

---

# LET'S FIX OUR RIVERS!

A COMPANION SERIES TO THE WRC COMPREHENSIVE  
MANUAL FOR RIVER REHABILITATION IN SOUTH AFRICA

---



## RESPONDING TO CHANGES IN WATER QUALITY AND FLOW IN URBAN, FARMING AND RURAL ENVIRONMENTS

HANDBOOK

07

Liz Day • Mandy Uys • Hans King



SP 193/26



#### **WATER RESEARCH COMMISSION**

Lynnwood Bridge Office Park, Bloukrans Building, 4 Daventry Street,  
Lynnwood Manor, Pretoria

All rights reserved ©2026 Water Research Commission

The moral rights of the authors have been asserted.

Authors: Liz Day, Mandy Uys, Hans King

The material contained in these documents may not be used, published or redistributed without the prior written consent of the Water Research Commission. The opinions expressed are in good faith and while every care has been taken in preparing these documents, Water Research Commission will not be liable for any incorrect data and for errors in the conclusions, opinions and interpretations emanating from this information.

#### **CITATION**

Day, L., Uys, M. and King, H. 2026. Let's Fix our Rivers Series. Handbook 7. Responding to changes in water quality and flow in urban, farming and rural environments. Water Research Commission Report No. SP193/26

NOTE: These handbooks have been developed as a companion series to Volumes 1–3 of 'The Comprehensive Manual for River Rehabilitation in South Africa', 2016, by Liz Day, Mark Rountree and Hans King. Water Research Commission Report No TT 646/16. Downloadable from [www.wrc.org.za](http://www.wrc.org.za) and also: [www.lizdayconsulting.co.za](http://www.lizdayconsulting.co.za), [hanskingsrs.com](http://hanskingsrs.com) and [www.mandyuys.com](http://www.mandyuys.com).

#### **DISCLAIMER**










To the best of the Water Research Commission's knowledge all pictures contained in this report are not held under copyright restrictions. Kindly inform us should you have knowledge to the contrary.

These materials may contain links for third party websites. We have no control over, and are not responsible for, the contents of such third party websites. Please use care when accessing them.

The inclusion of any specific companies, commercial products, trade names or otherwise does not constitute or imply its endorsement or recommendation by Water Research Commission or any of its partners.

# TABLE OF CONTENTS

---

	Introduction	4
	What have we done to our rivers?	6
	Rivers in urban areas	8
	Rivers in farming areas	10
	Rivers in rural settings	12
	What a well managed catchment looks like	14
	Best practice in action: Water Sensitive Urban Design	16
	Best practice in action: The war on water pollution	17
	Understanding water quality and data	18



# INTRODUCTION



### DAMS: BLESSING AND CURSE

**Katse Dam** in Lesotho supplies part of the arid Gauteng area with water. However it also represents a major change in the river's flow regime, the flooding of indigenous peoples' homes and lands, and extensive loss of plant and animal biodiversity.



A river that flows unimpeded has better water quality, more natural biodiversity and better overall condition.




Flood damages in cities are often due to poor planning around urban rivers. Baakens River, Gqeberha. 1908.



Stormwater danger warning sign on the Jukskei River, City of Johannesburg

This handbook has been written as a guide to understanding and responding appropriately to water quality and water quantity issues in rivers and floodplain wetlands. **Water quality** refers to the chemical composition, temperature, clarity and suspended particles in river water, and how suitable it is for various uses as well as for habitat for biota. **Water quantity** is, put simply, the amount of water there is in the natural landscape of a river or its catchment. The volume and movement of that water is river **flow**, or **discharge**. We use the terms water quantity and flow interchangeably in this handbook. The **natural flow regime** is the pattern and timing of river flow over time, prior to human impacts. In this handbook, we consider issues of flow and water quality for rivers in urban, rural, and farming environments.

 **FURTHER INFORMATION**  
 WRC River Rehabilitation Manual, Volume 1, Chapter 2.7 and 3; Handbook 1, page15

## Water quantity

The flow regime drives the river system's physical, chemical and biological state. Flow moves and distributes sediment through the river system, shaping the channel and banks, defining the habitats of plants and animals, and influencing water quality. The important aspects of river flow to system ecology are: how much (magnitude); when (timing); how deep (flow depth); how fast (velocity); where (distribution); for how long (duration); and how often (predictability). Rivers within the same Ecoregion tend to have similar flow regimes.

Worldwide, the natural flow regimes of rivers have been altered by human activities such as the building of large water-supply and irrigation dams, abstraction, interbasin transfers (IBTs), the planting of alien vegetation alongside rivers, the drainage of wetlands, and development alongside or into river channels. The effect of these changes depends on how much the flow has been modified. This is extreme in the case of large dams, where the upstream river is transformed to a deep, non-flowing, sediment-laden, low-oxygen environment, whilst the downstream system is starved of sediment and subjected to unnatural flows which have many effects, including interrupting seasonality of the biota.

It is only in recent decades that there has been recognition of the importance of restoring 'environmental flows' specifically for the benefit of the ecosystem. These flows are only a percentage of natural, but mimic natural seasonal flow patterns and so maintain ecological processes. In South Africa, this allotment of water is termed the 'Ecological Reserve' (ER). It is a legal requirement to determine the ER and it is gazetted for all major rivers.

**SEE HANDBOOK 2 PAGE 16 .**

## Water quality and pollution

When we consider water quality, it is always in relation to a particular user or use. For example, the quality of water that is fit for safe drinking by humans is different to that which is needed for good crop production, or for healthy aquatic ecosystems. Assessing what is 'good' or 'bad' water quality can be very variable, as the natural or baseline water chemistry varies from area to area and system to system.

Pollution is an easier concept to define, and refers to the introduction of harmful substances into the environment, impairing its fitness for its intended use. Pollution enters rivers through point sources, pipes and channels; or from diffuse or non-point sources, seeping in through groundwater or soils. Diffuse pollution can be difficult to identify and manage. Point-source pollution sources include untreated sewage or effluent from waste water treatment works (WWTW), runoff from livestock feedlots, industrial discharges (usually illegal), and contaminated outflows from stormwater systems (also illegal).

Polluted systems are often characterised by low oxygen levels, excess nutrients, high temperatures and toxic chemicals, which degrade aquatic ecosystems, favouring resilient invasive species like water hyacinth and carp. While natural rivers can partly self-regulate with respect to water quality, they have limited capacity to do so in polluted conditions. Polluted rivers affect human health, property values, amenity and recreational value, and the river ecosystem together with the goods and services that it could otherwise provide.



