GOVERNMENT OF WESTERN AUSTRALIA

Department of **Biodiversity, Conservation and Attractions**

PARKS AND WILDLIFE SERVICE

Bennett Brook Catchment Local Water Quality Improvement Plan Review Summary

December 2022

Acknowledgements

Thank you to the City of Swan, City of Bayswater, Town of Bassendean, the Friends of Bennett Brook, Water Corporation and Whiteman Park for their contributions to the review of the Bennett Brook Catchment Water Quality Improvement Plan (WQIP).

Purpose and use of this document

The Department of Biodiversity, Conservation and Attractions (DBCA), with the support of the organisations noted above, has reviewed the implementation of the Bennett Brook Catchment WQIP. The purpose of this document is to summarise that review and inform future updates of the Bennett Brook Catchment WQIP. The Swan Canning WQIP is currently under review and the updated catchment modelling will be used to inform updates of the local WQIPs. It is intended that these documents will be used by partner organisations that will continue to have a role in implementation of the WQIPs.

Front cover photos: A Friends of Bennett Brook restoration site south of the Reid Highway crossing. *Banksia attenuata* in flower. Bandicoot Creek restoration site. **Inset:** A young male Quenda (*Isoodon fusciventer*) found along Bennett Brook, which was released after receiving care. Photos – DBCA.

Organisation	**Abbreviation**
City of Bayswater	CoB
City of Swan	CoS
Department of Biodiversity, Conservation and Attractions (part of the agency was the former Swan River Trust)	DBCA
Department of Water and Environmental Regulation (formerly Department of Water)	DWER
South East Regional Centre for Urban Landcare	SERCUL
Town of Bassendean	ToB
Whiteman Park	WP

Local Water Quality Improvement Plans

DBCA Service works to reduce nutrients and other contaminants entering the Swan and Canning rivers.

DBCA developed and invested in the implementation of local Water Quality Improvement Plans (WQIPs). The WQIPs were designed to provide stakeholders with a mechanism to prioritise recommendations and resources and seek funding to improve water quality in catchments contributing the greatest amount of nutrients and contaminants to the Swan and Canning rivers.

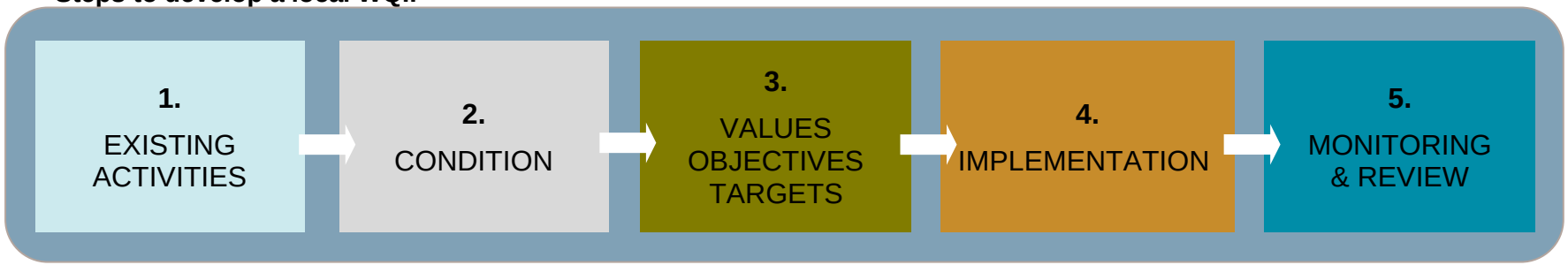
WQIP implementation takes a treatment train approach with actions falling into each of the following stages in the pathway of nutrients and non-nutrients from the source to the discharge point:

1. **Prevention** (land use planning)
2. **Minimisation** (eco-efficiency)
3. **Reduction** (source control)
4. **Amelioration** (conveyance and transmission)
5. **Treatment** (reuse and disposal)

Water Quality Improvement Plans:

- identify water quality issues and hotspots;
- identify environmental values of water bodies and water quality objectives required to protect the values; and
- identify and commit to a set of cost-effective management measures to achieve and maintain those values and objectives.

