

LET'S FIX OUR RIVERS!

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

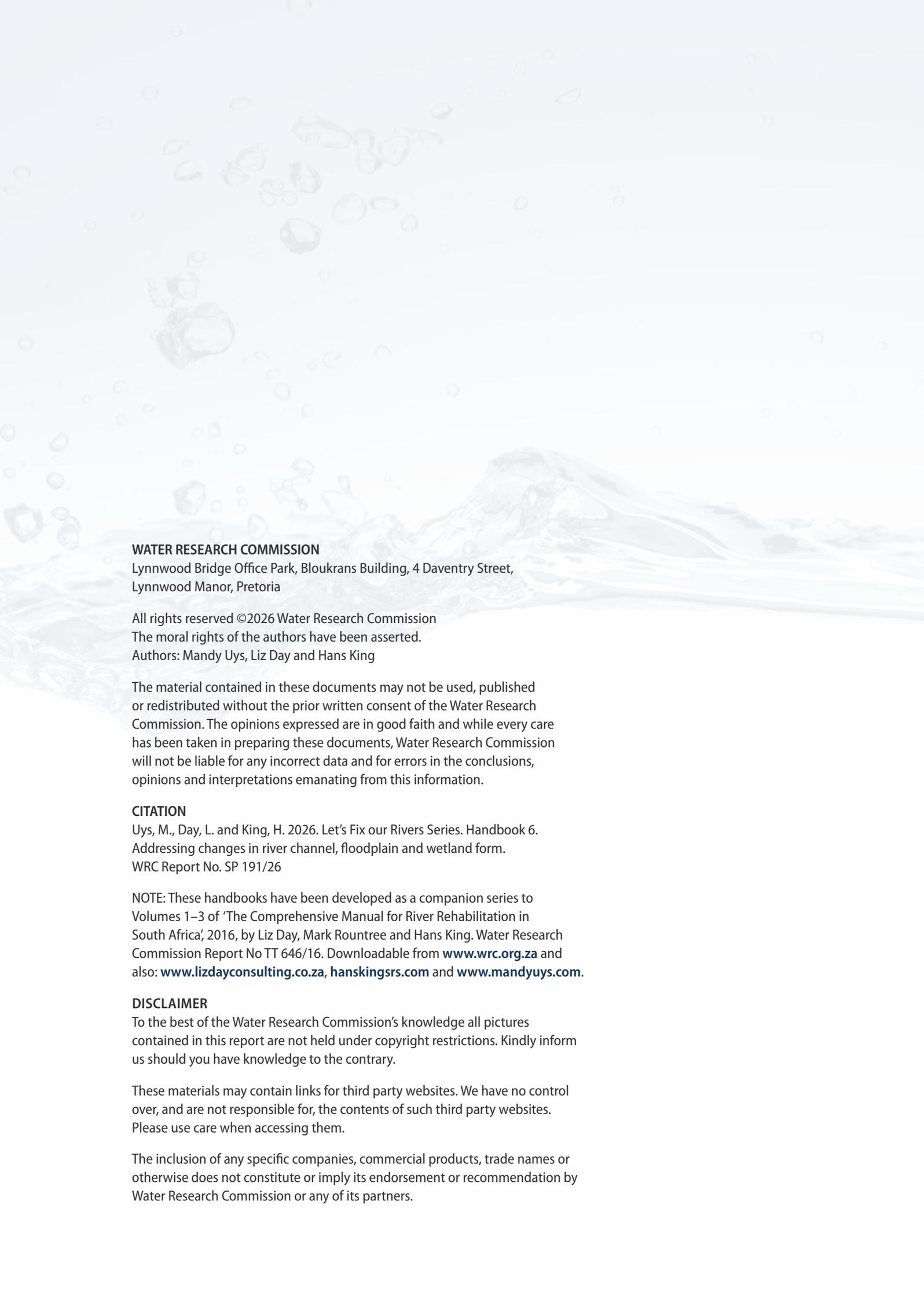


HANDBOOK

06

ADDRESSING CHANGES IN RIVER CHANNEL, FLOODPLAIN AND WETLAND FORM

Mandy Uys, Liz Day and Hans King

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 sense of dynamic motion.

WATER RESEARCH COMMISSION

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This handbook aims to give guidance on some of the problems associated with changing the natural form and pattern of river floodplains and channels; how and why such changes have taken place; and how they can be redressed or mitigated.



The meanders of the lower zone of the Great Kei River, Eastern Cape.
Source: Wikimedia Commons



The lower Limpopo River floodplain a week after major floods. Note the deposition on the point bars.
Source: Wikimedia Commons



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THE RIVER CHANNEL

All river rehabilitation relies on understanding the type of river catchment, where in the catchment you are working, and the natural (and altered) character of the river channel, banks, riparian area and floodplain. Interventions that affect any of these elements should only be done with specialist advice.

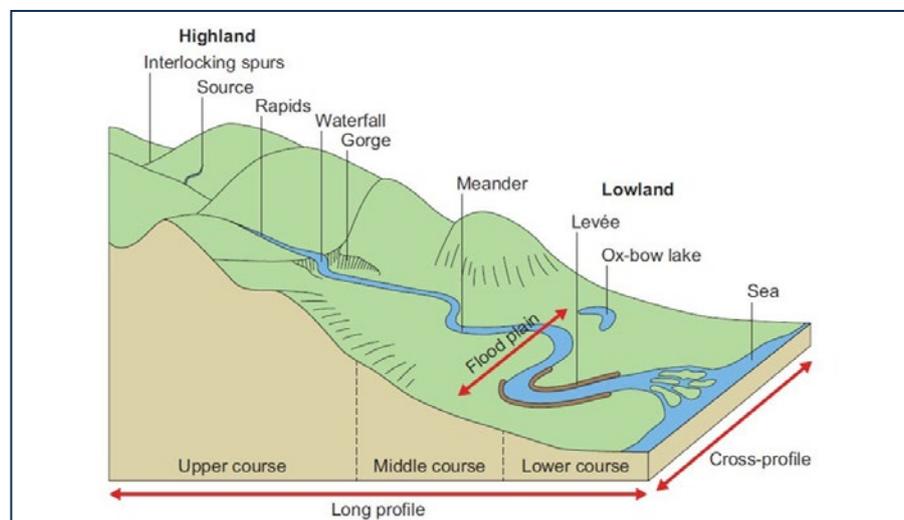
Rivers transport water and sediment from source to mouth and acquire and deposit sediments all along the way. The character of the channel also changes with distance from the source. It is usually described in terms of its gradient, width and depth, bed material, valley shape, and characteristic features (or 'morphology') such as riffles, rapids, runs and pools. Typically, rehabilitation is planned at the scale of the river reach (a section of river up to a few hundred metres long, in which river character and form don't change).

