Dam Management and Restoration of River Connectivity
Workshop Findings (draft)

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in partnership with:

World Fish Migration Foundation and Mulago

INR REPORT NO. 592/25

April 2025

“It is not just about the fish!” - M Burnett

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Acronyms

CMA	Catchment Management Agency
CME	Compliance Monitoring and Enforcement
DFFE	Department of Forests, Fisheries and Environment
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
EKZNW	Ezemvelo KZN Wildlife
INR	Institute of Natural Resources
NEMBA	National Environmental Management: Biodiversity Act 10 of 2004
NEMA	National Environmental Management Act 107 of 1998
NHRA	National Heritage Resources Act 25 of 1999 (NHRA)
NWA	National Water Act
NGO	Non-Governmental Organisation
PUCMA	Pongola-Umzimkhulu Catchment Management Agency
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
UUW	Umgeni-Uthukela Water
WFMF	World Fish Migration Foundation
WRC	Water Research Commission

Executive Summary

On November 6th and 7th, the World Fish Migration Foundation, in partnership with the Institute of Natural Resources (INR), hosted its first workshop on dam management and river connectivity in Durban, South Africa. The event brought together over 50 participants (Figure 1), including representatives from government agencies, environmental NGOs, research institutions, and international experts, all dedicated to advancing river restoration and sustainable dam management practices. The two-day program combined a field visit with a day of expert presentations and collaborative discussions focused on restoring river connectivity and sustainable dam management across South Africa.

Figure 1. Participants at the Workshop ©INR.

The workshop's first day began with a field visit to the lower uMkhomazi River, where participants had the chance to witness the ongoing upgrade of the Goodenough Weir (Figure 2). Experts from GIBB introduced the group to a key aspect of this project: the construction of a fish passage, designed to allow native fish species to migrate upstream. A short distance upstream, the U1H006 Department of Water and Sanitation Weir continues to impair the river due to its obsolete status and lack of connectivity measures, which affects the natural flow and habitat continuity. This visit offered attendees a direct look at the challenges of balancing necessary infrastructure with ecological aspects, sparking a vibrant exchange of ideas among the participants.

Figure 2. Participants at the uMkhomazi River weir fish passage construction ©WFMF

The second day began with insightful presentations from local and international experts on dam and catchment management, sediment management, and ecological restoration. Navashni Govender from the South African National Parks (SANParks) introduced pioneering efforts in Kruger National Park (Figure 3), where South Africa has become the first African country to remove dams for ecological purposes restoring river flow and enhancing biodiversity.

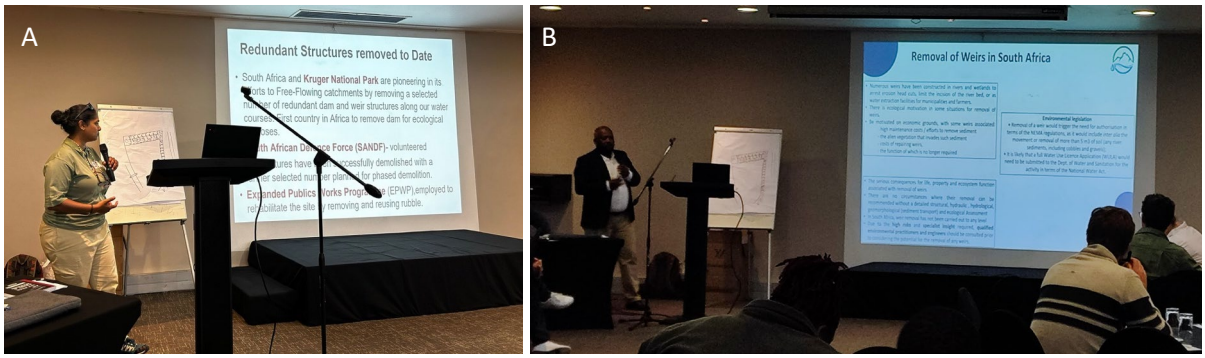

Figure 3. Navashni Govender from South Africa National Parks (SANParks, A) and Nkosinjani Mkhize from Pongola-Umzimkulu Catchment Management Agency (PUCMA, B) presenting at the workshop ©WFMF

Following this, two speakers from water management agencies shared their insights on effective management approaches. Nkosinjani Mkhize from the Pongola-Umzimkhulu Catchment Management Agency (PUCMA), presented new strategies in national catchment and water management, focused on balancing social and ecological needs (Figure 3). Futhi Vilakazi of uMngeni-uThukela Water then provided further local insight, discussing the challenges water utilities face in securing water while addressing ecosystem needs, including catchment intervention assessments.