Steps to develop a local WQIP



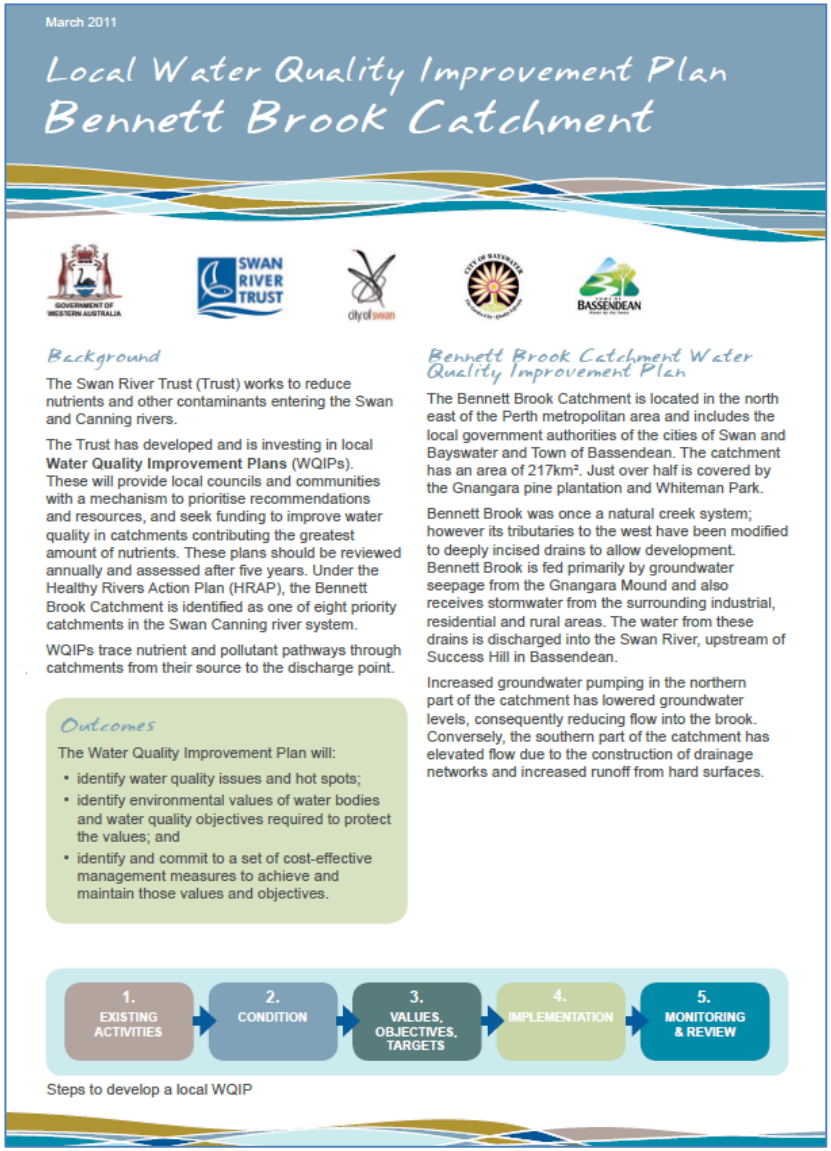
Local WQIP Review

Ten local WQIPs were developed between 2008 and 2012 with strong involvement of key stakeholders. Implementation of the WQIPs is ongoing, however, many of the actions are complete or require review. There are also actions that are still underway and others that will require an ongoing commitment and additional resources to maintain and improve water quality. This review of the Bennett Brook Catchment WQIP is based on achievements and stakeholder participation.

There has been significant investment in restoration of Bennett Brook Reserve and associated drains and compensation basins. Water and sediment quality monitoring in Bennett Brook Catchment indicates an improvement in water quality that may be due to the control of invasive weeds and replacement with native rushes and sedges.

Monitoring the effects of non-structural WQIP actions, such as community education and behaviour change programs, and changes to local government policies and procedures on catchment water quality is more complicated. Therefore, statistically linking WQIP actions to changes in overall catchment water quality is not attempted at this stage. Variations in annual flow, changes in catchment land uses, and the long timeframes required for some catchment management practices to affect water quality at the catchment discharge point are other factors that can contribute to discharge water quality.

The Swan Canning River Protection Strategy supports the development and implementation of the Swan Canning and local WQIPs as an action to achieve nutrient load reduction targets and provides the framework for DBCA to update local WQIPs. Modelling of water quality improvement targets is proposed as part of an update of the Swan Canning WQIP, which is currently underway. An updated Swan Canning WQIP will determine the local WQIPs to be updated based on the level of support from key stakeholders and need for further water quality improvement.


March 2011

Local Water Quality Improvement Plan
Bennett Brook Catchment

Background

The Swan River Trust (Trust) works to reduce nutrients and other contaminants entering the Swan and Canning rivers.

The Trust has developed and is investing in local **Water Quality Improvement Plans** (WQIPs). These will provide local councils and communities with a mechanism to prioritise recommendations and resources, and seek funding to improve water quality in catchments contributing the greatest amount of nutrients. These plans should be reviewed annually and assessed after five years. Under the Healthy Rivers Action Plan (HRAP), the Bennett Brook Catchment is identified as one of eight priority catchments in the Swan Canning river system.

WQIPs trace nutrient and pollutant pathways through catchments from their source to the discharge point.

Outcomes

The Water Quality Improvement Plan will:

- identify water quality issues and hot spots;
- identify environmental values of water bodies and water quality objectives required to protect the values; and
- identify and commit to a set of cost-effective management measures to achieve and maintain those values and objectives.

Bennett Brook Catchment Water Quality Improvement Plan

The Bennett Brook Catchment is located in the north east of the Perth metropolitan area and includes the local government authorities of the cities of Swan and Bayswater and Town of Bassendean. The catchment has an area of 217km². Just over half is covered by the Gnangara pine plantation and Whiteman Park.

Bennett Brook was once a natural creek system; however its tributaries to the west have been modified to deeply incised drains to allow development. Bennett Brook is fed primarily by groundwater seepage from the Gnangara Mound and also receives stormwater from the surrounding industrial, residential and rural areas. The water from these drains is discharged into the Swan River, upstream of Success Hill in Bassendean.

Increased groundwater pumping in the northern part of the catchment has lowered groundwater levels, consequently reducing flow into the brook. Conversely, the southern part of the catchment has elevated flow due to the construction of drainage networks and increased runoff from hard surfaces.

