

LET'S FIX OUR RIVERS!

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

HANDBOOK

02

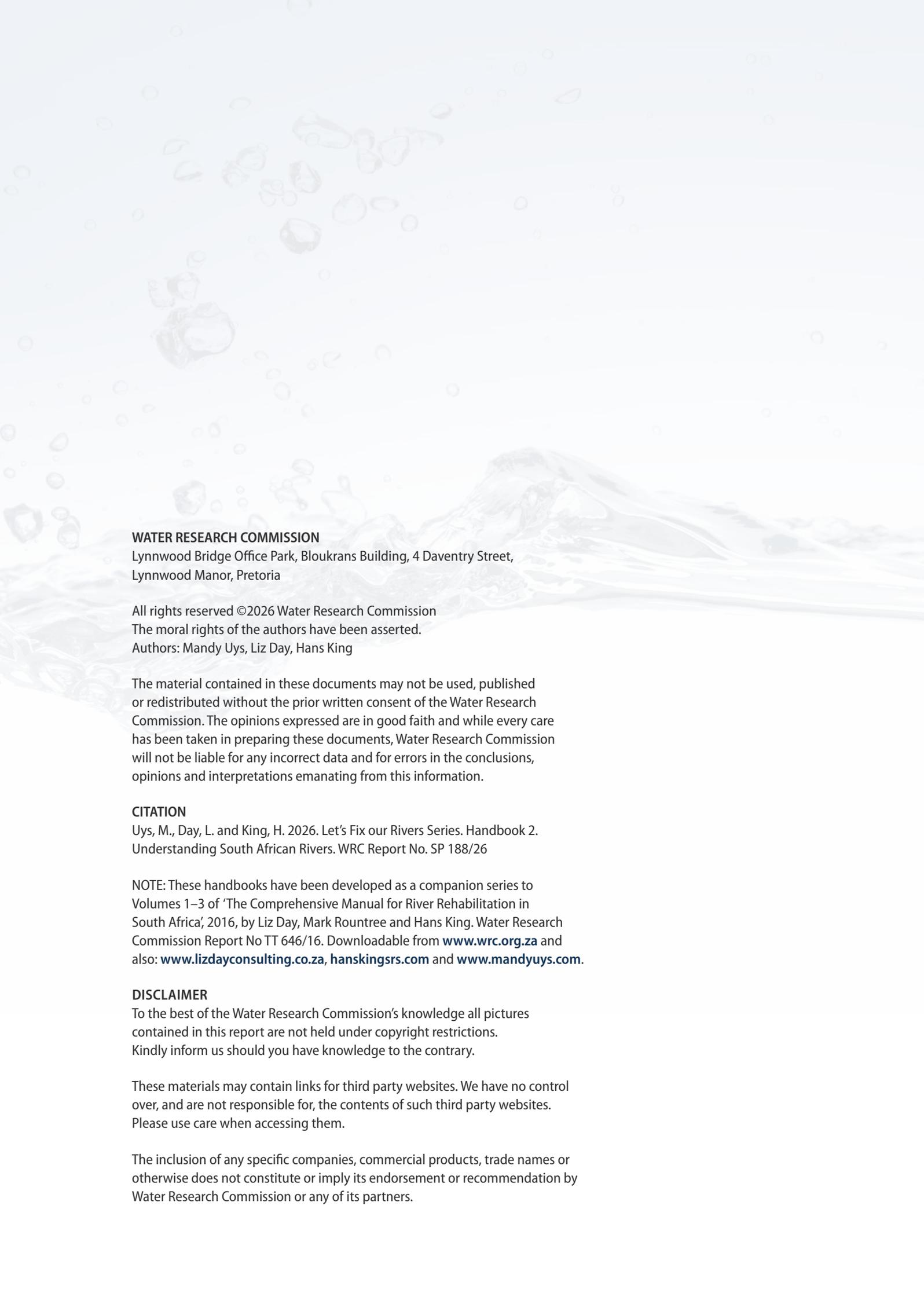


UNDERSTANDING SOUTH AFRICAN RIVERS

Mandy Uys • Liz Day • Hans King



SP 188/26

A background image of water splashing, with numerous bubbles and droplets of varying sizes scattered across the upper and middle portions of the page. The water appears to be moving from the right side towards the left, creating a dynamic, energetic feel.

WATER RESEARCH COMMISSION

Lynnwood Bridge Office Park, Bloukrans Building, 4 Daventry Street,
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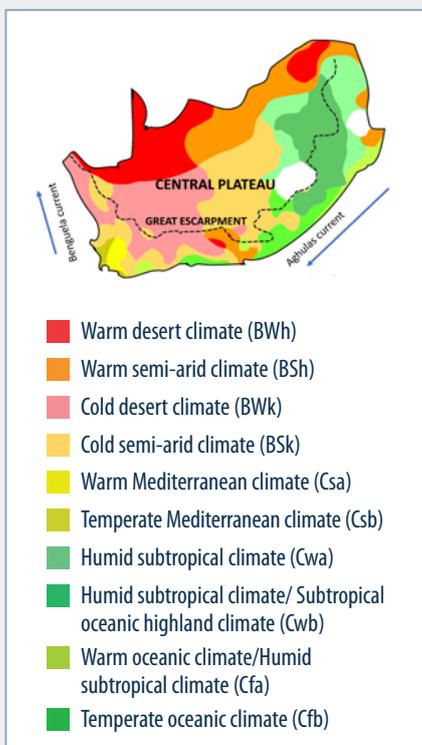
TABLE OF CONTENTS

	Setting the scene	04
	The catchments and rivers of South Africa	05
	Understanding our river systems	06
	The vegetation of South African watercourses	07
	River Ecoregions of South Africa	08
	Management of South African rivers	10
	Describing the ecological condition of South African rivers	12
	Degraded rivers: change and consequence	14
	Changes to water quality	15
	Changes to water quantity (flow)	16
	Changes to physical river form	18
	Changes to biota	20
	Getting involved with the protection and rehabilitation of our rivers	21
	Further reading and resources	22



WHAT THIS HANDBOOK IS ABOUT

It is likely that you have picked up this handbook to get a better understanding of our country's wild, beautiful, yet often damaged rivers. What did they look like naturally, and why have so many of them become so degraded? Perhaps you have a deteriorating section of river you wish to fix near your home, or would like to play a role in rehabilitating other rivers. This handbook will give you a basic understanding of some of the natural forces that shape South African rivers, the human impacts that continue to cause their decline, and the way in which our rivers are managed. Understanding the river at the catchment scale, and in its ecophysical and management context, is the starting point for 'river fixing' or rehabilitation.



The Köppen climate classification map of South Africa. *Source: Wikimedia Commons (Adapted, 2016)*

SETTING THE SCENE

There is no such thing as a typical South African river. If you drive across the country, you could see dry river beds, clear-flowing forested streams and turbulent, muddy waters. Even in a single river, there can be dramatic changes in form from source to mouth. The natural character of any part, or the whole, of our river systems is determined by the climate, topography, geology, soils and vegetation of the areas they are located in.

The country is a mosaic of different climate types (see **Climate Map**). The major influences on climate are: (i) the warm Agulhas ocean current on the east of the country, the cold Benguela ocean current on the west, and the temperature difference between these; and (ii) the high central plateau, surrounded on the east, south and west by the steep escarpment which forms our major mountain ranges – this is flanked by a flatter, narrow coastal strip. These influences result in a humid subtropical to temperate oceanic climate along the south-east and east coasts, increasingly arid climates (both warm and cold) to the centre, north and west of the country, and a Mediterranean climate in the southern and western Cape coastal areas.

Average monthly air temperatures in South Africa range between 11°C and 22°C, and average annual rainfall is less than 500 mm. This is well below the world average of 800 mm. The south-western Cape is a winter rainfall area, and east of this, most of the country's rainfall is summer-dominated or year-round. The timing and pattern of rainfall in a particular area influences the flow regime of a river. This has important implications for the management of the system, and also for the approaches and timing of rehabilitation activities. Also it must be taken into account that rainfall is highly variable within and between years, resulting in rivers with high flow variability, and unpredictable floods and droughts. This too has consequences for rehabilitation planning and design, and the kinds of materials most appropriate for use.

From east to west of the country, rainfall generally decreases and evaporation increases. As a result of this pattern, river catchments become more and more arid in general as one heads west. Vegetation type changes dramatically in response.

