Freshwater ecosystems

New tools developed to help restore our rivers

The Water Research Commission (WRC) has funded the development of a comprehensive River Rehabilitation Manual to enable more effective protection and management of watercourses.
Article by Sue Matthews.

A rehabilitation project to arrest headcut erosion in the Elandskloof River involves the construction of five gabion weirs, together with landscaping and re-vegetation of the gulley sides.

It began as a short, two-metre-deep erosion gulley in the rivercourse, after a small dam for watering horses was washed away during a flood in 2003. By 2015, the gulley had extended almost a kilometre upstream and deepened to 13 m in places, destroying a stretch of palmiet wetland up to 600 m long and 100 m wide. The sediment washed away had smothered another section of the wetland downstream and created temporary islands that diverted flow into the river bank, causing further erosion and threatening the adjacent farmland.

This disturbing account is one of 24 case studies included in the River Rehabilitation Manual, the final output of a WRC-funded project to develop national guidelines for river rehabilitation. The Manual is made up of three separate volumes, comprising the Guidelines themselves, a Technical Manual and the Case Studies. Most of the case studies are of sites in the Western Cape, reflecting the home base of the project team members – Liz Day of the Freshwater Consulting Group, Hans King of the provincial Department of Agriculture and Mark Rountree of Fluvius Environmental Consultants – but the problems, rehabilitation objectives and lessons learned are relevant countrywide.

In the case study above, dealing with headcut erosion in the Elandskloof River between Caledon and Hermanus, the main lesson learned is that action should have been taken as soon as the damage became apparent. The provincial Department of Agriculture considered undertaking rehabilitation work in 2004, but this was conditional upon the then landowner removing alien vegetation from the river banks so that indigenous wetland plants could re-establish. Since an agreement could not be reached, the department spent the limited funds it had available for such work in other areas.

A decade later, the situation had reached crisis proportions and the rehabilitation work required was considerably more expensive. Fortunately, the department was able to use national disaster relief funding allocated for a flood-aid scheme to construct five gabion weirs in the gulley, with the aim of halting the erosion and stabilising the river downstream. However, the project was frustratingly delayed while the necessary environmental authorisations and water licences were obtained, highlighting the need to fast-track these applications so that degradation of irreplaceable resources can be contained.

Options for addressing headcut erosion are discussed in detail in a chapter of the Technical Manual entitled 'Managing river downcutting (incision) and gulleys'. Likewise, a chapter on managing lateral erosion of river banks provides a comprehensive overview of indirect interventions – such as protecting the banks by using groynes to redirect water flow – and direct interventions in the form of bank reshaping or stabilisation.

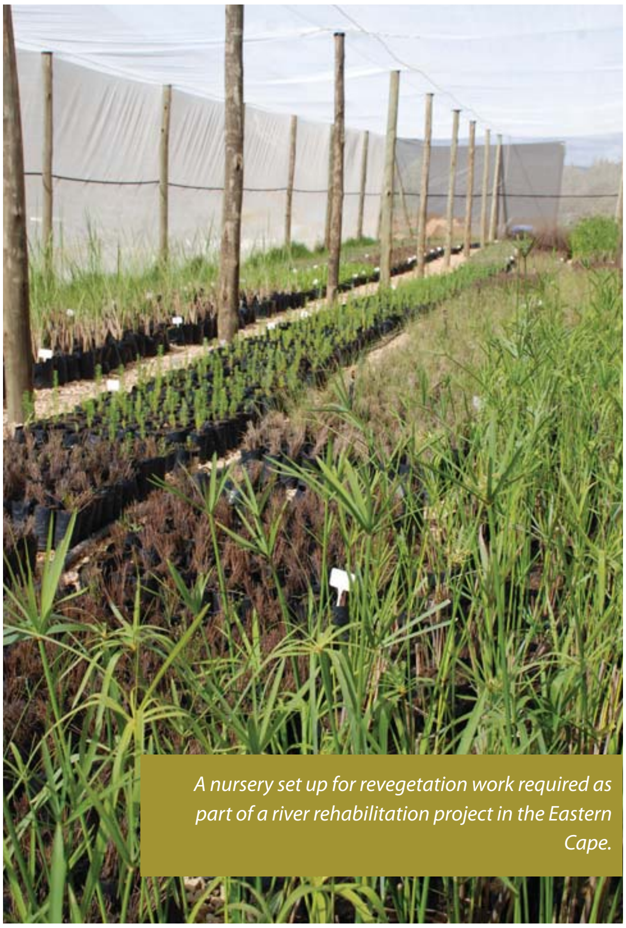
While bank reshaping involves landscaping combined with revegetation and/or erosion control mats, bank stabilisation options include concrete grass blocks, flexible armouring, riprap or retaining walls. The chapter covers various options for retaining walls, from rock-filled gabion baskets and Loffelstein blocks to the considerably less effective and less desirable use of materials such as tree stumps and tyres. The advantages and disadvantages are listed for each option, and there is a summary table rating them in terms of cost, ecological benefits, legal authorisations, technical limitations and cautions.