What type of channel is it?

There are two main channel types. Bedrock channels have a bed made up largely of sheet rock, usually overlain with boulders and cobbles. Features include waterfalls, cascades, rapids and plunge pools. *Alluvial channels* are dominated by sediments including boulders, cobbles, gravel and sand. They are associated with lowland rivers, and are characterised meandering and braided features. Riffle-pool and riffle-run type features occur in both or mixed channel types.

What is the channel form and pattern?

The 'long profile' of a river is a side view of the river that shows its height and gradient at different points along its length. It helps us to understand how the river behaves and interacts with the landscape; where it is eroding and depositing sediment; and where flood hazards may be. The long profile of 'rejuvenated' South African rivers, where channel gradient increases suddenly, differ from the classic long profiles of many rivers elsewhere, as a result of geological uplift and tilting about 4 million years ago, and a fall in sea level in successive ice ages.

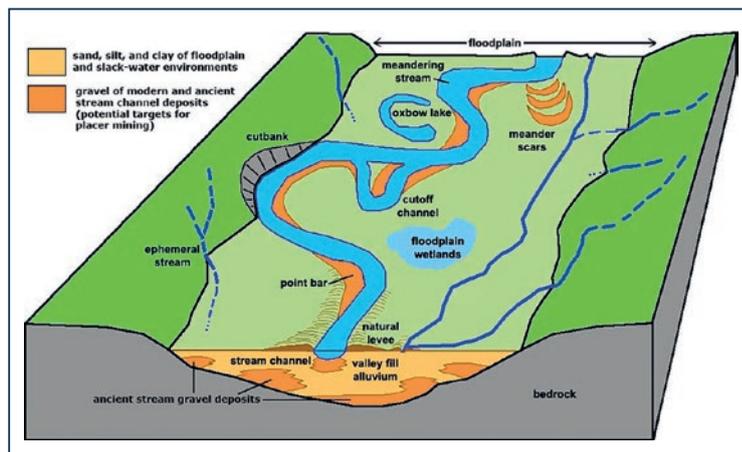


Upper, middle and lower river zone characteristics in a non-rejuvenated river
(Source: geographical.co.uk)

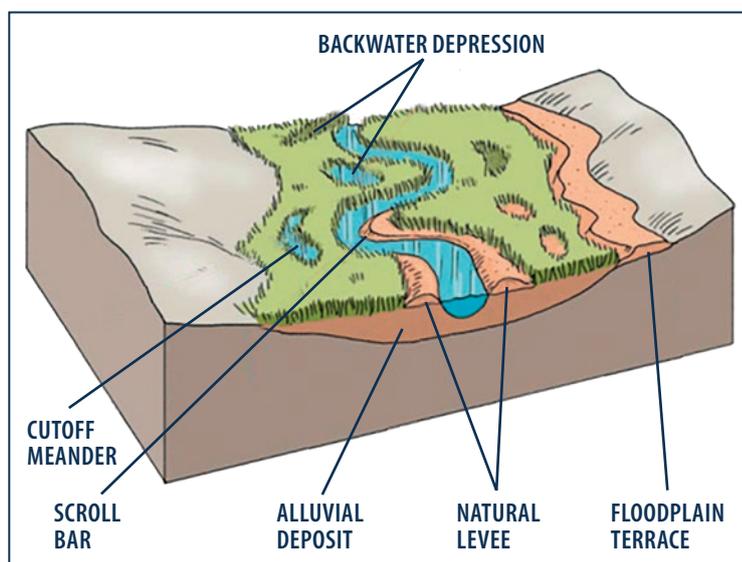
How does channel form change through river zones?

The source of a river is typically in flat, spongy or peaty soils at the top of a mountain. In the mountain headwater and stream zones, the channel gradient is steep and bed material is bedrock, boulders, and cobbles, with waterfalls, plunge pools, cascades and step-pools. The valley sides are typically steep and V-shaped. In the middle or foothill zones, the valley sides and channel gradient are less steep; bed material tends to be cobble and bedrock; and a narrow floodplain of sand, cobble or gravel may be present. In the middle and lower zones (in non-rejuvenated rivers), the channel can become wider, flatter in gradient, and alluvial. There may be one or more of these channel forms present: straight, meandering, braided or anastomosing (see **graphic bottom right**). Straight channels occur in flat, low-energy lowland systems. Meandering channels wind back and forth through the middle and lower river zones, and in the lowlands have a distinct wide floodplain (e.g. lower Limpopo River). The bends and curves are formed by the erosive power of the river on the outer banks and the deposition of sediment on the inner banks. When a meander is cut off, a free-standing oxbow lake is formed (see **graphic top right**). Braided channels tend to form in rivers with steeper slopes, highly variable discharge, easily erodible banks, and/or a high sediment load. They are characterised by a series of randomly interweaving and continually shifting channels, between temporary islands of coarse sediment. Anabranching or anastomosing rivers have multiple channels with relatively permanent, vegetated islands between them.