WIKIMEDIA COMMONS - AMANDA SOLOMON

### DOUBLE TROUBLE

Contaminated flood water covers a soccer field in the Jo Slovo area in Cape Town, following floods.



River in eThekweni, showing build-up of solid waste against felled alien trees in the channel (a flood and erosion risk) and the spread of in-channel alien vegetation in response to high nutrient loads



Point source inflows of industrial waste into natural river systems



# WHAT HAVE WE DONE TO OUR RIVERS?

## WATER QUALITY AND QUANTITY IN OUR CATCHMENTS

### 01 WATER SOURCE AREAS

Should be protected but are often subject to flow-reducing water uses such as forestry, agriculture and inter-basin transfers.

### 02 ALIEN VEGETATION

Including plantations of water-thirsty pines, blue-gums and others which consume water, leaving less water for the rivers.

### 03 DAMS

Most of our large rivers have been dammed for water supply, industry, agriculture or hydro-electric schemes. Downstream of dams, most rivers don't have enough water and sediment to sustain their aquatic ecosystems. Dam releases can alter natural flow seasonality and disrupt breeding cues for biota.

### 04 FARMING

Indigenous bankside vegetation is cleared and crops planted to the edge of the river. Bank erosion is likely and crop loss inevitable during floods.

### 05 FORMER WETLAND AREAS

Many wetlands have been drained and infilled to increase the land area for development.

### 06 WASTE WATER TREATMENT WORKS (WWTW)

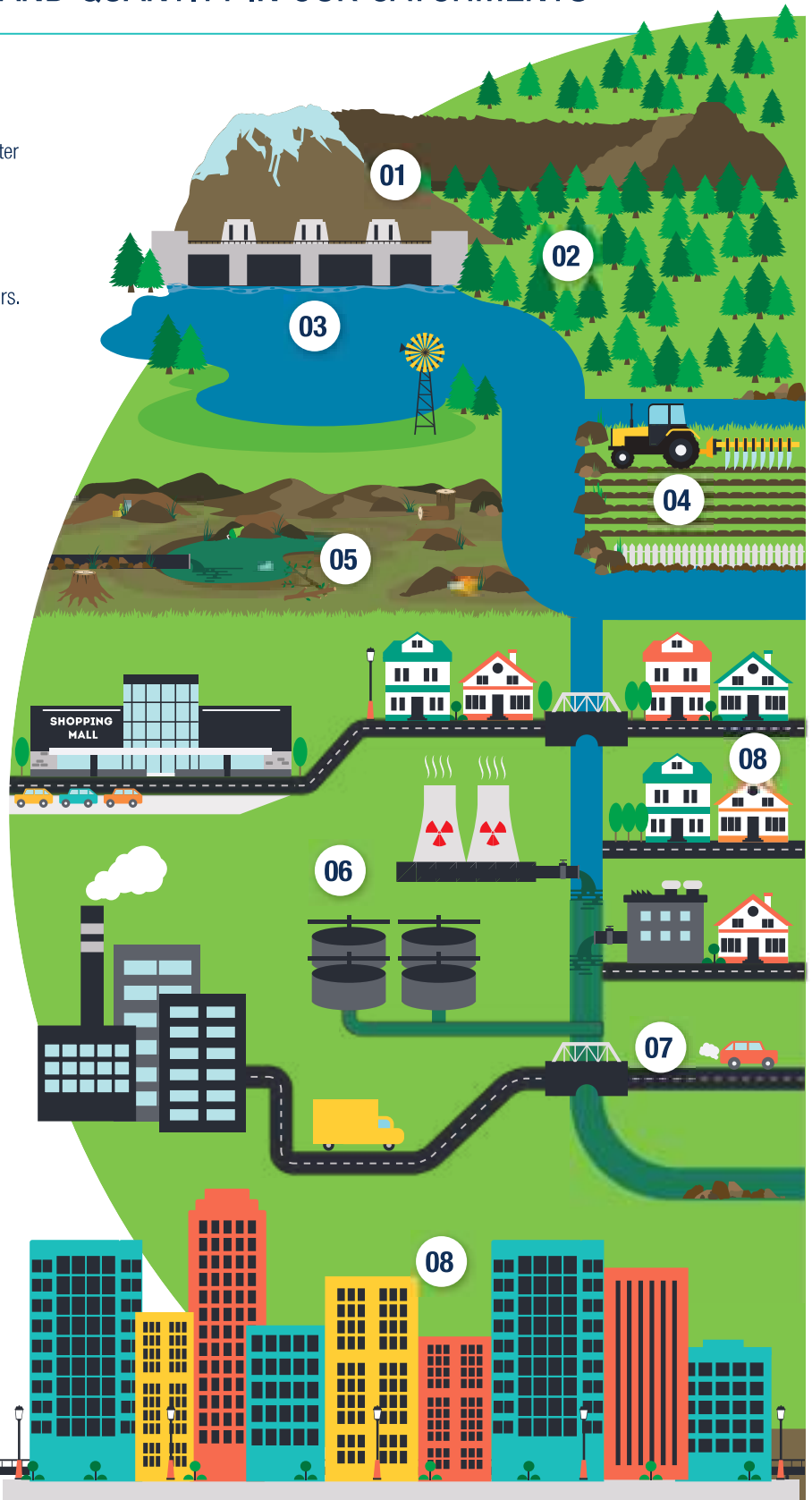
All waste-water should be directed to these systems for treatment and release of treated effluents into the river. However many WWTW are partly dysfunctional and cannot meet effluent quality standards. Effluent-returns can result in unnaturally high flows and pollution loading.

