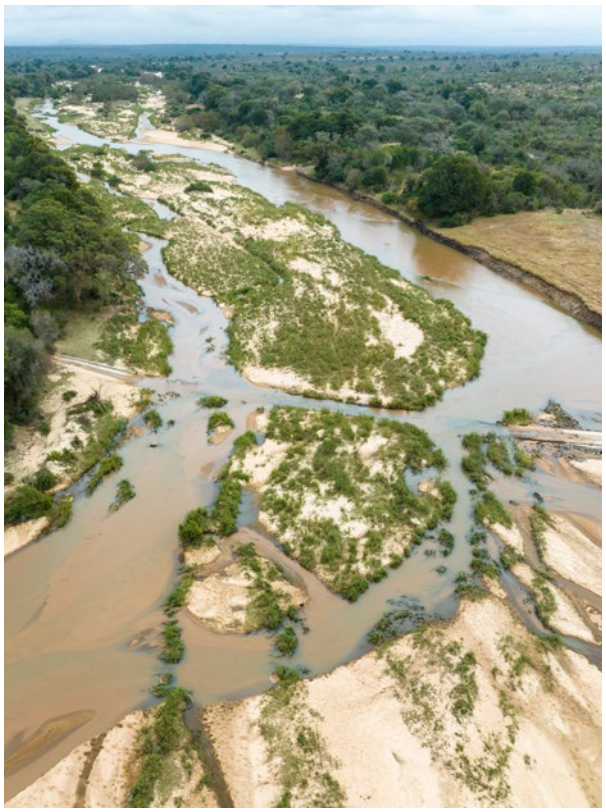
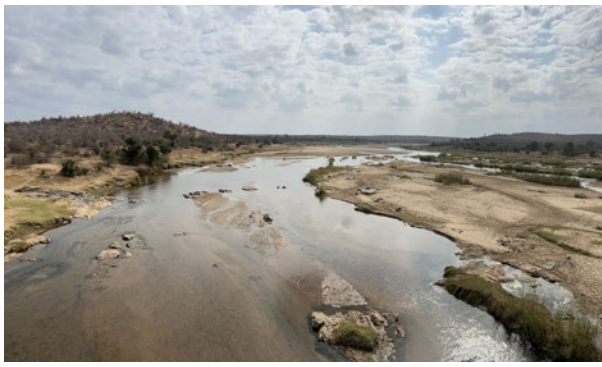
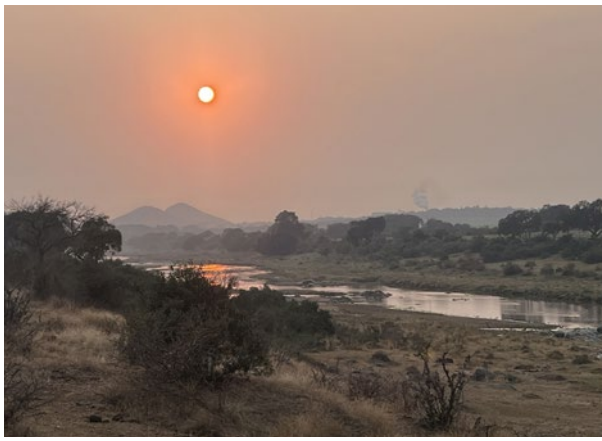
LET'S FIX OUR RIVERS!

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







HANDBOOK
05

RESPONDING TO SEDIMENT PROBLEMS IN SOUTH AFRICAN RIVERS

Hans King • Liz Day • Mandy Uys

WATER RESEARCH COMMISSION

SP 191/26

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

Authors: Hans King, Liz Day, Mandy Uys

CITATION
King, H., Day, L., and Uys, M. 2026. Let's Fix our Rivers Series. Handbook 5: Responding to sediment problems in South African rivers.
WRC Report No. SP191/26.

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** and also: **www.lizdayconsulting.co.za**, **hanskingsrs.com** and **www.mandyuys.com**.

TABLE OF CONTENTS

INTRODUCTION TO SEDIMENT

Sediment is solid material, which originates from the weathering (erosion) of rocks and soils.

Several factors influence the erodibility of sediments by water. These include soil **particle size** (smaller particles are washed away most easily in even small flows and floods); **particle size distribution** (soils with good particle size distribution form a tight matrix that is difficult to erode); the presence of **organic matter** (which helps bind soils); **vegetation** (which binds soils in its roots and also disperses the energy of falling raindrops and surface flows); and the **chemical nature** of the soil (sometimes chemical compounds in the soil cement the soil particles together – such as gypsum, while with other soils, the soil particles repel each when in the presence of water – such as dispersive clays).

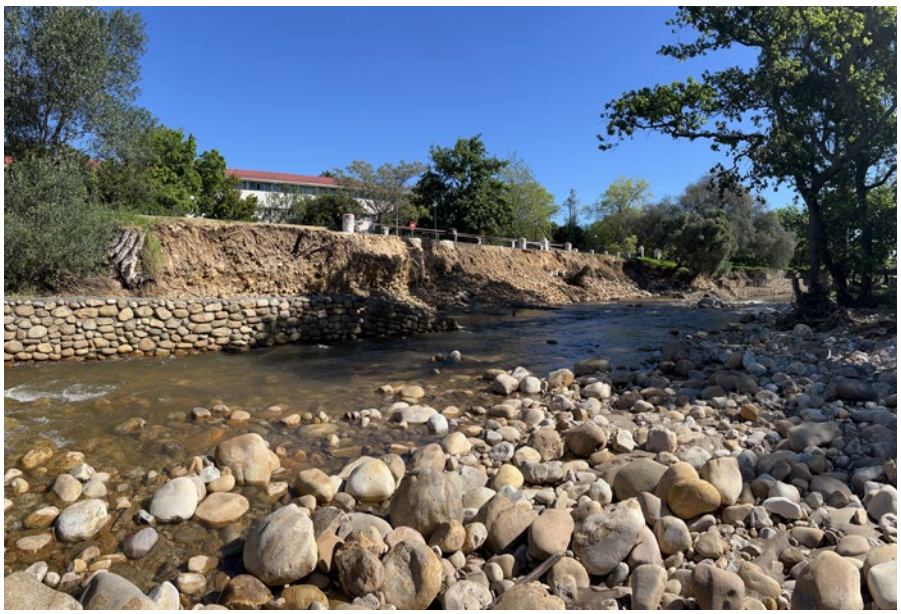
Sediment is often transported by water but can also be transported by other means such as wind.