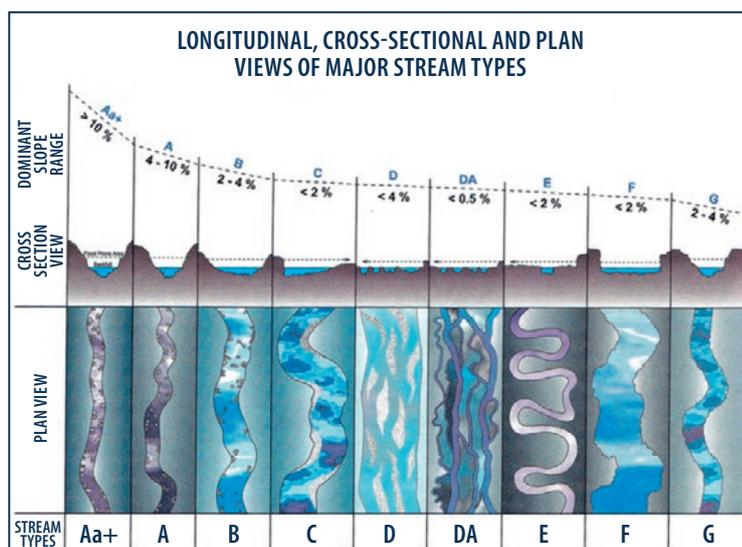
Rejuvenated rivers, in contrast, have steep upper sections and steep, gorged middle and lower sections. Bed material is bedrock, boulders and cobbles, and features include waterfalls, cascades, and pool-rapid sequences. Well-known rejuvenated river valleys occur along the Thugela, Mngeni and Mzimkhulu Rivers (Kwazulu-Natal), Storms River (Western Cape) and the Kei, Great Fish, and Baviaanskloof Rivers (Eastern Cape).



A graphic showing a classical meandering river within a floodplain, with the many features which form floodplain wetlands when inundated (Source: *gotbooks.miracosta.edu*).



Features of a floodplain (Job et al. (2018)).



Different channel forms occur in different rivers and river zones. (Source: *Rosgen and Silvey 1996*).



“Much of the focus of urban river management is on flood management. As a result, the vitally important role that floods play in the ecosystem has often been reduced or lost. Rehabilitation measures attempt to reinstate some of this functionality.”

– Mr Folotia, Mondo Farms



Flooded Eerste River floodplain, Cape Town



Bushmans River estuary floodplain, Eastern Cape

WHERE DO THE FLOODS GO?

The flooding area of a river changes in character and width from the source to the mouth of a river. In the upper and middle zones (steep to moderate valley sides), when floodwaters overtop the channel, they rise through and sometimes beyond the riparian zone. In the lower river zone, floodwaters spread out widely beyond the riparian area and onto the floodplain.

Riparian Areas

The riparian zone lies adjacent to the river channel and is characterised by flooding, wetting or a high water table, which is frequent enough to sustain vegetation that is different to that of surrounding terrestrial areas. Riparian plants have varying degrees of reliance on water. The vegetation changes in character with distance from the river's edge: the lower zone is inundated most years, and the higher zone inundated less frequently. The riparian area plays many important roles during floods, including retarding flow; regulating water quality by filtration; and providing habitat and a corridor for animals and plant seeds.

Floodplains

A typical floodplain is the flat land adjacent to the channel in the middle to lower reaches of the river, stretching from the river banks to the edge of the valley. Floodplains are depositional features formed by meandering, alluvial rivers.

Under natural conditions, the floodplain is inundated with water several times a year, during moderate flow events. During the flood, sediments are scoured from the river bed. As the flood waters spread out, they deposit layers of sediments or nutrient-rich alluvium, which sustain natural floodplain vegetation. The flooded area also provides a temporary habitat for biota including fish and water birds. Some floodplain wetlands are recognised as Important Bird and Biodiversity Areas (IBAs) (of international importance). The fertile floodplain soil is sought after for agriculture, and worldwide, large floodplains are colonised and used for sustainable agriculture, grazing and fishing by local communities.



Construction of bridges, factories and buildings on the lower Baakens River floodplain



The damage caused to the Baakens River floodplain, and infrastructure, inundated after floods.

Floodplain Wetlands

Floodplain wetlands are wetland areas on the floodplain adjacent to an alluvial river channel. They are typically formed as a result of river depositional processes, and include natural levees and oxbow lakes (see graphic). These systems are regularly inundated for extended periods when the channel is overtopped. They play a vital role in the flooding process, as they slow and detain flood waters, thus attenuating flood-peaks; enabling floodplain and vegetation recharge; filtering sediments from the water; and providing important habitats. Some of the water entering the wetlands filters back to the river channel as diffuse flow.

Flooding

Floods are naturally occurring events and a range of floods is important for river ecosystems. Large floods are responsible for channel formation, while smaller floods control and maintain instream and riparian habitats and biota. The very large or extreme (1:50 to 1:100 year return interval) floods are responsible for the very important function of scouring sediment and vegetation from the channels and redistributing that sediment through that section of the river (or reach). Infrequent moderate and large floods can be expected to overtop the river channel and inundate the floodplain (SEE HANDBOOK 2).

Floodlines

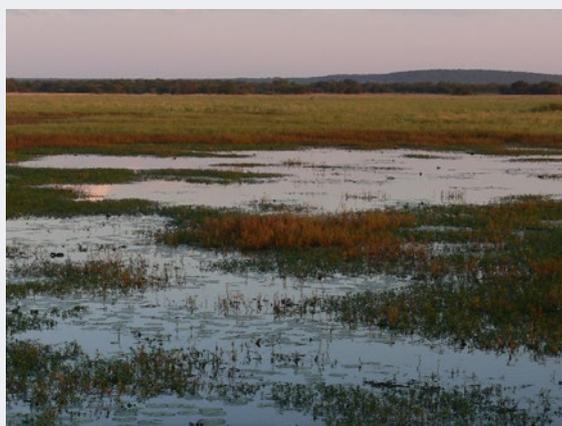
A floodline is an imaginary line drawn on a plan-view diagram of a river, indicating the likely outer edge of the water during a flood of a particular (average) recurrence interval. The most commonly depicted are the 1:10, 1:20, 1:50 and 1:100 year floodlines. A 1:100 year flood has a 1% chance of occurring in any given year (SEE HANDBOOK 2). These will be shown as separate lines, at an increasing distance from the channel (see graphic). Floodlines are generally drawn up by hydrologists or engineers, using relevant computer models which take into account rainfall, soils, vegetation, river conditions and river flows. They are required for any developments or human-induced changes of any kind, close to a river, in order to highlight and mitigate risk. Most South African municipalities have policies or by-laws controlling activities below the 1:50 or 1: 100 year floodline (see Legal Aspects page 18).