1. EXISTING ACTIVITIES
2. CONDITION
3. VALUES, OBJECTIVES, TARGETS
4. IMPLEMENTATION
5. MONITORING & REVIEW

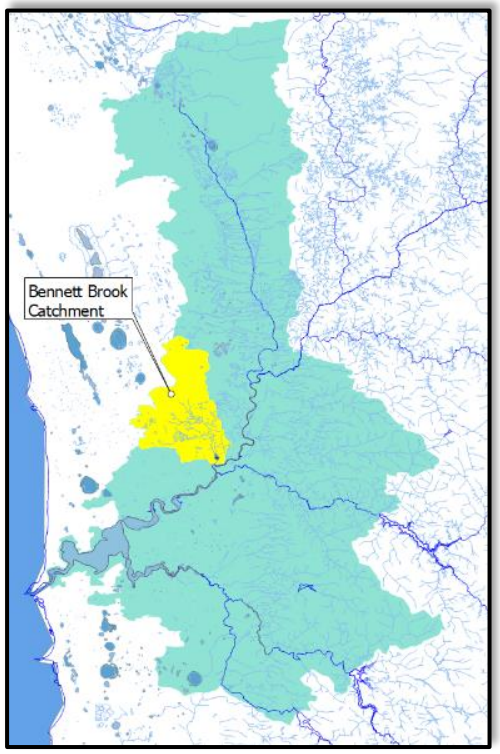
Steps to develop a local WQIP

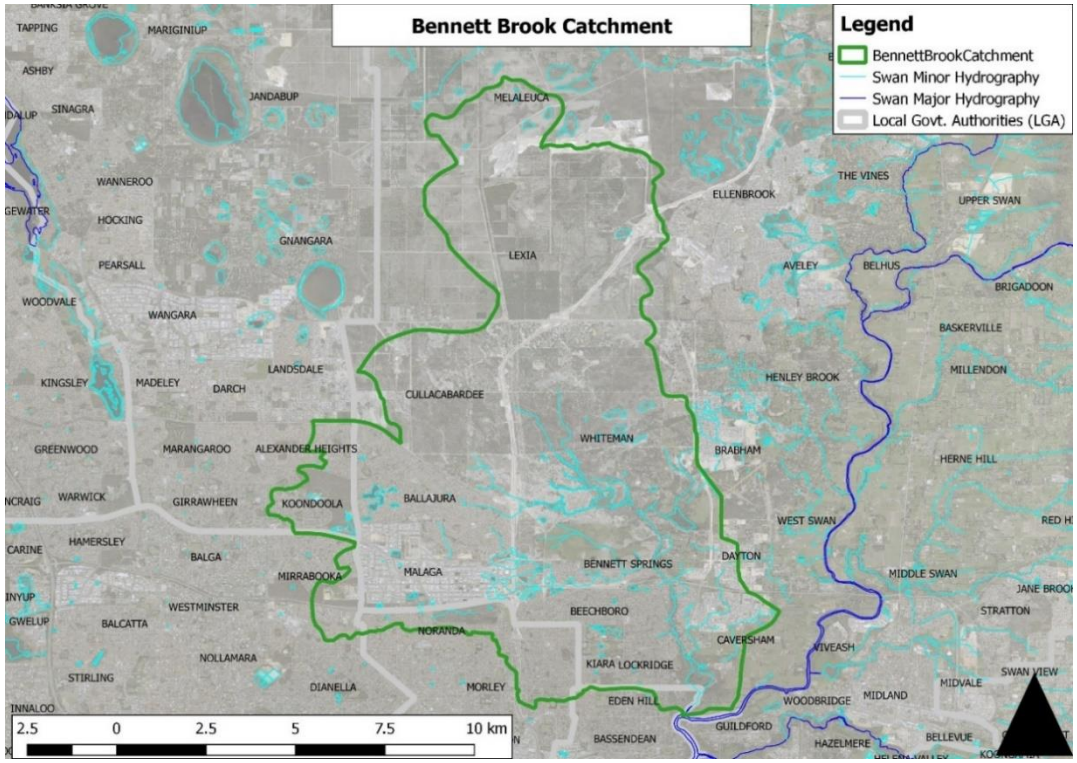
Local WQIP front cover for illustration purposes only

Bennett Brook Catchment

The Bennett Brook Catchment is on Perth's urban development fringe. The catchment covers approximately 217 square kilometres with just over half covered by Gnangara pine plantation and Whiteman Park. Bennett Brook was once a natural creek system, however, its tributaries to the west have been highly modified to deeply incised drains to allow for urban and industrial development. Bennett Brook discharges into the Swan River near Success Hill Reserve in Bassendean.

Bennett Brook is fed primarily by groundwater seepage from the Gnangara Mound and also receives stormwater from the surrounding industrial, residential and rural areas. Increased groundwater pumping in the northern part of the catchment has lowered groundwater levels, consequently reducing flows into the brook. Conversely, the southern part of the catchment has elevated flows due to the construction of drainage networks and increased runoff from hard surfaces. The soils in the catchment are Bassendean sands to the west and north with Southern River formation to the southeast. The groundwater is close to the surface and is intersected by stormwater drains in places. This combined with groundwater seepage from the Gnangara Mound results in a baseflow year-round.





Bennett Brook WQIP Review Summary

The Bennett Brook WQIP had a total of 25 actions. Significant progress has been made for six of those actions (24%) and they are likely to be completed in the near future. Eighteen actions have been implemented but ongoing commitments are required. One action (4%) is no longer relevant or viable.

The catchment is within the City of Swan's Urban Growth Corridor and substantial urbanisation has occurred in the suburbs of Bennett Springs, Caversham and Dayton with more planned. Major infrastructure projects in the catchment include the extension of Tonkin Highway (NorthLink) commencing in 2015, the extension of Reid Highway bridge crossing over Bennett Brook commencing in 2019, the planned construction of the Metronet Morley-Ellenbrook Line and the planned Daviot Road crossing of Bennett Brook. These projects have involved considerable input from State and local government into potential environmental and water quality impacts.

An opportunity arose to conduct on-ground management within Whiteman Park as part of an offset associated with the Metronet rail development. The Public Transport Authority, Whiteman Park, Department of Planning, Lands and Heritage, DBCA and Friends of Bennett Brook have formed a working group and provided advice on the development of an offset management plan and rehabilitation plan for the site.

Major projects:

- Restoration of Bennett Brook Reserve, from Marshall Road south to Clarry Small Park.
- Restoration of drainage channels and compensation basins that feed into Bennett Brook – including Lanius, Wonga Drain, Coonawarra Gully, Oriole Drain, Smallbrook and Thorburn Park.
- Restoration of Bandicoot Creek with WQIP funding.
- Aquatic weed management in response to outbreaks of invasive species.
- Weed management by Whiteman Park in Bennett Brook Reserve.
- Major infrastructure projects requiring input for environmental consideration, including Metronet Malaga-Ellenbrook Line; Reid Highway bridge upgrade, Tonkin Highway extension (NorthLink) and Daviot Road crossing.

Considerable progress in improved catchment management has occurred in the Bennett Brook Catchment since the development of the WQIP.

The Water Corporation administers a Waterwise Council Program in partnership with the Department of Water and Environmental Regulation (DWER), promoting water efficiency and water management within local government. The City of Bayswater has achieved platinum status, and the Town of Bassendean and the City of Swan have achieved gold status. These endorsements recognise local governments for demonstrating significant progress towards best practice sustainable water management, community education and behaviour change.

Friends of Bennett Brook has undertaken a significant amount of restoration work along Bennett Brook between Marshall Road in Bennett Springs and Clarry Small Park in Caversham for about 20 years. Working closely with Whiteman Park, DBCA and the City of Swan, drains and compensation basins in the catchment, as well as the brook itself, have been revegetated with native sedges and rushes to filter water entering the brook and eventually the Swan River.

The City of Swan and Friends of Bennett Brook have removed and continue to monitor and remove invasive species from many drains and compensation basins in the catchment, including a rapid response to priority aquatic weeds Salvinia (*Salvinia molesta*) and Amazon Frogbit (*Limnobium laevigatum*).

DBCA, the City of Swan and Whiteman Park assessed Bennett Brook from November 2016 to January 2017 to determine the current condition of the riparian zone using recognised foreshore condition methods. A comprehensive report was produced summarising the vegetation, bank stability and management issues along the brook, and listing recommendations for future management.

The Swan Canning WQIP provides nutrient-reduction targets for each of the sub catchments. Water quality is monitored fortnightly at a site close to where Bennett Brook flows into the Swan River. The median total phosphorus concentration continues to pass both the short and long-term targets (0.2mg/L and 0.1mg/L respectively). Bennett Brook continues to pass the short-term median total nitrogen concentration (target of 2mg/L), however, is still failing the long-term target of 1mg/L (DWER and DBCA 2019, Swan Canning Catchment Nutrient Report 2018).

Ensuring nutrient inputs do not increase through land use changes requires ongoing commitment and reducing non-nutrient contaminants from entering the waterways will also require ongoing attention.