Sediment can be classified in many ways, but is often classified based on particle size, as shown in the table below:

PARTICLE SIZE (mm)	SEDIMENT CLASSIFICATION
< 0.004	Clay
.004–.0625	Silt
0.0625–2.00	Sand
2.00–4.00	Gravel
4.00–64.00	Pebble
64.00–256.00	Cobble
256.00	Boulder

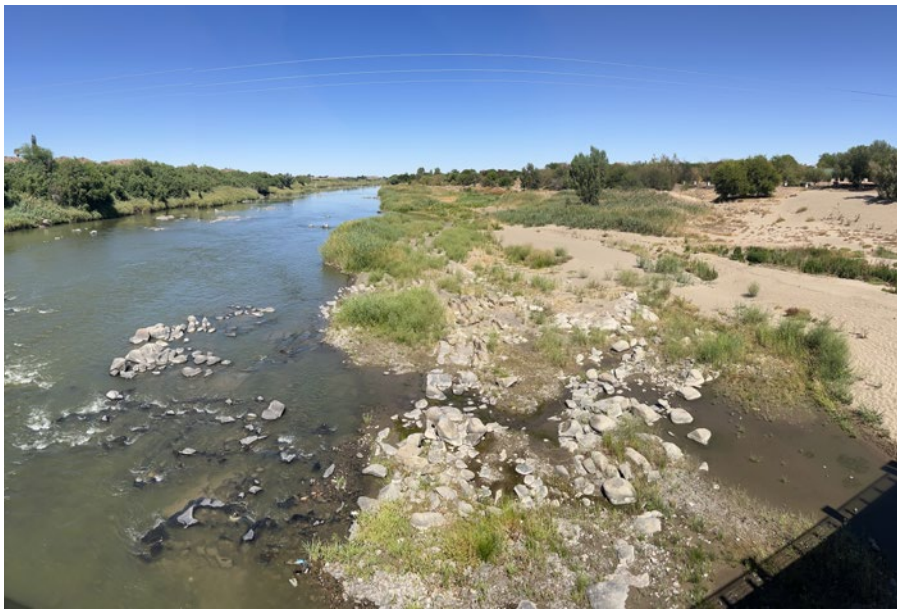
1

Much of the sediment we see today started as boulders on the side of a mountain.



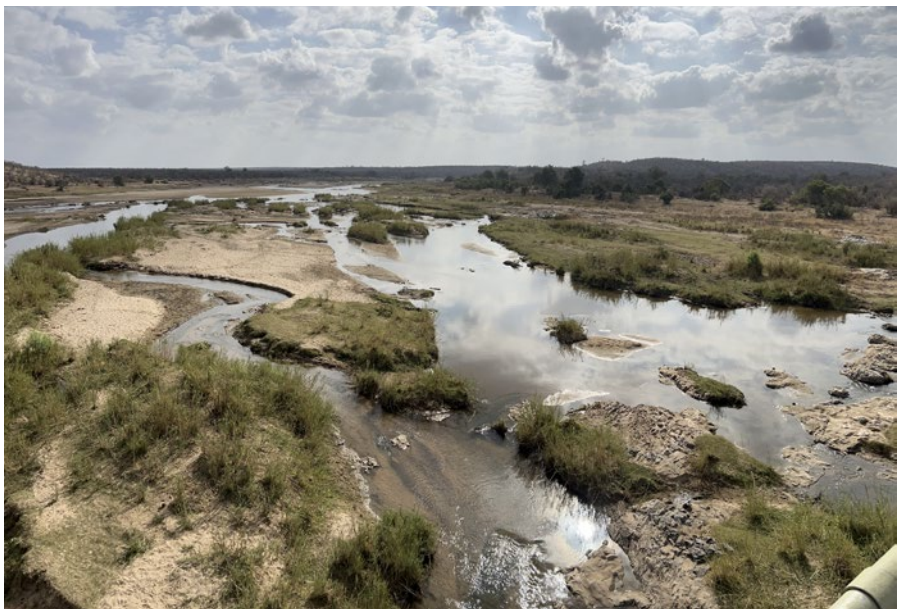
2

As they get washed down the river by water, the rocks collide with each other, rounding the edges of the rocks and generating finer particles like sand at the same time.



3

In the lowlands downstream of the mountains, sediment tends to be small pebbles and sand.



4

Down at the river estuary the sediment is very often fine, sand or silt.

PROBLEMS WITH SEDIMENT

This section aims to deal with some of the problems associated with sediment and its management in rivers.

The most common problem associated with the movement of sediment in rivers is the meandering of rivers. Meandering is the sideways to-and-fro swaying of rivers over time. Although this is a natural process, it is often accelerated because of human interference in the natural river state. The accelerated meandering of rivers can damage infrastructure that has been created along or across rivers, such as urban development, farms, roads and bridges, especially where bridges are narrower than the floodplain.