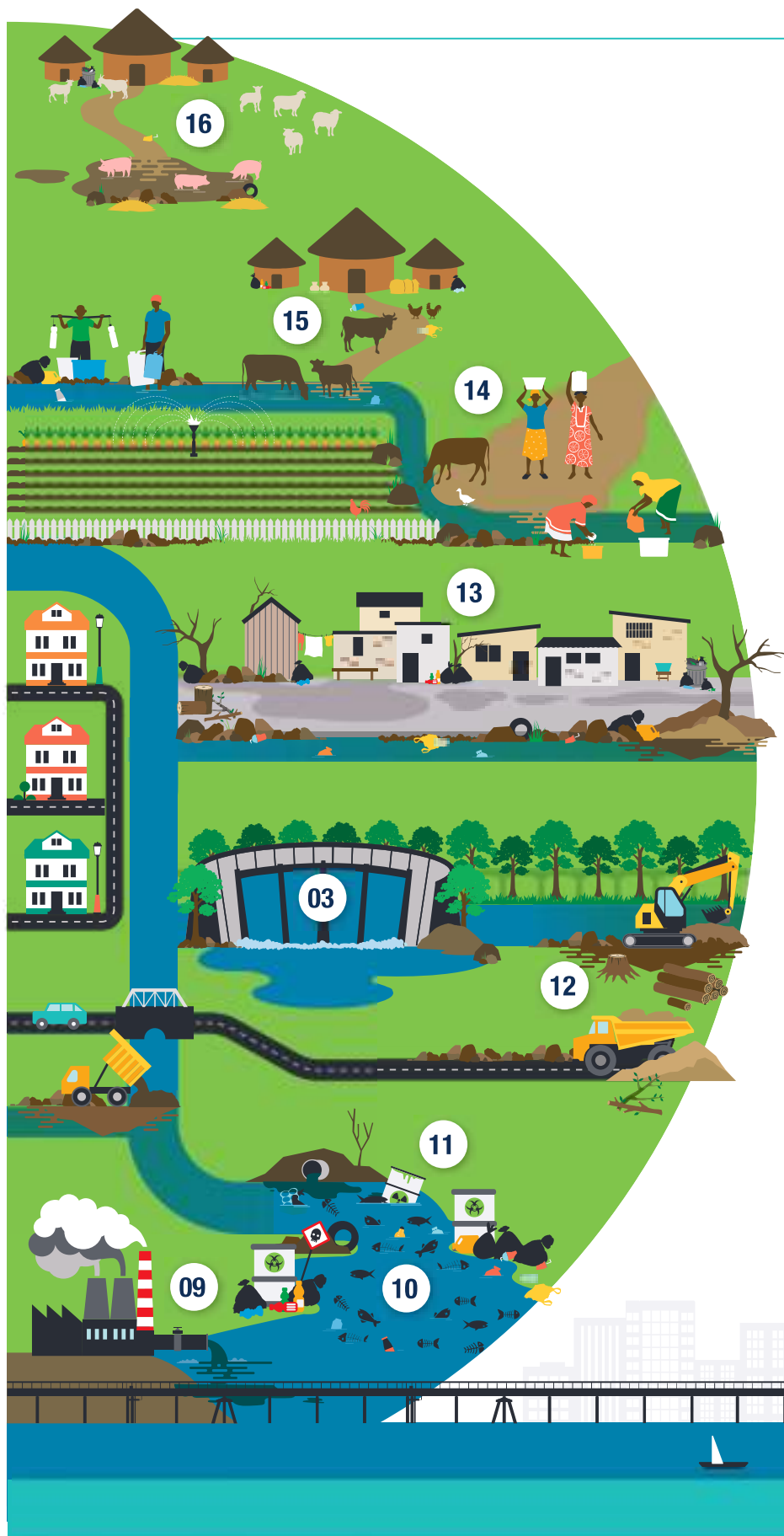
### 07 ROADS, BRIDGES AND WEIRS

When poorly designed, these impact on flow and connectivity in rivers. Structures affect sediment movement and hinder natural channel migration.

### 08 CITIES AND URBAN AREAS

Our urban rivers are subject to serious water quality degradation and impacts such as vegetation clearing, development on floodplains, infilling, canalisation, diversion, and invasion by alien vegetation. Extensive hardened surfaces result in high runoff during storms, and flood risks.





### RURAL AREAS 16

Water services are limited in rural areas, in part due to the remoteness of villages and the distance between homesteads. Wetlands are often heavily utilised by livestock.

### LIVESTOCK 15

Livestock drinking at rivers can result in faecal bacterial pollution with human health implications, while trampling causes localised erosion and sedimentation of the river.

### RURAL WATER 14

Villagers often have to carry river water long distances. Washing of clothes in the river results in phosphate loading in the river.

### INFORMAL SETTLEMENTS 13

Poorly-serviced informal settlements are among the most problematic urban challenges. Here, water quality and litter pose severe threats to human and ecosystem health.

### SANDMINING 12

Illegal sand-mining is common in rural areas and impacts severely on banks and river habitat.

### SEWAGE POLLUTION 11

During loadshedding, many sewage pump stations fail and sewage flows directly or via stormwater pipes and channels into the river or estuary.

### ESTUARY 10

Upstream impacts are felt in the lower river and estuary, which often do not get adequate freshwater inflow and can be very polluted. Estuaries can be important nursery areas for juvenile fish, and this function can be lost in polluted systems.

### INDUSTRIAL POLLUTION 09

Should be treated at a WWTW but is often illegally discharged into the river, and can carry chemical pollutants which can be toxic to river life and may bio-accumulate through the food chain.



## HOW HAS WATER QUANTITY CHANGED?

Natural river hydrology has been dramatically changed in urban areas, due to:

- Change in catchment surface from a permeable one (trees, grass and earth) to a hardened, impermeable one (concrete, tar and paving). This causes increased runoff during rainfall and stormflows, worsening the effects of flooding;
- Clearing of riparian zones and floodplains for construction (natural buffer and floodplain have been lost);
- Draining and infilling of floodplain wetlands (loss of water storage and flood attenuation capacity);
- Inflows to the river in the form of treated and untreated sewage effluent from Waste Water Treatment Works and other sources (further increase in quantity);
- Structures which obstruct flow or alter its path (e.g. weirs, low-level crossings, canals);
- Construction into or next to the river.



Increased runoff over hardened surfaces during storms.



Baakens River, Gqeberha 1847. Free-flowing.



Baakens River, same section, infilling in the 1860s.



The same section of river, now canalized – 2023.



A rehabilitation plan for this section of river by landscape architect Rose Buchanan, 2013.

## RIVERS IN URBAN AREAS

### Best practice for managing river water quantity in urban areas

**APPLY WATER SENSITIVE URBAN DESIGN.** WSUD integrates urban planning with the management, protection and conservation of the urban water cycle, making urban water management more sensitive to natural river hydrology and ecology. WSUD relies on any or all of the following: alien clearing; planting appropriate indigenous plants; improving infiltration of stormwater by increasing permeable surfaces; slowing the passage of high-flows; flood attenuation; and storage and slow release of stormwater. It includes Sustainable Urban Drainage Systems (SUDS), designed to reduce flood risks and ensure ecosystem benefit from catchment water. SUDS categories are: greening, permeable surfaces and water storage. SUDS include: indigenous vegetated river buffers; detention wetlands; bioswales; rainwater gardens; and permeable paving areas (see pages 16 and 17).

**REHABILITATE** sections of your local river to return a more natural hydrology, improve ecology, reconnect the river to the landscape, and improve flood management.