WQIP Review Summary

WQIP catchment	Release date	Total number of actions	Actions fully achieved or on track	Actions implemented but ongoing commitment required	Actions with little or no progress	% of actions being implemented
Bennett Brook	March 2011	25	6	18	1	**96**

Summary of investment in WQIP (from commencement of WQIP to December 2022)

	DBCA investment	Other State and Federal Government investment	Local Government and Community	**Total Investment (approximate)**
Investment in Bennett Brook WQIP projects	$974,000	$850,000	$382,000	**$2,207,000**

Future priorities and actions – Bennett Brook Catchment

- Relevant government and non-government organisations work collaboratively to implement the actions of the Swan Canning River Protection Strategy.
- Increase community awareness, education and involvement in catchment management to reduce nutrient and contaminant outputs in residential and industrial areas. In particular, involve Aboriginal custodians and businesses in restoration, guidance of on-ground activities and ethnobotanical surveys.
- Ensure all new development and infill/retrofit proposals are in line with Perth's transition to a water sensitive city.
- Ensure that all local government planning schemes and policies support the transition to a water sensitive city.
- Encourage the inclusion of water sensitive urban design in industrial subdivision guidelines.
- Ensure State Planning Policy 2.10 (Swan-Canning River System) requirement for developers to maintain or improve water quality is upheld during land-use planning decisions. Note that at the time of publication of this review, the Department of Planning, Lands and Heritage intends to replace it with the State Planning Policy 2.9 Planning for Water.
- Ensure all new developments are connected to sewer and aim for infill sewer to all existing urban areas. New subdivisions should include groundwater monitoring.
- Continue to take opportunities to retrofit existing drainage systems in line with Water Sensitive Urban Design (WSUD) principles.
- Continue to look for, and take opportunities to improve water quality, habitat, and community benefit of wetlands and vegetated areas in the catchment.
- Reduce local government's nutrient outputs through local management practices by providing up-to-date training to all staff involved in fertiliser application, grounds keeping and maintenance of drainage infrastructure, including WSUD features.
- Provide ongoing training to local government staff in WSUD and interpretation of water quality data.
- Seek commitment to maintain Light Industry Audits for an ongoing program to prevent industrial pollutants entering surface and groundwater.
- Discourage the planting of deciduous trees near drainage infrastructure to reduce organic loads and excessive nutrients entering waterways. Avoid planting other inappropriate landscaping species and encourage planting local natives.
- Develop a revised WQIP to continue the momentum for improved catchment management. Future actions should be specific, costed, and measurable.
- Include management actions to address sedimentation in the revised WQIP.

Bennett Brook Case Study: Bennett Brook Reserve

Bennett Brook Reserve has been the focus of the Friends of Bennett Brook since 1998. Significant progress has occurred in this time, restoring the once weed-infested brook between Marshall Road and Clarry Small Park to a sanctuary of native plants and habitat.

Together with Whiteman Park, the City of Swan and DBCA's Rivers and Estuaries Branch, the Friends group has secured funding to control invasive weeds, remove rubbish and re-establish native mid and understorey vegetation.

The brook was experiencing poor water and sediment quality, according to a monitoring snapshot of Bennett Brook Catchment in 2002 which aimed to locate pollution hotspots in residential and industrial areas contributing to contamination of the brook. Water and sediment monitoring have been conducted annually since, but results have continued to exceed ANZECC trigger values.

Foreshore assessments of Bennett Brook in 1998 by the former Water and Rivers Commission, and in 2007 by the former Swan River Trust, recorded an understorey dominated by Kikuyu, Blackberry and Arum Lily. The watercourse had dense populations of Watercress.

Native sedge Carex fasicularis *has outcompeted what had been a weedy understorey. Near Simla Park, Bennett Brook.*

The Friends group has tackled control of Blackberry, Morning Glory, Kikuyu, and many other broadleaf weeds and grasses at multiple sites in the reserve. Weed control has been undertaken by a contractor and partially by community volunteers. Weed control has been followed up with extensive planting of wetland and dryland species by volunteers. Large stands of Kikuyu have been replaced by native sedges and rushes. On the upper banks, annual grasses have been replaced with native dryland species.

The City of Swan and the Friends group have also restored drainage channels that flow into Bennett Brook, including Bandicoot Creek, Coonawarra Gully, Wonga Way and Lanius Drain. This has required the successful engagement of several business units within the City of Swan working in partnership to conduct the initial restoration and the handover of management of natural areas.

Whiteman Park, DBCA and Water Corporation have contributed funds for restoration, and the group has successfully secured support from the Australian Government, Swan Alcoa Landcare Program and other Western Australian Government funding programs.

Restoration of Bennett Brook Reserve

An area of Bennett Brook Reserve before restoration, 2007

A nearby area after restoration, 2018

Years of active restoration:	1998 – present
Area of project site:	Approximately 25 ha
Number of seedlings planted:	339,020 (local wetland and dryland species)
Project partners:	Department of Biodiversity, Conservation and Attractions, City of Swan, Whiteman Park, Friends of Bennett Brook
Cost of restoration:	Approximately $1,662,000

Appendix 1: Bennett Brook Catchment WQIP - Action Review

Tally and explanation of WQIP actions review categories – Bennett Brook			
Total number of actions	**25**	**Percentage**	**Explanation**
Action achieved	0	0%	The action has been completely fulfilled.
Action on track	6	24%	Significant progress has been made and the action is likely to be completed in the near future.
Ongoing action	12	48%	This action will require ongoing commitment or maintenance.
Projects/Programs implemented	6	24%	There are projects and programs in place that address this action, however significantly more investment is required to enable catchment wide implementation.
Little or no progress	0	0%	Little or no progress has been made on this action. This can be for various reasons.
No longer relevant or viable	1	4%	Can be for various reasons.
Summary categories			
Total number of actions	**25**	**Percentage**	**Explanation**
Action fully achieved or on track to being achieved	6	24%	First two categories above combined.
Action implemented but ongoing commitment required	18	72%	Second two categories above combined.
Little or no progress	1	4%	Last two categories above combined.