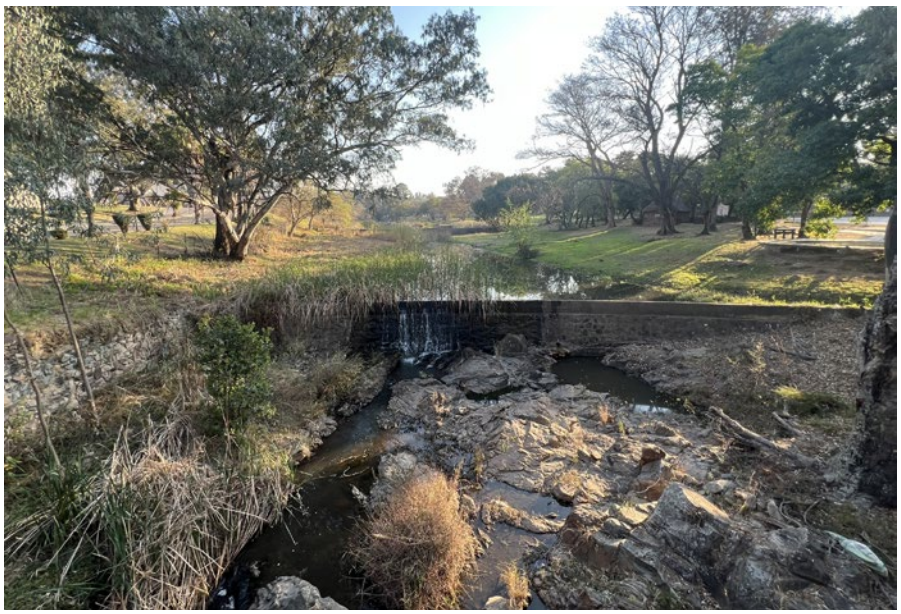
The unnatural blocking of river channels with sediment may lead to flooding of riparian land or developments. It has often been observed that blockage of rivers by sediment has been initiated by the unnatural modification of the river channel upstream. For instance, when a river channel has been deepened to contain the flow of the river in a narrower channel, allowing more space for development on either side , the increased flow velocity due to the change in river cross section at the development may result in an increase in sediment build-up in the channel downstream, where the flow of the water slows down and sediment is deposited.

River channels may become unintentionally blocked as a result of the construction of weirs. Introducing a weir into a river creates a localised flatter slope in the river. This can cause the unnatural deposition of sediment upstream of the weir, which in turn can increase the risk of riparian flooding, and lead to erosion downstream, as the river is now 'sediment hungry'.

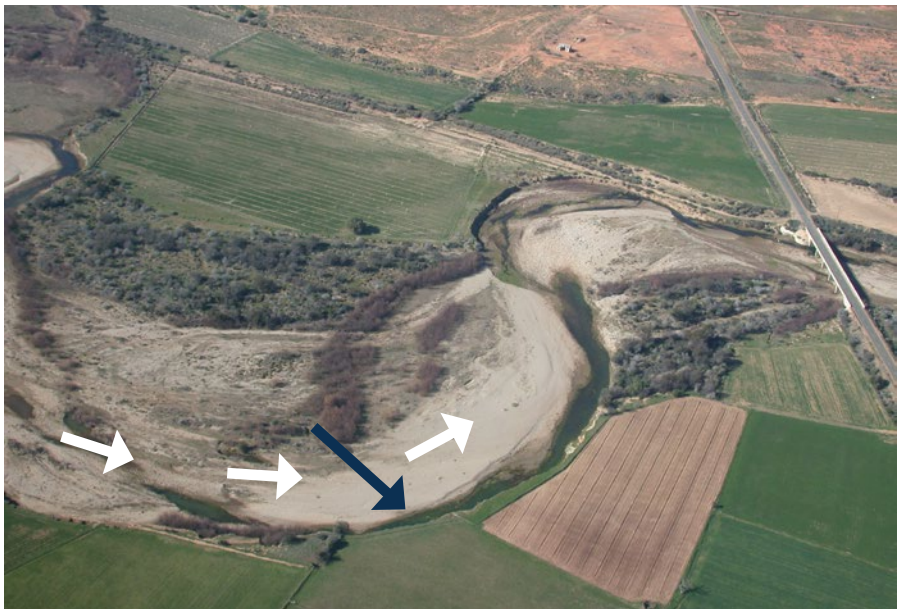
Fine sediment that gets into suspension may impact on the quality of water. This silt could block irrigation filters or make it expensive to purify to drinking water standards.

Problems are not only limited to the deposition of sediment. Large dams interfere with the natural movement of sediment in rivers by trapping sediment. Downstream of the dam, when floods naturally wash sediment away, it is not replaced by sediment from upstream and 'sediment starvation' results. This can cause the river bed level to drop and can result in bank erosion or bridge foundations becoming exposed.

