Aerial of JJ Smith Park Lakes (stormwater pipe network shown in blue-purple lines)

Figure 6. JJ Smith Park Lakes site photos—top left: generally well vegetated edges; top right: steep banks beside channel with mixed vegetation composition; bottom left: upstream channel lacking canopy species; bottom right: downstream waterbody lying in lowland floodplain with good riparian and floodplain condition

3.3 Hawthorn Park

The reach of Hawthorn Park (figures 7 and 8) included in this pilot study contains a concrete low flow channel within an intact riparian corridor. The surrounding land is relatively flat, well vegetated and largely unconstrained. It's unknown why the concrete low flow channel was originally constructed. It does not relate to flood management, given the broad unconstrained floodplain, so it may have been associated with a real or perceived improvement in ease of maintenance. There's high potential to improve in-stream habitat by removing the concrete invert.

Figure 7. Aerial of Hawthorn Park (stormwater pipe network shown in blue–purple lines)

Figure 8. Hawthorn Park site photos—top left: concrete channel surrounded by intact riparian vegetation with good canopy; top right: concrete channel directly adjacent to public park; bottom left: concrete channel with floodplain grasses; bottom right: public park adjacent to concrete channel

3.4 Grand Plaza site

The channel beside Grand Plaza Shopping Centre (figures 9 and 10) is a vegetated open channel located immediately downstream of a historic landfill site. It's located within an industrial area and has a skate park adjacent to it. The landfill site lacks a trade waste connection for the site's leachate, and it's believed it was poorly capped.

The riparian edge is currently heavily infested with weeds (especially Singapore daisy) and has varied but mostly good canopy cover. The waterway corridor within this reach is well vegetated with good presence of large woody debris. Further upstream, the waterway has been straightened, channelised and significantly cleared.

Water quality at this site is poor, with extremely high measured salinity levels and significant odour.

Figure 9. Aerial of Grand Plaza site (stormwater pipe network shown in blue–purple lines)

Figure 10. Grand Plaza site photos—top: water quality sampling location infested with Singapore daisy; middle: skate park adjacent to waterway corridor; bottom: waterway with varied canopy cover and grassy groundcovers

Key recommendations for improving the ecological condition from the Scrubby Creek Recovery Plan include:

1. Pursue weed management and increase canopy cover at some locations
2. Implement selective revegetation to improve diversity of tree stock and ensure long-term canopy cover is retained to improve long-term woody debris for in-stream habitat
3. Remove or redesign fish barriers from downstream to upstream to improve fish passage and overall aquatic ecosystem health
4. Restock endangered Mary River cod and Australia bass to pool habitats to reduce threats posed by pest fish (via predation and competition)
5. Provide terrestrial fauna movement at many road crossings (needed for local and regional connectivity)
6. Increase in-stream habitat condition and complexity in key locations (e.g. by adding large woody debris to create snags and log jams, and recreating pool and riffle sequences)
7. Increase streamside vegetation cover to improve nutrient filtering
8. Protect existing native vegetation throughout the catchment
9. Reinstate riparian vegetation in suitable locations along Scrubby Creek and associated online waterbodies, to shade out weeds and provide better habitat and ecological corridors to improve both waterway health and biodiversity
10. Test alternative strategies to transform existing concrete channel throughout the catchment in identified low-risk areas
11. Ensure new development areas treat stormwater to best practice, as well as manage flows to maintain existing hydrologic conditions to protect high value wetlands
12. Investigate areas where stormwater retrofit could be undertaken to address key pollutant hotspots
13. Investigate cause of water quality hotspots
14. Identify the potential for new developments to use alternative water sources to meet non-potable water demands.

4. Results

The RESTORE Tool ranks each of the nine ecological components (hydrology, geomorphology, longitudinal connectivity, lateral connectivity, vertical connectivity, riparian, physico-chemical water quality, nutrients and biota) in relation to:

- **Importance**—to ecosystem function at the site:
  - Higher scores suggest greater importance of the respective ecological component to stream health. Lower scores suggest that the respective ecological component is not as important to stream health at the site.
- **Severity of stress**—i.e., departure from reference, and:
  - Scores allude to how stressed the stream health is at the site. A high score suggests that the ecological component under investigation is under stress at the location being investigated.
- **Potential recovery**—potential to be repaired or protected into the future:
  - Higher scores suggest a greater potential for recovery and repair into the future at the site under investigation.

The tool then calculates a prioritisation score to help identify priority ecological components, and to focus management efforts. The overall score is derived as a product of the importance, severity of stress and potential recovery scores. A high prioritisation score indicates the ecological component is highly altered, has a significant influence on ecosystem function, and has a good capacity for recovery.

The following presents the outputs of the RESTORE Tool for each of the pilot sites.

4.1 RESTORE Tool results

4.1.1 Site 1—Gould Adams Park

Table 1 and Figure 11 present the RESTORE Tool scores for each ecological component at Gould Adams Park.

Table 1. RESTORE Tool results for Gould Adams Park

Ecological component	Importance	Stress	Potential recovery	Prioritisation score
Hydrology	**2.00**	1.12	0.80	1.8
Geomorphology	1.25	1.33	**1.67**	**2.8**
Connectivity: longitudinal	1.20	**1.50**	**1.40**	**2.5**
Connectivity: lateral	1.00	1.22	1.25	1.5
Connectivity: vertical	1.00	1.10	1.14	1.3
Riparian	1.14	1.11	1.00	1.3
Water quality: physico-chemical	0.80	0.88	1.00	0.7
Water quality: nutrients	1.33	0.88	0.88	1.0
Biota	**1.67**	1.27	**1.33**	**2.8**

Hydrology and biota ranked the highest in importance to ecosystem function at the site, and longitudinal connectivity ranked the highest for severity of stress. These rankings align with the project team's understanding of the site, given the lower/downstream location in the catchment, and the major waterway barrier that is present. Geomorphology, biota and longitudinal connectivity were the highest priorities for this site. This ranking aligns with the team's understanding, given the south-western bank of the waterbody provided minimal tree canopy cover and was overgrown with weedy vegetation, while the northern bank was predominantly bare earth with minimal bank vegetation leading to a highly modified system. Improving fish passage would be a simple fix to improve longitudinal connectivity and biota, and therefore these priorities appear accurate with the team's understanding of the site.