Bennett Brook Catchment WQIP – Action Review Status

Implementation actions	Lead organisations	Supporting partners	Status comments
1. Prevention Land use and planning			
1.1 Application of Water Sensitive Urban Design (WSUD)			
1.1.1 Ensure the planning process for retrofitting incorporates WSUD principles as stated in the Stormwater Management Manual for Western Australia	City of Swan (CoS), City of Bayswater (CoB), Town of Bassendean (ToB)	Department of Water and Environment Regulation (DWER), Perth NRM	• CoB and CoS receive funding from DBCA for part-time water quality officers to support the community and LGAs in projects improving water quality. The officers engage with LGA environmental officers to plan WSUD projects including living streams, biofilters and tree pits. • CoB and ToB work predominantly with retrofitting old subdivisions rather than incorporating WSUD into new developments. There is support to incorporate WSUD into these projects. • For CoS, the capacity to retrofit is constrained at older sites that were constructed with insufficient buffers to incorporate effective WSUD. Only the minimum buffer is enforced in many newer developments and it can contain firebreaks, paths and other hard engineering. The remaining area is not always sufficient to allow effective WSUD. • Retrofitting of compensation basins and drains in association with major civil works projects has been identified as an opportunity for further improvement. Sites have been observed to have insufficient planting and infill densities and inappropriate species for the hydrology of some system designs.
1.1.2 Develop and implement a condition for development approvals for industrial buildings / areas to incorporate wastewater treatment systems	CoS, CoB, ToB, Perth NRM	DWER, Department of Biodiversity, Conservation and Attractions (DBCA)	• CoS requires industrial developments to be connected to the reticulated sewerage where available. If not available, the effluent must be retained on site with a suitable septic tank. An approved on-site storage system may be used for controlled waste such as oily water, however, it must be disposed of by a licensed contractor and receipts kept for 3 years detailing the quantity and type of waste removed. • CoS requires a stormwater plan to be submitted with applications, allowing for 1 in 5-year rainfall event within the kerb and a 1 in 100-year event to the road or authorised outlet. Premises may be connected to the Water Corporation's stormwater system if authorised. • ToB LPP14 requires stormwater to be contained onsite (unless ground conditions are unsuitable for onsite infiltration). On site system must be designed to a 1 in 20-year event.
1.1.3 Ensure WSUD is incorporated into all relevant planning proposals consistent	Department of Planning, Lands and	DWER	• The new draft State Planning Policy 2.9 Planning for Water is being developed. • Larger developments and infrastructure projects are managed at a State level, which restricts the level of influence and involvement from LGAs.

Implementation actions	Lead organisations	Supporting partners	Status comments
with the requirements of Better Urban Water Management, State Planning Policy 2.9 Water Resources and local environmental conditions	Heritage (DPLH), CoS, CoB, ToB		• Water Corporation administers a Waterwise Council Program in partnership with DWER, promoting water efficiency and water management within LGAs. CoB has achieved platinum status and ToB and CoS have achieved gold status. These endorsements recognise LGAs for demonstrating significant progress towards best practice sustainable water management, community education and behaviour change. • Each LGA has developed a Waterwise Council Action Plan, which is a requirement by Water Corporation in order to be endorsed as a Waterwise Council. These plans contain actions and targets to achieve water quality and quantity outcomes for the catchment. • ToB has developed a Waterwise Council Action Plan and will be developing a Waterwise Bassendean Strategy in 2022/23. • ToB applies the following policies to planning applications: Local Planning Policy (LPP) No. 3 Water Sensitive Design; Water Sensitive Urban Design and Water Conservation Policy; and LPP14 Stormwater. • CoB's draft Local Planning Strategy includes an action to "Develop water sensitive urban design principles for new development" but it is still to be finalised. • CoB has developed the Waterwise Bayswater Strategy and Urban Forest Strategy which incorporate WSUD principles and help improve stormwater management and catchment permeability. • CoS, ToB and CoB completed Water Indexing Workshops in 2020/21 through the Water Sensitive Cities program. • Established mosquito and chironomid management can conflict with environmental design. If a site is well maintained and water can flow, mosquito breeding is reduced, Issues can arise where WSUD sites are not well maintained. • An issue noted by CoS is the limited parking provided in new developments and CoS receive many requests to hardstand residential verges. Consideration should be made for current and future hardstand needs to ensure that allocated areas are sufficient and permeable areas are maintained for infiltration. • DBCA's Statutory Assessments Unit and Swan Region provide advice on relevant planning proposals including incorporation of good WSUD principles in the Swan Canning Catchment.

Implementation actions	Lead organisations	Supporting partners	Status comments
1.2 Improving wetland health			
1.2.1 Develop a Stormwater Management Plan to assess quantity and quality discharging into Lightning Swamp and identify threats to wetland hydrology	CoB, CoS	Friends of Lightning Swamp (FoLS), DWER, DBCA, Water Corporation)	• The 2002 Lightning Swamp Bushland Management Plan is under review. • Groundwater levels are monitored monthly in Lightning Swamp catchment. Groundwater contaminant monitoring was previously conducted, however, guidelines were not exceeded so only groundwater levels are currently monitored. • CoB provides training and equipment to Friends of Lightning Swamp to undertake groundwater level monitoring. • CoB focused investment in revegetation of Lightning Swamp, instead of groundwater contaminant monitoring. • Catchment monitoring is undertaken across the Bennett Brook catchment three times per year over winter, which includes four surface water sites at Lightning Swamp.
1.3 Sustainable Landscaping			
1.3.1 Implement sustainable landscaping as part of future retrofitting in public open space and LGA managed areas	CoS, CoB, ToB	DBCA	• Water Efficiency Action Plans, developed by each LGA, include targets and actions for sustainable landscaping including when retrofitting drainage infrastructure. • CoS Landscape Guidelines are focussed on streetscapes and open space (parks rather than natural areas). Guidelines for natural areas are not endorsed by Council and are currently being reviewed. • CoS incorporates low water use plants, hydrozoning and soil amendments into landscape design. The new playing fields in Dayton and Brabham were designed with soil amendment products to reduce watering and nutrient needs. • CoS is close to endorsement of an Urban Forest Plan. Several actions have already been implemented, including a significant tree register. • ToB does not have an overarching landscaping plan or guidelines, although there is a move to reduce turf and replace with local native plants. Landscaping is specific to a reserve. A Landscape Plan Information Sheet provides guidance to developers. • CoB integrates Water Sensitive Urban Design practices as standard best practice when reserves are updated. This can include improvements such as soil amendments, native plant selection and hydrozoning.