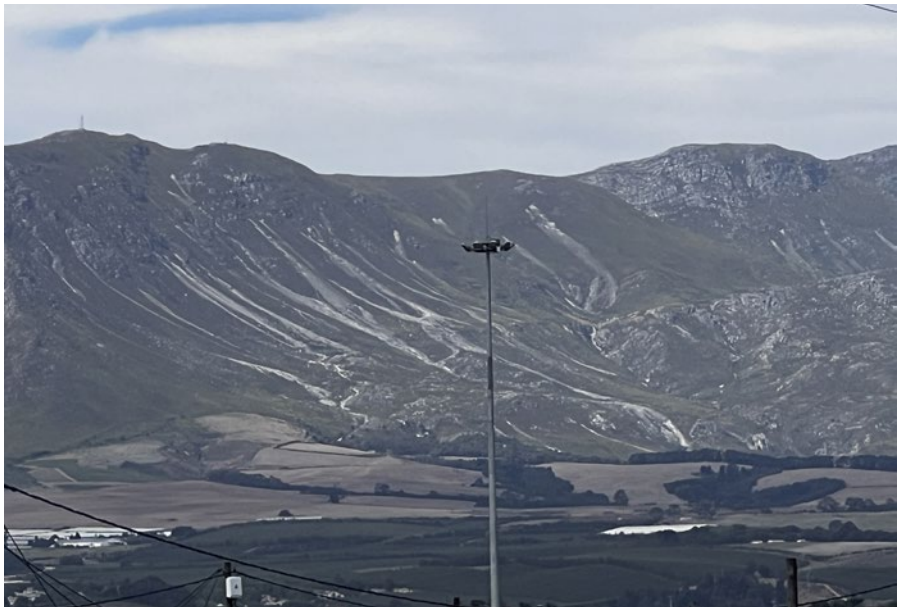
An aerial view of damage to agricultural lands caused by the blocking of a river with sediment in 2013.



As water falls over this weir its kinetic energy increases (i.e. the flow accelerates) such that no sediment can be deposited immediately downstream of the weir.



The meandering of a Karoo river being driven by the deposition of fine silt on the inside of a bend in the river. *© Jan Smit*



In 2023, extremely high intensity rainfall in the Western Cape caused many landslides in the mountains. This exceptional but probably natural event resulted in many rivers being choked with sediment and meandering much more vigorously than usual.

PRINCIPLES AFFECTING SEDIMENTATION

When discussing the behaviour of sediment under the influence of moving water, understanding sediment particle size helps us predict how the sediment will behave.

The role of flow velocity in sediment particle movement

Larger sediment particles require a higher flow velocity to dislodge them from a riverbed than smaller particles.

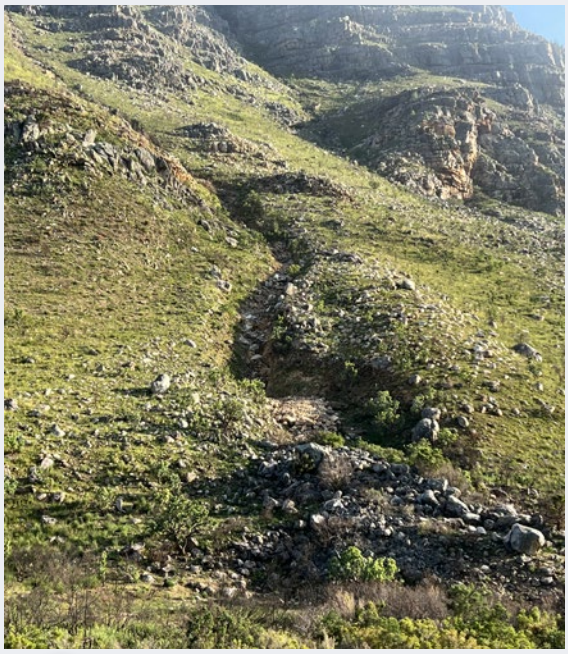
The gradient of a river is generally greatest near its source and progressively flattens as it moves to the sea. The flow velocity of a river is greatly influenced by the slope of the river, so one expects greater flow velocities in the mountains and slower flow velocities towards the sea. This results in mainly coarser sediment being found in the mountainous zone and mainly finer sediment being found towards the sea.

Impacts of local topography on sedimentation

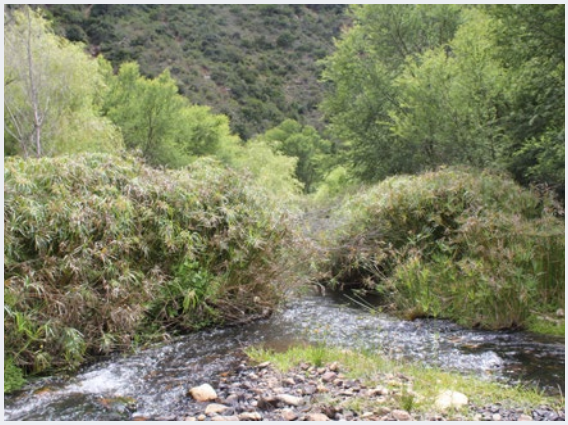
Within a given river reach, the topography causes variations in flow velocity, and these variations change the way sediment settles out.

- On the inside of river bends the flow velocity is usually lower than on the outside of the bend;
- An obstruction in the river can create a localised zone of lower flow velocity downstream;
- A change in river gradient can increase or decrease the rate of sedimentation;
- A sudden widening of the river channel can cause a sudden drop in flow velocity and increase in sedimentation.