**PLAN SMART PARKS:** These are purpose-designed parks which include functional, safe and attractive SUDS features to assist water quantity management (see page 16). These parks assist with flood-management and provide safe, biodiverse recreation areas.

**REVISE FLOODLINES:** Revisions should take cognizance of urban expansion, increased hardened surfaces and altered hydrology. Work with climate change predictions to assist in sustainable development planning.

**IMPROVE CONNECTIVITY:** Install fishways and low-flow spillways on urban weirs to improve river through-flow, source-to-mouth connectivity and biodiversity value, and to reinstate fish migration.



#### LOCAL STREAM REHABILITATION

Raise the profile of your river as part of a local project, as this community and sponsors have done. Upper Liesbeek River Garden in Cape Town.



#### PLAN SMART PARKS

This is an inner-city 'Biodiversity Showcase Garden' in which an indigenous Cape wetland has been constructed. *Source: Wikimedia Commons*

## Best practice for reducing urban river pollution

Dealing with urban river pollution requires a co-ordinated, multi-disciplinary approach that must include political and financial investment by the local municipality. Here are some things to try.

**POLICE.** When the quality of our urban rivers is known and understood, pollution sources can be tracked and interventions planned. Regular river water quality monitoring is essential (see page 18).

**PREVENT.** The only long-term fixes for urban water quality are improved sanitation and water-related services, effective solid waste removal at source, and regular monitoring and response. In the interim, options to reduce river pollution can include:

- Diverting polluted surface flows from informal settlements into existing or new sewers (only practical for dry weather flows);
- Installing or enlarging storage areas at pump stations, to store sewage overflows when pump stations fail;
- Fitting pump stations with generators or inverters to manage power-outages;
- Using the WSUD and SUDS approaches to filter stormwater from roads and parking lots – this should be mandatory in new developments;
- Ensuring that swimming pools are backwashed into sewers and not stormwater systems, ensuring that stormwater is not directed into the sewerage system by lazy householders;
- Including litter sediment traps in stormwater systems upstream of rivers.



Remember that what flows on the streets finds its way into the river by way of stormwater systems.

**IMPROVE.** Rehabilitating urban rivers by installing drop structures to aerate water, and planting banks, can improve water quality - but severely polluted rivers won't support riverine ecosystems and pollution sources must be addressed first.

**MANAGE.** Litter fences and booms in rivers trap solid waste and help protect downstream systems. This is however a costly and inefficient measure and does not address the source of the problem.



Solid waste accumulating in a river in eThekweni



Collection of solid waste from litter fence on the Big Lotus River, Cape Town.

## HOW HAS WATER QUALITY CHANGED?

Most of our urban rivers are polluted, often with water from upstream areas, but mainly from pollution generated within our towns. Poor solid waste management, failing sewage treatment works and poorly functioning sewage pump stations, and growing informal settlements are issues that plague many of our urban areas and result in high levels of pollution in our rivers.

When rivers are polluted beyond their capacity for recovery, they are no longer able to function as healthy ecosystems and ecological assets. Foul smells, visible pollution, solid waste and often an absence of most visible life forms turn these systems into liabilities that detract from property value, are risks to human health and wildlife, and impact on downstream areas such as lakes and estuaries.



Poorly treated sewage effluent in the Diep River, Milnerton Lagoon, creates water that is foul smelling and toxic to downstream systems.



Plastic bags litter the edges of the Crocodile River.  
*Source: Wikimedia Commons*



Canalised rivers have less capacity to deal with pollution as they lack plants that could take up or trap pollutants.



The relationship between farming and water is complex. Food and water are life-support systems and their availability and health must be assured. So rehabilitation of rivers in farming areas must be practical and take into account the needs of both the farming and the river system.

## WATER QUANTITY PROBLEMS

Many rivers in farming areas have been degraded because of poor understanding of river ecosystem processes and the natural flow regime. Impacts to the river include: clearing of the riparian zone to the river's edge; planting of the floodplain with crops, vineyards or plantations; construction of in-channel dams and weirs; straightening, diversion or relocation of the channel; removal of riverine habitat or regrading of the river bed; draining or reclamation of wetland areas. Upstream impacts to flow that are outside of the farmer's control can include abstraction by other farmers, large irrigation or hydro dams, and interbasin transfers (IBTs). Many of the changes made to rivers can have negative or disastrous results for both the farmer and the river.



SEE THE INFOGRAPHICS ON PAGES 6 AND 7 FOR ILLUSTRATIONS OF THE IMPACTS OF POOR FARMING (AND OTHER) PRACTICES ON RIVERS, CONTRASTED WITH GOOD PRACTICES, HIGHLIGHTED ON PAGES 14 AND 15.

# RIVERS IN FARMING AREAS

## Best practice for managing water quantity and quality in farming areas

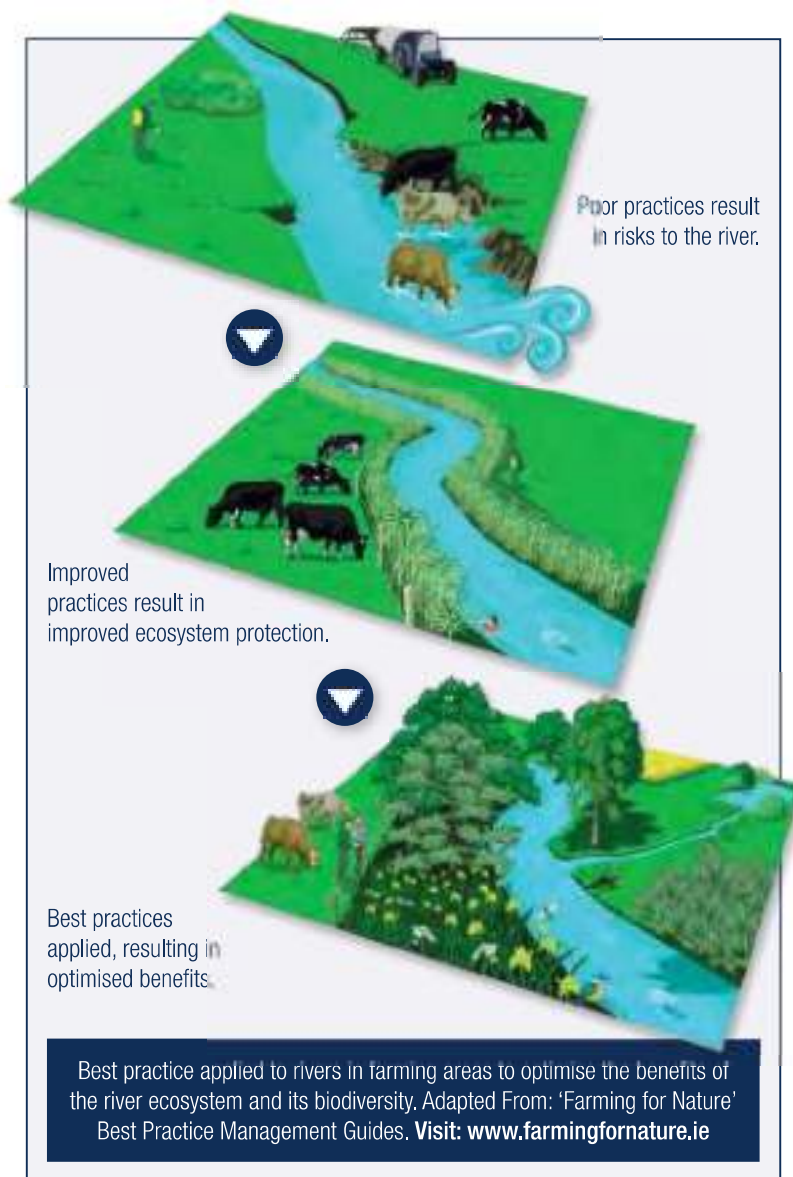
The basic principles are:

1. Maintain the natural integrity and form of the river, floodplain and wetlands.
2. Allow the river space to flood.
3. Maintain flow connectivity (upstream-downstream and channel-floodplain).
4. Maintain an indigenous buffer zone between the river and adjacent landscape.
5. Treat water as a scarce and valuable resource.

Best practice guidelines:

- Abstract only the volume of water that has been licensed, to ensure that the river's Ecological Reserve can be met;
- Keep the river in its original course – avoid straightening, diverting or rerouting river channels, as this could worsen the impacts of flooding on your land or downstream;
- Retain or reinstate secondary channels;
- Clear alien vegetation from the river banks and create indigenous river buffers to improve river resilience in floods and low flows;
- Select crops appropriate to the area and rainfall/runoff;
- Avoid planting crops or vineyards too close to the river's edge, to reduce flood losses; leave filter strips or buffers (15–25 m) between crops, orchards and rivers;
- Design or adapt weirs to ensure low-flows are delivered downstream, and indigenous fish can move upstream;
- Avoid construction of levees, which concentrate flood flows in the channel, leading to channel downcutting;
- Rehabilitate drained wetland areas;
- Create wetlands in drainage furrows to allow collection of sediments;
- Fence off areas to prevent livestock access to river banks and manage trampling and water pollution;
- Limit the use of insecticides, and where used, spray in controlled, windless conditions;
- Collect and divert runoff from feed-lots into purification systems;
- Manage roads, plantations and cultivated areas to minimise erosion and runoff of sediments into rivers.

## WATER QUALITY AS A TWO-WAY ISSUE



Best practice applied to rivers in farming areas to optimise the benefits of the river ecosystem and its biodiversity. Adapted From: 'Farming for Nature' Best Practice Management Guides. Visit: [www.farmingfornature.ie](http://www.farmingfornature.ie)



Satellite image showing the extent to which irrigation draws water from the river in contrast to surrounding land.  
*Source: Wikimedia Commons*



2023 Floods devastated farmlands in W.Cape. This situation was worsened by upstream land management and planting of orchards too close to the river's edge.



SEE HANDBOOKS 3 AND 4



Upstream pollution from urban informal settlements and sewage treatment works threaten export markets for grape farmers irrigating from the Berg River.



Like the Sout River, some of the least-impacted rivers are those that are naturally brackish or saline, and can't be used for irrigation or by livestock.



## RIVERS IN RURAL SETTINGS

### TIPS TO ENSURE HEALTHY WATER QUANTITY IN RURAL AREAS

- **Ensure buffers:** A river is healthy when it has a healthy riparian zone which will buffer and protect the river banks from erosion and reduce flooding risks. Clear out alien vegetation, and plant appropriate indigenous plants and trees along the river. Get planting advice from a horticulturist or a local nursery. Ensure the community do not source firewood from the riparian zone.
- **Restrict access:** Keep livestock out of these buffer zones and out of springs and wetlands by putting up fences with community buy-in.
- **Make space for the river:** Ensure crops are set back 15–25 m away from the river's edge (outside the riparian buffer) to prevent flood damage.
- **Ensure connectivity:** Where there are funds, low-level crossings in which culverts are often blocked should be retrofitted with larger, box culverts to facilitate flow-through.
- **Reinstate and protect wetlands:** If wetlands have been drained, close off the drain, backfill, and plant with indigenous plants.
- **Limit sand-mining:** Get community buy-in for manual harvesting of river sand for building (i.e. using spades and not large machinery). Cover the damaged areas with brush or backfill to prevent erosion.

### What are the water quantity challenges?

In rural areas, healthy, flowing rivers provide basic needs in the form of clean water for drinking, cooking, washing, livestock watering and vegetable-growing; river clay for brickmaking; reeds and other materials for house-building and basket-weaving; and food in the form of fish and water plants. When a river's flow is altered and the system degrades, these benefits are threatened, and community health and productivity is threatened. Waterborne diseases such as cholera and dysentery can appear.

In terms of SA water law the 'Basic Human Needs Reserve' or BHNR of 25 litres of safe drinkable water per person per day must be met before water is allocated for other uses. This and drinking water for livestock is supposed to be provided or sourced directly from surface waters. Daily challenges in rural areas include the distance to the river, the water quality, and the absence or excess of flow. Rural areas are poorly serviced. The solutions to the potable water issue are sometimes solved by Non Government Organisation (NGO) projects that assist by supplying boreholes, pumps, water tanks, water tank rollers, and standpipes.

The natural water quantity in rural rivers or wetlands is affected by natural events such as droughts or floods, and by upstream water uses such as dams, weirs, inter-basin transfers, and forestry plantations or alien vegetation invasions. Local impacts to flow include the draining of wetlands (compromising the water source); poorly planned roads and culverts (which affect the river and flow, see photo); and weirs without low-flow releases or fishways.



SEE INFOGRAPHICS (PAGES 6–7 AND 14–15) AND HANDBOOK 8  
INFRASTRUCTURE ALONG AND ACROSS RIVERS



Water rollers or buckets are used by communities to get water from the river or standpoint, often involving community members walking long distances.



Water supply during drought in rural areas is particularly challenging in terms of water quantity and quality.

## What are the water quality problems?

River water quality is often important for rural communities, where alternative water sources are scarce. However, rural rivers often carry pollutants such as pathogens, heavy metals, and toxins from various sources upstream, posing risks to communities reliant on untreated water for washing, drinking, and irrigation.