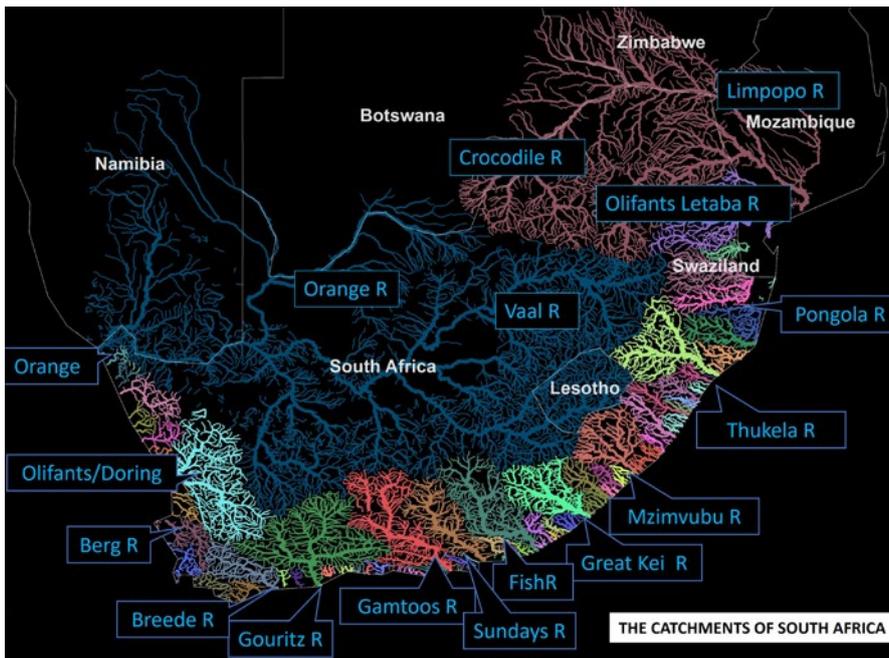
The flow in South African rivers ranges from perennial (flow all year round) in the wetter areas, to seasonal (flowing seasonally), intermittent (flowing at times), and ephemeral (flowing seldom) in the driest parts of the country. The scarcity of permanent surface water over much of the country, together with the high evaporation rates and already-dry soils, make water a scarce resource. With climate change there is less predictability about rainfall and surface water availability, as well as the likelihood of more extreme, intense and prolonged events such as floods and droughts. All planning for rehabilitation has to be done with these challenges in mind.

THE CATCHMENTS AND RIVERS OF SOUTH AFRICA



HOW SA RIVERS DIFFER FROM THOSE IN OTHER PARTS OF THE WORLD

The whole of South Africa can be divided into river catchments: these are basin areas into which rainfall drains into individual river systems. These come to life in the stunning map of South African river catchments below.



The river basins of South Africa. Source: Dr Sukhmani Mantel. 2019. Permission granted (major river names added)

The longest rivers in the country are the Orange; its tributary the Vaal; the Limpopo; Molopo; Nossob; Great Fish; Gamtoos; Olifants (tributary of Limpopo); Great Kei; Thukela; Breede; Komati; Lepelle (previously Olifants); and Mzimvubu.

The massive Orange-Vaal system rises in the Drakensberg mountains and drains virtually the entire central part of the country. The catchments in the south and east of the country are generally small and drained by rivers arising in highlands close to the coast. Where the coastal plain is narrow and the mountains steep, as on the south coast, the rivers plunge into the sea almost as mountain streams with no lowland sections.

The catchment is a logical management unit for a river system. Within it, river length can be divided into **river zones** (10–100 km), and further subdivided into **river reaches** up to 10 km. While much of the work and planning in river rehabilitation is at the scale of the river reach, it is important to keep the catchment perspective, and also to know about large developments and activities (such as dams, abstractions, pollution) upstream of the reach you are working in.

South African rivers are not suitable for navigation and transport of people and goods, whereas rivers elsewhere in the world (Europe in particular) are extensively used for this purpose, and have in many instances been dramatically modified for this purpose.

In South Africa the difference between 'normal' flow rates and 'flood' flows is a factor of 20 to 500. In Europe this is very much less. As a result, river stabilisation techniques suited to European conditions may not be suited to South African rivers.

The deeply incised glacial valleys of the northern hemisphere, which in warmer times may serve as beds of deep lakes or rivers, do not occur in South Africa, as this part of the southern hemisphere did not experience the major Pleistocene glaciations which were a feature of the northern continents. This partly explains the scarcity of natural lakes in South Africa.

These differences illustrate the importance of understanding the context of the river you are rehabilitating, and of using geographically-relevant approaches and methods in your rehabilitation project.



UNDERSTANDING OUR RIVER SYSTEMS

Headwater zone



Upper foothill zone



Lower foothill zone



Lowland/floodplain zone



Estuary

Rivers are longitudinal ecosystems, connected from source to sea. There are continuous natural changes in physical and chemical conditions along their length. Whatever happens at one point in the system will inevitably have consequences downstream. However, because the water continues to flow along the system, a healthy river is able to recover to some extent from limited impacts, over both distance and time.

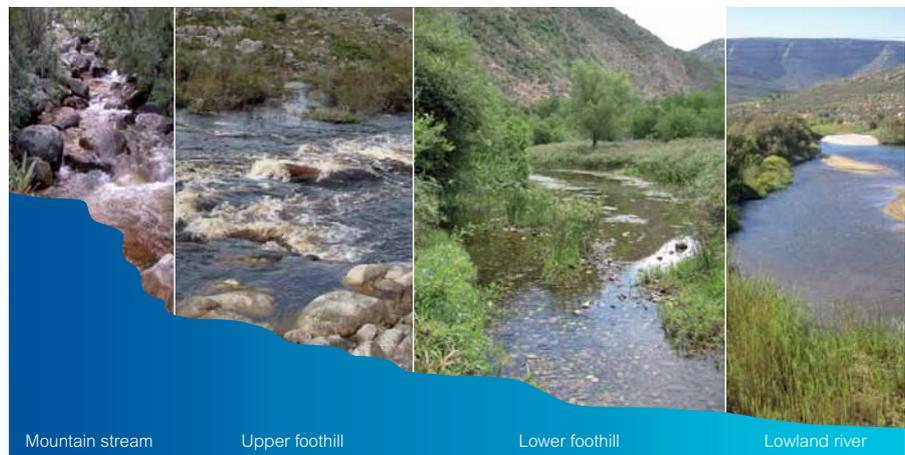
River scientists recognise different geomorphic zones in a typical South African river. These are distinguished from each other largely on the basis of the gradient of the channel. Within each zone, the character of the river is relatively constant. The zones are, broadly: the source zone (which can be a wetland), headwater zone (which may or may not be a mountain stream), upper foothill zone, lower foothill zone, lowland or floodplain zone, and the estuary (saline). Between zones, the river character differs in terms of channel gradient, flow type (velocity, turbulence, oxygenation), width, depth, tree canopy cover, substrate make-up (boulder/rock/cobble), variety of habitat types, and vegetation. Not all rivers have all the zones listed, and there are variations between them.

Animal and plant communities shift in character along the river in response to the river system's physical and chemical changes. Different species have different preferences for habitat, food type, temperature, water quality, depth or flow conditions, and those with similar preferences tend to group where they find these conditions.



FOR MORE DETAIL:

WRC River Rehabilitation Manual, Volume 1, Chapter 2: Understanding the Landscape.



Mountain stream

Upper foothill

Lower foothill

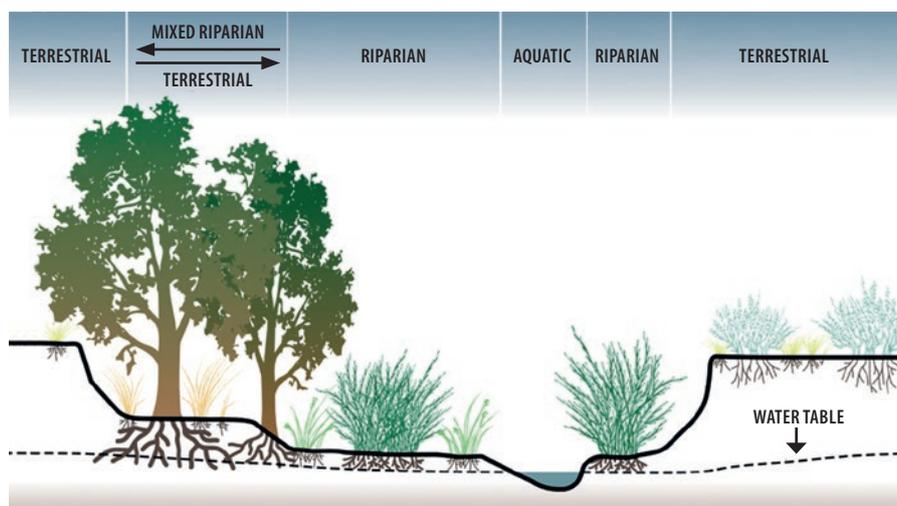
Lowland river

A graphic broadly illustrating river zonation. Source: Statistics SA (2017)

THE VEGETATION OF SOUTH AFRICAN WATERCOURSES



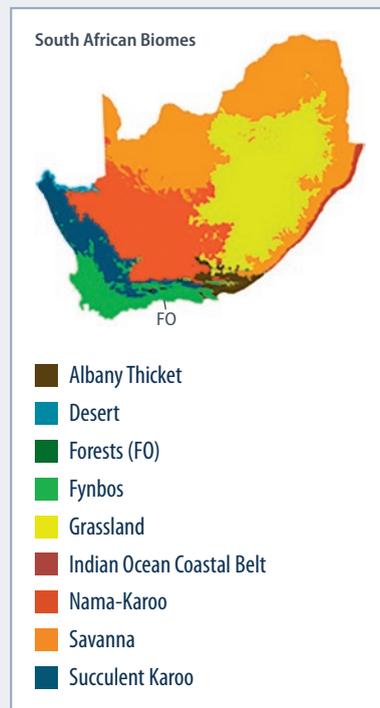
The indigenous vegetation of a catchment plays an important role in determining river character and condition. South African vegetation types are grouped into nine **vegetation biomes**, based on dominant forms of plant life, geology and soils, and climatic factors such as rainfall and temperature. The biomes are: Fynbos, Succulent Karoo, Desert, Nama-Karoo, Grassland, Savanna, Albany Thicket, Indian Ocean Coastal Belt, and Forest (**see Map**). The character and species of plants in each biome are the result of the rainfall and temperature patterns, landscape, geology and soils. Knowing what biome you are working in provides you with information about the sorts of indigenous terrestrial plants should be there, and which plants may occur in the riparian zone.. Some of the natural riparian zone plants won't be included in the biome lists, and those species are important to include in planting. Consult a specialist before starting.