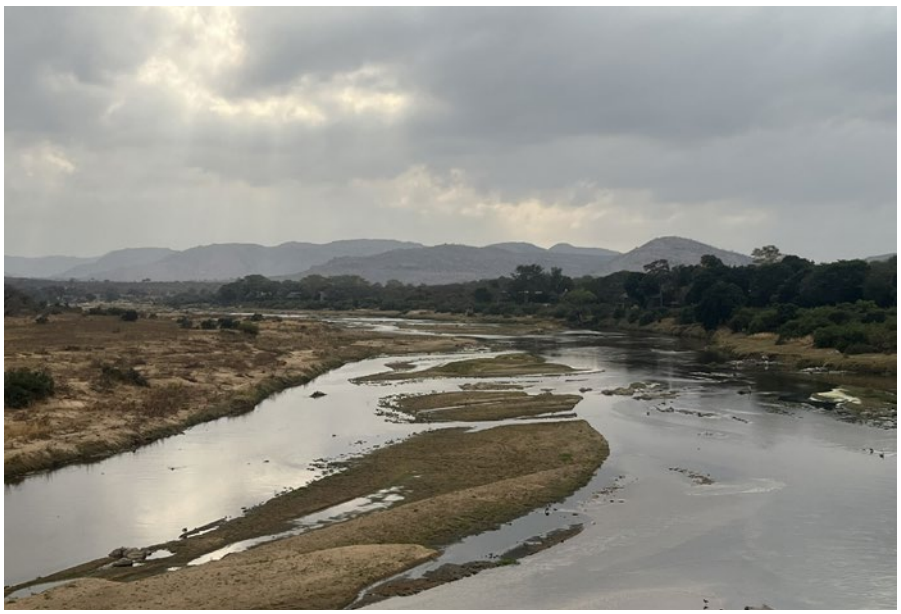
These areas where the rate of sedimentation changes often drive the river meandering process, and/or change the flow level during flooding.



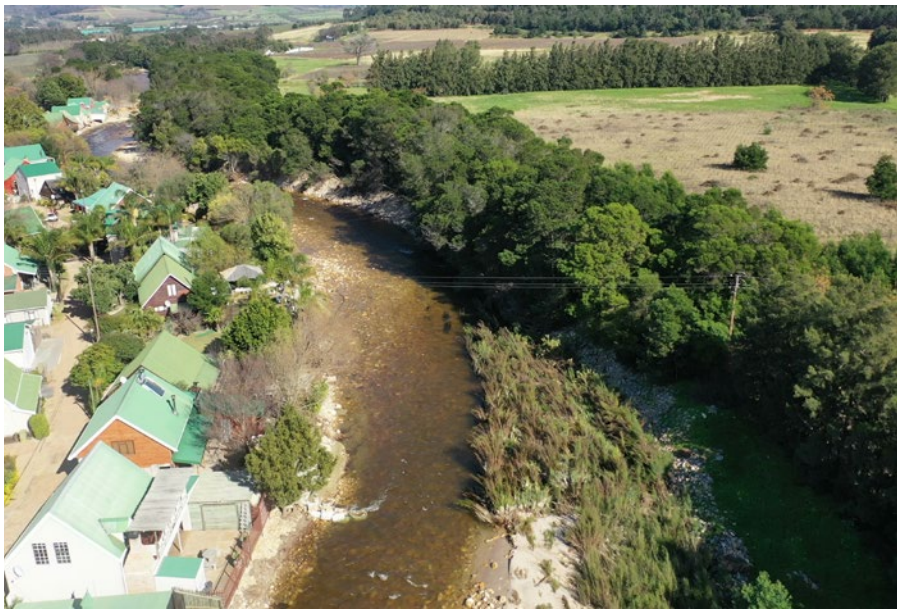
On mountainsides, the river slope is steep, flow velocity high, and large rocks can be moved by the river. As the slope flattens, these rocks get deposited in the stream bed. This is why instream habitats vary with distance downstream through a river. Mountain stream habitats are characterised by boulders; foothills by smaller rocks and sands; lowland rivers are usually muddy or sandy, and may have bedrock in places.



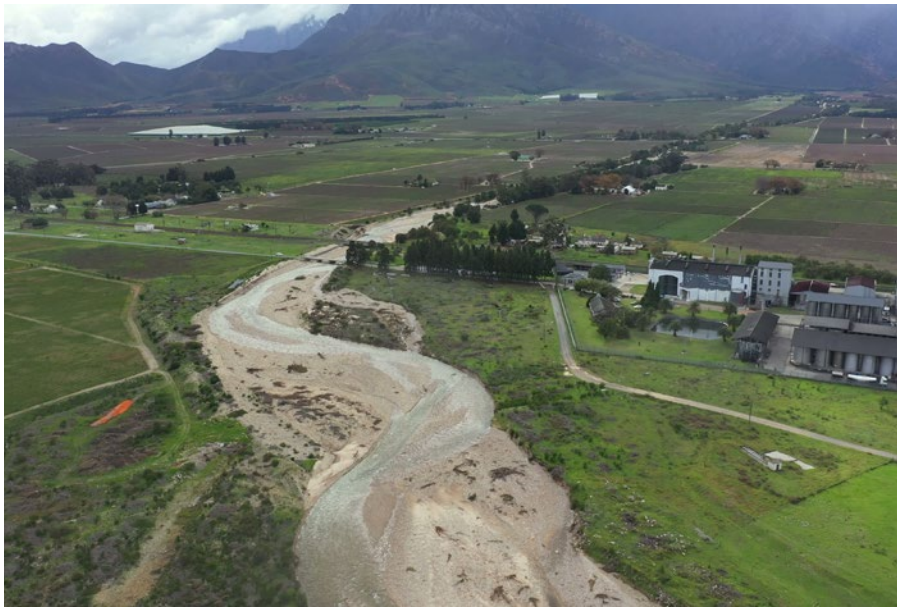
In the intermediate (or foothill) zone, the river slope is flatter. Sediment is a mixture of sand and smaller rocks.



In lowland rivers, closer to the sea, the river slope becomes very flat; flow velocities become very low; and sand can be deposited, often forming bars and islands. These can be vulnerable to invasion by alien vegetation, causing problems under flood conditions.