The following recommendations were made for Gould Adams Park prior to applying the RESORE Tool to the site:

- Re-create and connect fish habitat (biota and longitudinal connectivity)
- Enhance riparian vegetation for koalas and swift parrots as well as a source of woody debris (longitudinal connectivity, biota, riparian and geomorphology)
- Increase awareness of native and pest fish.

These recommendations are consistent with the management priorities resulting from application of the RESTORE Tool to Gould Adams Park (figure 12). Note the RESTORE Tool does not recommend any actions relating to community awareness and knowledge sharing.

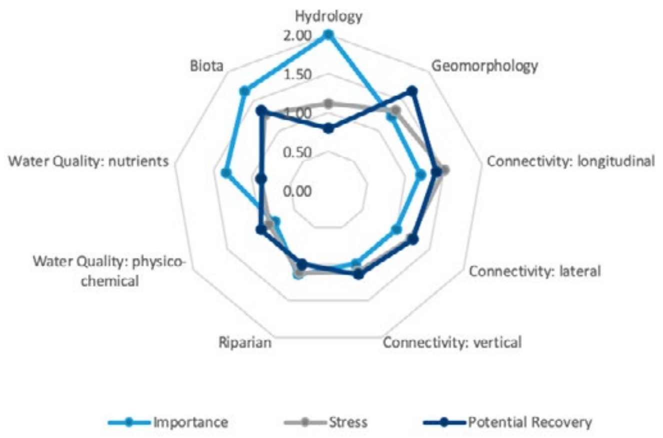


Figure 11. Results spider diagram for Gould Adams Park

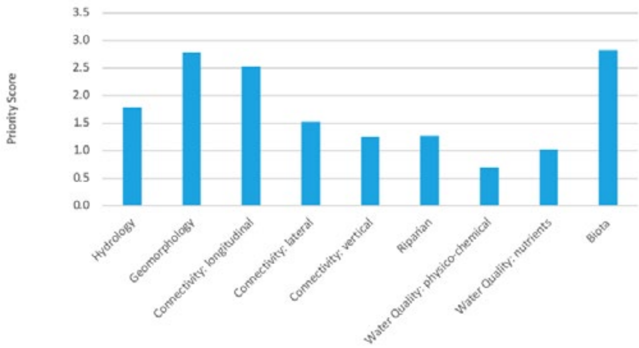


Figure 12. Priority management scores for ecological components at Gould Adams Park

4.1.2 Site 2—JJ Smith Park

Table 2 and figure 13 present the RESTORE Tool scores for each ecological component at JJ Smith Park.

Table 2. RESTORE Tool results for JJ Smith Park

Ecological component	Importance	Stress	Potential recovery	Prioritisation score
Hydrology	**2.00**	1.18	0.80	**1.9**
Geomorphology	1.25	**1.42**	**1.50**	**2.7**
Connectivity: longitudinal	1.20	**1.50**	1.40	**2.5**
Connectivity: lateral	0.67	**1.44**	1.00	1.0
Connectivity: vertical	1.00	1.10	1.14	1.3
Riparian	1.14	1.22	1.00	1.4
Water quality: physico-chemical	0.80	0.94	1.00	0.8
Water quality: nutrients	**1.33**	1.24	1.00	1.6
Biota	**1.33**	1.18	1.00	1.6

The findings of the RESTORE Tool for this site were largely consistent with expectations, but there was some notable disagreement about the importance of hydrology at the site. Geomorphology, longitudinal connectivity and hydrology ranked as the top three priorities for management effort (figure 14). The former two aligned with our expectations given the highly modified nature of the site impedes natural processes and the fish barriers downstream interrupt longitudinal connectivity. Flows through the site are highly dynamic and would have a strong influence on ecosystem function. The site is notable for its role in managing broader hydrology, and flood protection and resilience, but we struggled to reconcile hydrology as a management priority due to the extent of hydrologic change that has occurred at the site through urbanisation and construction of the online lakes. Because of difficulties in managing hydrology, it is unlikely to be a priority for management.

The following recommendations were made for JJ Smith Park prior to applying the RESORE Tool to the site:

- Improve the floodplain (hydrology)
- Pursue riparian revegetation on northern banks to improve connectivity and maintain park view lines (longitudinal connectivity)
- Improve access, amenity and shade.

These priorities only loosely align with the RESTORE priorities, but it is likely this is a consequence of the Scrubby Creek Recovery Plan taking a more holistic view of the waterway corridor and its role within the community, particularly at JJ Smith Park. It also may reflect the challenge of understanding the recovery potential of the site in terms of feasibility and how that may (or may not) be reflected in the RESTORE Tool.