An international viewpoint was provided by Geoffrey Goll from Princeton Hydro in the USA, on sediment management before and after barrier removal, emphasizing the crucial role sediment plays in maintaining river health (Figure 4). Hamish Moir from Scotland's CBEC Eco-Engineering highlighted European case studies on nature-based river reconnection, demonstrating how selectively removing obsolete barriers has improved ecosystem dynamics and flood risk management (Figure 4).

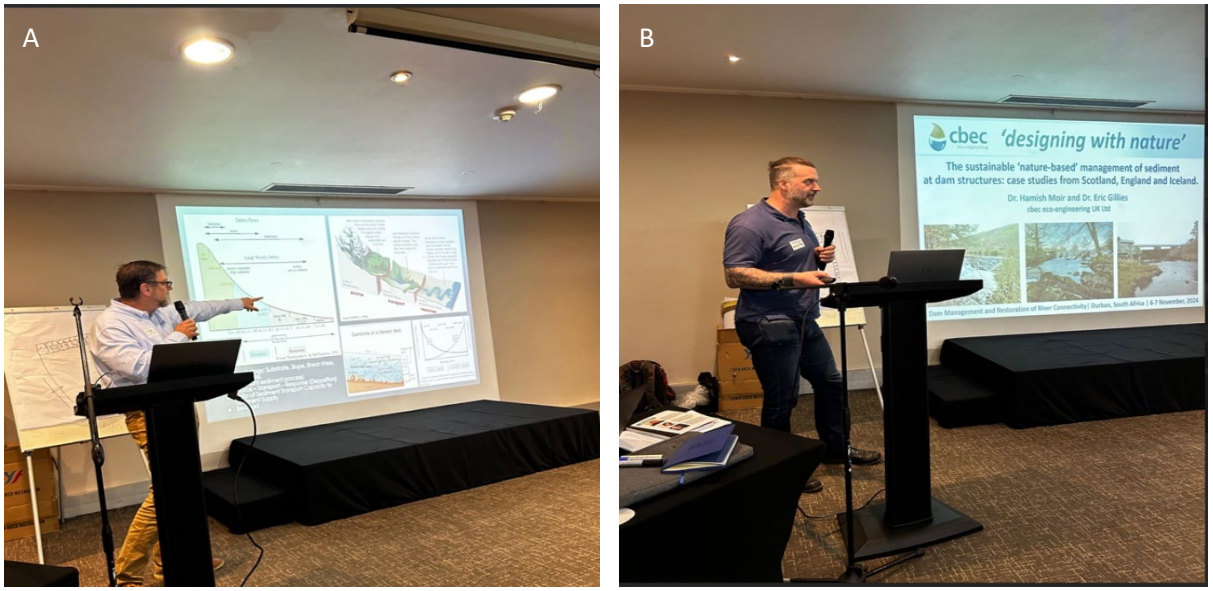

Figure 4. Geoffrey Goll (A) from PH presenting, Hamish Moir (B) fom CBEC presenting ©WFMF

Concluding the morning session, Andrew Blackmore from Ezemvelo KZN Wildlife explored the complex regulatory landscape around dam removal in South Africa, shedding light on the intricate legal frameworks governing environmental and barrier management.

The afternoon featured an interactive "World Café" session (Figure 5), where participants moved between five thematic stations: stakeholder involvement, governance mechanisms, water scarcity and biodiversity, socio-economic and ecological impacts, and funding models. These discussions emphasized the importance of a cohesive approach to dam/catchment management, integrating both ecological and community perspectives to develop effective monitoring measures for long-term solutions. Two case scenarios were explored to assess the current pressures and stressors on rivers and discuss how these could be addressed in dam removal or river restoration projects under ideal conditions.

The event highlighted the pressing need for integrated governance structures that support sustainable dam management while also addressing social necessities and ecological balance. Attendees gained deeper understanding of the potential ecological and social benefits of barrier removal, such as

improved water quality, enhanced biodiversity, risks reduction, and increased habitat connectivity. The discussions emphasized the importance of raising awareness and communicating these projects effectively, and the need to secure diverse funding to support integrated planning and execution of catchment management and restoration initiatives.