### Contributing factors

Local practises exacerbate poor water quality, including inadequate solid waste management, malfunctioning sewage treatment facilities, and reliance on unsanitary sanitation methods like pit latrines and river washing. Additionally, livestock grazing and trampling near water sources worsen contamination.

### Local solutions to water quality problems in rural areas

While communities may lack the power to address upstream pollution sources, local initiatives, provided they have community buy-in, can mitigate risks:

- **Teach the Teacher:** Training educators and leaders to raise awareness about river and wetland conservation promotes clean drinking water and ecosystem health.
- **Limit litter:** Litter can be reduced by agreeing at a community level on one or more sites, where waste can be contained in containers or pits. Build a local culture of No Litter, and create composting areas for organics.
- **Treat water:** Educating residents on water disinfection methods like boiling, sunlight exposure, and filtration can reduce their risk of infection.
- **Manage wastewater:** Advocate for improved sewerage infrastructure and sewage treatment by municipalities.
- **Avoid contaminating water:** Encourage practices such as locating livestock away from water sources, using troughs for livestock drinking water, and proper septic tank management to reduce pollution risks. Educate community members on how septic tanks work and how to maintain them.
- **Monitor the water so you understand the problem:** Push for regular testing of river water by municipalities or DWS officials, and regular report-back to communities or simple graphic summaries in the local press.



Livestock trampling can result in bank erosion, sedimentation of the river and habitat, and water pollution.



Cattle grazing in community water supply source.



White arrows show two pipe culverts in a rural river-crossing, blocked with sediment and obstructing downstream flow. Poor road/river drainage and lack of maintenance is not uncommon in rural areas.

## RURAL RIVERS ARE THE PRODUCT OF THEIR CATCHMENTS

Rural rivers are shaped by their catchments. Polluted rivers affect not only rural communities but also natural areas like downstream nature reserves. These areas can suffer from poor water quality due to nearby industries, mining, and wastewater treatment plants. This pollution harms the sensitive river life and disrupts the entire food web. For instance, the Kruger National Park saw many Nile Crocodiles die because of pollution from upstream industries. Though the park cannot control these activities, Kruger Park Management and SANParks have been advocating for better practices to improve water quality in the rivers that support the park and its wildlife.





# WHAT A WELL MANAGED CATCHMENT LOOKS LIKE

**IN GENERAL:** There is a buffer zone of indigenous, mixed-height plants and trees along the river's edge, water quality, water quantity and erosion have been addressed, and connectivity has been reinstated.

## 01 FORMAL PROTECTION

Water source areas are formally protected, with strict controls on water uses. Invasive alien trees along the river have been cleared.

## 02 INVASIVE ALIENS

Those alongside the river have been cleared. New forestry areas are located further upslope and must meet Forestry Stewardship Certification standards. Forestry roads are managed so as not to create erosion dongas, and disused forestry areas are well managed and maintained.

## 03 DAMS

Environmental flows are released to support downstream ecosystem functions, water quality enhancement by dilution, and estuarine condition. Water quality of inflows is managed and no WWTW effluents may be discharged into the dam or upstream rivers

## 04 WETLAND RECREATIONAL AREAS

Restored, managed wetlands return natural recreational spaces, add value to adjacent properties, contribute to climate-change resilience, and offer ecosystem services.

## 05 FACTORIES

Industrial waste is directed to the WWTW.

## 06 WASTE WATER TREATMENT WORKS (WWTW)

Upgraded and managed by trained staff.

## 07 URBAN AREAS

Channel meanders have been reinstated to naturalise river sections. Indigenous plant buffers and permeable paving areas increase infiltration of rainwater (SUDS).

**7A: SEWAGE PUMP STATIONS** are secured (fenced, full time security) and have emergency backup generators and expanded overflow sumps. Sewage spills are rare.

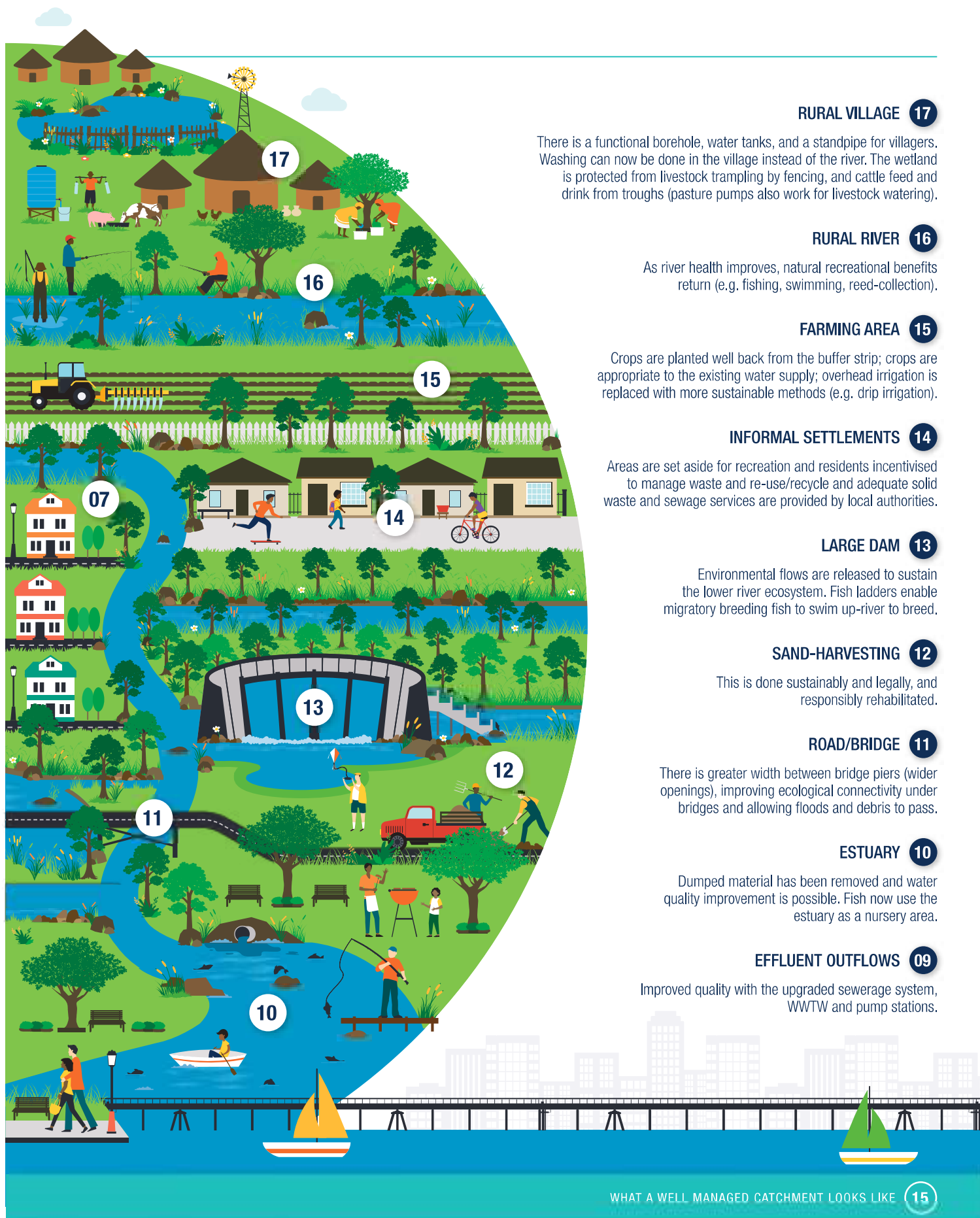
**7B: THE STORMWATER DETENTION WETLAND** provides flood attenuation and a biodiversity 'island'.

