Repairing water quality: what to do at the site

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CRC for Water Sensitive Cities

Strategy 1. Keep the water as cool as possible

Suitability of strategy: Most suitable for small streams with naturally cool water. Most likely to be effective where a small portion of the catchment is impervious and a sizeable tract of the upstream waterway is still relatively intact. Less achievable when the urban area is anticipating marked increases in temperature associated with climate change.

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
1a. Shade the stream See *Repairing riparian function: what to do at the site* factsheet, Strategy 1, all actions	Increasing the shading of the stream will reduce the penetration of UV light into the waterway and reduce water temperature.	Where the stream channel is relatively narrow (< 10 m) and where the natural vegetation is trees rather than grassland. See *Repairing riparian function: what to do at the site* factsheet, Strategy 1, for the suitability of specific actions.	[1-4]	See associated factsheet
1b. Relocate stormwater inputs so they run stormwater through vegetated filter strips / riparian land	Stormwater should not be directly piped to waterways, instead it should be allowed to flow through vegetated filter strips or riparian land where it can cool before entering the stream via surface or sub-surface pathways.	Where the riparian land is shaded by trees. Where the vegetated buffer that the stormwater passes through is > 10 m wide.	[5]	[5]
1c. Promote groundwater upwelling See *Repairing vertical connectivity: what to do at the site and in the catchment* factsheet, all Strategies	Typically groundwater is considerably cooler than surface water, hence actions that improve the flow of groundwater into the waterway help to moderate elevated temperatures.	Where the site would naturally receive a significant proportion of its flow from groundwater – i.e. highly permeable bed sediment (gravel, coarse sand) and has a shallow watertable (< 4 m deep). Not appropriate if the groundwater is contaminated with pollutants (nutrient or non-nutrient).	[4, 6-8]	See associated factsheet

Strategy 2. Keep oxygen levels high

Suitability of strategy: most suitable where the waterway experiences protracted periods of low flow, particularly during warm months, and where nutrient concentrations are elevated.

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
2a. Increase turbulence instream using logs and riffles	Turbulent flow associated with instream structures such as logs and riffles promotes oxygenation of water.	Where the waterway has very little instream habitat complexity.	[9]	Riffles [10, 11] LWD [10, 12-18]
2b. Artificially aerate the waterway	Artificial aeration can either bubble air through the water or inject pure oxygen. In some cases, water low in oxygen is removed from the waterway, oxygenated, and then returned to the river.	In high value locations where the water is deep and prone to stratification, such as the lowland sections of urban rivers. River reaches downstream of flow regulating structures (e.g. weirs) are particularly susceptible to oxygen crashes.	[19]	Aerator [20]
2c. Use pumps to maintain flow	Water can be pumped from the downstream end of a site to the upstream end to maintain constant flow and aeration.	In high value locations where there is a differential in height between the upstream and downstream end of the waterway reach. Most appropriate for constructed or novel living streams in new urban developments.		
2d. Keep the water as cool as possible – as per Strategy 1	The solubility of oxygen in water decreases as the water temperature increases, therefore efforts to cool instream water will also improve oxygen levels.	Most suitable for small streams with naturally cool water. Most likely to be effective where a small portion of the catchment is impervious and a sizeable tract of the upstream waterway is still relatively intact. Less achievable when the urban area is anticipating marked increases in temperature associated with climate change.	[21]	As per Strategy 1 this factsheet

Strategy 3. Reduce non-nutrient pollutants (i.e. heavy metals, hydrocarbons, PCBs, pharmaceuticals and other personal care products)

Suitability of strategy: most suitable where the site has large quantities of fine sediments (e.g. mid to lowland river sites), given fine sediments bond to contaminants and increase the exposure of the site to pollutants. Particularly suited to sites adjacent to, or downstream of an industrial area.