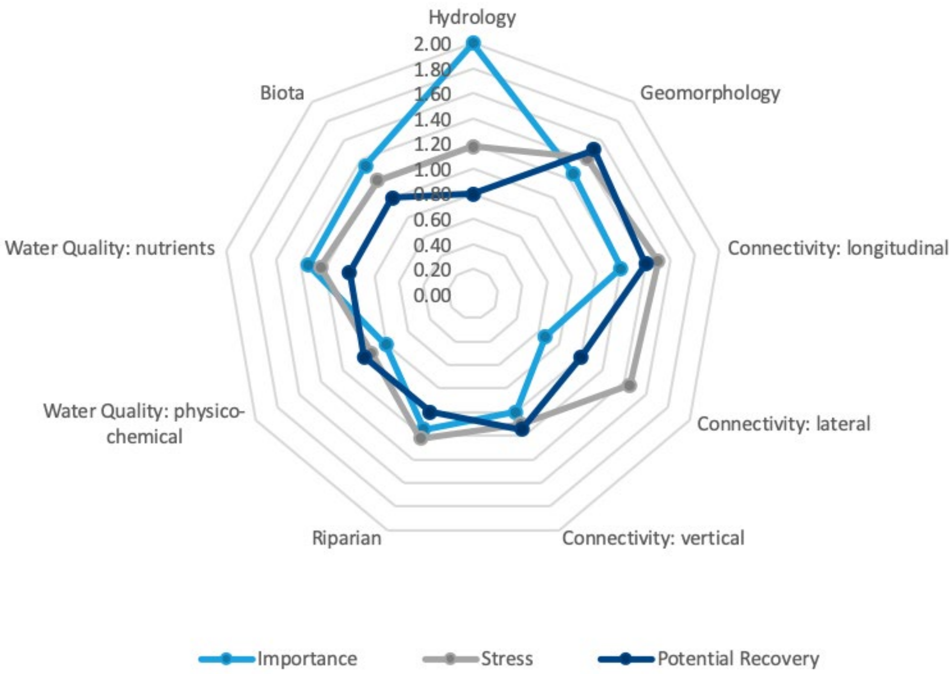


Figure 13. Results spider diagram for JJ Smith Park

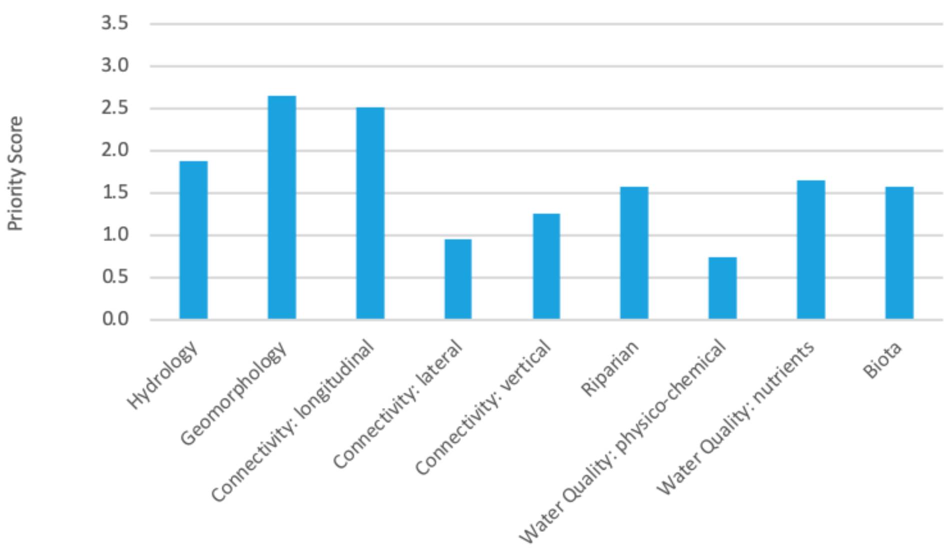


Figure 14. Priority management scores for ecological components at JJ Smith Park

4.1.3 Site 3—Hawthorn Park

Table 3 and Figure 15 present the RESTORE Tool scores for each ecological component at Hawthorn Park.

Table 3. RESTORE Tool results for Hawthorn Park

Ecological component	Importance	Stress	Potential recovery	Prioritisation score
Hydrology	**2.00**	0.88	1.00	1.8
Geomorphology	1.25	1.00	**1.67**	**2.1**
Connectivity: longitudinal	1.20	**1.33**	**1.60**	**2.6**
Connectivity: lateral	1.00	1.11	1.25	1.4
Connectivity: vertical	1.00	1.00	**1.71**	1.7
Riparian	1.00	0.67	**1.67**	1.1
Water quality: physico-chemical	0.80	0.81	1.33	0.9
Water quality: nutrients	1.33	0.76	1.50	1.5
Biota	1.00	1.10	0.67	0.7

Longitudinal connectivity followed by geomorphology received the highest prioritisation scores (figure 16). This is a logical conclusion since the channel is concrete lined, with adjacent urban catchments discharging directly into the predominantly straight, main channel. Velocities are expected to be high with minimal or no engagement of riparian vegetation. There is potential to remove the concrete, reshape the channel and revegetate the batters, to achieve a healthy riparian zone. While this is an often expensive process, the concrete channel offers limited value and, as such, should hold a high priority for recovery.

The following recommendations were made for JJ Smith Park prior to applying the RESORE Tool to the site:

- Improve the floodplain (hydrology)
- Pursue riparian revegetation on northern banks to improve connectivity and maintain park view lines

The following recommendations were made for Hawthorn Park prior to applying the RESORE Tool to the site:

- Test a range of alternative strategies to transform the existing channels throughout the catchment in identified low flood risk areas (hydrology and geomorphology)
- Prioritise the improved connectivity between the channel and ecological corridors (longitudinal connectivity)
- Include community involvement and engagement in the design of channels, revegetation and ongoing maintenance.

These conclusions generally align with the results from the RESTORE Tool, validating the tool's effectiveness at this site.