Figure 5. World Café session ©WFMF

This event marked a meaningful step toward a shared vision for South Africa's river systems, opening doors for continued partnerships and innovative projects aimed at reconnecting rivers. The positive momentum generated over these two days reflects a growing recognition of the urgent need to protect and revitalize the country's aquatic ecosystems.

Introduction

Freshwater ecosystems are among the most impacted systems by various factors imposed by human activities (Dudgeon 2019). River connectivity, between the river and its tributaries is essential to maintain a healthy aquatic ecosystem (Larrieu et al. 2021; Shao et al. 2019). Here, the transference of sediment, nutrients and fauna and flora are dependent on the connectivity of a river (Hooke 2003). The introduction of artificial impoundments compromises river connectivity, mostly the longitudinal connectivity, which allows for the natural continuity of the river (Panagiotou et al. 2022). Over 65% of the perennial rivers in the world are fragmented by artificial instream barriers (Grill et al. 2019; Thieme et al. 2023), with many of these artificial instream barriers are aged, redundant, and at high risk to failure.

Over 60% of South African endemic fish taxa are threatened, and according to an assessment on the decline in native freshwater species, introducing artificial physical barriers such as dams, weirs, fords, and culverts in freshwater ecosystems reduces river connectivity and alters habitat (Chakona et al. 2022). It may be one of the drivers behind the decline in freshwater fish especially for migratory species (Jackson et al. 2001; Harris et al. 2016; Hanzen et al. 2022). The connectivity in a stream is

essential for migrating fish as they need to access different habitats for various purposes, such as breeding, feeding, or taking refuge (Branco et al. 2017).

In the case of diadromous species (species that migrate between freshwater and seawater) (Bok et al. 2007; Branco et al. 2017) the presence of a single barrier along the longitudinal dimension of the river may pose a significant threat to them (Branco et al. 2012). Multiple barriers may cause even more drastic impacts (Branco et al. 2017). Such effects have already been shown for African freshwater eels in KwaZulu-Natal, South Africa (Hanzen et al. 2022). For potamodromous fish, which migrate within freshwater habitats, there has been a remarkable decline in their abundance, indicating the disturbance in the rivers of Australia (Harris et al. 2016). Potadromous migrating fish species may highlight the importance of river connectivity to maintain biodiversity but other aquatic fauna relies on river connectivity to complete their life cycles, such as the *Varuna litterata* (Burnett et al. 2024).

Small artificial barriers such as culverts and low-head weirs tend to be more numerous in rivers than larger barriers and are believed to have a far more significant impact on migrating freshwater fish (Branco et al. 2017). In addition, poor management, lack of capacity and resources has shown that ageing, redundant and failing instream barriers are exasperating river connectivity issues while new infrastructure is planned to meet water security needs.

River connectivity is integral to maintain river ecosystems functioning (Branco et al. 2014). It allows for the transport of sediment, water, and organic material, and movement of fauna and flora through the landscape. Importantly, river ecosystem that are highly connected that when altered can increase risk to flooding, water security, and disrupt migratory pathways for aquatic organisms. However, to improve water security impoundments are created to minimize risk, meet water demand and maintain the water provision for the general population. Therefore, river connectivity and meeting water security poses a conundrum in needing to meet a balance between these two aspects. Many sectors, including agriculture, and inland fisheries depend particularly on healthy aquatic systems for irrigation and watering livestock and fish production respectively. The World Fish Migration Foundation (WFMF) a Netherlands based NGO, focusing on the topic of river connectivity to maintain healthy fish stock, but more importantly healthy aquatic ecosystem so many livelihoods depend on global. The WFMF, has supported and called for the study assess river connectivity in the South African.

Methods

To address the challenges associated with impaired river connectivity a workshop title: The Dam Management and River Connectivity Workshop was organised. The workshop was funded and hosted by the World Fish Migration Foundation (WFMF) that highlights the plight of migratory fish globally. The workshop co-hosted by the University of KwaZulu-Natal (UKZN) in South Africa, and the Institute of Natural Resources (INR), in collaboration with the South Africa National Biodiversity Institute (SANBI), and uMngeni-uThukela Water (UUW) in South Africa, and the World Fish Migration Foundation (WFMF) in the Netherlands. The workshop aimed to address multiply challenges facing river connectivity in South Africa and not just fish movement.