A cross section through a river, showing its riparian zone and floodplain. *Source: Wikimedia Commons – Dickard et al 2016.*

The natural vegetated area alongside a river, where present, is referred to as the riparian zone (RZ). It is the transitional area between the aquatic ecosystem and the terrestrial one. The RZ and its soils and vegetation are shaped by the presence of water, and the plants growing here are water-loving or water-tolerant. The RZ serves as a buffer for the river system; and has many other important functions (**see textbox page 14**). In South African law, the RZ is considered to be part of the watercourse and hence enjoys legal protection. The outer edge of the RZ is also sometimes used as a surrogate for the 1 in 100 year floodline (**see Glossary**).

South African floodplains and their wetlands can be home to a complex mosaic of vegetation, the character of which is determined by the nature of the alluvial sediments, the topography of the floodplain, and the wetting regime. Floodplain wetlands play a vital role in flood management and in carbon sequestration.



The nine vegetation biomes of South Africa. *Source: SANBI (2018)*

IN RIVERS, AQUATIC

VEGETATION includes all those plant species that live in the river channel in a number of forms – submerged, emergent, free-floating or floating-leaved. There are many indigenous aquatic vegetation species, however these are seen less and less commonly in our rivers due to the influx of alien aquatic vegetation.



A healthy riparian zone



RIVER ECOREGIONS OF SOUTH AFRICA

In South Africa, rivers have been grouped into 31 'Level 1 River Ecoregions' (ER), on the basis of similarities in climate, geology, physiography, and natural vegetation (see Kleynhans et al. 2005). Rivers or sections of rivers in the same ER are ecologically more similar to one another than to rivers in a different ER. Some rivers pass through two or more ecoregions.

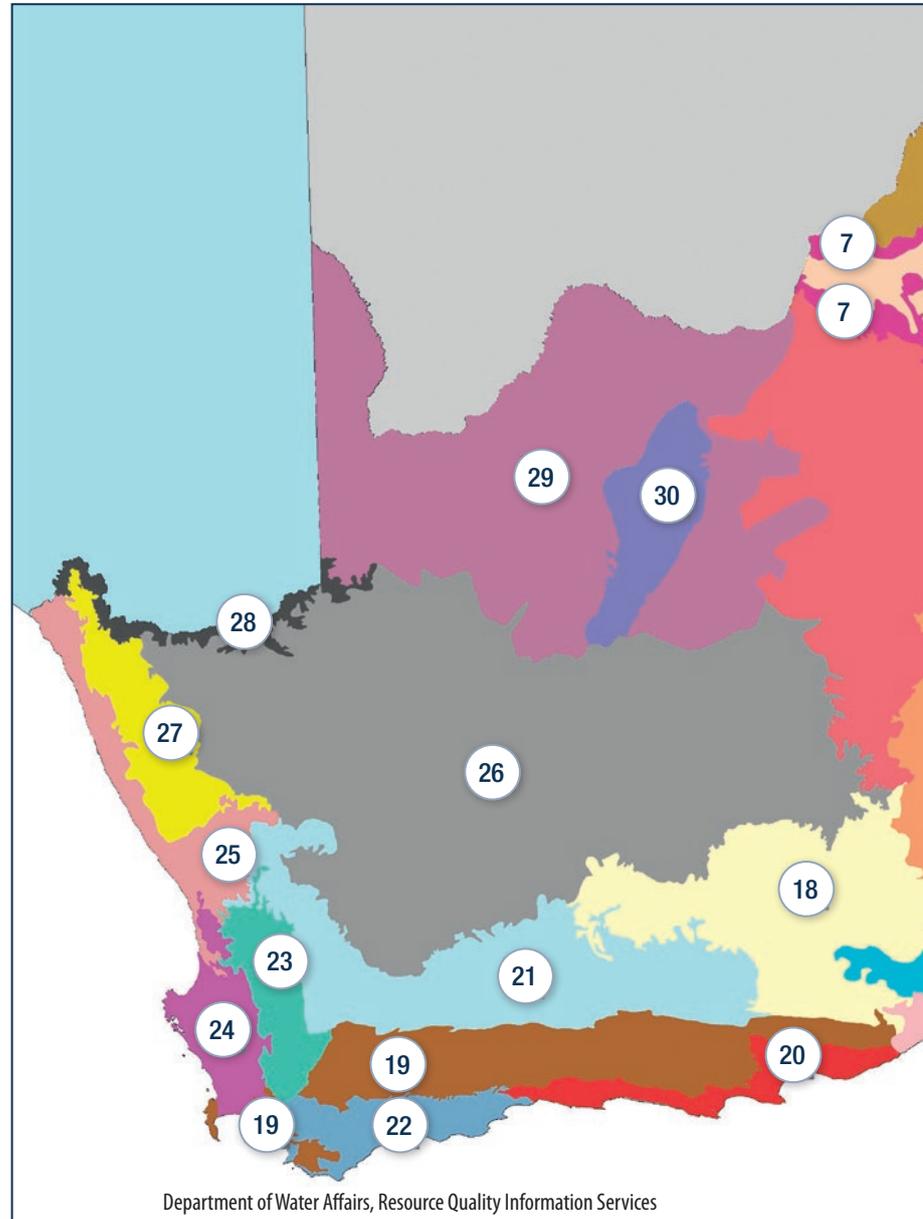
While ERs are largely a tool for management, research and resource development, they are also very useful in providing an understanding of a river catchment and assisting to reconstruct a 'baseline' (pre-impact, natural, or expected condition) picture for a river zone or reach. Knowing the ER and geomorphic zone of the river reach in question helps in identifying the original causes of damage to the river, and can also guide the most appropriate ways to address its problems. Less impacted river reaches in the same ER can also be used to envision the more natural state towards which to rehabilitate, although this is not always achievable.



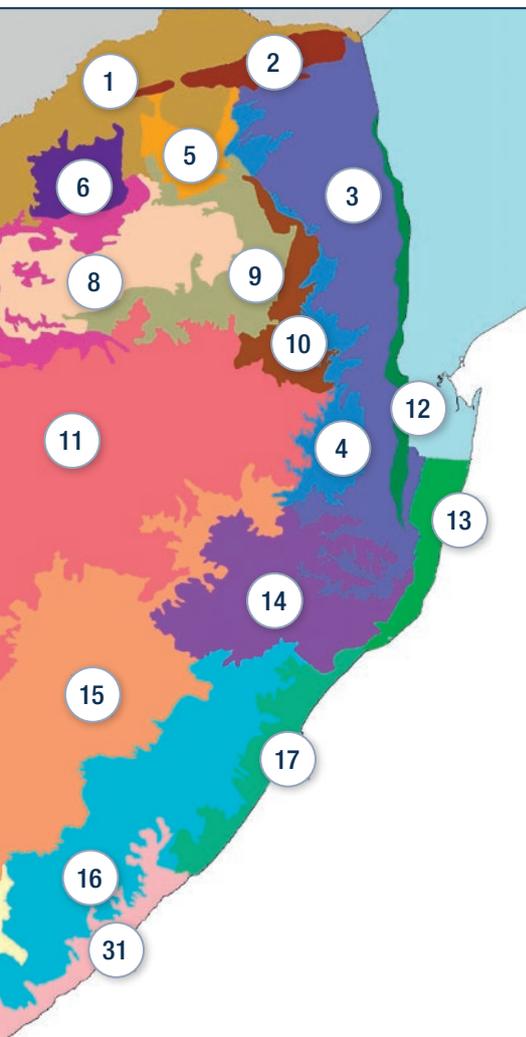
Lower Orange River near Voolsdrif, ER28



Typical Karoo River, ER21



Goukou River, ER22



ECOREGIONS LEVEL 1, 2005

1. LIMPOPO PLAIN
2. SOUTPANSBERG
3. LOWVELD
4. NE HIGHLANDS
5. NORTHERN PLATEAU
6. WATERBERG
7. WESTERN BANKENVELD
8. BUSHVELD BASIN
9. EASTERN BANKENVELD
10. N ESCARPMENT MTS
11. HIGHVELD
12. LEBOMBO UPLANDS
13. NATAL COASTAL PLAIN
14. NE UPLANDS
15. EASTERN ESCARPMENT MTS
16. SE UPLANDS
17. NE COASTAL BELT
18. DROUGHT CORRIDOR
19. SOUTHERN FOLDED MTS
20. SE COASTAL BELTS
21. GREAT KAROO
22. SOUTHERN COASTAL BELT
23. WESTERN FOLDED MTS
24. SW COASTAL BELT
25. WESTERN COASTAL BELT
26. NAMA KAROO
27. NAMAQUA HIGHLANDS
28. ORANGE RIVER GORGE
29. SOUTHERN KALAHARI
30. GHAAP PLATEAU
31. EASTERN COASTAL BELT