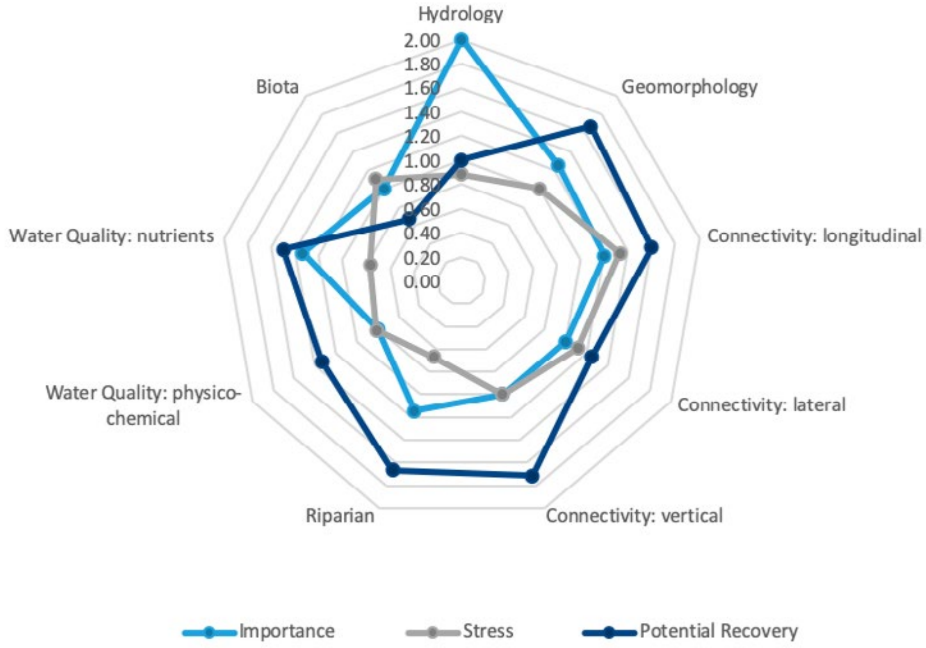


Figure 15. Results spider diagram for Hawthorn Park

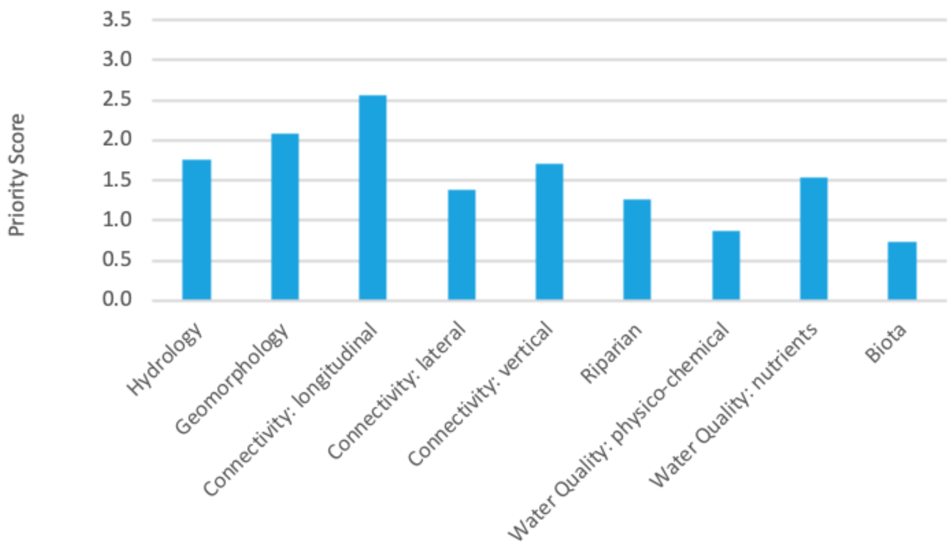


Figure 16. Priority management scores for ecological components at Hawthorn Park

4.1.4 Site 4—Grand Plaza site

Table 4 and figure 17 present the RESTORE Tool scores for each ecological component at Grand Plaza site.

Table 4. RESTORE Tool results for Grand Plaza site

Ecological component	Importance	Stress	Potential recovery	Prioritisation score
Hydrology	**2.00**	1.24	1.20	**3.0**
Geomorphology	1.25	1.25	**1.67**	**2.6**
Connectivity: longitudinal	1.20	1.33	1.40	**2.2**
Connectivity: lateral	0.67	**1.44**	1.00	1.0
Connectivity: vertical	1.00	1.20	1.29	1.5
Riparian	1.00	1.11	**1.67**	1.9
Water quality: physico-chemical	0.80	1.06	1.17	1.0
Water quality: nutrients	**1.33**	1.18	1.13	1.8
Biota	1.00	**1.36**	0.67	0.9

Hydrology, geomorphology and longitudinal connectivity were considered the priority for management effort (figure 18). This matched our assessment of conditions at the Grand Plaza site. There is a large, mostly piped stormwater network contributing to the site, and the stream was heavily incised. Waterway barriers exist both upstream and downstream, with some level of management intervention possible for these barriers, particularly since they exist downstream. There are also opportunities for recovery from reconnecting secondary channels, making some improvement in geomorphology possible. It was surprising that water quality (nutrients) was the fifth highest scoring component, since significant odours were present and there was an old landfill that was assumed to be leaking leachate. But, the difficulty in arresting this issue may have made it a lower priority.

The following recommendations were made for Grand Plaza site prior to applying the RESORE Tool to the site:

- Investigate cause of water quality hotspot (water quality: physico-chemical and water quality: nutrients)
- Reinstate riparian vegetation in suitable locations along Scrubby Creek and associated online waterbodies, to shade out weeds and provide better habitat and ecological corridors to improve both waterway health and biodiversity (geomorphology and riparian)
- Encourage local community groups and educational facilities to engage with the Creek through education or research programs (e.g. water quality monitoring).