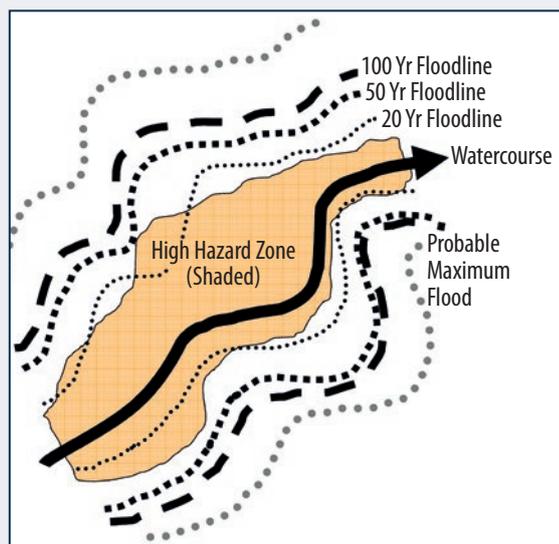
NOTE: In rehabilitation projects, ensure you know the date that your floodlines were modelled. Those older than 5 years may need to be revised to take account of predicted alterations in rainfall, runoff and flow regimes associated with catchment development and climate change.



Estuarine floodplain saltmarshes: Kei River, Eastern Cape



Nyl Floodplain in Nylsvley Nature Reserve.
NonCommercial (CC BY-NC 2.0). By: Gwendolyn



An illustration of Floodlines. *Floodplain and river corridor management policy, City of Cape Town, Department of Roads and Stormwater, 2009.*



LINED CHANNELS

Gabions are rock-filled wire baskets, that are used in river bed and bank stabilisation projects. They are typically 1 m × 1 m × 1 m boxes, that are hand-packed and joined together or packed vertically to create a stable structure.



Canalised Jukskei River (Gauteng)



Low flow section of Elsieskraal River canal (Cape Town), designed to speed up flows and prevent sedimentation



Underground canal beneath Cape Town CBD, designed for water conveyance with no ecological function at all

Many rivers, particularly in urban areas, have been lined with concrete or gabions. Historically, concrete channel lining (i.e. canalisation), in combination with channel straightening, was done to allow for rapid conveyance of water out of the area. Concrete lining creates a smooth surface with little resistance, resulting in very fast flows. That meant that the river floodlines could be reduced, allowing urban development to intrude much closer to rivers.

Concrete canals also:

- Separate river flows from groundwater, so that riverine wetlands and riparian areas reliant on inflows from the river in high flow conditions do not receive these flows; and the river does not receive groundwater inflows during low-flow periods, nor contributes to groundwater recharge;
- Provide little habitat in the form of plants or coarse material (rocks, sand) to support aquatic ecosystems and their macroinvertebrate and fish biota. As a result, ecosystem services such as water quality improvement from plant nutrient uptake are absent, and habitat for fauna such as wading birds (that rely on feeding on macroinvertebrates in river sediments) largely disappears;
- Create ecologically sterile, isolated environments, that do not allow movement of riverine fauna between the river canal and adjacent areas – thus trapping non-flying fauna in the canals, and preventing the free movement of fauna laterally across the riverine corridors;
- Separate human communities from natural ecosystems, with lined canals increasingly disconnected from the people that reside near them; and often associated with solid waste / litter and safety issues. During flood conditions, very fast flows down canals mean that these environments are unsafe and many do not have easy escape routes.



Measures to address the impacts of canalisation

In an ideal world, canals would be removed and rivers restored to their natural state. However, this is often not possible due to urban and other developments in river floodplains. Still, several interventions can improve canal habitat quality and ecosystem services. Here are a few examples.

Creating opportunities for plant establishment in canals

Along canals, shaded areas, such as overhanging vegetation or even in-channel vegetation, offer shady (and thus cool) resting spots; protection from predators; and shelter from strong canal flows that would otherwise wash plants and small fauna (e.g. macroinvertebrates) downstream. Canal rehabilitation measures could aim to create such environments, though care is needed to avoid inadvertently supporting alien species (e.g. fish) that could harm indigenous wildlife. Canal rehabilitation (or remediation) measures could include:

- Establishing in-canal holes for rocks and plants:**

Roughening the base of concrete canals by breaking open portions and sinking concrete rings filled with rocks or plants can create short-term habitat diversity for macroinvertebrates and plants. However, strong flows may wash the rocks downstream **(for guidance on rock placement and sizing, refer to Volume 2, Chapter 10.2.5.2 of the WRC River Rehabilitation Manual)**.
- Encouraging overhanging vegetation:**

Allowing trees or plants on canal banks to grow over the water can diversify physical and hydraulic habitats by providing shading and sheltered out-of-current aquatic habitats.
- Encouraging or maintaining vegetation in cracks and irregularities in the canal**

In canals where sediment accumulates, vegetation can be encouraged to grow on sediment bars or in irregularities on the canal floor. This increases cover, hydraulic diversity, and access to shaded banks, especially during low-water seasons. However, this measure should only be applied where canal maintenance measures (e.g. excavation of vegetation from canal floors) can be minimised without undue flood risk. Artificial establishment of plants in these sites should be done with the recognition that plants will probably wash away at times in flood conditions – so Species of Conservation Concern should not be planted.



Planted riverine margins create cooling and riverine shading without impacting on river flood lines



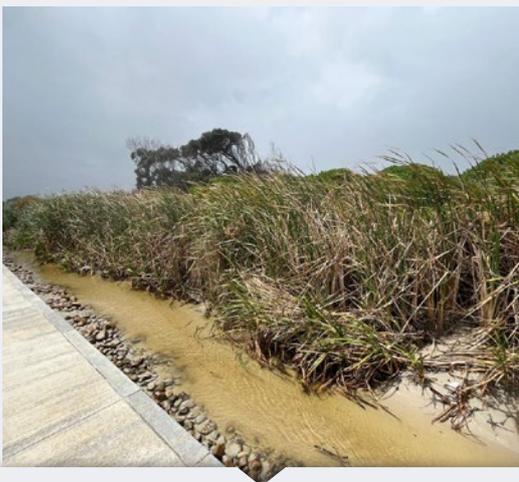
Establishment of indigenous riverine vegetation along the Liesbeek Canal, Cape Town. The vegetation creates desirable aquatic and marginal habitat – but its implications for flooding are untested



REMEDIATING LINED CHANNELS



Gabion planter



Low-flow channel at Paardevlei, Western Cape – high flows are routed along a raised concrete walkway, while low flows flow in a cobble / riprap lined, vegetated channel (*Bau-afrika Modular Eco River Barrier System*).