Albers Equal Area 24°E Std|| 18°S 32°S



Sand River, ER3



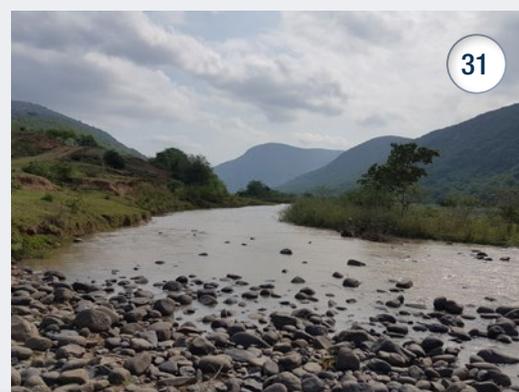
Klip River (trib Vaal), ER11



Upper Thukela River, Drakensberg, ER15



Melk River near Graaff Reinet, ER18



Lower Mzimvubu, ER31



MANAGEMENT OF SOUTH AFRICAN RIVERS

WHAT IS DEFINED AS A WATER USE

The National Water Act (NWA) Section 21 lists the following 'water uses' which require general or full authorisation:

- a) Taking water from a water resource;
- b) Storing water;
- c) Impeding or diverting the flow of water in a watercourse;
- d) Engaging in a stream flow reduction activity contemplated in NWA Section 36 (e.g. afforestation);
- e) Engaging in a controlled activity identified as such in Section 37 or 38 (e.g. irrigation with waste water or water containing waste)
- f) Discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;
- g) Disposing of waste in a manner which may detrimentally impact on a water resource;
- h) Disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process;
- i) Altering the bed, banks, course or characteristics of a watercourse;
- j) Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people;
- k) Using water for recreational purposes.

DON'T BE MISLED BY 'SMALL SCALE'!

The disturbance thresholds in rivers are small. For example, infilling, depositing or removal of material into or from a watercourse is limited to 10 m³ (with exceptions), and clearing of any area of indigenous vegetation is limited to 1–20 Ha (with exceptions). Above these thresholds, environmental authorisation is required.

Almost anything you do to, or in, a river could potentially require either registration or authorisation with an authority. It can be daunting to know where to start. This section provides you with a basic introduction to the key laws and authorities, and how to get started. Getting some professional assistance is highly recommended.

All of South Africa's water resources, including watercourses, surface water, estuaries and aquifers, are under the management and protection of the Department of Water and Sanitation (DWS) and the National Water Act (NWA, Act 36 of 1998). There are regional and local DWS offices countrywide. The mandate of the Department of Forestry, Fisheries and the Environment (DFFE) somewhat overlaps that of DWS, being the management, protection and conservation of South Africa's environment and natural resources. This overlap can be confusing to the uninitiated. A little light is shed on this in the following section.

The legal tools

The key laws of relevance to river rehabilitation in South Africa are the National Water Act (NWA, Act No 36 of 1998) and the National Environmental Management Act (NEMA, Act 107 of 1998) and its several subsidiary Acts. The Acts make provision for small-scale interventions to continue without major authorisation – either as generally authorised (NWA) or without prior environmental authorisation (NEMA). However, medium and larger-scale activities generally require approval from one or other Department in the form of licenses, general or environmental authorisations, permits or rights. Always consult a specialist to determine if any authorisation is required, even for rehabilitation activities.

Who authorises what

DWS is responsible for authorising eleven different 'water uses' as listed in Section 21 of the National Water Act (**see sidebar**). The two generally most relevant to river rehabilitation are the Section 21 (c) and (i) uses. There are standard 'procedures to follow to apply for authorisation.

DFFE's main involvement with water resources is to authorise activities requiring environmental assessment, and to protect and conserve the biodiversity of different environments, including rivers. Activities requiring authorisation are listed in the most recent 'Listing Notices' associated with the most recent Environmental Impact Assessment Regulations. These are updated and amended from time to time.

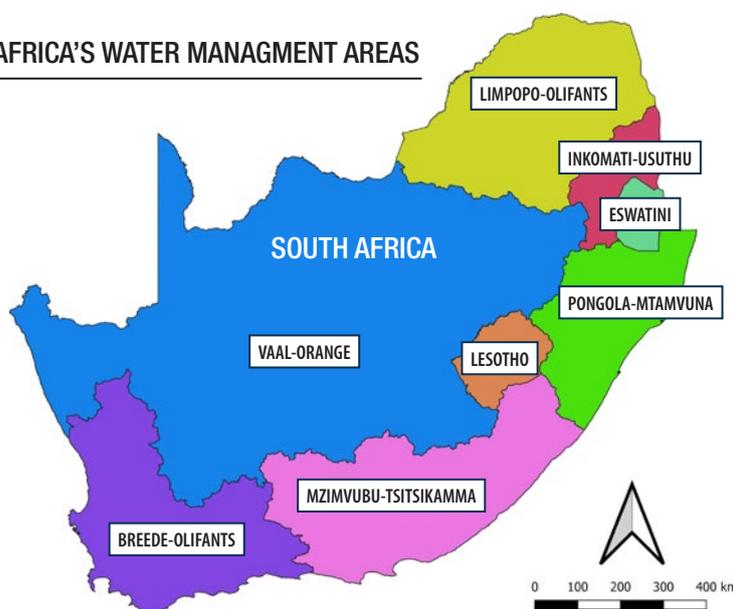


IMPORTANT NOTE: For any intervention in a river or wetland, you are advised to consult an Environmental Assessment Practitioner (EAP) or an Aquatic Scientist, as well as the relevant authorities.

Managing at a catchment level

For the purposes of managing the water resources of South Africa, the country is divided into **Water Management Areas (WMAs)**, each of which is named after the largest river catchment/s located in the area. The WMAs overlap the provincial boundaries. Within each WMA there are a number of river catchments. The individual catchments are further subdivided into smaller units (secondary, tertiary and quaternary catchments), which are used for management and for ongoing assessment (e.g. water quality testing, present state assessment, biomonitoring). There are currently six WMAs in the country (see map).

SOUTH AFRICA'S WATER MANAGEMENT AREAS



Catchment Management Agencies (CMAs) made up of the relevant authorities and a range of local stakeholders in the catchment, are in the process of being set up for each of the WMAs in the country. The idea behind CMAs is to decentralise water management and encourage inclusive stewardship of water resources. The CMA will manage water resources and coordinate the functions of the other water management institutions. This is a complex undertaking, already being implemented but likely to take some time to be implemented countrywide.

While CMAs are statutory bodies, a **Catchment Management Forum (CMF)** is a voluntary organisation, and a way in which the catchment community can participate in the management of their own river (see sidebar).



FOR MORE INFORMATION:

Please consult Handbook 1: Planning a River Rehabilitation Project: What you need to know to get started.

HOW TO START A CATCHMENT MANAGEMENT FORUM

Around South Africa there are many voluntary groups set up by individuals or communities to assist with the cleaning and fixing up of their rivers.

At a national policy level, CMFs are intended to support CMAs and all localised integrated water resource management. Although CMFs exist in policy, there has been a delayed roll-out of CMAs nationally. However, since water resource management is a national competence, this enables different spheres of government to play a role in establishing and operating CMFs. In Cape Town for example, the local municipality has driven the establishment of municipal-level CMFs, with the intention of fostering a more formal relationship with the Breede-Olifants CMA going forwards.

The role of a CMF is to act as a communication channel between catchment residents and local government, municipality and other institutions. They can also be educational bodies, watchdogs, and structures for initiating and organising activities in a river catchment.

For an estuary, an Estuary Management Plan (EMP) is a legal requirement. Many communities living alongside estuaries in South Africa have established Estuary Management Forums (EMFs) and worked with DFFE to get an EMP done for their estuary. This is often self-funded.