The main difference in recommendations at this site is that water quality was identified as a management priority over hydrology.

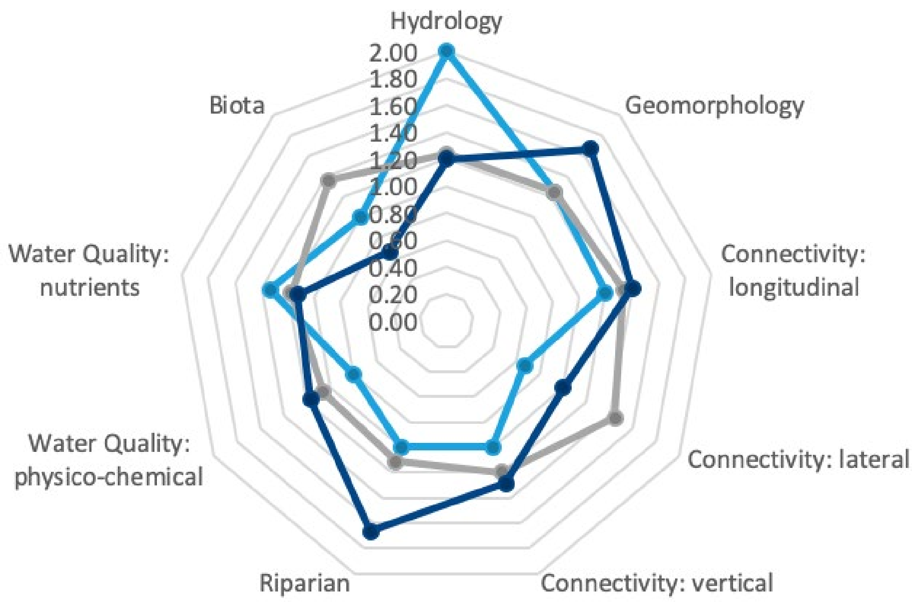


Figure 17. Results spider diagram for Grand Plaza site

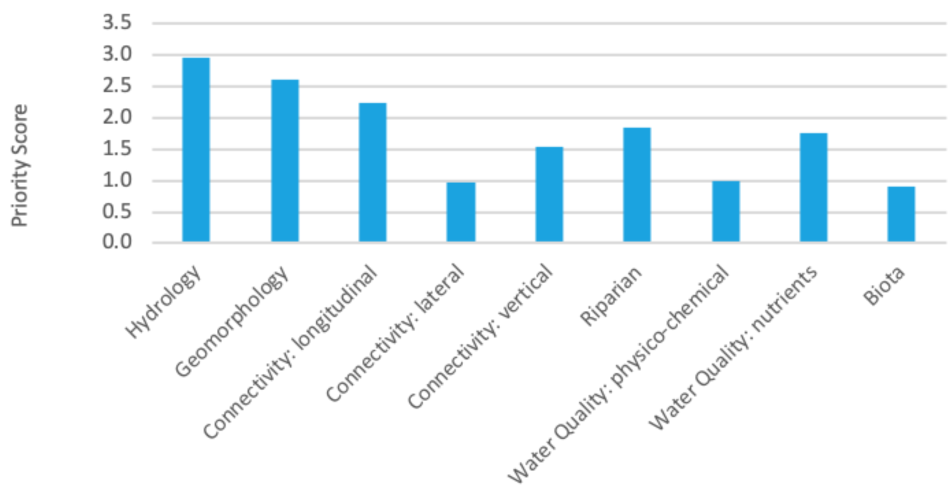


Figure 18. Priority management scores for ecological components at Grand Plaza site

4.2 Recommendations from factsheets

We used the RESTORE Tool prioritisation score to focus on the ecological components where management effort is likely to yield the largest ecological return. We referred to the compendium of 13 factsheets, *Improving the ecological function of urban waterways*, for information on the range of available actions (table 5) that are shown to address each of the priority ecological components, at either the site or catchment scale (or both).

Marked actions (X) were identified as the most viable given the site conditions and priority management scores.

Table 5. Potential management actions to improve priority ecological components for four Scrubby Creek sites

Ecological component	Scale	Strategy	Action #	Action	Site 1: Gould Adams	Site 2: JJ Smith	Site 3: Hawthorn Park	Site 4: Grand Plaza
Hydrology	Catchment	Strategy 1: Reduce the flow	1a	Harvest rainwater at the lot scale using rainwater tanks and roof gardens		X		X
Hydrology	Catchment	Strategy 1: Reduce the flow	1b	Infiltrate stormwater at the lot scale using soak-wells and permeable paving. Discourage the use of fake lawn		X		
Hydrology	Catchment	Strategy 1: Reduce the flow	1c	Infiltrate stormwater at the street scale using raingardens, swales and tree pits		X		
Hydrology	Catchment	Strategy 1: Reduce the flow	1e	Remove (daylight) pipes and remove channel hard-lining		X		X
Hydrology	Catchment	Strategy 1: Reduce the flow	1f	Infiltrate stormwater at the precinct scale using biofiltration basins				X

Note: Potential management actions were extracted from the Improving the ecological function of urban waterways: a compendium of factsheets.