## 08 CITY

There is extensive planting and greening. Shoreline water quality and amenity value has improved. Bioswales and rainwater gardens (SUDS) improve stormwater management.

## 09





**RURAL VILLAGE 17**

There is a functional borehole, water tanks, and a standpipe for villagers. Washing can now be done in the village instead of the river. The wetland is protected from livestock trampling by fencing, and cattle feed and drink from troughs (pasture pumps also work for livestock watering).

**RURAL RIVER 16**

As river health improves, natural recreational benefits return (e.g. fishing, swimming, reed-collection).

**FARMING AREA 15**

Crops are planted well back from the buffer strip; crops are appropriate to the existing water supply; overhead irrigation is replaced with more sustainable methods (e.g. drip irrigation).

**INFORMAL SETTLEMENTS 14**

Areas are set aside for recreation and residents incentivised to manage waste and re-use/recycle and adequate solid waste and sewage services are provided by local authorities.

**LARGE DAM 13**

Environmental flows are released to sustain the lower river ecosystem. Fish ladders enable migratory breeding fish to swim up-river to breed.

**SAND-HARVESTING 12**

This is done sustainably and legally, and responsibly rehabilitated.

**ROAD/BRIDGE 11**

There is greater width between bridge piers (wider openings), improving ecological connectivity under bridges and allowing floods and debris to pass.

**ESTUARY 10**

Dumped material has been removed and water quality improvement is possible. Fish now use the estuary as a nursery area.

**EFFLUENT OUTFLOWS 09**

Improved quality with the upgraded sewerage system, WWTW and pump stations.



## BEST PRACTICE IN ACTION: WATER SENSITIVE URBAN DESIGN

**Stormwater treatment pond** treats stormwater runoff from a parking area in Noordhoek, Cape Town. The system includes a vegetated forebay, separated from a seasonally inundated treatment pond, which also provides indigenous wetland habitat to insects, birds, frogs and other fauna and flora.



**Porous paving** overlies an underground stormwater bioretention system to treat runoff from parking and loading areas in a shopping centre, before passing it as diffuse seepage into planted riverine corridor (**LHS of photo**)



**Bioswales and rainwater gardens** both work on the principle of capturing stormwater runoff and retaining it for a short period, allowing the water to infiltrate through vegetation and soil and removing much of its sediment load and pollutants. Some are designed such that the drained water runs into the stormwater system.



**Bioswales** may serve some part of a suburb, whereas rain-gardens are designed generally for individual buildings or houses, and may be used to grow water-tolerant food plants. Both systems are increasingly in use in urban water quality and quantity management.



### USEFUL (NON SA) RESOURCES:

<https://www.tenthacrefarm.com/how-to-build-swale/>

# BEST PRACTICE IN ACTION: THE WAR ON WATER POLLUTION



## Short term interventions for really big

**issues:** This naturally seasonal stream receives increasing volumes of raw sewage and grey water from growing informal settlement on the floodplain. Diversion of the stream to bypass the settlement is an option under consideration, to protect downstream aquatic ecosystems such as the estuary; and to reduce the volume of polluted effluent, making it more feasible to pump or divert to sewers.



## Low-flow diversions:

A low-flow diversion conveys polluted water from a tributary of the Berg River into the sewer via a pump station inlet. The tributary is fed by discharges from informal settlements and backyard dwellers in Wellington, Western Cape. Sewage flows are best treated in designed wastewater treatment works, and are not suitable for processing in rivers and wetlands.



## Working with local communities:

The eThekweni Municipality's Sihlamzimvelo Stream Clearing Programme was developed to address stream blockages that contribute to severe urban flooding. co-operatives of 6–8 members are contracted for a 36 month period to perform tasks such as clearing litter and alien vegetation from 5 to 10 km lengths of stream, and paid at a pre-determined rate for tasks completed for the month. Streams managed within this programme were less damaged during major floods in 2022. The eThekweni Municipality's Transformative River Management Programme is another initiative that aims to adapt the 7,400 km of streams and rivers in the city to the flooding, drought and higher temperatures that can be expected from climate change.



## Knowledge is power

The Jukskei River Improvement project is using multi-disciplinary teams, NGOs and institutions to fund a ground-breaking water quality monitoring programme in the upper reaches to inform options for overall system improvement.



## UNDERSTANDING WATER QUALITY AND DATA

If you are concerned about water quality from your rivers or dams, you need to understand what the concentrations of different water quality variables mean. Remember that good or acceptable quality for human drinking or recreation is not the same as that for ecosystems. As an extreme example, a chlorinated swimming pool would be safe for us to swim in, but a death trap for fish, insects or frogs **see Table below**.

Activate local DWS officials or municipalities to test river water for important water quality variables such as *E.coli* (typically, bacteria from sewage, but in fact found in faeces from all warm-blooded animals (mammals and birds); **orthophosphates** (nutrients found in sewage, livestock waste, fertilizers, soaps etc, which result in vigorous plant growth and algal blooms); nitrate, nitrite and ammoniacal nitrogen, reported together as **total inorganic nitrogen** or TIN (nitrogen nutrients can be taken up by plants but can also be toxic; free ammonia can be toxic to fish and aquatic insects in even low concentrations). Also be aware that the water may contain other chemicals which are not commonly tested for, such as Contaminants of Emerging Concern (CECs), which include pharmaceuticals, and personal and domestic products.