- **Low-level weirs**

Low-level concrete or gabion weirs in canals can help aerate water and create permanent pools for wildlife, especially during the dry season. They also discourage illegal activities, as inundated canals are less likely to be used as access routes by criminals.

Note that input from a river hydraulic engineer is required to confirm that the height of the weir has no significant effect on flood height.

- **Creation of planting ledges in canals**

These measures are appropriate where there is adequate flood capacity in the canal or channel (usually low-energy, low-gradient canals and channels or artificial channels where space can be created for planting and where flood velocities are below thresholds likely to result in erosion of introduced planting structures). Note that plant establishment is generally more successful where plants have ready access to water on a permanent basis, so planting ledges are located at or just above base-flow water levels.

- Planting areas may comprise perforated PVC piping (> 300 mm diameter) installed in gabion baskets, with a bidem lining on the pipe base, and infilled with topsoil. Plants thus installed may access water at the water table level and thus create high quality riverine habitat.
- Planting areas may also be made from gabion-stabilised cells, infilled with topsoil and planted with aquatic vegetation. Access to low flow water levels is a fundamental requirement (see photo top left).

- **Partial canal removal – Diversion of canalised high flows**

Outright removal of canals and rehabilitation of flows into more natural river channels is simply not feasible in most canalised situations, where encroachment of development into the river's original floodplain means that there is no space for such measures. There are however some situations where sufficient space remains for the separate treatment of low flows and flood flows, such that low flows at least can be managed in a more natural, non-canalised environment. The difficulty of only allowing for low flows through aquatic ecosystems is however that there are no flushing flood flows that remove sediment and algae and rejuvenate low flow channels.



Refer to Handbook 3 and Chapter 12, Volume 2 of the WRC River Rehabilitation Manual for practical recommendations about planting into canals and gabions.

- **Partial canal removal – removal of canal base and establishment of plants and rock substrate**

It is seldom feasible to remove a canal entirely, given that the reason for canal construction was often to facilitate the rapid removal of floodwater to allow development across the natural floodplain; and there may be existing developments adjacent to the canal. Partial removal becomes a more viable, but compromised, approach.

The approach in the Medlock River ([see photos right](#)) entailed removal of the concrete canal base, the placement of boulders and cobbles in the channel to increase instream habitat diversity, and the shaping and planting of the canal banks where possible. **Ideally, reshaping and vegetation of banks should be included in this kind of rehabilitation project, provided that adequate bank erosion protection is provided – either in terms of vegetation or by reducing flow velocities**

- This approach can be applied only to canals where sufficient space is available for canal capacity to be maintained in the face of increased channel roughness. This means that, unless the canal was over-designed – that is, with excess flow capacity during floods – widening or deepening of the final channel would be required, in order to prevent flooding impacts;
- The approach should also only be applied in situations where instream water quality is relatively unimpacted – there is little point in trying to establish a more natural physical habitat if the chemical composition of the river will prevent the establishment of natural riverine ecosystems;

- **Partial canal removal with river bank stabilisation**

This approach taken in the Liesbeek River ([see photo right](#)) entailed removal of the canal base as well as the side slopes on one side of the canal, but required gabion side slope retention on one river bank to preserve terrestrial biodiversity. The river width required to accommodate the 1:100 year flood was considerably greater than that provided by the canal, but ecological connectivity and function as well as amenity value were considerably enhanced ([see Handbook 9, Case Study 5](#)).



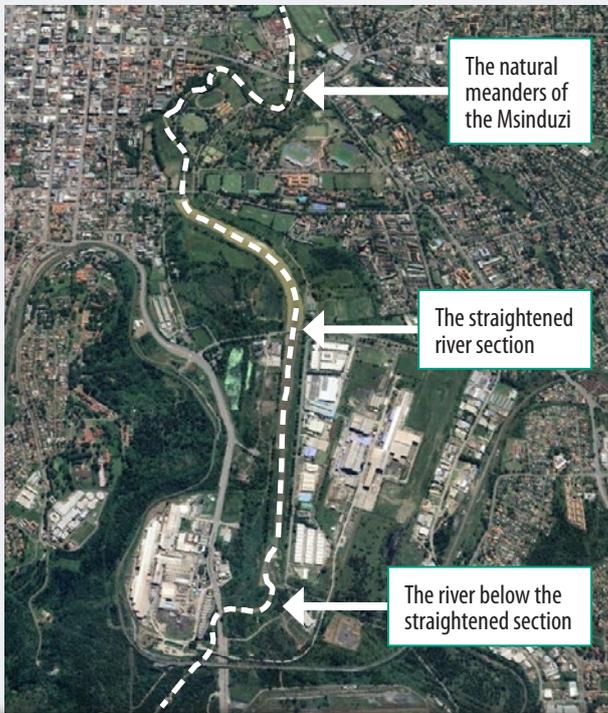
Un-rehabilitated, canalised section of the river Medlock (Manchester, United Kingdom) (top photo) and upstream, post rehabilitation channel (bottom photo), showing removal of concrete channel base, addition of rocks to improve instream habitat diversity and establishment of marginal vegetation. Canal side-walls largely retained because of concerns around possible contaminants in fill on either side of the channel. Note that the same discharge is conveyed in each of the two channels, illustrating the role of lined canals in speeding up rate of flow.



Liesbeek River, Cape Town. Early phase planting out of re-shaped bank following partial canal removal (one side only)



RIVER STRAIGHTENING



The Camps Drift section of the Msinduzi River in Pietermaritzburg, KZN, where meanders were removed and a section of the river straightened as a flood protection measure. Major weirs were installed upstream and downstream of the altered course. *Google Earth ©*



Flood banks can be set back from the channel to create space for high flows and flooding.



Detention basins attenuate high flows, assisting with downstream flood management.

Straightening of river channels, and/or the creation of earth berms or levees along the top of the banks, are age-old techniques for increasing the flood conveyance of river channels. This has been done to rivers worldwide, variously for the purposes of gaining land for cultivation in agricultural settings; to speed up the drainage of high flows and floodwaters off the catchment; or to create space for development (**Photo – top left**). It is not uncommon for rivers to have been straightened, deepened, canalised (and lined), or rerouted into a box culvert and built over (**see also ‘Lined canals’, pages 8–11**).