Ecological component	Scale	Strategy	Action #	Action	Site 1: Gould Adams	Site 2: JJ Smith	Site 3: Hawthorn Park	Site 4: Grand Plaza
Hydrology	Catchment	Strategy 1: Reduce the flow	1h	Strategically place biofiltration basins and stormwater wetlands in locations that receive the most stormwater		X		X
Hydrology	Catchment	Strategy 1: Reduce the flow	1i	Redirect or retrofit subsurface drainage so it empties into wetland basins or riparian swales, not directly into waterways				X
Hydrology	Catchment	Strategy 2: Reduce the velocity of in-stream flow, particularly peak flows	2a	Harvest, infiltrate and detain stormwater. See all actions in Strategy 1				X
Hydrology	Catchment	Strategy 3: Reduce the frequency of pulses	3a	Harvest, infiltrate, detain and disconnect stormwater. See all actions in Strategy 1				
Hydrology	Catchment	Strategy 4: Slow the rate of flow risk and fall	4a	Infiltrate, detaiwn and disconnect stormwater. See Strategy 1, actions 1b–1h				
Hydrology	Catchment	Strategy 5: Repair stream baseflow	5i	Harvest rainwater at the lot scale using rainwater tanks and roof gardens (as per action 1a)		X		
Hydrology	Catchment	Strategy 5: Repair stream baseflow	5k	Undertake catchment-wide planting of native trees		X		X

Ecological component	Scale	Strategy	Action #	Action	Site 1: Gould Adams	Site 2: JJ Smith	Site 3: Hawthorn Park	Site 4: Grand Plaza
Hydrology	Catchment	Strategy 5: Repair stream baseflow	5l	Pursue irrigation using stormwater up to, but not above, evaporative demand		X		
Hydrology	Catchment	Strategy 5: Repair stream baseflow	5o	Repair leaks from water supply or wastewater infrastructure				X
Geomorphology	Site and catchment	Strategy 3: Allow the channel to naturally self-adjust to altered flow	3a	Remove channel hard-lining		X	X	X
Geomorphology	Site and catchment	Strategy 3: Allow the channel to naturally self-adjust to altered flow	3b	Recreate channel sinuosity			X	
Geomorphology	Site and catchment	Strategy 3: Allow the channel to naturally self-adjust to altered flow	3c	Increase the width of the riparian buffer	X	X	X	X
Geomorphology	Site and catchment	Strategy 4: Mitigate erosion caused by urban infrastructure or head-cutting	4a	Relocate/redesign stormwater drainage inputs		X	X	
Geomorphology	Site and catchment	Strategy 4: Mitigate erosion caused by urban infrastructure or head-cutting	4b	Redesign culverts (to open-bottom culverts)			X	

Ecological component	Scale	Strategy	Action #	Action	Site 1: Gould Adams	Site 2: JJ Smith	Site 3: Hawthorn Park	Site 4: Grand Plaza
Geomorphology	Site and catchment	Strategy 4: Mitigate erosion caused by urban infrastructure or head-cutting	4c	Employ grade control structure (boulder weirs – cross vane, w-weir, j-hook; rigid weirs)		X	X	
Geomorphology	Site and catchment	Strategy 6: Increase geomorphic complexity	6a	Recreate channel sinuosity			X	
Geomorphology	Site and catchment	Strategy 6: Increase geomorphic complexity	6b	Create pool-riffle sequence			X	
Geomorphology	Site and catchment	Strategy 6: Increase geomorphic complexity	6c	Add logs (LWD) or boulder clusters	X	X	X	X
Geomorphology	Site and catchment	Strategy 6: Increase geomorphic complexity	6d	Add gravel to the channel (sediment augmentation)	X	X	X	
Geomorphology	Site and catchment	Strategy 6: Increase geomorphic complexity	6e	Encourage the channel to naturally self-adjust (see all of Strategy 3)	X	X	X	X
Geomorphology	Site and catchment	Strategy 6: Increase geomorphic complexity	6f	Remove the sediment from the channel manually or using a controlled flushing flow			X	
Geomorphology	Site and catchment	Strategy 6: Increase geomorphic complexity	6g	Promote/protect trees and native vegetation along the bank	X	X	X	X

Ecological component	Scale	Strategy	Action #	Action	Site 1: Gould Adams	Site 2: JJ Smith	Site 3: Hawthorn Park	Site 4: Grand Plaza
Geomorphology	Site and catchment	Strategy 7: Restore connection with the floodplain	7a	Act as per *Repairing lateral connectivity: What to do at the site and in the catchment* factsheet, Strategy 2 all actions				
Longitudinal connectivity	Site and catchment	Strategy 1: Assist in in-stream movement of water and biota	1a	Daylight or remove piped streams				
Longitudinal connectivity	Site and catchment	Strategy 1: Assist in in-stream movement of water and biota	1b	Remove or modify artificial in-stream barriers (e.g. rock dams, weirs)	X	X	X	
Longitudinal connectivity	Site and catchment	Strategy 1: Assist in in-stream movement of water and biota	1c	Minimise or retrofit road crossings (i.e., use flyovers, minimise road crossings, use fish-friendly culverts)	X	X	X	
Longitudinal connectivity	Site and catchment	Strategy 1: Assist in in-stream movement of water and biota	1d	Repair stream baseflow (see hydrology Strategy 5)			X	
Longitudinal connectivity	Site and catchment	Strategy 1: Assist in in-stream movement of water and biota	1e	Improve in-stream cover (see riparian site scale actions 5a, 5b, 5d and 5e)				