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
3a. Install gross pollutant traps (GPTs)	GPTs catch plastic and other rubbish in stormwater, preventing it from entering the waterway.	Where stormwater pipes discharge into the site. Care should be taken the GPT's do not prevent coarse sediment and leaf litter from entering the stream.	WSUD manuals	See WSUD manuals
3b. Relocate/ redesign stormwater inputs	Direct piping of stormwater into the stream bypasses riparian filtration. Stormwater outputs should be allowed to filter through riparian soils so that biogeochemical processes can transform pollutants. Flush road kerbing or kerbless roads should be used on the side of the road that drains to riparian land. Where stormwater pipes exist they should terminate at swales/ filter strips/biofilters on the distal (road side) edge of the riparian buffer.	Sites where stormwater pipes or subsurface drainage pipes are present and where a road borders the riparian land.	[22]	[23, 24] See WSUD manuals
3c. Promote hyporheic exchange See *Repairing vertical connectivity* factsheet, Strategies 3 and 4	The hyporheic zone is an active area of pollutant breakdown. Actions that increase downwelling and upwelling at the site, such as removing channel hard-lining, increasing channel sinuosity, adding logs, creating pool-riffle sequences or adding gravel will promote pollutant biodegradation.	Most effective where a large portion of flow occurs through the hyporheic zone – i.e. streams that experience protracted low flows and where bed permeability is moderate to high (sand, gravel). Less effective where high-volume scouring urban flows persist year round and where bed permeability is low (e.g. clay). See associated factsheet for additional advice on specific actions.	[9]	See associated factsheet

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
3d. Keep oxygen levels high – see Strategy 2 this factsheet	The biodegradation of many pharmaceuticals and most trace organic contaminants is accelerated under aerobic conditions.	Where oxygen levels are prone to fall below 4 mg/L.	[9]	As per Strategy 2 this factsheet
3e. Use aquatic macrophytes to stabilise fine sediment	Most metals and hydrophobic pollutants bind more readily to fine sediments than large sediments. Macrophyte roots are effective in stabilising these fine polluted sediments and preventing them from entering the water column where they can create stress for macroinvertebrates.	Where scouring urban flows have been managed. Where macrophytes (e.g. sedges) are planted in low-velocity, depositional areas such as the inside of meander bends, backwater habitats, and floodplain depressions or wetlands.	[25]	See biofiltration guidelines

Strategy 4. Improve water clarity

Suitability of strategy: suitable for most sites, particularly those with large quantities of fine sediments (e.g. clay, silt). May not be appropriate if improved water clarity will cause nuisance algal growth.

Action	Explanation	Conditions where action is most likely to be suitable andeffective	Other references recommending action	Guidelines for implementation
4a. Establish macrophyte beds and plant streamside vegetation to stabilise banks	Macrophytes are known to improve water clarity because their dense fibrous roots stabilise bed and bank sediments – reducing the entrainment of these fine sediments by high flows.	Where channel form is stable such that macrophyte beds won't get washed away. Where scouring urban flows have been managed. Sedges are most likely to survive if planted in low-velocity areas such as the inside of meander bends.	[26, 27]	
4b. Control non-native bioturbating species	Species that feed by digging around in the mud stir up fine sediments and increase water turbidity. Removing these species should improve water clarity.	Where non-native bioturbating pest species are present. Where successful control or eradication is feasible (e.g. site is small).		[28-31]