Eastern Cape estuary



DESCRIBING THE ECOLOGICAL CONDITION OF SOUTH AFRICAN RIVERS

Knowing the present and historic condition of the river or reach you are rehabilitating is the starting point of river rehabilitation. The system in use in South Africa to determine and describe the Present Ecological State (PES) of any component, and the overall condition or Ecstatus of a river site, is known as **Ecoclassification**. This method gives us some insight into what has caused one or more aspects of the river to become damaged, and provides clues as to what needs to be addressed. This information is used to set targets for the recommended future state of the river and its biota. To calculate the Present Ecological State (PES) of a site, we assess system 'drivers' and system 'responses'. The system drivers are the physical aspects of the river – water quality, geomorphology (land-form), and hydrology (flow patterns). They determine the physical and hydraulic habitat 'template' of the river and its biota. System responses are the physical and biological components that respond to the drivers. These are: riparian vegetation, fish, and aquatic invertebrates. The condition of these biota represents their response to the state of the system drivers.

PES, EIS and Ecstatus

Both system drivers and system responses should be individually assessed (either using desktop methodologies, or with a site survey by the relevant specialists). The data from this exercise are used to calculate the Present Ecological State (PES) for each individual component.

The Ecological Importance and Sensitivity (EIS) of the site or the reach is also assessed at this stage and has many purposes, including the refinement of the future desired state or Recommended Ecological Category (REC) of the river.

SYSTEM DRIVERS



Water quality



Flow



Geomorphology

SYSTEM RESPONSES



Riparian vegetation



Macroinvertebrates



Fish

The PES results for fish, invertebrates and riparian vegetation are integrated in the process of determining the overall Ecstatus of the site or river. The Ecstatus is a description of the river condition at the time of assessment, relative to how it is likely to have looked in its natural pre-impact state. The difference between present state and natural state is expressed as a percentage, with natural or pre-impact set at 100%. In other words, the higher the PES percentage, the closer the system is to its natural state, and the better the condition and Ecstatus of the river reach. The percentage ranges are divided into six categories, A to F, as well as half categories, on a continuum represented by colour bands. The graphic below shows the six categories of river condition, their percentage ranges, and a description of the relevant condition. The band below shows the colour-banded continuum of categories.

CATEGORY	CONDITION	DESCRIPTION OF GENERALLY EXPECTED CONDITIONS
A	Excellent	Near natural (>89% to 100% of natural)
B	Good	Largely natural with few modifications (> 80% to 89% of natural)
C	Fair	Moderately modified (> 60% to 79% of natural)
D	Poor	Largely modified (>40% to 59% of natural)
E	Very Poor	Seriously modified (>20% to 39% of natural)
F	Critical	Critically modified (<20% of natural)



Further assistance in developing a picture of natural state

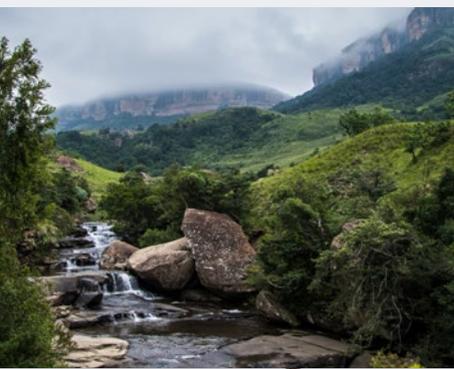
There is a fair amount of information available to help in developing an understanding of what a South African river would have looked like under natural (pre-impact) conditions, and to build up some understanding of historic impacts to it. This is valuable, as the rehabilitation 'vision' for the river or reach should be to return some of the physical form, natural flow, water quality, biota and ecological functionality of the pre-impact condition. Some of these information sources are listed below. **See also 'Further Resources' and 'Glossary'.**

- Aerial photographs of the river over past decades (usually available from municipal offices in electronic format) – these can be interpreted by a fluvial geomorphologist;
- Maps or data indicating any Critical Biodiversity Areas (CBAs) in the catchment area in which you are working;
- National Freshwater Ecosystem Priority Areas (NFEPA) status: Information on the priority status of the river or site for protection in terms of the National Freshwater Priority Areas Atlas. Check if there are any fish sanctuaries present;
- Species of Conservation Concern (SCCs) – Check if there are any SCCs – i.e. sensitive, vulnerable, or endangered species in your catchment, and if so where?



DEGRADED RIVERS: CHANGE AND CONSEQUENCE

Free-flowing, healthy rivers, with few impacts from human activities, are sadly now largely a memory in South Africa. However there are sections of many rivers which remain in reasonable condition.



With human settlement in South Africa, and over subsequent centuries, came the development of small and large-scale farming, towns and cities, and the increasing need for infrastructure, industry, water supply and sanitation. Along with the advantages of these developments came major disadvantages to our natural world and our water resources. The benefits provided by our natural waterbodies, described below, have gradually been compromised, and in some cases lost altogether. Measures to address the widespread systemic damage to our aquatic ecosystems have not yet been implemented to any major extent. This is the task of **ecological rehabilitation**.

In the following pages we explore the benefits generally provided by ways in which the system drivers have been affected by human activities, and what the system responses have been.

A healthy river provides:

- Clean water and protection of its source
- A 'conduit' for nutrient transport from source to estuary and ocean
- Plant and animal biodiversity
- Good quality habitat for these indigenous fauna and flora
- Corridors for the movement of instream and riparian animals
- Oxygen supply (where there is a healthy riparian zone)
- A source of food for animals and humans
- Breeding and nursery areas for fish
- A degree of protection against flood damage
- Sporting, recreational and amenity value
- An important role in SA spirituality, culture and traditions
- A contribution to our recreational economy.

A well-vegetated, indigenous riparian zone provides:

- Rooting, erosion protection and stabilisation of the river bank
- Trees and shrubs which filter pollution and improve air quality
- A buffer and filter for polluted or high-nutrient surface runoff flowing towards the river
- A zone of entrapment for sediments washing down-slope
- A corridor for animal movement and a habitat for wildlife
- Plant material for thatching and construction
- When well-vegetated a carbon sink, and a means of assisting with the effects of climate change.

A naturally-functioning floodplain provides:

- An effective buffer, reducing disaster risks such as drought, veld fires and floods
- A high surface area for water filtration
- Erosion control and bank or shoreline stabilisation
- Standing water habitat, particularly important where the surrounding areas are increasingly ecologically sterile
- Habitat for species of conservation concern (SCCs) – there are many threatened or endemic wetland plants which rely on specific wetland types, sometimes in specific areas, for their survival
- Flood attenuation
- Slow release of water back to the river, sustaining base flow.

CHANGES TO WATER QUALITY



Natural water quality may be affected by:

Sewage and industrial effluent inflows

Sewage effluents contain high levels of bacteria and other pathogens, which can cause serious and contagious diseases. They have a high chemical oxygen demand which can be lethal to fauna. Industrial effluents contain both organic and inorganic substances and may have high concentrations of toxic heavy metals.

Inorganic pollution

This can include dissolved salts (which can affect body chemistry and processes), metals including heavy metals (both of which can be toxic to aquatic life), and minerals.

Organic pollution

This includes phosphorus (can stimulate aquatic plant growth), nitrates, nitrites and ammonia (the latter is common in effluents, and can affect respiration in many animals and be highly toxic).

Changes in pH

One of the concerning causes of this is Acid Mine Drainage (AMD) which also contains high concentrations of metals, sulphides and salts. When water is more acidic than normal, metals become more bio-available to aquatic animals. Other causes of pH change include sewage effluent, runoff from building sites, industrial discharges.

Litter, plastics and other Contaminants of Emerging Concern (CECs)

Physical CECs including plastics (particularly single use and microplastics), and chemical CECs including pharmaceuticals, household cleaning products and personal products, are increasingly significant contaminants of rivers and oceans. Amongst other harmful effects, physical CECs cause blockages and obstruction of waterways, and can be ingested by biota, while chemical CECs are persistent and can disrupt endocrine cycles.

Changes in flow regime

Unnaturally elevated flows result in dilution of, for example, inorganic dissolved salts; while unnatural flow reduction will result in concentration of substances, including pollutants.

Changes in river form

Bank erosion and bed incision lead to instream sedimentation and increases in suspended solids.

Suspended solids

Unnaturally high sediment loads lead to reduced light penetration and decreased photosynthesis, reduced food supply, and effects on animal feeding and breathing. Settled sediments can smother habitat and biota.

Under natural conditions, water quality is determined by climate, catchment geology and soil type, geomorphology, and biota. Because these factors vary widely, 'good' water quality is a relative term, and 'normal' water quality criteria are presented as a range of values.

NATURALLY SELF-CLEANING SYSTEMS ... NO MORE

A natural, unimpacted river self-cleans and self-regulates by ongoing interactive physical, chemical and biological processes, including: dilution, sedimentation, filtering, and aeration (physical); oxidation, reduction, adsorption and absorption (chemical), and mineralisation and assimilation (biological).

Macroinvertebrates and microbes play a major role in the breakdown, decomposition and transformation of organic matter. Because of this, rivers can tolerate a limited amount of pollution, but this ability has been exceeded in many of our rivers! With major changes in water quality, the system's ability to self clean and self regulate is gradually lost.



A river covered with plastic and other litter.