The workshop consisted of topical presentations, a site visit and open discussion session aims to address the challenges when restoring river connectivity and to catalyse the process of addressing aged, failing, and redundant instream barriers that impede river connectivity, threatening ecological functioning associated with connected rivers, including by not limited to biodiversity, water quality

and quantity associated with river flow and potentially a risk to livelihoods if breached. The workshop aims to achieve this through:

i. Presenting the present water security constraints and demands in a South African context and shedding light on instream barrier removals occurring in Europe and North America.
ii. Participating in a field site visit to:
    a. A redundant weir to investigate and evaluate the potential river connectivity issues and challenges associated with removal.
    b. Exposure to the present mitigation methods used in the construction of weir to maintain river connectivity.
iii. Through a participatory workshop, mapping the barriers and enablers to instream barrier removal to restore river connectivity.
iv. Developing a roadmap to river restoration to improve ecological infrastructure and the biodiversity and livelihood associated with these.

The two-day workshop explored the integration of river connectivity restoration into river basin management strategies. Key topics included for discussion were:

- Water security.
- Sediment management.
- Economic impacts.
- Biodiversity conservation.
- Crucial areas for enhancing both ecosystem health and community resilience.
- Issues of governance.

The gathering assembled a wide range of stakeholders and interested parties to explore the complexities, challenges and opportunities of restoring river connectivity, with a particular emphasis on water security, sediment management, economic impacts, and biodiversity conservation. This workshop also marks the commencement of a longer process aimed at establishing the Dam Removal Africa - an initiative for effective discussions, knowledge sharing, and collaboration to restore the river connectivity across Africa.

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The workshop focused on identifying social barriers when removing instream barriers in south Africa and gathered insights from stakeholders to assist in the development of a roadmap to remove redundant structures in South African river systems, and to design more appropriate river connectivity mitigation measures. The focus of attention is on redundant, old and or aging instream infrastructure to assess how decommissioning or upgrading these can support river connectivity, in ways that does not disrupt or challenge water security, and where redundancy is informed by considering original purpose, current purpose, actual utility and impact.

Hosted by the World Fish Migration Foundation and the Institute of Natural Resources, the two-day event explored the integration of river connectivity restoration into river basin management strategies. Key topics included for discussion were:

- Water security.
- Sediment management.
- Economic impacts.
- Biodiversity conservation.
- Crucial areas for enhancing both ecosystem health and community resilience.
- Issues of governance.

An agenda was set for the workshop aimed at the thematic areas identified for the workshop (Table 1) The workshop was held over two days with the first day a field site visit to the upgraded Good enough Weir that is constructing a fishway directly below a old gauging weir that is no longer is use, with no management plan for its removal. The second day was a full day workshop with a morning of presentation from key sectors and an afternoon set aside for discussion in the form of a world café activity. For the World café, delegates were divided into five groups to discuss one topic for a period and then shuffled to discuss another topic. Topics were chosen on by the delegates based on expertise and interest. After discussion, a report back was given on the five topics in plenary.

Conference Agenda

Field Trip

Visit to the upgrading of Goodenough Weir to witness the in-progress construction of a water abstraction and storage weir, with a fishway modification:

- Safety briefing from GIBB engineers (Figure 1).
- Walk to the fishway construction with design explanation by GIBB engineers.
- Detailed explanation by Matthew Burnett regarding the fishway mitigation measures.
- Semi-aerial view of the U1H006 Weir 500m upstream of the new Goodenough Weir from a hilltop above the site.
- Opportunity for Q & A with construction team and Matthew Burnett.

A debriefing session back at the workshop venue with delegates around river connectivity and questions and topics arising from the field trip, led by Matthew Burnett.

Presentations and deep-dive discussions

The second day was dedicated to receiving and sharing inputs, both from key experts invited to provide detailed information, and between interested and involved stakeholders. All those who attended represented a stakeholder grouping related to aspects of the deliberation, from fish migration to river functionality, river restoration, catchment management, water provision, conservation, policy and research, as well as others.