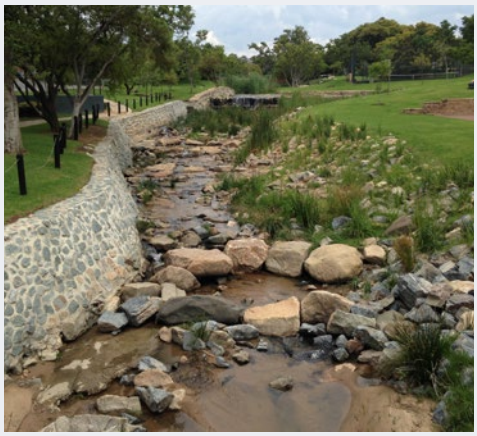


The flow velocity on the inside of a bend in a river is normally less than that on the outside of the bend. This is part of the reason for sediment building up on the inside of the bend and driving the meandering process.

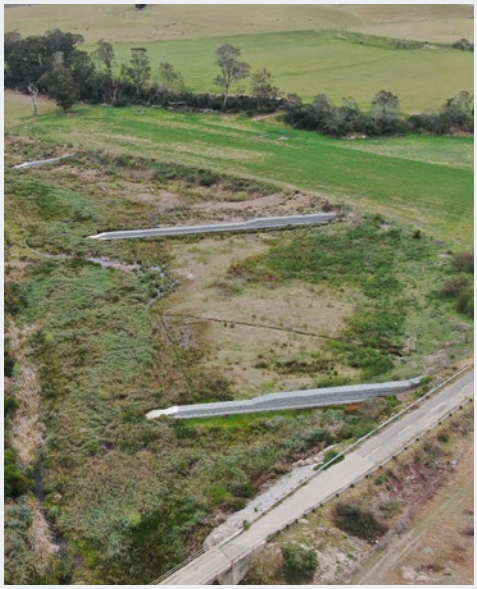


The sudden widening of this river downstream of this bridge slows down the flow velocity and enables the river to suddenly deposit large quantities of sediment. This artificially encourages the meandering of the river and can damage infrastructure.

APPROPRIATE RESPONSES TO SEDIMENT



A 'block ramp', made up of strategically placed large boulders, can reduce flood flow velocities so that sediment does not get washed out of a channel. It also creates more diverse in-stream habitat that can support more macroinvertebrate and plant communities more effectively than an eroding channel or concrete canal. Side slopes can be made as natural as possible, using rocks, topsoil and indigenous vegetation.



'Groyne structures' can be used to manage where a river deposits sediment, and thus train the flow direction of a river.

WHEN ADDRESSING RIVER SILTATION PROBLEMS:

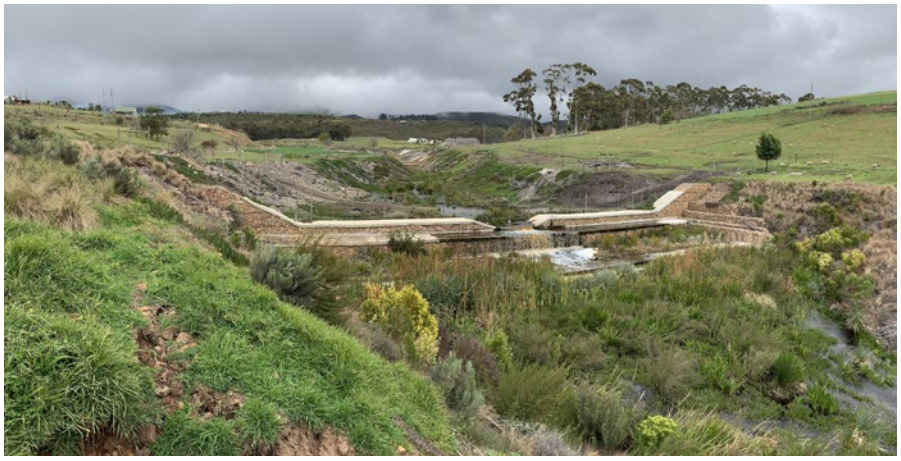
DO

- Accept that rivers naturally carry a measure of sediment. This handbook has no intention of encouraging land users to interfere with what is happening naturally. When human interference in the natural river environment causes abnormal amounts of sediment to start moving (inappropriate river diversions or excavations, infrastructure like bridges, allowing alien vegetation to block rivers etc.), then it is justifiable and necessary to address the unnatural source of sediment moving in the river.
- Seek to understand what is causing the unnatural flow of sediment to move in the river. Addressing this will tend to address the problem at its source and not just the symptom. Naturally this implies that one should start investigating from the top of the catchment and work downstream towards the site in question – historical satellite imagery can be useful in this process.
- Although it is often not practical to try to restore a river to its natural state, it is useful to understand what the natural state was, and try and move closer towards it by means of appropriate interventions. This typically will include getting rid of unnatural blockages and implementing interventions promoting more natural flow velocities.
- When building infrastructure such as bridges across rivers, make sure that the impact on the flow of sediment in the river is minimised. Select wider bridge pier spacing and make sure that the distance between bridge abutments is at least the expected flow width of the river during expected floods.

DO NOT

- Be overly reliant on solving sedimentation problems by regular excavation of the sediment (even if a Maintenance Management Plan or MMP provides for this – **see pages 12 and 13**). Rather seek to address why the sediment is moving. Although mechanical interventions afford short-term relief at a given site, they also loosen sediment, so that it can be washed downstream with the next flood and create problems elsewhere.
- Even if provided for by an MMP, use levees to train the flow of a river in a particular convenient direction. This is very undesirable and should only be resorted to when all other possible solutions have failed. Levees confine flood flows, making localised erosion and downstream sedimentation more likely.
- Have unrealistic expectations – rivers are natural systems and despite our best efforts can be unpredictable.