Generally, informal structures and 'soft' or 'greening' options involving revegetation, either on its own or in combination with geotextile mats or groynes, are only suitable for addressing small eroding areas in low-energy rivers and where failure would have limited consequences. With increasing risk, flood volumes and flow velocities, 'hard' engineered solutions need to be considered.

"When I first started out in river rehabilitation work more than 20 years ago, I naively thought we could green everything if we just planted it properly," says Liz Day. "But there are times when we need significant engineering intervention if the greener options are going to have any chance of success. The hard options can stabilise the bank to the point that we can start working on habitat quality and the softer aspects."

She points out, however, that hard options are only as good as their design, and there are plenty of examples of massive structural failure, as well as unforeseen impacts such as accelerated incision downstream due to sediment starvation.

By the same token, efforts to 'soften' hard structures – for instance, opening up a section of canal to landscape the banks and create wetland habitat – can also backfire. The case studies include examples from urban areas that have become degraded through neglect, vandalism, littering, eutrophication and alien plant invasion. While the intention may have been to provide



A nursery set up for revegetation work required as part of a river rehabilitation project in the Eastern Cape.

Credit: Sue Matthews

'green open spaces' with conservation and amenity value, changes at the site over time may not be appreciated by the local community.

Dense reedbeds are often viewed as a threat to safety and security because they pose a fire hazard and can shelter criminals, plus the large quantities of pollen and fine seed they release can be a nuisance and a hayfever trigger. And then there's the croaking frogs and the whining mosquitoes, which often preclude a good night's sleep!

"We need to think more carefully about how to integrate people into natural systems," says Day. "If not enough space is left between people and riverine or wetland systems, it's not great for the system – and it's not great for the people who live there either!"

Even in rural areas, the lack of an adequate buffer zone between rivers and human activities is detrimental to both, and is often the main driver of rehabilitation projects. This is well illustrated by a case study on the middle reaches of the Buffeljags River near Swellendam.

Historically, the river flowed as a braided system over a broad floodplain up to two kilometres wide, but agricultural development has since confined the river to a channel as narrow as 20 m. The resultant increase in flow velocities during floods, combined with deliberate removal of indigenous plants and invasion by black wattle, has had the effect of accelerating erosion.

At the site in question, rapid erosion of the outer bank at a river bend was threatening to cause financially crippling losses of orchards planted rather too close to the bank. It was also contributing significantly to the river's increased sediment load, which would encourage meandering of the watercourse, placing farmers downstream at risk.

The Western Cape Department of Agriculture therefore implemented rehabilitation works in 2012, when four groynes constructed of rock-filled gabions were built along the bend to deflect the water away from the outer bank and create a protected zone for revegetation. The structures performed well during subsequent flood events, and the river channel has been successfully re-aligned.

"Certainly it would be better for the resilience of the system if the farmlands were pulled back, but most of the floodplain has been taken over by crops and that inevitably degrades the system," says Day. "Structures like groynes, to my way of thinking, are really a last resort in a system where we accept that the river needs to be permanently managed in an altered state. They allow us to prevent further degradation, make the best of what we've got, and start establishing a new level of ecosystem function."

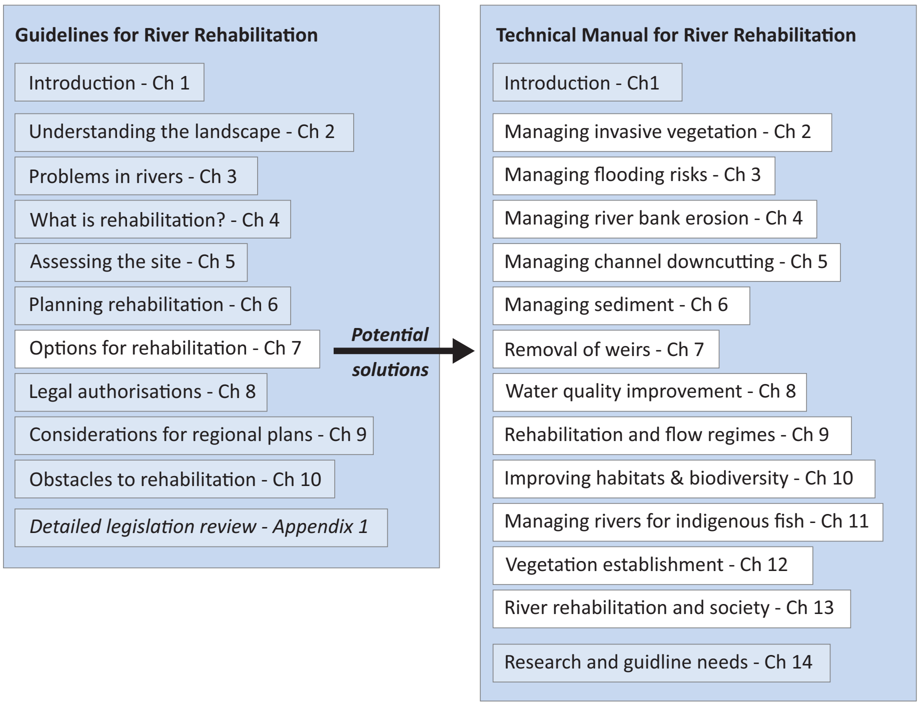
Clearly, it is important to differentiate between changes caused by normal, natural processes of erosion, deposition and vegetation succession resulting from floods or landslips and subsequent recovery, versus lasting or ongoing damage that warrants rehabilitation. The Guidelines therefore recommend using historical records – such as anecdotal evidence, old maps, aerial photographs, Google Earth imagery and data from flow gauges and water quality monitoring – to develop an understanding of the natural condition and dynamics of the river reach before planning a rehabilitation effort or deciding on its objectives.