Implementation actions	Lead organisations	Supporting partners	Status comments
1.4 Monitoring water quality in the catchment			
1.4.1 Continue to monitor existing groundwater bores and investigate future groundwater monitoring to determine groundwater levels and contribution from the groundwater system	CoS, CoB, ToB, Developers	DWER, Whiteman Park (WP)	• CoB provided training and equipment to Friends of Lightning Swamp bore level monitoring in Lightning Swamp. Groundwater levels have been monitored monthly in Lightning Swamp catchment from January 2017. • Catchment monitoring is undertaken across the Bennett Brook catchment three times per year over winter. This does not currently include groundwater bore monitoring, however it has previously been conducted at the Atlas Landfill site in Mirrabooka and Lightning Swamp (see above). • The Atlas landfill site (formerly a putrescible landfill until 1997, where it was relicensed as Class I inert landfill) has been identified as a "potentially contaminated site – investigation required" by DWER. Groundwater monitoring of a leachate plume on- and off-site is undertaken by the proponent annually to determine its extent and movement. This will ensure that the site is suitably classified under the *Contaminated Sites Act 2003*, which will enable appropriate remediation planning. • Several other contaminated sites are located within the Bennett Brook catchment and are monitored through the DWER process for contaminated site classification and management. Most groundwater contamination in CoS comes from the Malaga Industrial Area. • Historically, data from ground and surface water monitoring was not included in handovers from developers to CoS. Contemporary subdivisions do undertake monitoring pre-development as part of their Urban Water Management Plan (UWMP) but residential fertilizer use is not modelled. Monitoring trigger levels are established for "disturbed ecosystems" in recognition of historical land uses e.g. agriculture. • Even though CoS may ask developers to re-commence monitoring for up to two years around the time of house construction and before handover, high nutrient loads cannot be attributed solely to subdivisions. Residents establishing their gardens and lawns may unknowingly allow fertilizers to wash into lakes and waterways. It is therefore difficult for CoS to induce a developer to redesign landscaping / improve water quality on the basis of monitoring results once approval for an UWMP has been granted. • There is no catchment-wide groundwater monitoring program in place specifically for the Bennett Brook catchment. Targeted groundwater monitoring is conducted when deemed necessary.

Implementation actions	Lead organisations	Supporting partners	Status comments
1.4.2 Based on a review of historical land use data, identify sites currently contributing to nutrient and non-nutrient load	CoS, CoB, ToB, WP	Universities	• A formal historical land use report has not been developed. However, water quality monitoring identifies sites which require further investigation into their previous land use to enable effective management. • The South East Regional Centre for Urban Landcare (SERCUL) released a report in 2013: *Bennett Brook catchment – water and sediment quality monitoring and evaluation: Ten-year analysis 2002 – 2011*, which collated and interpreted water and sediment data on 28 sites and identified future management actions. • DWER's Contaminated Sites Database contains information regarding sites that are identified as containing soil or groundwater contamination and provides details of their historical use. • The wetland in Thorburn Park in Beechboro has been identified as a historical nutrient source. It was a water source for an old dairy and high nutrient levels have been identified in this wetland. • The three LGAs conduct water quality monitoring, including near industrial areas. This has identified several areas and has guided where restoration works have and are being undertaken.
1.4.3 Conduct intensive water quality sampling in the Malaga industrial area to isolate sources of contaminants	DBCA, Perth NRM	DWER, WP, CoS, CoB, SERCUL	• Monitoring is now funded by LGAs rather than DBCA. • Water quality of the input drains into Lightning Swamp from Malaga Industrial Area is monitored regularly by SERCUL. One of the three sites monitored was ranked 2 out of 28 sites as a high priority for improvement (SERCUL 2013). • CoS conducts internal sampling of five sites within the industrial area. An additional site will be included from 2021. • CoS provides water sampling kits in City vehicles, and advocates for sampling if issues are sighted. Visual assessments and water quality results have triggered visits to industrial sites to investigate sources.
1.4.4 Seek funding to expand, review and continue the water quality monitoring program	DBCA, Perth NRM	DWER, WP, CoS, CoB, SERCUL	• Water and sediment quality sampling has been conducted in Bennett Brook Catchment regularly since at least 2002. Perth NRM and DBCA provided funding to initiate sampling and analysis plans and annual reports. CoB, CoS and WP currently fund the plans, reports and laboratory analysis. Sampling is conducted by SERCUL. Sampling funded by ToB in its jurisdiction is located outside of Bennett Brook Catchment. • CoB have developed a specific sampling and analysis plan for Bennett Springs. The SAP is implemented annually and data are analysed. • CoS conducts annual monitoring of up to 27 basins in the Bennett Brook Catchment, depending on water levels.

Implementation actions	Lead organisations	Supporting partners	Status comments
2. Minimisation Efficiency in nutrient use			
2.1 Reduce output by land managers			
2.1.1 Encourage land managers to investigate fertilisers and soil amendments to determine effectiveness in reducing nutrient run off and groundwater contamination	DBCA	CoS, CoB, ToB, WP	• The Fertiliser Partnership (2012-16) superseded the Fertiliser Action Plan (2007). DBCA worked with the Department of Primary Industries and Regional Development and other partners to deliver the Partnership objectives. • DBCA supported the Phosphorus Awareness Program Fertiliser Wise Fertiliser Training delivered by SERCUL across the Swan Canning Catchment up until 2018-19. The training is still run but no longer subsidised by DBCA. • Turf management guidelines were produced through the Fertiliser Partnership by DBCA with support from Fertiliser Partnership stakeholders. • CoB has completed a Nutrient and Irrigation Management Practice in conjunction with Environmental Services and Parks and Gardens. • CoB and CoS conduct soil and leaf tissue analysis to guide fertilisation of public open spaces. • CoB doesn't fertilise passive reserves. A good quality turf wetting agent is applied to these reserves annually. • ToB does not conduct soil and leaf tissue analysis, but has a Nutrient and Irrigation Management Policy to promote use of native species and ensure irrigation is water efficient.
2.2 Reduce community output			
2.2.1 Educate the community on sustainable landscaping practices	DBCA	CoS, CoB, ToB	• DBCA supports part-time water quality officers in CoB and CoS to work with community groups, schools, universities and general community on revegetation and water quality improvement projects. •DBCA sponsored the Great Gardens workshop series for three years from 2012 to 2015. The program has since developed into the Riverwise Gardens Program . Workshops are free for residents to attend and promote waterwise and water quality improvement actions. The workshops series is delivered each year in priority subcatchments for water quality improvement. • CoS and CoB have hosted Beyond Gardens/Gardenwise seminars on verge gardens, offering a prize of a free waterwise verge makeover. CoB also provides verge makeover demonstrations. • CoS updated its Grow Local Plants brochure, targeted to residents, in 2015. Verge information is available on their website, including how to create a waterwise garden and obtain free mulch and street trees.