Time	Topic	Speaker
8:00	Registration	
8:30	Welcome and Introductions	
9:00	Catchment based approach to water resource protection in the Pongola to Mtamvuna Water Management Area	Nkosinjani Mkhize (PUCMA's Governance) and Futhi Vilakazi (Water Utility - UUW) - South Africa
9:30	Engineering and Sediment Management Considerations for Dam/Weir Removal in the US	Geoffrey Goll (Princeton Hydro - USA)
9:50	Interactive Q&A Session	
10:20	Break	
10:50	The sustainable 'nature-based' management of weir and dam structures: case studies from Scotland, England and Iceland	Hamish Moir (CBEC Eco-Engeneering - UK)
11:10	Removing instream barriers in South Africa: An overview of the legal challenges	Andrew Blackmore (KZN Wildlife - South Africa)
11:30	Interactive Q&A Session	
12:00	Lunch	
13:00	World Café Panel (SANBI) Small group session, topics:	• **Session 1:** Problematisation and development • **Session 2:** Mapping the enablers and barriers as solutions
15:30	Break	
16:00	Plenary Feedback and Conclusion	

Table 1. Agenda for day 2, A change to the planned agenda was a brief field day report by Matthew Burnett and an opening address by Ruben Rocha on behalf of the World Fish Migration Foundation and Navashni Govender from South African National Park, showcasing work on dam removals in Kruger National Park,

The keynote speakers were selected to provide critical perspectives into the discussion. Defining a way forward requires that multiple interests, mandates and sources of evidence be brought together. The *World Fish Migration Foundation* drove the gathering with several interests, primarily looking at the need to protect fish species, on the basis that "Half of the migratory fish populations declined in half a century, and several species are going extinct. This threatens the primary food source of over

one billion people, decreases biodiversity and puts life-sustaining river and marine ecosystems at risk"[1].

The *University of KwaZulu-Natal* and the *Institute of Natural Resources*[2] provide an important research and monitoring function, generating knowledge and data to inform policy, practice, reflection and learning. Matthew Burnett described the team he works with to investigate, observe, record, share and advocate.

The *Pongola to uMzimkulu Catchment Management Agency*[3] *(PUCMA)* is the regional legislated authority and custodian of catchments in a specified water management area, working on behalf of the National Department of Water and Sanitation. These mandates carry the key responsibility of ensuring that policy and regulation is both rational and practiced, and must channel information from the ground up to inform policy decision-making. Mr Nkosinjani Mkhize spoke to the complexities of the PUCMA mandate in respect of efforts to build river connectivity and health.

Ezemvelo KZN Wildlife[4] (EKZNW) is also a mandated Authority, responsible for large tracts of natural and reserve landscapes, especially in water source areas. EKZNW representative, Andrew Blackmore, is also an environmental lawyer, with a deep and expert knowledge of relevant legislation in respect of natural landscape management, including water.

uMngeni-uThukela Water[5] (UUW) is a state-owned entity, and is the designated water for the province of KwaZulu-Natal. The entity provides water and related services to other water services institutions and other customers in its gazetted service area of the Province of KwaZulu-Natal. The entity operates in accordance with the Water Services Act (Act 108 of 1997) and the Public Finance Management Act (Act 1 of 1999), amongst others, and is categorised as a National Government Business Enterprise. Futhi Vilakazi spoke about source water security challenges and catchment-based interventions planned and implemented by UUW.

Key conservationist, Navashni Govender from the *South African National Parks*[6]*, South African National Parks* provided a case study of an area where artificial dams were both installed for a reason and then decommissioned for the same reason! This case study provides critical evidence-based learning.

Decommissioning instream river infrastructure installation is as technical as installation. The engineering involved is complex as all impacts need to be managed. The practice of dam and weir removal is more mature in the United States (US) and in Europe. These international perspectives were provided by Geoff Goll from the *Princeton Hydro* in the US, who brought the issues related to sedimentation management into the discussion. Hamish Moir from *cbec eco-engineering* in the United

[1] https://worldfishmigrationfoundation.com/why/
[2] https://inr.org.za/
[3] https://www.dws.gov.za/IO/Docs/CMA/CMA/PONGOLA-UMZIMKULU.pdf
[4] https://www.kznwildlife.com/
[5] https://umngeni-uthukela.co.za/
[6] https://www.sanparks.org/

Kingdom (UK) gave a presentation titled “designing with nature” in which he described a range of instream structure removals and river restoration examples, illustrating different approaches.

Workshop participants

The conference was attended by a range of international and national delegates representing learning and research institutes, government mandates, the non-governmental sector, the private sector. Over 50 delegates[7] from 27 organisations were in attendance.