If your community is located downstream of major industries, especially mining, ask for testing for heavy metals such as arsenic, cadmium, mercury, lead, copper and others. Request that test result data are presented together with Guideline standards. Otherwise, interpret results using either the Table below or DWAF 1996 Water Quality Guidelines (**see Resources**). Consult a water quality specialist for assistance. Using satellite imagery such as Google Earth can also help identify upstream threats.

**TABLE 1:** Rating ranges for variables considered in river water quality assessment from an ecological perspective. Guidelines from DWAF 2008 (Ammonia concentrations adapted from DWAF 1996)

WATER QUALITY CATEGORIES AND WHAT THEY MEAN IN TERMS OF PRESENT ECOLOGICAL STATE (PES) CATEGORIES FOR RIVERS	ORTHOPHOSPHATE PHOSPHORUS (PO <sub>4</sub> -P) mg/l	TOTAL INORGANIC NITROGEN (TIN) mg/l	DISSOLVED OXYGEN (DO) mg/l	AMMONIA (NH <sub>3</sub> ) mg/l
<b>GOOD</b> PES A AND B	≤ 0.015 (oligotrophic)	≤ 0.70 (oligotrophic -mesotrophic)	> 7.0	≤ 0.044
<b>FAIR</b> PES C	> 0.015–0.025 (mesotrophic)	> 0.70–1.0 (mesotrophic)	> 6–7	> 0.044–0.072
<b>POOR</b> PES D	> 0.025–0.125 (eutrophic)	> 1.0–4.00 (mesotrophic -eutrophic)	> 4–6	> 0.072–0.1
<b>UNACCEPTABLE</b> PES E AND F	> 0.125 (hypertrophic)	> 4.00 (eutrophic) > 10 mg/L (classified as hypertrophic)	≤ 4	> 0.1

Regarding faecal bacterial pollution, *E.coli* guidelines are controversial. For full contact recreation in freshwater systems, the World Health Organisation guideline is < 400 colony forming units or cfu/100 ml. For intermediate contact recreation (no immersion), the City of Cape Town sets acceptable risk at < 2500 cfu/100 ml, and unacceptable risk at or above 4000 cfu/100 ml.

Pollution isn't always visible in water, and clear water does not necessarily mean that water is safe for use. Test your water and get help interpreting what the results mean.



## REFERENCES AND RESOURCES

---

### Books and Reports

Department of Water Affairs and Forestry (DWAf). 1996. South African Water Quality Guidelines (second edition), Volume 7: Aquatic Ecosystems.

Department of Water Affairs and Forestry (DWAf). 2008. Methods for determining the water quality component of the Ecological Reserve. Report prepared for Department of Water Affairs and Forestry, Pretoria, South Africa by P-A Scherman of Scherman Consulting.

FAO, SER & IUCN CEM. 2023. *Standards of practice to guide ecosystem restoration. A contribution to the United Nations Decade on Ecosystem Restoration. Summary report.* Rome, FAO. <https://doi.org/10.4060/cc5223en>

Vanishing Waters. 2023. Edited by Jenny Day and Bryan Davies. 3rd Edition. Water Research Commission Report No. SP 160/23.

### Websites

US Environmental Protection Agency (EPA).

Urban Hydrology. Caddis Volume 2.

**Urbanization – Hydrology | US EPA**

Water Sensitive Urban Design South Africa: Community of Practice – <https://wsudsa.org/>

Towards the Blue-Green City: Building Urban Water Resilience. 2021. Editors: L.A. Swatuk, G. Brill, C. Büchner-Marais, K. Carden, E. Conradie, J. Day, J. Fatch, J. Fell, M. Hara, and B. Ncube.

Water Research Commission Report No SP 153/21.

[https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/Towards%20a%20blue%20green%20city\\_final%20web.pdf](https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/Towards%20a%20blue%20green%20city_final%20web.pdf)

## REFERENCES FOR OPEN SOURCE IMAGES

---

Katze Dam image: By Christian Wörtz (woertz) – Own work, CC BY-SA 2.5, <https://commons.wikimedia.org/w/index.php?curid=830701>

Cape wetland in the Biodiversity showcase, CT: Abu Shawka, CC0. [https://commons.wikimedia.org/wiki/File:Indigenous\\_Wetland\\_Garden\\_-\\_Cape\\_Town\\_BSG.jpg](https://commons.wikimedia.org/wiki/File:Indigenous_Wetland_Garden_-_Cape_Town_BSG.jpg)

Crocodile River aerial image: Modified Copernicus Sentinel data 2019. CC BY-SA 3.0 IGO <https://creativecommons.org/licenses/by-sa/3.0/igo/deed.en>, via Wikimedia Commons

Litter in the Crocodile River. By JMK. [https://upload.wikimedia.org/wikipedia/commons/6/6d/Plastic\\_bag\\_litter\\_in\\_Crocodile\\_river%2C\\_Pelindaba.jpg](https://upload.wikimedia.org/wikipedia/commons/6/6d/Plastic_bag_litter_in_Crocodile_river%2C_Pelindaba.jpg)

Soccer field under water: By Amanda Solomon – Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=116774816>

South African Farm. CC BY-SA 4.0 <<https://creativecommons.org/licenses/by-sa/4.0>> [https://upload.wikimedia.org/wikipedia/commons/8/80/South\\_African\\_Farm.jpg](https://upload.wikimedia.org/wikipedia/commons/8/80/South_African_Farm.jpg)

## ACKNOWLEDGEMENTS

---

This project was made possible with the support of the Water Research Commission.

Sincere gratitude is due to everyone involved for their contributions and insights.

Special thanks to our Reference Group Members for their contributions. They are listed by name in Handbook 9.

**PHOTO CREDITS:** All photographs by Liz Day, Mandy Uys and Hans King, unless otherwise credited.

**DESIGN AND LAYOUT:** Ink Design Publishing Solutions, Cape Town, [www.inkdesign.co.za](http://www.inkdesign.co.za)

HANDBOOK

01

Planning a river rehabilitation project:  
What you need to know to get started

HANDBOOK

02

Understanding South African Rivers

HANDBOOK

03

Rewilding rivers: the role of  
habitat, plants and animals in  
river rehabilitation

HANDBOOK

04

Dealing with river erosion in  
South Africa

HANDBOOK

05

Responding to sediment problems  
in South African rivers

HANDBOOK

06

Addressing changes in river channel,  
floodplain and wetland form

HANDBOOK

07

Responding to changes in water  
quality and flow in urban, farming  
and rural environments

HANDBOOK

08

Infrastructure in and near rivers  
(fences, pipelines, bridges, culverts  
and other crossings)

HANDBOOK

09

River rehabilitation case studies