Ecological component	Scale	Strategy	Action #	Action	Site 1: Gould Adams	Site 2: JJ Smith	Site 3: Hawthorn Park	Site 4: Grand Plaza
Longitudinal connectivity	Site and catchment	Strategy 1: Assist in in-stream movement of water and biota	1f	Repair streamside vegetation	X	X	X	X
Longitudinal connectivity	Site and catchment	Strategy 1: Assist in in-stream movement of water and biota	1h	Attenuate or remove urban point-source pollution		X		X
Longitudinal connectivity	Site and catchment	Strategy 2: Support the terrestrial movement of semi-aquatic biota	2a	Connect riparian corridors	X	X	X	X
Longitudinal connectivity	Site and catchment	Strategy 2: Support the terrestrial movement of semi-aquatic biota	2b	Minimise or retrofit road crossings (i.e., use flyovers, minimise road crossings)	X			
Longitudinal connectivity	Site and catchment	Strategy 2: Support the terrestrial movement of semi-aquatic biota	2c	Increase buffer width	X	X	X	X
Longitudinal connectivity	Site and catchment	Strategy 2: Support the terrestrial movement of semi-aquatic biota	2d	Increase the structural complexity of riparian vegetation	X	X	X	X
Biota	Site	Strategy 2: Improve the quality of in-stream habitat	2a	Repair flow (see flow factsheet)				

Ecological component	Scale	Strategy	Action #	Action	Site 1: Gould Adams	Site 2: JJ Smith	Site 3: Hawthorn Park	Site 4: Grand Plaza
Biota	Site	Strategy 2: Improve the quality of in-stream habitat	2b	Repair geomorphic complexity (see geomorphology factsheet)	X			
Biota	Site	Strategy 2: Improve the quality of in-stream habitat	2d	Repair leaf litter inputs (see riparian site scale factsheet, Strategy 4)				
Biota	Site	Strategy 2: Improve the quality of in-stream habitat	2e	Repair aquatic habitat (see riparian site scale fact sheet, Strategy 5)	X			
Biota	Site	Strategy 2: Improve the quality of in-stream habitat	2f	Ensure the habitat requirements for all life history stages of valued species are present at the site	X			
Biota	Site	Strategy 2: Improve the quality of in-stream habitat	2g	Ensure the banks of the waterway have a gentle slope	X			
Biota	Site	Strategy 3: Reduce negative interactions with non-native species	3a	Control non-native species by removing or excluding	X			
Biota	Site	Strategy 3: Reduce negative interactions with non-native species	3b	Increase the complexity of in-stream habitat	X			

Ecological component	Scale	Strategy	Action #	Action	Site 1: Gould Adams	Site 2: JJ Smith	Site 3: Hawthorn Park	Site 4: Grand Plaza
Biota	Site	Strategy 3: Reduce negative interactions with non-native species	3c	Repair baseflow (see flow catchment scale fact sheet, Strategy 5)				
Riparian	Site	Strategy 4: Improve leaf litter inputs and retention	4a	Plant native vegetation in the stream-side zone				
Riparian	Site	Strategy 4: Improve leaf litter inputs and retention	4b	Increase channel sinuosity				
Riparian	Site	Strategy 4: Improve leaf litter inputs and retention	4c	Increase buffer width				
Riparian	Site	Strategy 4: Improve leaf litter inputs and retention	4d	Revegetate the riparian buffer				
Riparian	Site	Strategy 4: Improve leaf litter inputs and retention	4e	Add large woody debris (LWD) to the channel				
Riparian	Site	Strategy 4: Improve leaf litter inputs and retention	4f	Promote hydrologic connectivity by grading the bank, lowering the floodplain (e.g. terracing), raising the channel or other methods (see lateral connectivity actions 2a–2d)				

Ecological component	Scale	Strategy	Action #	Action	Site 1: Gould Adams	Site 2: JJ Smith	Site 3: Hawthorn Park	Site 4: Grand Plaza
Riparian	Site	Strategy 4: Improve leaf litter inputs and retention	4g	Remove levees or other barriers				
Riparian	Site	Strategy 4: Improve leaf litter inputs and retention	4h	Manage or redesign gross pollutant traps (GPTs) so that leaves pass to the stream				
Riparian	Site	Strategy 5: Improve aquatic habitat	5a	Add large woody debris (LWD) to the channel	X			
Riparian	Site	Strategy 5: Improve aquatic habitat	5b	Plant native vegetation in the stream-side zone	X			
Riparian	Site	Strategy 5: Improve aquatic habitat	5c	Line the stream with wet/dry tolerant plants	X			
Riparian	Site	Strategy 5: Improve aquatic habitat	5e	Create floodplain wetlands or depressions				
Riparian	Site	Strategy 5: Improve aquatic habitat	5f	Promote hydrologic connectivity by grading the bank, lowering the floodplain (e.g. terracing), raising the channel or other methods (see lateral connectivity actions 2a–2d)				

5. Discussions and recommendations

5.1 Benefits of the RESTORE Tool

- There's a wealth of scientific evidence supporting the questions and the tool's development, making the tool a highly valuable educational tool and literature source.
- The RESTORE Tool challenges any perceptions and biases by presenting scientific evidence for each of the questions and their relevance to stream restoration, forcing professionals to evaluate their own assumptions.
- The tool asks questions that the user may otherwise overlook, making it difficult for the user to unintentionally miss important information because they're focusing on components they understand well.
- The tool provides a framework for understanding that ecological restoration should consider the likely success of restoration. It breaks down the likely success into three factors: importance, stress, and potential for recovery.
- The tool encourages collaboration, since users need a breadth of expertise and knowledge of the sites to comprehensively and effectively use the tool.

5.2 Limitations

The tool has some limitations, including those acknowledged within the tool itself. The limitations acknowledged within the tool are:

1. **Equal weighting among criteria (importance, stress, potential recovery)**

   The tool assumes that importance, stress and potential recovery are equally important to the prioritisation of each ecological component. This has not been empirically tested, and it is possible that one criterion is more influential than the others.