‘THE RESERVE’

In South African water law, the only priority right to water is known as the Reserve, which is made up of the Basic Human Needs Reserve or BHNR, and the Ecological Reserve or ER. Together these, theoretically, provide assurance that there is enough water remaining in the aquatic ecosystem (i) to meet the basic human needs of those living in the river catchment, and (ii) to protect the ecosystem and to ensure sustainable use and development of its water resources. To calculate the ER for a river, the ‘Environmental Flow Requirements’ (EFRs) of the system (also called IFRs or EFRs) must be determined. Different methods have been developed for this purpose in recent decades.

The EFR determination process results in a recommendation as to what the Environmental Flows (EF) for the river should be. These are defined as ‘the quality, quantity and timing of water flows required to maintain the components, functions, processes and resilience of an aquatic ecosystem which provides goods and services to people’. The EFs mimic the natural flow pattern of the river within and between years, but represent only a percentage of the natural flow. The Reserve results include revised operating rules for dams, which allow the EFs to be delivered.

The illustration of the bucket opposite shows the theoretical allocation of water. However in many instances, the water resources of a river are already over-allocated and the ER and BHNR cannot be met without significant changes in resource allocation.

CHANGES TO WATER QUANTITY (FLOW)

The two biggest reasons for flow modification in our rivers are, simply, water demand and water supply. Without water as an available resource, every social, economic and ecological aspect of the country would fail. But in providing this supply, there have been costs to our watercourses.

Ecosystem changes with change in flow regime

A critical component of river condition is the extent to which its natural flow regime is maintained. Natural flow in rivers can be altered in their frequency, duration, timing, and rate of change. The effects include changes to physical form, instream and riparian habitat, hydraulic habitat and water quality.

The major causes of modified flow are:

Water abstraction

The obvious consequences are the draw-down of surface or groundwater; the changing of seasonal ecological patterns; and the loss of seasonal cues to biota for breeding and other life cycle aspects.

Dams

In-channel dams inundate the basins upstream of them, creating lake-like conditions in formerly terrestrial, wetland or riverine habitats. The dam wall holds back (impounds) at least part of the flow to the downstream river, disrupting normal ecosystem functioning and causing the loss of important seasonal flow-related cues for downstream fish. In the case of hydropower dams, large volumes of water can be released through turbines, resulting in unnatural and daily fluctuating flow conditions downstream, which can have devastating effects on river form, habitat, and biota. Irrigation supply schemes with daily releases can have similar effects.

Flow diversion

Rivers are diverted to transfer water or to maximize areas for mining, agricultural land or other developments. Diversions range from irrigation canals to large interbasin transfers (IBTs). Diversion canals can disconnect the channel from the floodplain, and where they are built at a higher level than the river, can cause flooding of low-lying areas. IBTs result in reduced flow in the ‘donor’ river and increased flow in both the transfer channels and the receiving rivers.

Land use

Clearing of natural vegetation leads to sealing of exposed land surfaces, reduced infiltration of water into soil (surface ponding) and potentially the lowering of the all-important base flows which sustain the river. Flow of surface water across the sealed land surface can increase the size and frequency of high flows in the river.

Changes in flow intensity

These often result from development encroachment onto floodplains, with floods being confined to reduced river channels and floodplains. They are also caused by narrow bridges and stream-crossings.

Groundwater abstraction (boreholes)

When poorly managed or excessive, groundwater abstraction can lower the groundwater table, and affect normal baseflows in the river.

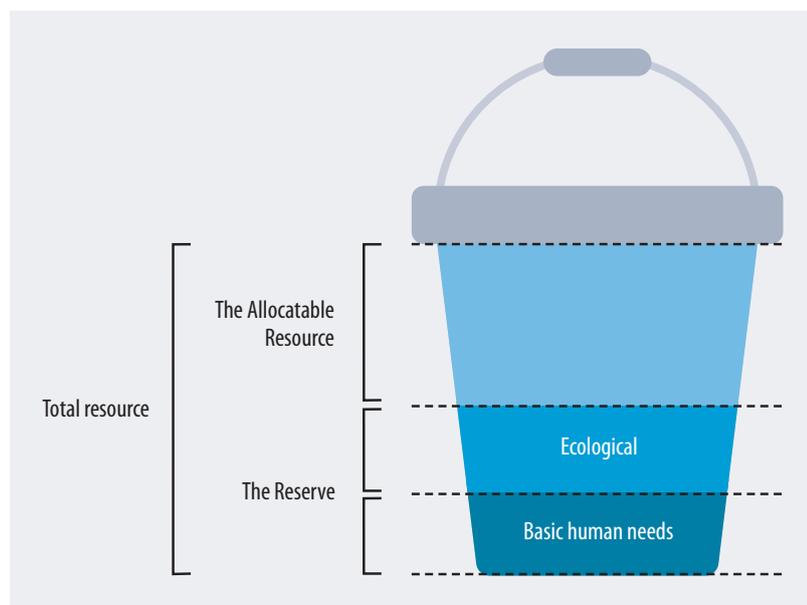
Alien vegetation

Alien vegetation infestation in a river generally results in reduced river flows due to relatively high water requirements.

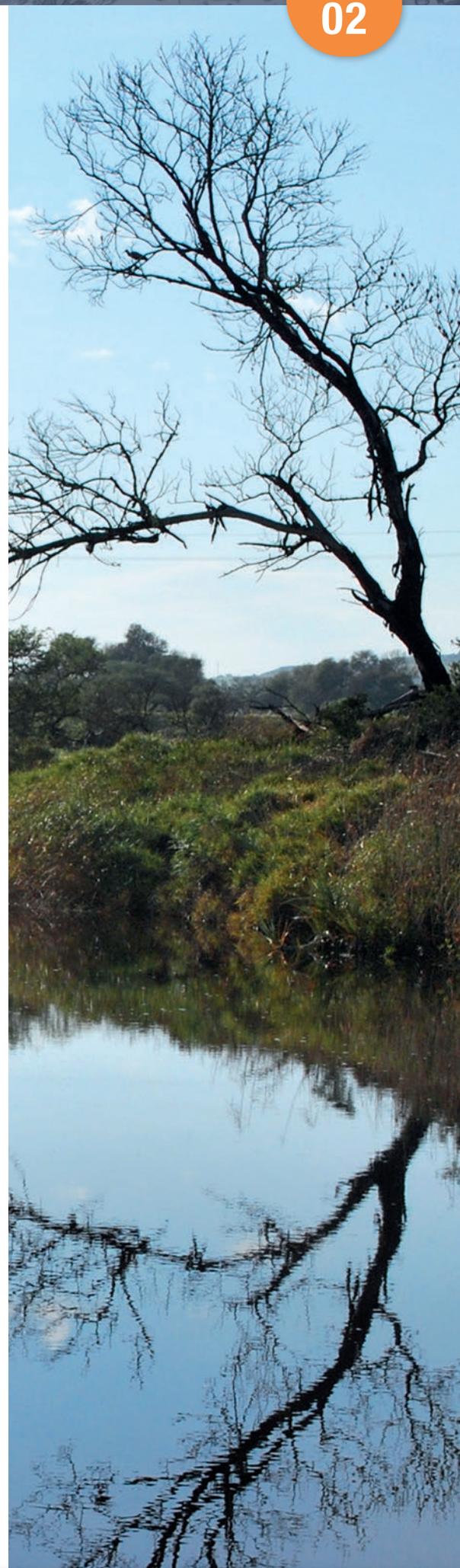
Effluent releases into the river

These can be substantial and sustained, altering the flow regime and having worst consequences in naturally seasonal rivers

Returning flow to the river



The bucket illustrates the total water available. This, in theory at least, should comprise the Ecological and Basic Human Needs Reserves, balancing the Allocatable Resources. **See sidebar text on The Reserve, page 16.**





CHANGES TO PHYSICAL RIVER FORM

POOR LAND-USE MANAGEMENT



PONDING

The start of the erosion process – accumulation of water on a sealed, formerly cleared land surface of the catchment.



GULLEY EROSION

Erosion on a riverward slope, likely to lead to in-channel sedimentation.



BANK EROSION, CHANNEL INCISION AND SEDIMENTATION

Caused by extensive overgrazing in the upper catchment.

Land form and land-forming processes (studied as 'geomorphology') have been altered in many ways in South Africa. Poor landuse practises (e.g. clearing of vegetation, overgrazing, alien invasive vegetation) or careless developments (e.g. roads built through wetlands) have resulted in large-scale effects such as head-cuts, gulley erosion, or sheet flow, typically with consequences to the river down-slope. At the scale of the river reach, many developments result in disturbance or destabilisation of the floodplain, river channel or banks. These include: cross-channel structures such as dam walls, weirs, roads, bridges and low-level crossings; development on floodplains; alteration of channel form by straightening or canalising; diversion of flow; and bankside activities such as clearing of riparian zone vegetation.