Implementation actions	Lead organisations	Supporting partners	Status comments
			• Verge makeover programs have been undertaken in all LGAs. Water Corporation provides additional funding to the LGAs. • ToB has implemented a street transformation program at Mary Crescent, to reduce water and fertiliser use and improve habitat corridors. It has also hosted native verge garden workshops and run a verge rebate program. • CoB runs a catchment activity day for schools, which has included a 'Green Lab' at Lightning Park with Nearer to Nature and Millennium Kids. • CoB and ToB coordinate annual programs providing plants to residents. CoS runs an annual Rural Revegetation Program which offers free native plants to eligible residents. Only residents whose property is 4,000m^2 or greater are eligible. • CoS presents a series of free community, sustainable living workshops calling Thinking Green. • CoS and CoB participate in WP's Groundwater Festival providing education to school groups about the value of groundwater and contamination issues. • In CoB kerb markers were installed along main drainage networks above the stormwater entry pits. A kerb marker project was undertaken with schools. A community education booklet was produced.
2.2.2 Develop and implement a community education program for new developments	DBCA	Developers	• Development specific programs have not been prepared. Several community education programs have been held in new estates, which have included fertilise wise messaging. • Developers and/or LGAs provide welcome packages to residents in new developments, however these can contain a broad range of topics relating to the property and community. The content of these packages is not regulated and may not necessarily contain information regarding fertiliser use. The challenge for LGAs is to build a profile for good quality environmental outcomes. • There is an opportunity to work with developers on a verge program in new estates. A verge makeover program could be targeted to these areas.
2.3 Reduce nutrient and non-nutrient input from industry			
2.3.1 Regulate industry input through the application of the Unauthorised Discharge Regulations	DWER	CoS, CoB, ToB	• CoS note that response times to issues are sometimes long, and the discharge has dissipated by the time sampling is conducted. • The CoS Environmental Health Officer conducts audits in industrial areas, but has limited capacity compared to when the DWER Light Industry Program (LIP) officer position was funded.

Implementation actions	Lead organisations	Supporting partners	Status comments
			• New industrial areas have developed since the LIP ended. The audits were conducted on a rotation, however, there is some shortfall now with reduced capacity.
3. Reduction and source control			
3.1 Undertake soil investigation			
3.1.1 Conduct an Acid Sulphate Soils (ASS) analysis at the headwaters of Bennett Brook and develop an ASS management plan if appropriate	DWER	WP	• Observations of Mussel Pool since 2015 indicate that the acidity and condition of the area have been deteriorating. As a result, a Mussel Pool recovery plan was drafted in 2021. One of the key recommendations was for a comprehensive ASS investigation around the site, which commenced in 2021. • An ASS Preliminary Investigation was conducted along the southern and eastern boundaries of WP by Metronet in 2020 for the Morley-Ellenbrook Line. Sites sampled are located south of Woollcott Ave into Bennett Springs, west to the eastern parts of Ballajura and Malaga, and along the eastern and northern boundaries of the park through Dayton, Brabham, Henley Brook, Ellenbrook and Lexia. • Several urban infill and state infrastructure projects have been implemented or planned in the area, including northern and eastern Bennett Springs residential developments, Metronet commencing in 2020 and NorthLink Tonkin Highway extension commencing in 2015.
3.2 Reduce nutrient and non-nutrient input from industry			
3.2.1 Implement an education program for small to medium businesses to prevent inappropriate disposal of wastes	DWER	CoS, CoB, ToB	• The Eastern Metropolitan Regional Council (of which CoS is a member Council) provides waste education to the community and manages the R-Gang website. This assists households and businesses in knowing how and where to dispose of various materials. • CoS and CoB were part of the LIP. A series of high priority fact sheets tailored for light industrial premises were being developed by DWER. Water quality protection notes were also being updated by the DWER LIP officer.
3.2.2 Encourage adoption of best management practices for specific industries	Perth NRM, DWER	DBCA	• CoB implements cost-effective measures that aim to maximise infiltration and disconnect the existing piped drainage system throughout the catchment. • CoB's Environmental Health Officer jointly audited businesses with the former Department of Environment Regulation in the Upper Swan area as part of the 2015-17 LIP. The audits focussed on education and assisting businesses to improve environmental performance, particularly the

Implementation actions	Lead organisations	Supporting partners	Status comments
			correct storage, use and disposal of solids and liquids on site and protecting groundwater and stormwater from contamination. • The Sediment Taskforce was established in 2014 to develop practical solutions to prevent sediment runoff in the Swan Canning catchment, particularly from construction activities. It is a collaboration between government agencies, community organisations and industry groups. Outcomes include the development of a Builders Checklist for Preventing Sediment for builders to use to assess their sites and an Onsite Checklist for Inspecting Soil Erosion and Sediment Loss from Building, Subdivision and Construction Sites for local government officers to inspect building projects. • CoB has produced a sediment case study (available on the website) • Perth NRM has developed information sheets for sediment management, light industry and sustainable agriculture, which are publicly available on their website.
3.2.3 Develop and implement an audit program for small to medium businesses in the Malaga industrial area	Perth NRM, DWER	CoS	• An audit and education program was developed by Perth NRM in 2010-11, which CoS and premises in Malaga participated in. • Audits continued as part of the 2015-17 LIP. The LIP funded a Program Officer to carry out local government liaison and light industry inspections with local government officers. When serious pollution incidents were identified during the audits, DWER's Pollution Response team had the capacity to intervene. • The LIP involved seven local governments in the Swan Canning catchment to conduct joint inspections of light industrial premises, including premises in the Malaga Light Industrial Area. From 1 January to 31 December 2017, 19 audits were conducted in the Malaga industrial area. • The LIP increased local government capability to regulate light industry under the *Environmental Protection Act 1986* and established a consistent approach to light industry regulation across Local Governments. • Due to the success of the LIP, DWER agreed to continue the program until July 2018, providing auditing assistance to local government partners. • CoB and ToB meet to develop opportunities for ongoing work and industrial audits based on water quality monitoring results.

Implementation actions	Lead organisations	Supporting partners	Status comments
3.3 Other relevant programs			
3.3.1 Implement strategies to prevent shopping trolleys ending up in Bennett Brook	CoS	Friends of Bennett Brook (FoBB), shopping centres	• Effective solutions have been identified (e.g. coin locks, perimeter clamps), however, they required outlay by supermarket owners to install new systems and have not been undertaken on a broad scale. • FoBB removes shopping trolleys from the brook when sighted, but they are not as much an issue now. Bikes and other large items are also dumped in the waterway, although apps to report dumping has helped rubbish removal more quickly.
4. Amelioration			
4.1 Apply best management practices for nutrient management			
4.1.1 Identify and prioritise parks for retrofitting potential	CoS, CoB, ToB	Perth NRM	• CoB implement cost-effective measures that aim to maximise infiltration and disconnect the existing piped drainage system in the catchment. • CoS compensation basin assessment in 2011 included parks with subsurface, bubble-up drainage or other stormwater capacity. Simla Park and Clarry Small were identified as possible project sites. • CoS held local area consultation and residents requested works in Bennett Brook specifically. • ToB is planning to begin a program of hydrozoning in existing parks to increase native garden areas and decrease turf area. • ToB is continually looking at opportunities to increase infiltration and reduce direct out letting into the river.
4.1.2 Identify and prioritise compensation basins and drains for revegetation to reduce erosion and nutrient and non-nutrient contaminants	CoS, CoB, ToB	FoBB, FoLS, Water Corporation	• Compensation basins have been improved throughout the catchment by LGAs and developers. Revegetation and re-engineering of old compensation basins has been undertaken in Caversham and Dayton as part of the infill developments. • CoS completed a compensation basin assessment in 2011 on 51 basins. Recommendations were given for each site to reduce nutrient discharge into the Swan River. A visual assessment of basins has since been undertaken in Dayton, Brabham and new areas of Caversham. The 2011 assessment is being repeated to reflect changes in basins. • CoS and FoBB actively restore drains and compensations that flow into Bennett Brook, including Lanius, Bandicoot Creek, Oriole Park, Coonawarra Gully, Rosher Park, Kobosky, Simla Park, Thorburn Park, Fountain Park, Cassowary Park, Pelican/Kingfisher, Cassowary East, Wonga, Stirling Crescent and Smallbrook.