2. **Equal weighting among factors (attributes, characteristics, questions)**

   The tool has a series of 126 questions. Each question will be relevant to one or multiple ecological components and its importance, stress or potential recovery. The score for each ecological component's criteria (importance, stress, potential recovery) is the average of scores across the relevant factors/ questions. The number of relevant factors ranges for each component and criteria.

   For example, the stress to hydrology is the combination (taken as the average score) of the level of catchment imperviousness, stormwater management actions, drainage density, clearing of catchment vegetation, flow regulating structures, etc.

   The tool's default is to weight each factor equally, but certain factors will be much more influential than others. The justification for not differentially weighting them is that the influence of different factors is likely to vary among landscapes and urban areas. This is a reasonable justification, but practitioners should be aware that some factors may be so influential as to prevent recovery of the relevant attribute, or even other related attributes.

3. **Assumption of linear relationships**

   The ranking for each question is based on a numerical range from 0 to 2. The tool assumes there is a linear response among these rankings. For example, that the impact of catchment imperviousness on flow stress increases linearly between low, medium and high levels. But we know that ecological relationships are often non-linear (e.g. threshold) and that factors can interact and create feedbacks.

4. **Lack of sensitivity analysis**

   Currently, the tool will alert you to which question feeds into other questions, but it won't tell you how much the outcome of the tool will change if you adjust the score for any given question (sensitivity analysis).

5. **Number of solutions provided in the compendium of factsheets**

   Once priorities are determined, the factsheets provide many options for management. Within these solutions, there is still some complexity in determining which would be the appropriate solutions. Future iterations of the tool (and perhaps a more complex scaling of scores, such as 1–7) could account for which attributes of, for example, hydrology are more important and which actions should be considered more important.

Other limitations of the tool observed during pilot are:

- **There is no simple way to link the results back to key factors, since the results are based on a combination of all 126 questions.**

  If the user wishes to understand why a certain ecological component and its criteria scored highly, they must review every question relevant to that ecological component. This may be cumbersome and time consuming, but is a good way to undertake quality assurance for the results. This is like the lack of sensitivity testing.

- **The results intrinsically depend on the knowledge and experience of the user, given this affects their ability to respond to each question.**

  For every question, there is an option to score based on 'unsure', but it takes significant time to review the results (or to take notes outside the tool) to understand which ecological components may have been affected by missing information and knowledge. Acknowledging and understanding the implication of this limitation is important, to know which results the user can confidently rely on. A lack of information in an area (e.g. site soils) may mean that a certain ecological component may appear to have a low priority.

- **The potential recovery questions do not fully reflect the feasibility of actions needed for recovery.**

  We found a limitation in the results of the potential recovery of hydrology at site 4. This limitation may apply more broadly and highlights that the tool does not replace the importance of site investigations and understanding the catchment. Users should not consider the results of the tool final, and should review and update them where they find information gaps in results. For example, see next point.

- **The potential recovery of hydrology (and therefore its overall priority) was based on its location in the catchment, and the assumption that because it had a relatively small upstream catchment, its potential recovery was quite high.**

  When looking at the recommended actions, very few actions at the site or within the catchment are financially or spatially feasible, meaning that this site has in fact very low potential for recovery, which the results don't reflect.

- **Input from many disciplines is needed to maximise the results from the tool.**

  While a key benefit of the tool is ensuring key information is not overlooked, the results are still highly dependent on knowledge and the ability to respond to each question. Where information or knowledge is missing, the factors relating to that information will never receive a high score, meaning that the related ecological components may appear to be a low priority in the results. It's important for users to acknowledge and understand the implications of this limitation, so they can know whether they can view the results with confidence or not.

- **Priorities are allocated purely on ecological attributes.**

  While this is the intent of the tool, it fails to adequately consider the importance of social aspects in waterway planning and recovery. We consider this a major cause of discrepancies between actions noted in the *Scrubby Creek Recovery Plan* and priorities assigned through the RESTORE Tool.

- **Recovery potential may not adequately reflect feasible actions.**

  There may be room for improvement in this space, potentially by modifying the scoring scales and weighting of questions. We acknowledge that this is a site-specific issue and, as such, it may be more appropriately addressed on a site assessment scale.

6. Conclusion

We believe the RESTORE Tool offers a rapid assessment of waterway sites, to determine relevant attributes that are most important in a system and priorities for management. Its simplicity means it is highly useful where budgets and resources may not be available for complex technical assessments. The tool offers great potential for multidisciplinary team use, and would become more robust, efficient and effective over the long term if more time could be invested in the tool's details.

Users who have narrow expertise and apply this tool for rapid evaluation of options may not reveal the true priorities for the sites. The ability to record 'level of confidence' against questions would add transparency to the process and may be useful for future reference.

When applying this tool in its recommended setting (to determine ecological priorities for repairing ecological health at specific sites), we see it being most effective when applied in a facilitated workshop environment. This could be done in a process like that of the WSC Index Benchmarking, which brings together a team of relevant experts, stakeholders and decision makers. So that such workshops could be run over a reasonable timeframe, the tool would need to ask fewer questions. High level questions could be supported by more detailed technical questions that are only accessed where the expertise is available to answer those with a reasonable level of confidence.

Some elements of the RESTORE Tool may be refined in future iterations, to consider the relative importance of particular factors at a site. Some guidance around providing weightings may be useful so practitioners can accurately assign importance to various factors. This version of the tool is useful in its current setting, and could be improved with more investment in the key site issues and the feasibility of implementing certain actions.

CRC for
Water Sensitive Cities

Cooperative Research Centre for Water Sensitive Cities

Level 1, 8 Scenic Boulevard
Monash University
Clayton VIC 3800

info@crcwsc.org.au

www.watersensitivecities.org.au