These impacts can have one or more of the following effects, at varying degrees of severity: channel and bank erosion; changes in sediment dynamics; changes in the river's ability to transport and store sediment; alteration of channel planform (channel shape as viewed from above); alteration of channel roughness (flow resistance); separation of the river and the floodplain area; loss of upstream-downstream and channel-bank connectivity; alteration of flow velocity.

Canalisation or changing of river planform



Results: Change in planform, alignment, often width and depth; loss of channel and riparian habitat; reduced flow resistance; increase in flow velocity; loss of ecosystem functionality.

Developments close to the watercourse



Results: Loss of riparian zone, river bank destabilisation, channel sedimentation, damage to infrastructure.

Dams and weirs



Results: Change in upstream and downstream flow conditions, sediment trapping upstream (**see photo on far right**) with related habitat loss, erosion and scour downstream, barriers to fish migration, loss of system connectivity.

River crossings (roads, bridges, low-level crossings, culverts]



Results: Riparian vegetation is typically cleared for the construction of a crossing, and alien invasive vegetation can become established. During high flows, debris gets entrapped upstream of the crossing structure due to undersized openings, and a debris dam forms upstream, forcing the high flow to outflank the structure and cause damage to it (**see photo far left**). Where too few culverts are installed, the river and its wetlands may 'be constrained' downstream. Where culverts are oversized this can lead to serious erosion downstream, and this can result in a sizeable 'step' in the river channel, which can also act as a barrier to upstream migration by fish including eels.



We can only estimate how biota are responding to the worsening condition of our rivers. This page provides a summary of some of the most common responses.



Alien invasive water hyacinth forms a virtual carpet in a nutrient-rich section of river downstream of a low-level crossing.



Largemouth Bass *Micropterus salmoides* has been introduced to SA, most likely as a sport fish. It is an alien predator that has no competition, so is displacing indigenous fish and could cause their extinction.



The redclaw crayfish *Cherax quadricarinatus*, an alien invasive invertebrate species of our freshwaters.

CHANGES TO BIOTA

Loss of species and biodiversity

When important habitats are lost or degraded due to any of these problems, or system connectivity is lost, then more sensitive species of biota particularly can lose condition, be reduced in abundance or be completely lost from the system. Indigenous species can also be threatened by alien fauna. Abundances of other more tolerant species may change, resulting in an overall shift in abundance of different species. Community structure is altered, and tougher species may become dominant.

Following development (e.g. a road bridge), unless the post-development rehabilitation of a watercourse is done with great care and the guidance of a management plan, the associated disturbance to the system often provides an opportunity for alien plant and animal species to move in and become established.

Invasive alien vegetation

Invasive alien plant species can establish rapidly and often successfully in new habitats such as cleared floodplains and riverbanks. They are tolerant of the disturbance, they grow fast, and they reproduce in large numbers, so are often able to out-compete indigenous plants (unless a particular planting plan is in place). Depending on the species, invasive alien plants can have serious impacts on river function and are often seen to be the main factor triggering degradation.

Invasive alien fish

Invasion of rivers and other water bodies by alien fauna has had profound impacts on riverine species diversity and, in some cases, habitat quality. Most of the alien biota invading freshwater habitats are fish, with over 20 taxa reported established in South African waters. Amongst the impacts they have are the transfer of parasites, alteration of instream conditions due to feeding and behavioural differences (e.g. increase in algal cover, increase in mobile sediments), impacts on indigenous fish (which can lead to local extinctions) and impacts on aquatic macroinvertebrates.

Invasive alien aquatic invertebrates

Alien invertebrates are also on the increase in South African rivers and include crustaceans, insects and molluscs. Some of these species are already naturalised in our rivers. They are detrimental to indigenous aquatic species for various reasons. For example, the alien reticulate pond snail carries various pathogens which may be harmful to indigenous species. Indigenous invertebrates can also become pests, where they thrive because they are relocated to another area, or can tolerate changes in flow or water quality. For example, indigenous midge adults can form nuisance swarms or even biting plagues.

GETTING INVOLVED WITH REHABILITATION OF OUR RIVERS



South Africans can no longer afford to be passive onlookers when it comes to water resources. The longer we wait for the management action needed to return healthy ecological function to our watercourses, the more time is lost to assisting river recovery, and the more deterioration we will see in our rivers and in their ability to deliver natural benefits. As ordinary citizens and citizen scientists, we can play a role in protecting and rehabilitating these vital ecosystems towards ecological health.

Many individuals and communities in South Africa and beyond are working against river degradation. This is a major contribution to rehabilitation. Their activities include starting community organisations, organising regular river clean-ups, trying to tackle waste at source, clearing aliens, planting indigenous vegetation, developing relationships with local municipal officials and other authorities responsible for environment and waste collection, forming coalitions with business to get sponsorship for the work needed, and in some cases taking authorities to court over dysfunctional sanitation infrastructure.

What can you as one South African do?

If you are concerned about the state of a river or wetland in your area, take action. Do a search on the many groups in South Africa doing great work in their local catchments with the help of experts. Spend time exploring your own local natural waters (if they are safe) and finding out what the problems are. Speak to your Municipal Councillor and see how much awareness there is about the issue, and how much interest in fixing it. Find out which river-focussed organisations are busy in your area, and link up with them. If there aren't any, consider starting one. Gather with neighbours, friends, or ratepayers associations etc, to get support. Contact your local DWS and DFFE offices and set up meetings to inform them of your plan and to attempt to work together with them, or even consider setting up a Catchment Management Forum (or, for an estuary, an Estuary Care group which could lead to formation of a Forum). It is important to work hand in hand with your local authorities wherever possible, as they know what can and cannot be done and they will value your assistance.

Consider joining the Society for Ecological Restoration (www.ser.org), an active organisation doing ecological restoration work around the world. Or, get inspired by the power of individuals to create change in rivers, by reading about some of the world's fearless water warriors: <https://www.lewispuughfoundation.org/river-warriors>. We hope to meet you out there, fixing our beautiful rivers.

'South Africa needs to take action on climate change, but that in itself is not enough to save the water-scarce country and its people from an acute water crisis. Failing infrastructure, corruption, resource mismanagement and unsustainably high water demands coupled with inadequate supply must also be addressed if a humanitarian disaster is to be avoided'.

– Special Reports, Mail and Guardian,
March 30 2023



The Litterboom Project, a South African NGO working to keep plastic out of rivers and the ocean.



FURTHER READING AND RESOURCES

Here are some of the resources that will assist you in understanding rivers and wetlands and their rehabilitation. Many of these are used by specialists in the field, in assessing the condition of rivers or wetlands, determining buffers, or in rehabilitation work.

Biomes and Bioregions of South Africa: Chapter 3 of The Vegetation of SA (reference below). By MC Rutherford, L Mucina and LW Powrie.

Buffer zones: Preliminary Guideline for the Determination of Buffer Zones for Rivers, Wetlands and Estuaries: Consolidated Report WRC Report No. TT 610/14. 2014. By DM Macfarlane, IP Bredin, JB Adams, MM Zungu, GC Bate and CWS Dickens. Download from: www.wrc.org.za

Catchment Management Forums: Guidelines for Catchment Management Forums in Cape Town. https://resource.capetown.gov.za/documentcentre/Documents/Procedures,%20guidelines%20and%20regulations/Catchment_management_forum_Guideline.pdf

National Biodiversity Assessment for South Africa 2018. This includes an Inland Aquatic Assessment. Accessible at: <https://biodiversityadvisor.sanbi.org/contentmanagement/index?guid=6dd4d744-69f8-478d-8707-45b8466667ac>

National Freshwater Ecosystem Priority Areas (NFEPAs). Implementation manual for Freshwater Ecosystem Priority Areas. Water Research Commission report No 1801/1/11. By A Driver, JL Nel, K Snaddon, K Murray, DJ Roux, L Hill, ER Swartz, J Manuel & N Funk.

Present Ecological State and Ecological Importance and Sensitivity (PES/EIS) data for the rivers of South Africa, Accessible at: <https://www.dws.gov.za/iwqs/rhp/eco/peseismodel.aspx> (you may need specialist assistance with these data).

River rehabilitation (South Africa): This 'Let's Fix our Rivers!' handbook is one of nine companion guides to the much more comprehensive information available in the WRC South African River Rehabilitation Manual (2016), by Liz Day, Mark Rountree and Hans King. Water Research Commission, Report No TT 646/16. https://wrc.org.za/wp-content/uploads/mdocs/TT%20646%20consolidated%20FINAL_web.pdf.

River rehabilitation (Australia): The Australian manual for stream rehabilitation. Volumes 1 and 2. By ID Rutherford, K Jerie, and N Marsh. 2000. https://www.researchgate.net/publication/228806740_A_Rehabilitation_Manual_for_Australian_Streams.

River restoration (UK): The River Restoration Centre (UK) manual of river restoration techniques. <https://www.therrc.co.uk/manual-river-restoration-techniques>.

River Life: Freshwater Life: A field guide to the plants and animals of southern Africa. By C Griffiths, J Day and M Picker. Struik Nature.