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Supporting documents

1. Bunn, S., et al. (1999) Temperature and light. Riparian Land Management Technical Guidelines Volume One: Principles of Sound Management: p. 17-24.
2. Davies, P.M., et al. (2007) Temperature and light, In: Principles for riparian lands management, S. Lovett and P. Price, Editors. p. 33-46. Available from: https://pdfs.semanticscholar.org/b29e/62f1bf22ec4c9c62e22303b8f50d657d9fae.pdf.
3. Rutherford, J.C., et al. (2004) Effects of patchy shade on stream water temperature: how quickly do small streams heat and cool? Marine and Freshwater Research, 55: p. 737-748.
4. Poole, G.C. and C.H. Berman (2001) An ecological perspective on in-stream temperature: natural heat dynamics and mechanisms of human-causedthermal degradation. Environmental Management, 27: p. 787-802.
5. Winston, R.J., et al. (2011) Thermal mitigation of urban storm water by level spreader - vegetative filter strips. Journal of Environmental Engineering, 137: p. 707-716.
6. Kondolf, G., et al. (2006) Process-based ecological river restoration: visualizing three-dimensional connectivity and dynamic vectors to recover lost linkages. Ecology and Society, 11.
7. Hester, E.T. and M.N. Gooseff (2010) Moving beyond the banks: hyporheic restoration is fundamental to restoring ecological services and functions of streams. Environmental Science and Technology, 44: p. 1521-1525.
8. WDF (2004) Channel modification, In: Stream habitat restoration guidelines, K. Saldi-Caromile, et al., Editors. Washington Department of Forestry, Olympia, Washington, US. Available from: https://www.wou.edu/las/physci/taylor/g407/restoration/WA_Dept_Forestory_2004_Channel_Modification_Techniques.pdf.
9. Lawrence, J.E., et al. (2013) Hyporheic zone in urban streams: a review and opportunities for enhancing water quality and improving aquatic habitat by active management. Environmental Engineering Science, 30: p. 480-501.
10. Rutherford, I.D., et al. (2000) A rehabilitation manual for australian streams: volume 2. Cooperative Research Centre for Catchment Hydrology. Land and Water Resources Research and Development Corporation. Available from: http://www.engr.colostate.edu/~bbledsoe/CIVE413/Rehabilitation_Manual_for_Australian_Streams_vol2.pdf.
11. WRC (2005) River restoration manual. Available from: http://www.water.wa.gov.au/water-topics/waterways/managing-our-waterways2/river-restoration-manual.
12. Treadwell, S., et al. (2007) Wood and other aquatic habitat. Available from: https://arrc.com.au/wp-content/uploads/2015/08/Wood%20and%20other%20aquatic%20habitat.pdf.
13. Brooks, A.P., et al. (2006) Design guideline for the reintroduction of wood into Australian streams. Land and Water Australia Canberra. Available from: https://arrc.com.au/wp-content/uploads/2015/08/Design%20guideline%20for%20the%20reintroduction%20of%20wood%20into%20Australian%20streams.pdf.
14. Wohl, E., et al. (2016) Management of large wood in streams: an overview and proposed framework for hazard evaluation. JAWRA Journal of the American Water Resources Association, 52: p. 315-335.
15. Erskine, W., et al. (2007) River restoration based on natural channel characteristics: how to develop restoration designs for different rivers and riparian plant communities. In: 5th Australian Stream Management Conference. Thurgoona, NSW.
16. Rafferty, M. (2017) Computational design tool for evaluating the stability of large wood structures. Department of Agriculture, National Stream and Aquatic Ecology Centre. Fort Collins, Colorado, USA. Available from: https://www.fs.fed.us/biology/nsaec/assets/rafferty_usfs_nsaec_tn-103-2_stabilitylargewoodstructurestool.pdf.
17. Beesley, L., et al. (2017) Riparian design guidelines to inform the repair urban waterways. Cooperative Research Centre for Water Sensitive Cities. Melbourne Australia.
18. Shields, J., F Douglas, et al. (2000) Large woody debris structures for incised channel rehabilitation. In: Joint conference of Water Resources Engineering and Water Resources Planning and Management. Minneapolis, USA.
19. DoW (2000) Oxygenating the Swan and Canning rivers. Western Australian Departmet of Water. Perth, WA. Available from: https://www.water.wa.gov.au/__data/assets/pdf_file/0016/3265/45460.pdf.
20. Greenop, B., et al. (2001) The use of artificial oxygenation to reduce nutrient availability in the canning river, western australia. Water science and technology, 43: p. 133-144.
21. Auckland Council (2013) Caring for urban streams. Available from: http://www.aucklandcouncil.govt.nz/EN/environmentwaste/stormwater/Documents/caringforurbanstreamsguide3streamwaterquality.pdf.
22. Walsh, C.J., et al. (2005) The urban stream syndrome: current knowledge and the search for a cure. Journal of the North American Benthological Society, 24: p. 706-723.
23. Torre, A., et al. (2006) Retrofitting, In: Stormwater management manual for Western Australia. Deparment of Environment and Swan River Trust Perth, Western Australia. Available from http://www.water.wa.gov.au/urban-water/urban-development/stormwater/stormwater-management-manual.
24. Browning, G., et al. (2014) Water sensitive designs. Water By Design.
25. Sharley, D.J., et al. (2017) Linking urban land use to pollutants in constructed wetlands: implications for stormwater and urban planning. Landscape and Urban Planning, 162: p. 80-91.
26. Albertoni, E.F., et al. (2014) Field evidence of the influence of aquatic macrophytes on water quality in a shallow eutrophic lake over a 13-year period. Acta Limnologica Brasiliensia, 26: p. 176-185.

27. Burns, M., et al. (2016) Hydrologic and water quality responses to catchment-wide implementation of stormwater control measures. Novatech Conference. Lyon, France.