The levee in the middle of the image has the function of keeping the river away from the railway line. As a temporary measure it is useful but it is unlikely to still be there after the next flood. When it washes away, it will contribute to the sediment load of the river.



A 'cascade of weirs' can artificially alter the slope of a river such that it is non-eroding and that vegetation can be re-established.

Interventions such as culverts and bridges at river crossings are usually planned to anticipate and manage various standardised flood conditions. Sometimes the natural environment produces loading that is not anticipated. For instance, landslides in mountains deposit large volumes of sediment in rivers over a very short time period. It is difficult to make provision for this in designs, and emergency responses are sometimes needed.

SEDIMENT MANAGEMENT AND THE LAW

CAUTION:

At the time this handbook was produced, the threshold for sediment removal, movement or infilling within a watercourse was 10 m^3 in urban areas and 5 m^3 in rural areas. Volumes at or above these thresholds require authorisation in terms of the National Environmental Management Act (NEMA) No. 107 of 1998.

Any interventions that impede or divert flows and/or alter the bed, course or characteristic of a watercourse are 'water uses' and require authorisation in terms of the National Water Act (NWA) No. 36 of 1998.

These constraints should not be taken lightly by landowners. Unlawful exceedance can result in severe fines and/or criminal proceedings.

MAINTENANCE AND MANAGEMENT PLANS

MMPs, once approved, allow for the lawful movement of sediment in quantities that exceed the legislated thresholds. The MMP outlines strict best-practice measures that must be implemented when undertaking sediment movement, to reduce harmful ecological impacts and, where possible, to improve ecological condition. **If these measures are implemented as required**, the landowner may undertake the measures necessary to protect or repair infrastructure that is threatened by sediment issues.

The previous sections have shown how dynamic the movement of sediment through a system can be, and how even small unnatural changes can result in big changes in sediment patterns and river behaviour. They also highlighted some of the problems landowners experience when faced with high sediment loads, which can block culverts and bridges; divert river flows; and lead to riverbank erosion and damage to orchards, crops, infrastructure and settlements.

Given this, it is clear that at times, landowners may need to move sediment (or construct sediment management structures), to prevent such damage or to relieve situations, often after major floods, when sedimentation has caused and is causing damage or threatening livelihoods. Uncontrolled and unnatural sedimentation also threatens riverine ecosystems.

It is however very important to understand that South Africa's legislation has very strict controls over the movement of sediment within watercourses. This is because poorly considered sediment removal may have multiple knock-on effects that worsen overall conditions and risks.

The law

Depositing, excavating or moving sediment in a river, including its floodplain (i.e. a watercourse) requires authorisation from the Department of Water and Sanitation (DWS) as well as (subject to certain thresholds) the Department of Forestry, Fisheries and the Environment (DFFE). Depending on the location and/or scale of the project, national or regional departments would need to be consulted, and authorisations in terms of the National Environmental Management Act (NEMA) (Act 107 of 1998) and the National Water Act (NWA) (Act 36 of 1998) would need to be sought.

Note that different legislation governs the management of trans-boundary rivers, such as the Orange and Limpopo Rivers, and should also be considered.

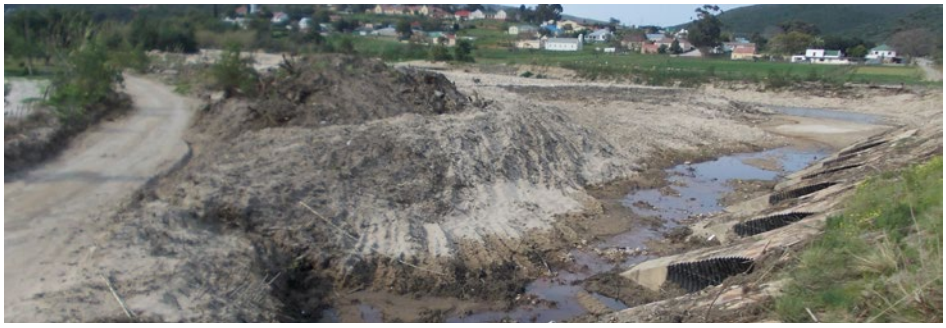
How to respond legally to sediment problems?

1. Understand the law;
2. Understand where the watercourse boundaries are;
3. Get appropriate advice from a specialist before commencing with sediment movement in a watercourse;
4. Have an aquatic ecologist compile a **Maintenance and Management Plan (MMP)** to cover the routine activities that you need to perform – for example, clearing sediment from sumps and dams; clearing culverts; opening up blocked channels;
5. Consult an Aquatic Ecologist, Environmental Assessment Practitioner (EAP), your local DWS office and/or your local Department of Environment officals, to get guidance on how to obtain a water use authorisation and/or environmental authorisation. Obtain the required authorisations prior to undertaking the planned activities.

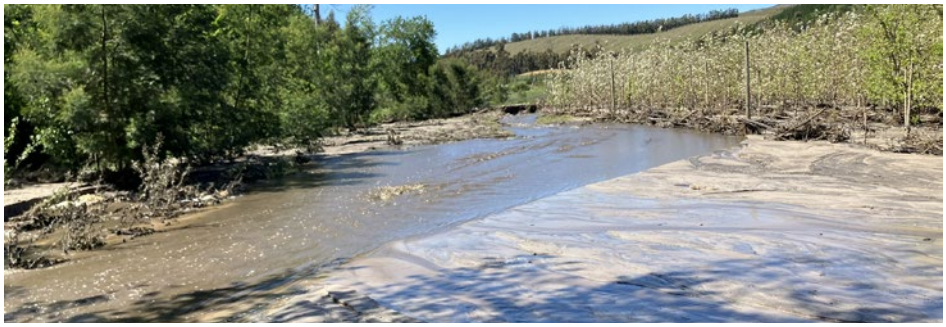
REMEMBER:

Wetlands and dams are (even if they only have water in them for part of the year) are governed by the same legislation as rivers (they are all watercourses), and the 'extent of a watercourse' includes the river and its floodplain up to the 1:100 year mark !!!