Where a meandering or sinuous river is straightened, the bends of the river are filled in, and a straight central canal is created, often at greater depth. The river bed is typically excavated, and banks are disturbed, cleared or even lost altogether. The channel length is typically shortened, and its gradient increased, resulting in increased flow velocity and sediment transport capacity. Both have consequences for the river upstream and downstream of the straightening.

Alternatives to channel straightening

There are a number of environmentally acceptable alternatives to channel straightening, in which the natural channel is left intact or minimally disturbed.

- **Distant flood banks:** Where there is enough space, flood banks (or levees) can be constructed at some distance from the channel, typically at the meander edge. These are considered highly effective (**Photo – centre left**).
- **Two-stage channels:** These are created by excavating the upper section of the floodplain adjacent to the river. The low-flow channel is unaltered, and the high-flows are contained within the flood berm. This is best suited to the lower zones of urban channels, where the second channel could be developed and used as a linear parkland.
- **Relief channels:** These can be constructed to divert flood flows away from the meandering channel, into an attenuation pond or floodplain, and may be dry or wet during low-flows.
- **Construction of upstream detention structures:** The idea is to mitigate against lower-zone floods by slowing and detaining flood flows higher in the catchment. This is usually achieved by installing flood detention basins or wetlands upstream of ‘hotspots’ (**Photo – bottom left**).

REHABILITATION OF STRAIGHTENED RIVERS



Generally, once a river channel has been manipulated, it will not recover its original pattern without intervention. Because channel response to manipulation is complex, rehabilitation requires the skill of teams including biologists, engineers, geomorphologists, geologists, hydrologists, and landscape architects.

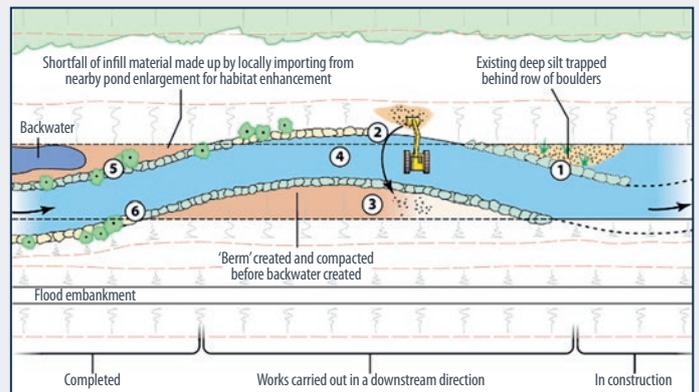
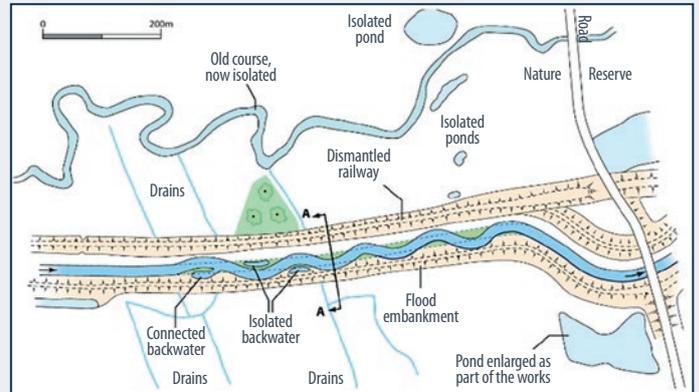
There are three options: to reinstate the river's sinuosity or meanders; to create a new more natural channel; or to naturalise the straightened system as it is, to enhance its ecosystem functionality.

Reinstating form: Projects aiming to reinstate original channel form and process are major efforts, involving expert teams and planning and large budgets. They are challenging, as the hydromorphological drivers (energy, flow, sediment) of the river need to be understood, and may have been modified since straightening, particularly with climate change, and there may no longer be space for meanders. Major projects of this nature have however been done effectively elsewhere in the world (see **River Restoration Centre Graphic and Resources, page 19**).

Creating a more natural channel: This is the more common approach to redressing straightened channels, and is in common practise around the world. The process of naturalisation differs from project to project, but the aims are typically to enhance ecological conditions by imitating nature and natural processes, improve or maintain flood control, and support the recreational value of the river or wetland. The interventions typically involve the creation of a more natural planform, width and depth for the channel, the introduction of habitat, and the planting of the marginal and riparian zones with appropriate species **SEE HANDBOOK 3**.

Naturalising a straightened and lined channel: Means of naturalising straightened and lined canals are discussed on **pages 9–11** of this handbook.

 Refer to the WRC River Rehabilitation Manual, Volume 1, Chapter 7.



The channel of the River Dearne in the UK was degraded by mining and had been relocated, widened and channelised for flood protection in the 1970s (**top and second images**). As remeandering was not possible, a scheme was developed to maximise the river's fishery and spawning potential by introducing sinuosity into the over-widened channel, while having no detrimental effect on the flood protection (**third and fourth images**).

Images courtesy of the River Restoration Centre, UK (Restoration Manual). Further case studies: <https://www.therrc.co.uk/>.

NOTE: While the principles of naturalising are consistent, the technical details for a South African river would be very different due to the highly variable flow and flashy flood regime of SA rivers.



REHABILITATION OF FLOODPLAINS AND FLOODPLAIN WETLANDS



An ecologically healthy floodplain of the Eerste River (in flood), Western Cape.



Buildings constructed on the Elsiekraal River floodplain.



A neatly machined river, planted to its edge, soon after a flood.



A rain garden installed to intercept runoff in an urban area.

Development on floodplains and floodplain wetlands

Historically, humans have done their utmost to manage and manipulate floodwaters and floodplains. In agricultural areas, natural riparian zones and floodplains have been cleared to make space for crop planting or grazing. In urban areas, dams, roads, bridges, buildings, public open spaces and parks have been built onto floodplains, over rivers, or in many cases, to the river's edge. Sewerage lines, pump stations and stormwater infrastructure have been situated on or close to river banks. Floodplain wetlands have been drained or infilled. River channels have been altered so as to keep floodwaters away from crops or infrastructure. This can be damaging to both river ecosystems and humans occupying flood-vulnerable areas. When floods do come, they result in costly losses of orchards, crops and infrastructure.