Rivers and Wetlands: Vanishing Waters (3rd Edition). 2023. Water Research Commission Report No SP160/23. By J. Day and B. Davies. Available from www.wrc.org.za.

Water Quality: National State of Water Report 2021. Department of Water and Sanitation. Download from www.dws.gov.za.

Water Quality Guidelines: South African Water Quality Guidelines Volumes 1–8 (covering all water uses). DWAF 1996. Download from www.dws.gov.za.

Wetland Management Series. A series of ten handbooks on all aspects of wetland ecology and management. 2007. Series editors: C Breen, J Dini, S Mitchell, M Uys. Water Research Commission Report No TT 321/07. Order online from www.wrc.org.za.

REFERENCES

Department of Water and Sanitation (DWS). 2023. Rehabilitation Management Guidelines for Rivers. Report 2.1.. Sources Directed Studies. Report No: RDM/RMG/00/IHP/SDS/0122. Pretoria, South Africa.

DWAF (Department of Water Affairs and Forestry). 1999. Resource Directed Measures for the Protection of Water Resources. Volume 1.

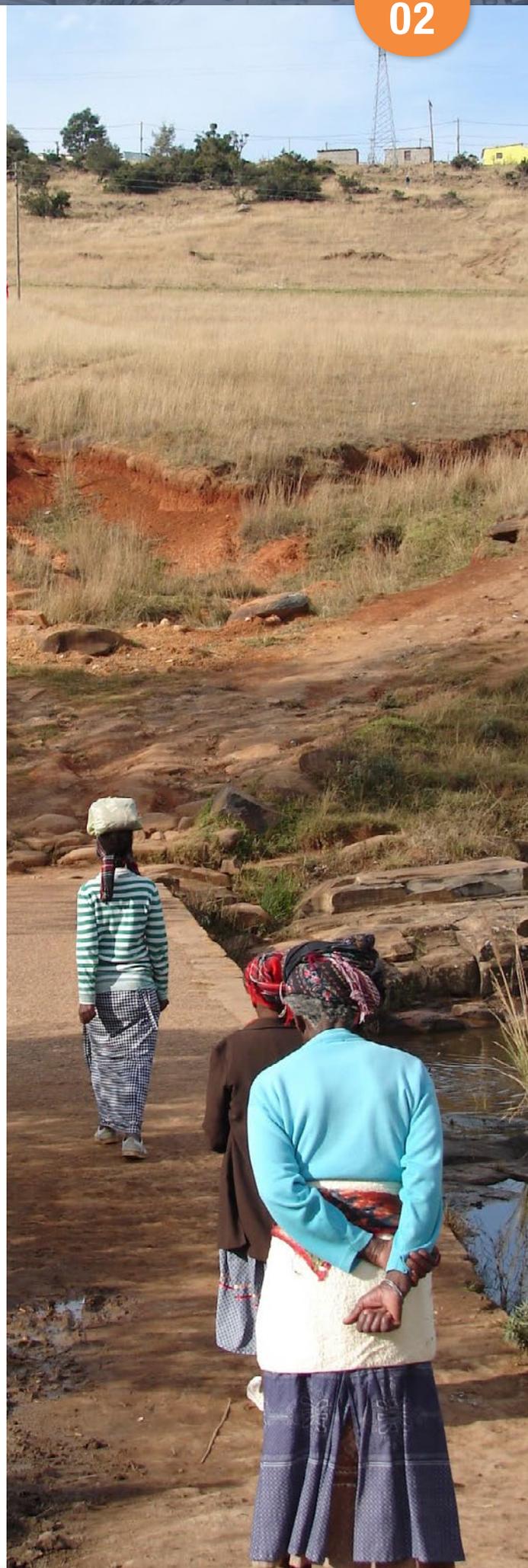
Kleynhans, C.J. and Louw, M.D. 2008. River Ecoclassification Manual for Ecstatus Determination (v.2). Module A. Ecoclassification and Ecstatus Determination. Report to the Water Research Commission, Report No. TT 329/08.

Kleynhans, C.J., Thirion, C. and Moolman, J. 2005. A Level I River Ecoregion classification System for South Africa, Lesotho and Swaziland. Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

SANBI (South African National Biodiversity Institute). 2018. The Vegetation Map of South Africa,

Lesotho and Swaziland, (2006- 2018), Mucina, L., Rutherford, M.C. and Powrie, L.W. (Editors), Online, Version 2018.

Statistics SA. 2017. Four facts about our rivers you probably didn't know. <https://www.statssa.gov.za/?p=9490>





OPEN SOURCE IMAGE CREDITS

Climate map, page 4: Ali Zifan (Enhanced, modified and vectorized). https://af.wikipedia.org/wiki/L%C3%AAer:South_Africa_map_of_K%C3%B6ppen_climate_classification.svg
Note: escarpment trace and ocean current annotations added by author.

River basins, page 5: Dr Sukhmani Mantel. 2019. River Basins of South Africa. Published with permission to download: The Conversation. February 3, 2019. <https://theconversation.com/what-we-learned-when-our-map-of-southern-africas-rivers-went-viral-110735>

Riparian Zone, page 7: M. Dickard, M.Gonzalez, W.Elmore, S.Leonard, D.Smith, S.Smith, J.Staats, P.Summers, D.Weixelman, S.Wyman. United States Department of Agriculture. Page URL: https://commons.wikimedia.org/wiki/File:Example_of_a_riparian_area.png

Lower Orange River, page 8: Maurits Vermeulen, CT. Page URL: <https://commons.wikimedia.org/wiki/File:OrangeRiverRafting.jpg>

Upper Thukela River, page 9: Rudolf Botha. Page URL: https://commons.wikimedia.org/wiki/File:Amphitheatre_Drakensberg.jpg

Fish Eagle, page 14: Chris Eason. Page URL: https://commons.wikimedia.org/wiki/File:African_Fish-eagle_2320915691.jpg

Gariiep Dam overflowing, page 19: Aliwal2012. Page URL: https://commons.wikimedia.org/wiki/File:Gariiep_dam_overflowing_in_Jan_2011.jpg

ACRONYMS & ABBREVIATIONS

CBA	Critical Biodiversity Area
CMA	Catchment Management Agency
DFFE	Department of Forestry, Fisheries and the Environment
DWAF	Department of Water Affairs and Forestry (previous)
DWS	Department of Water and Sanitation (Name change from DWA/F)
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
ER	Ecoregions
GA	General Authorisation (in terms of the NWA)
IAP	Invasive Alien Plants
MAR	Mean Annual Runoff
NFEPA	National Freshwater Ecosystem Priority Area
NWA	National Water Act
PES	Present Ecological State
SASS	South African Scoring System (instream invertebrate biomonitoring tool)
SCS	Species of Conservation Concern
WfW	Working for Water
WfWetlands	Working for Wetlands
WMA	Water Management Area
WULA	Water Use Licence Application – relating to NWA Section 21 Water Uses

GLOSSARY OF TERMS

1:100 year floodline	An event that has an annual probability of exceedance of 1%. That is, there is a 1% probability that a flood greater than this discharge will occur in any given year.
Baseflow	The portion of the streamflow that is not runoff, but water which percolates through the ground at shallow depths, providing delayed flows into the channel which are sustained between rainfall events.
Catchment	The area contributing to runoff at a particular point in a river system.
Ecological Importance	An expression of the importance of a watercourse to the maintenance of ecological diversity and function on local and wider scales (DWAF 1999).
Ecological Sensitivity	Refers to the system's ability to resist disturbance and to recover from disturbance.
Floodplain	A relatively level alluvial (sand or gravel) area lying alongside the river channel, built up through deposition of alluvial (water-transported) sediments by the watercourse.
Geomorphology	The science and study of surface features and landforms, and the forms and processes that create them.
Habitat	The natural physical home of species of plants or animals.
Hydrology	The study of the occurrence, distribution, and movement of water over, on and under the land surface.
Present Ecological State (PES)	The present day ecological condition of the resource.
Reference Condition	The natural or pre-impacted condition of the system. This includes the natural dynamics of the system prior to development.
Rehabilitation	An intervention that promotes the recovery of ecosystem functions and values in a degraded system to regain some of the ecological and other values the system previously provided.
Riparian	A riparian zone is that area that is transitional between the aquatic area and the terrestrial area. Vegetation is expected to change from species adapted to wetter sites near the channel to species adapted to drier sites in the terrestrial zone, with a mixture of species occurring in between.
Runoff	Surface water runoff from rainfall, which can enter the stream channel network.
Macroinvertebrates	Aquatic macroinvertebrates are small organisms that have no internal skeletal system and live part or all their lives in water.

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Sincere gratitude is due to everyone involved for their contributions and insights. Reference Group members in particular are thanked, and listed by name in Handbook 9.

PHOTO CREDITS:

Cover Images:

Left: Small river in the Kogelberg, Western Cape. *Photo: Andrew Birkhead*

Top Right: Tributary of the Doorn River near Nieuwhoutville. *Photo: Liz Day*

Bottom Right: Mzimvubu River, Eastern Cape. *Photo: Mandy Uys*

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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