28. Roberts, J. and R. Tilzey (1997) Controlling carp: Exploring the options for Australia. CSIRO Land and Water Griffith, NSW, Australia.

29. Koehn, J.D. (2004) Carp (cyprinus carpio) as a powerful invader in australian waterways. Freshwater Biology, 49: p. 882-894.

30. Pinto, L., et al. (2005) Managing invasive carp (cyprinus carpio l.) for habitat enhancement at botany wetlands, Australia. Aquatic Conservation: Marine and Freshwater Ecosystems, 15: p. 447-462.

31. Weber, M.J. and M.L. Brown (2009) Effects of common carp on aquatic ecosystems 80 years after "carp as a dominant": Ecological insights for fisheries management. Reviews in Fisheries Science, 17: p. 524-537.

Water Sensitive Urban Design (WSUD) guidelines

<u>Australia Wide</u>

CSIRO, Urban stormwater: Best practice environmental management guidelines. 1999, Collingwood, Victoria: CSIRO Publishing.

Allen, M.D., et al. (2004) Water sensitive urban design: Basic procedures for'source control'of stormwater: A handbook for australian practice.

<u>New South Wales</u>

URS (2003) Water sensitive urban design technical guidelines for western sydney. Available from: http://www.richmondvalley.nsw.gov.au/icms_docs/138067_Development_Control_Plan_No_9_-_Water_Sensitive_Urban_Design.pdf.

<u>South Australia</u>

South Australian Government (2010) Water sensitive urban design greater adelaide region: Technical manual. Available from: https://www.sa.gov.au/__data/assets/pdf_file/0003/7770/WSUD_contents_and_glossary.pdf.

South Australian EPA. Rain garden 500: Application guide. Available from: www.epa.sa.gov.au/files/10793_raingarden_guide.pdf.

<u>Queensland</u>

Moreton Bay Waterways (2006) Water sensitive urban design: Technical design guidelines for south east queensland. Moreton Bay Waterways and Catchment Partnership. Available from: http:www.melbournewater.com.au/Planning-and-building/Applications/Documents/South-Eastern-councils-WSUD-guidelines.pdf

<u>Victoria</u>

Melbourne Water (2013) Water sensitive urban design guidelines: South eastern councils. Melbourne Water. Docklands, Melbourne.

<u>Western Australia</u>

Department of Water (2004) Stormwater management manual for western australia. Available from: http://www.water.wa.gov.au/urban-water/urban-development/stormwater/stormwater-management-manual.

Commission, P.D. (2006) Peel-harvey coastal catchment water sensitive urban design technical guidelines. Available from: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/AppendixE_2.pdf.

Biofiltration guidelines

<u>Australia Wide</u>

Deletic, A., et al. Adoption guidelines for stormwater biofiltration systems. 2015; Available from: https://watersensitivecities.org.au/content/stormwater-biofilter-design/

<u>New South Wales</u>

Water By Design(2017) Draft wetland technical design guidelines (version 1). Healthy Land and Water Ltd. Brisbane. Available from: http://hlw.org.au/u/lib/mob/20170530131525_2632c5a65b696f6b1/wetlands-guidelines-final-v1.pdf.

<u>Queensland</u>

Water sensitive urban design engineering guidelines (superseded) and factsheets. 2000; Available from: https://www.brisbane.qld.gov.au/planning-building/planning-guidelines-and-tools/superseded-brisbane-city-plan-2000/water-sensitive-urban-design/engineering

<u>Victoria</u>

Melbourne Water (2017) Design, construction and establishment of constructed wetlands: design manual. Melbourne Water. Available from: https://www.melbournewater.com.au/planning-and-building/standards-and-specifications/design-wsud/pages/constructed-wetlands-design-manual.aspx.

<u>Western Australia</u>

Hatt, B.E. and E. Payne (2014) Vegetation guidelines for stormwater biofilters in the south-west of Western Australia. Cooperative Research Centre for Water Sensitive Cities. Melbourne, Australia. Available from: https://watersensitivecities.org.au/content/vegetation-guidelines-stormwater-biofilters-south-west-western-australia/

Repairing water quality: what to do at the site

Strategy 1. Keep the water as cool as possible

Strategy 2. Keep oxygen levels high

Strategy 3. Reduce non-nutrient pollutants

Strategy 4. Improve water clarity

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