Implementation actions	Lead organisations	Supporting partners	Status comments
			• CoS support Lockridge Environmental Action Project (LEAP) community group to revegetate Lockridge Drain that flows into Grogan Swamp, in partnership with DBCA and Water Corporation's Drainage for Liveability program. • In 2017-18, CoS coordinated planting at a relocated basin on Sanderling Grove in Ballajura. • CoS conducts regular monitoring visits to basin sites in the catchment. Weed control, rubbish removal and watering of revegetation areas is carried out. • CoB are conducting a rolling program of open drain conversions into living streams.
4.1.3 Where practical create vegetated buffer zones/verges and implement WSUD principles between waterways and turf in council reserves to help prevent herbicides, fertilisers and grass clippings entering waterways	CoS, CoB, ToB	FoBB, FoLS	• Revegetation of Lightning Park adjacent to Lightning Swamp Bushland was conducted by CoB, incorporating WSUD in the carpark and a living stream. • Riparian vegetation in Coonawarra Park in Caversham has been restored and the drainage line separated from the surrounding turf using limestone blocks. • Flush kerbing has been installed at Thorburn Park to delineate between revegetation and turf.
4.1.4 Manage aquatic invasive species in drains and compensation basins to prevent spread to wetlands and waterbodies	DBCA, Water Corporation	CoB, CoS, ToB, Main Roads WA	• CoS and FoBB have removed and continue to monitor and remove invasive species from many drains and compensation basins in the catchment, including watercress, blackberry, morning glory and Typha (where Typha is having a significant impact on water flow). • Salvinia was removed by CoS at the Simla east and west basins in 2017-18 and weekly monitoring was conducted in June 2018. Salvinia has also been removed from Emu Lake and Cassowary East basin. • Salvinia was detected in Lanius Drain for the first time in December 2018. CoS has removed the infestation and is conducting regular monitoring. • Amazon Frogbit was detected at Fountain Park and Oriole drain in January 2019. CoS has installed booms to prevent its spread into Bennett Brook and initiated regular monitoring and removal. • CoS has produced brochures about aquatic weeds, algae and feral fish. These are available on their website. • ToB implement a weed control program, targeting priority species, including aquatic weeds. CoB is conducting the same in Lightning Swamp.

Implementation actions	Lead organisations	Supporting partners	Status comments
4.1.5 Seek funding to continue the rehabilitation of Bennett Brook Reserve to stabilise the banks and reduce sediment loads	FoBB	WP	• Since the WQIP was released, FoBB and WP have continued active restoration of Bennett Brook Reserve through various funding sources. • Swan Alcoa Landcare Program (SALP) funding has supported the restoration of 18 sites between the Marshall Rd crossing and Grogan Swamp. • WP conducts a regular weed control program, particularly targeting arum lily on Bennett Brook. WP also provides funds to FoBB to coordinate control of various priority environmental weeds. • DBCA's WQIP funding supported the restoration of Bandicoot Creek from 2016 to 2017 and management of the site has been handed over to FoBB. • From 2013 to 2017 the Australian Government's Caring for our Country program provided $250,000 to revegetate compensation basins and drains in the catchment. • Friends of Bennett Brook have successfully applied to DBCA's Community Rivercare Program for funding for four projects along Bennett Brook, since 2018. • Other funding sources for weed control and revegetation include volunteer contributions, State NRM and the state government's Community Rivercare Program. • Sedimentation is an ongoing issue. Sediment from developments and civil works projects have resulted in cumulative sedimentation in the brook, however there is currently no process or funding to remove it. • DBCA and FoBB conducted a foreshore condition assessment of Bennett Brook, from its headwaters to the Swan River in 2016 and 2017. Areas and issues were prioritised to guide future restoration of Bennett Brook.
5. Treatment-Reuse-Disposal			
5.1 Full connection to infill sewerage			
5.1.1 Increase management and maintenance of infrastructure to reduce the incidence of sewage spills to the environment.	Water Corporation		• A mechanical fault or loss of power to a sewage pumping station or a sewerage pipe failure can result in a sewage discharge into the stormwater system • Sewage overflows are managed by Water Corporation with key stakeholders including Department of Water and Environmental Regulation, Department of Health, DBCA and the Local Authority in accordance with the following legislation: o *Water Services Act 2012* o *Environmental Protection Act 1986* o *Health (Miscellaneous Provisions) Act 1911* o *Public Health Act 2016*

Implementation actions	Lead organisations	Supporting partners	Status comments
			• Water Corporation implements and funds the maintenance program for sewerage infrastructure. From recent data supplied by Water Corporation on the incidence of sewage overflows, between January 2020 and December 2022, there were no overflows directly into Bennett Brook. One incident occurred which flowed into the Wonga Road Branch Drain during this period, but there was no evidence to show that it had reached Bennett Brook.
5.1.2 Full connection of existing residential areas where a sewerage scheme is available	Water Corporation		• The 2015-17 LIP resulted in some light industrial premises being required to connect to sewer in cases where stormwater drains or groundwater was at risk of contamination from trade waste or wash-down run-off. • New subdivisions need to be connected to the sewerage scheme, however there are many existing properties that still use septic tanks. CoS does not have maps for older areas to ascertain the extent of septic tank use. • When sewage becomes available in a previously unserviced area, owners have five years to disconnect the septic tank and connect to the sewer. When this occurs, there is no requirement or incentive to decommission and remove a septic tank. Decommissioning is only required when: a) there is a change in use to the premises, b) the property is sold, or c) extensions to the property encroach on setbacks requirements for the system.