Natural Flood Management (NFM) Principles for rehabilitation of floodplains and floodplain wetlands

NFM measures aim to reduce the effects of flooding, and to restore some of the river ecosystem's own ecology and natural flood management system. If NFM is applied, it is a first step towards rehabilitation of the river floodplain and floodplain wetland function. The idea of NFM is to reduce the downstream flood peak (maximum height of a flood) or to delay the arrival of the flood peak downstream, by slowing the movement of floodwater through a catchment. The principles are in keeping with natural catchment processes, as outlined below.

Reduce surface runoff: This involves increasing infiltration in the catchment area. There are many ways of doing this. In urban areas, Sustainable Urban Drainage Systems (SUDs) and rain gardens are designed to enhance infiltration.

Allow the river as much lateral space as possible: This allows floodwater to spread, reducing velocities and minimizing erosion and safety hazards. One way of doing this is to widen the channel (if it has been unnaturally confined historically), and stabilise the banks. This allows for a greater flow area and reduced flow depths and velocities, and can increase flood conveyance in a reach. In general, banks would be re-sloped to gentler slopes of 1:4 or less. Stabilise the bank and protect the bank-toe with appropriate measures (see [WRC River Rehabilitation Manual, Volume 2, Chapter 4](#)).

Another option to allow the river flooding space is to pull back existing levees. This pertains to agricultural and urban areas, but is only possible where there is sufficient land available. This also creates a larger riparian corridor. The flood zone should then be kept clear of invasive vegetation to ensure flood conveyance.



Low levees must be moved further away from channel

Levee Setback

Slow water down: The main way to do this is by increasing resistance to flow – for example, by re-planting the floodplain or riverside areas, or by rehabilitating floodplain wetlands ([see graphic right](#)).

Change to flood-compatible land uses: This is an option where space is available. The idea is to change land uses to those compatible with occasional flooding. These include pasture areas, some orchard types (mango, macadamia) and recreational areas (public parks and sportsfields are particularly good options). This is expensive and ecological benefits may need to be offset against the cost of losing productive agricultural land or relocation of existing infrastructure, while remembering avoided damage costs.

Clear invasive vegetation: this is important to maintain the channel conveyance function, open up the channel and riparian zone, and reduce flood peaks. Many invasive species are not natural riparian species and lack the branch and stem structures of indigenous trees, thus providing high flow resistance. Indigenous vegetation tends to lie flat during floods. The removal of indigenous vegetation from channels and riparian areas is not generally considered good practice, although may in some cases be necessary.

Intercept rainfall: by planting appropriate indigenous trees, for example, in the right places and with relevant indigenous species.

Store water: during extreme rainfall events, wetland detention ponds and other detention structures serve to reduce and delay the flood-peak lower in the catchment where the flood hazard hotspots are. Small detention ponds throughout urban areas, together with alternative technologies such as SUDS, can be used to reduce peak runoff in cities. Caution must be applied, as the sediment trapping capability of these structures and resultant downstream sediment starvation to the river must be considered.



Removal of the left floodbank of the Great Eau in the UK, to demonstrate a technique for improved flood protection. A flood storage area was created on the adjacent land on the left bank. Picture courtesy of the UK River Restoration Centre (Manual of Techniques).



Active rehabilitation of a floodplain wetland mosaic, Pinkhill Meadow, Thames River. Picture courtesy of the UK River Restoration Centre.

Note: Rehabilitation techniques are developed to suit individual rivers and may not apply to other rivers, particularly those in South Africa which have very different hydrological regimes to those in UK.



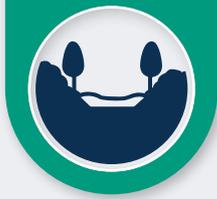
IMPORTANT TO REMEMBER:

Flood attenuation measures on a floodplain or within a channel necessarily increase flooding at that location, but should decrease flooding downstream. **So, solving flood problems at one site will have implications for flooding risks at the site, as well as downstream.**

The effect of any activities that alter the flood regime must be clearly understood before any rehabilitation begins. This requires specialist assistance from a Hydrologist and a specialist structural Engineer. In all instances involve specialists, to minimize the risk of exacerbating flood effects.



Refer to the WRC River Rehabilitation Manual, Volume 2, Chapter 3 for detailed measures.



SECONDARY CHANNELS AND CHANNEL DIVERSIONS



Lines of alien trees contribute to erosion and channel deepening in this once-valley bottom wetland system.



Alien vegetation on an in-channel bar led to accumulation of sediments such that the main channel of the river was deflected into the secondary channel, causing severe bank and bed erosion, that necessitated the installation of groynes and the removal of excess sediment from the bar.



Bulldozed secondary channel in agricultural area – such practices invite flood damages such as erosion

Secondary channels (also called flood channels) occur naturally in floodplains or along braided rivers. As the main river channel fills with water in flood conditions, water starts to flow down the slightly higher-lying secondary channel(s). Secondary channels are important habitat types, often providing areas of lower flow velocities suitable for the breeding of fish and amphibians and for shallow access by wading birds.

They are also very important in flood attenuation, because they provide new routes and space for rivers to flow under relatively small flood conditions, reducing velocities and erosion.

Secondary channels do however take up space that could be used for other activities. In many agricultural and particularly urban areas, they have thus been entirely lost as a result of channel straightening and infilling within the floodplain. These approaches can cause great problems for landowners when floods do occur, and the natural means of dissipating flows through secondary channels are no longer available. Erosion and uncontrolled flooding can result, with valuable agricultural crops, established too close to the channel, often being lost in the process.

Invasion by alien vegetation can also result in loss of secondary channels, by blocking flood flows down these channels leading to down-cutting and deepening of the main channel.

Once lost, secondary channels can be difficult to reinstate as they were, because very often the main channel incises deeply down and is too deep to overtop easily into side channels.

Artificial re-instatement of secondary channels needs to take into consideration flow velocities and the need to manage sediment, so that slow inflows do not simply deposit sediment and fill in newly created channels, or alternatively re-divert the entire river flow into the secondary channel, leaving the primary channel dry.

Creating artificial secondary channels

In urban areas where flooding is a problem but floodplains have largely been lost, diverting flood flows out of the main channel where there is still space for secondary channels can provide (albeit limited) relief from flooding, with the possibility of creating ecologically valuable floodplain wetlands as well.