Of course, bridges, weirs and dams in the watercourse, adjacent land-use practices as well as catchment-wide changes have impacts in terms of erosion, sediment load, flow regimes or water quality that are usually beyond the control of individual landowners downstream.

Invasion by alien vegetation is a particularly widespread problem, with a range of insidious effects, and the topic is comprehensively addressed in all three volumes of the River Rehabilitation Manual. The authors point out, however, that in some cases alien-clearing results in more severe and longer-lasting negative impacts on riverine ecosystems than the invasive vegetation itself.

Rehabilitation does not need to result in restoration of a system to its natural state. Such an objective is often neither achievable nor even desirable in some contexts. Rehabilitation can simply be about improving some aspect of river function or condition to a more sustainable and/or more natural state.

The progression of erosion on a bend in the Buffeljags River and subsequent recovery after groyne construction in 2012. From left to right: 2004, 2011 and 2016.



Alien trees that have been felled but left in the watercourse can be washed downriver during floods, leading to blockages that damage infrastructure and increase bank erosion and riverbed scour. In addition, large areas of denuded land following alien-clearing are prone to erosion, increasing the sediment loads of adjacent rivers.

Planting cleared areas with indigenous vegetation is one means of addressing the latter, and since it is also an important part of many other rehabilitation initiatives, the chapter on vegetation establishment in the Technical Manual was contributed by landscape architect Megan Anderson, who also provided many of the illustrations.

But the authors note in their recommendations for further research that more work is needed before quantitative guidelines on using plants in river rehabilitation can be compiled.

"We've got very little data to back up how far we can go in using plants as erosion stabilisers," notes Day. "For engineering interventions there's quite a lot of data about velocities and roughness coefficients, and how hard options should be designed accordingly, but when you're talking about using root structures in soils, for example, we just don't have enough data to be able to sign off with confidence that in any particular scenario, planting with species x, y and z will be adequate."

During the course of the project, a first step towards quantifying conditions for using vegetation for erosion control was provided by Prof Chris James and an MSc student, Megan van der Haar, of the Witwatersrand University's School of Civil and Environmental Engineering. They developed guidelines for using plant roots to control slip failure on river banks, but these relied on functional trait classes developed for Northern Hemisphere conditions and plant species, so adaptation to South Africa was at a relatively low confidence level.

Prof James co-authored a number of chapters in the Technical Manual, while freshwater fish specialists Bruce Paxton and Dean Impson contributed the chapter about managing rivers and dams for freshwater fish. A detailed overview of legislation applicable to river and wetland rehabilitation activities was compiled by Samantha Braid and Clarissa Molteno, with the recommendation that the provincial environmental authority and regional catchment authority be contacted prior to undertaking any rehabilitation activities, to ensure that the most up to date requirements are adhered to.

Braid was the author of an earlier guideline entitled *Tools to determine enforcement-driven rehabilitation objectives on urban river reaches*, published by the WRC in 2014. That guideline focused specifically on enforced rehabilitation, when a regulatory body issues an Administrative Notice – such as a directive, compliance notice or court order – instructing a perpetrator to rehabilitate a river reach to remedy an illegal or non-compliant activity and the resulting disturbance.

The WRC Research Manager for both projects, Bonani Madikizela, notes that there are also commonalities with earlier WRC-funded research projects to develop guidelines on water sensitive urban design and the implementation of sustainable drainage systems, or SuDS, for stormwater management. Many of our urban rivers are little more than stormwater conduits, and the River Rehabilitation Manual includes case studies on efforts to improve their water quantity management, water quality treatment, amenity value and biodiversity.

In its latest open call for proposals, the WRC has budgeted R900 000 for the 2017/18 financial year for the thrust 'Ecosystem rehabilitation, remediation and restoration', which falls under KSA 2: Water-linked Ecosystems. The River Rehabilitation Manual is sure to prove an informative reference for future researchers, as well as a vital resource for anybody planning to implement a rehabilitation project.