Bulldozing sediment to clear channels requires authorisation – but is in any case highly undesirable as it creates fast-flowing channels without vegetation to slow down floods.



Sediment build-up upstream of an inappropriately designed bridge (with many small openings), requiring clearing.



River flow diverted through orchards as a result of flood-driven sediment movement.

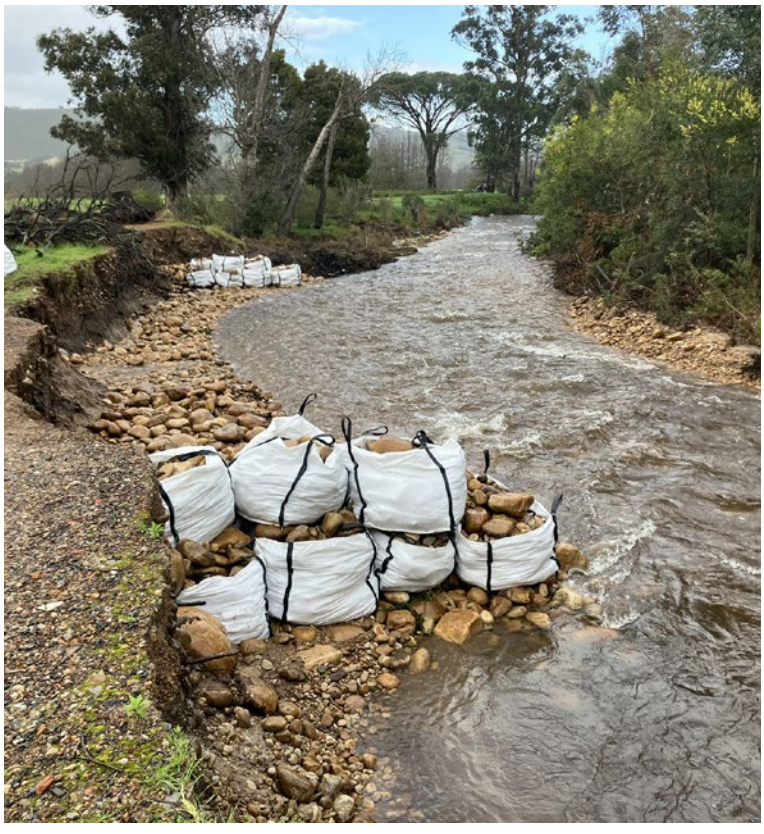
Irrigation sumps such as this need periodic clearing of sediment, especially after floods. An MMP is usually needed for this to be legal, unless very small volumes are involved (< 5 m^3 in rural areas), and even then, registration of the water "use" is needed.

EMERGENCY MEASURES

When life happens and big floods or other unforeseen events result in major changes to watercourses (e.g. large-scale erosion in some areas, downstream sedimentation and sometimes associated channel diversion, South Africa's laws do make provision for landowners to take emergency measures. However, it must be clear that there is indeed an emergency and that lives, infrastructure or the environment is threatened **(see box below)**.

Section 30A of the NEMA makes provision for emergency interventions without having to go through lengthy authorisation processes, as does Government Notice (GN) 4167 of 2023, which allows for activities that alter the bed, course and characteristics of a warercourses and/or diversions or impediments to flows, in order to address emergency conditions.

Making use of these emergency measures does require urgent communication with DWS and DFFE officials (as the law provides only for a very brief window of time post the emergency event for such emergency applications) and also still requires that best practice and least-environmentally damaging measures are undertaken.



Temporary 'groynes' constructed from block bags under emergency legislation to address bank erosion after major floods. More permanent approaches would be required going forwards, and would also require authorisation.

IMPORTANT DEFINITIONS

GN 4167 of 2023 includes the following definitions:

- **'Emergency incident'** means an unexpected, sudden and uncontrolled incident or accident in which a substance or activity:
  a) pollutes or has the potential to pollute a water resource, or
  b) has caused, or is likely to have, a detrimental effect on a water resource.
- **'Emergency situation'** means a situation that has arisen suddenly that poses an eminent and serious threat to the water resource, human life or property, including a disaster as defined in section 1 of the Disaster Management Act, 57 of 2002;

NOTE: The above was relevant at the time that this handbook was produced – new definitions and thresholds may however be introduced and landowners should always check in with local authorities before commencing with any potentially illegal activity that may attract large fines or criminal prosecution.

ACRONYMS

DFFE	Department of Forestry, Fisheries and the Environment
DWS	Department of Water and Sanitations
GN	Government Notice
MMP	Maintenance and Management Plan
NEMA	National Environmental Management Act (Act 107 of 1998)
NWA	National Water Act (Act 36 of 1998)
WULA	Water Use Licence Application

FURTHER READING

WRC River Rehabilitation Manual	Volume 1 Chapter 2 (how rivers work)
	Volume 1 Chapter 3.5 (sediment problems)
	Volume 1 Chapter 8 (legal)
	Volume 2 Chapter 2 (managing invasive alien plants)
	Volume 2 Chapter 6 (managing sediment)

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.

PHOTO CREDITS:
Cover Images:

All photographs by Liz Day, Hans King, and Mandy Uys, unless otherwise credited.

DESIGN AND LAYOUT: Ink Design Publishing Solutions, Cape Town, **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

WATER RESEARCH COMMISSION

SP 191/26