Flow diversion

Historically, many of our rivers have been diverted, to create more “convenient” land parcels (e.g. forestry plantation blocks; agricultural fields; housing areas). These new river channels are thus perched, with their upper banks no longer being the natural low point in the landscape. This makes adjacent areas highly vulnerable to flooding, as when large floods overtop the banks, they naturally find their way to the low point, where development of some kind has often taken place. At the same time, downstream systems, sometimes including extensive riverine wetlands, are deprived of the river and floodwater flows that naturally sustained them.

Other problems with such flow diversions are that natural channel geomorphology is disrupted, and the re-created channels tend to incise into steep-sided conveyance channels, often associated with erosion and bank collapse and with little lateral connectivity, owing to the steep banks.

Measures to address these issues could be **symptomatic** (that is, stabilising eroding banks with the use of gabions, riprap (large, specifically sized, loose rock packs) and plantings) or could entail **proactive rehabilitation** measures, such as shifting the river or stream back to its original course. The latter is only possible where the original course remains open and available, and with input from hydrological and hydraulic engineers around designing for different velocities and channel type.

Flow diversion to prevent pollution

A sad case for artificial channel diversion occurs when illegal land invasion has occurred into the heart of floodplains, with unserviced settlements discharging raw sewage and other waste into the river channel. In such circumstances, the pragmatic alternative may be to divert the river outside of these areas, where space, gradient and engineering budget allows.



Flood flow diversion channel excavated into the Liesbeek River, Cape Town.



River channel historically re-aligned from natural watercourse (blue arrow) to make way for forestry, resulting in a perched channel (green arrow) and drying out of natural wetlands.



Re-aligned river channel with steep banks and a trapped channel that incises deeper and destabilises banks



Polluted flows from largely unserviced informal settlements pass into the aptly named Kleine Stink River in Cape Town



LEGAL ISSUES

This section tries to give some perspective on legal considerations when undertaking any activity within rivers and their floodplains.

Key concepts are:

1. The area of a watercourse that is regulated by legislation is (a) (for rivers, springs, natural channels, dams and lakes): The outer edge of the 1 in 100 year flood line and/or delineated riparian habitat, whichever is the greatest distance or, where this information is not available, (b) the area within 100 m of the edge of a watercourse (excluding floodplains and defined by the annual bankful flood bench) and (c) for wetlands and pans – a 500 m radius around the wetland or pan.
2. Activities within the above areas that would impact on the water resource (that is, would be considered water uses in terms of the National Water Act (NWA)) require authorisation. Note that not all activities in these areas constitute water uses and therefore do not need authorisation in terms of this legislation.
3. Water uses that are defined in Section 21 of the NWA are the following:
 - 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;
 - e. engaging in a controlled activity;
 - 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 recreation.



NOTE: The above are simply broad guidelines as to important legislation to consider. See Appendix 1 in Volume 1 of the WRC River Rehabilitation Manual and consult an Environmental Assessment Practitioner and/or local DWS officials if you are in any way unsure, because falling foul of this legislature can be extremely costly.

Activities such as excavating river banks or channels, infilling wetlands or secondary channels, or even removing fill from wetlands and secondary channels would all constitute water uses – specifically, Section 21c and 21i water uses. They would need to be authorised by the DWS, either through a water use license application, or may already be authorised through a General Authorisation. Specialist aquatic ecosystem input would be required to determine the applicable situation. Authorisation in terms of the National Environmental Management Act (NEMA) (Act 107 of 1998) could also be required for works in or near rivers and wetlands.

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RIVER REHABILITATION MANUALS AND OTHER RESOURCES

A comprehensive manual for river rehabilitation in South Africa. 2016. Volumes 1, 2 and 3. By Liz Day, Mark Rountree and Hans King. Water Research Commission Report No TT646/16. Available at: www.wrc.org.za

Manuals from other countries (*these are excellent and have numerous case studies to learn from, however remember that South African rivers have very different hydrological regimes from those in other parts of the world, and that techniques may not be transferable*).

The River Restoration Centre Manual of River Restoration Techniques. 2020. *This is a well-organised resource which includes a large number of case studies of restoration projects across the United Kingdom.* <https://www.therrc.co.uk/manual-river-restoration-techniques>.

A Rehabilitation Manual for Australian Streams. Volumes 1 and 2. 2000. By I. Rutherford, K. Jerie, and N. Marsh. Land and Water Resources Research and Development Corporation with the Cooperative Research Centre for Catchment Hydrology. Available at https://www.researchgate.net/publication/340135028_A_Rehabilitation_Manual_for_Australian_Streams_VOLUME_1 and https://www.researchgate.net/publication/340134793_Australian_stream_rehabilitation_manual_vol_2.
Bau-afrika Modular Eco River Barrier System. <https://www.youtube.com/watch?v=TBN7eFsilTw>

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- P4. Photo of Great Kei River: <https://writingmuscle.wordpress.com/2013/01/17/the-world-in-one-country-south-africa/>
- P4. Photo of Limpopo floodplain: <https://commons.wikimedia.org/wiki/File:Limpopo.jpg>
- P4. Graphic of river zones: <https://geographical.co.uk/wp-content/uploads/Floodplains-river-diagram.jpg>
- p5. Graphic of meandering river: https://gotbooks.miracosta.edu/earth_science/images/floodplain_landforms.jpg
- P5. Graphic of floodplain wetland: *Job, N., Mbona, M. & Kotze, D. 2018. Guidelines for mapping wetlands in South Africa. SANBI Biodiversity Series No 18. South African National Biodiversity Institute.*
- P5. Graphic of channel types: *Rosgen, D.L. and Silvey, H.L. 1996. Applied River Morphology. Wildland Hydrology Books, Fort Collins, CO.*
- P7. Nyl Floodplain in Nylsvley Nature Reserve. Creative Commons Non Commercial (CC by NC 2.0). By Gwendolyn. <https://www.flickr.com/photos/ginz/2479570297>
- P7. An illustration of floodlines. *Floodplain and river corridor management policy, City of Cape Town, Department of Roads and Stormwater, 2009.*
- p12. Photo of Camphill Drift: from Google Earth Pro. 2024.
- p17. Aerial image of cleared section of Tokai Forest, Cape Town. Image from Google Earth Pro, 2025.

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and other crossings)

HANDBOOK

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River rehabilitation case studies