Table 2.Organisations represented at the event

Sector	Organisation
Learning and research institutes	- South African National Biodiversity Institute (SANBI) - University of KwaZulu Natal - Durban University of Technology - University of the Western Cape - University of the Mpumalanga - Expanded Freshwater and Terrestrial Environmental Observation Network (EFTEON) - South African Environmental Observation Network (SAEON)
Government Depts, SOEs & Municipalities (National)	- National Department of Water & Sanitation and PUCMA - National Department of Environment, Forestry and Fisheries & SANParks - uMngeni-uThukela Water - Ezemvelo KZN Wildlife (EKZNW) - Maloti-Drakensberg TFCA - eThekwini Municipality
Government Depts (International)	- Ministry of Tourism, Environment and Culture (Lesotho)
Non-governmental sector (National)	- Wild Trust - Palmiet River Watch - eThekwini Conservancies Forum
Non-governmental sector (International)	- World Fish Migration Foundation (Portugal, Netherlands, South Africa) - Worldwide Fund for Nature - The Nature Conservancy
Private Sector (consultants)	- Institute of Natural Resources - Princeton Hydro (US) - Rivers of Life - Cbec eco-engineering (UK) - GroundTruth - Verdant Environmental
Private Sector	- Sappi

[7] The attendance list is attached as Appendix 1.

Results

The following section presents the details of the two-day event.

Day 1: Field visit

The aim of the field visit was to provide an experiential insight into a location where the Goodenough Weir was being built on the uMkhomazi River to address water security issues, but which included the installation of a fish ladder to enable fish migrations. The construction site was utilising the site of the old Goodenough Weir, to upgrade the weir to meet abstraction requirements for the surrounding regions. The construction site demonstrated clearly a range of issues indicative of the inherent complexities associated with instream obstructions. For example, as well as the extensive construction and associated costs of this kind of water abstraction and storage infrastructure, it was noted that there was another defunct weir some 500m upstream from the new weir (the redundant weir), and that this would have impacts of various kinds on the efficacy of the new weir's modified fishway. There is also a temporary weir downstream of the Goodenough Weir, that is owned by Sappi-Saiccor, which is in the process of being reconstructed to improve the abstraction of water to the Sappi-Saiccor Mill. It is uncertain if there is any consideration for aquatic fauna migration requirements during the time of this report.

The field visit aimed to demonstrate the replacement of the old redundant Goodenough Weir by a new weir that is specifically designed to mitigate flow disruption and facilitate fish migration, specifically through the installation of a fishway and design features to manage sedimentation impacts so that sedimentation can reach the ocean (Figure 6).

The complicating factor is the existence of another weir upstream from the new weir[8], as well as the Sappi weir downstream. The upstream weir is an old gauging weir listed as a Department of Water Affairs (DWS) asset. The weir is less than 500m upstream of the new weir and doesn't have any mechanism in place to facilitate river connectivity.

The field visit enabled the participants to engage with engineers on site who described the infrastructure design, and explained that it was modelled almost exactly on a similar weir on the Tugela River, as part of the Lower uThukela Bulk Water Service Scheme. It was noted that the installation of the fishway was a condition of the Environmental Authorisation for uMkhomazi and uThukela weirs. The engineers on site identified a key challenge in the design of the Goodenough Weir (as with the uThukela Weir) was balancing engineering and ecological imperatives.

As a water abstraction facility, the Goodenough Weir had to ensure that a maximum about of sediment remained in the river, away from the abstraction point to prevent sludging. The facility is designed to abstract a daily volume of 130 megalitres.

To fully understand the effectiveness of the vertical slot fishway and rock ramp fishway used at the Lower Thukela River Bulk Water Supply Scheme Weir and the Goodenough Weir, it was indicated that

[8] The DWS representative present agreed to investigate what plans there were regarding the upstream weir which is owned by DWS, although it was noted that currently there is no specific plan to remove it.

more monitoring is necessary. A key challenge mentioned was the need to ensure that the flow of water past the fishway is managed, ensuring that low flows go past the fish ladder, so fish can find it. Managing turbulence (through use of rocks) but ensuring plumes of momentum required by the fish to navigate the fishway. Flows that are too strong will inhibit their ability to find the access sites. Designing for optimal sediment management, facilitating continual scouring for both abstraction requirements as well as to ensure sediment flow down the waterway.

Figure 6. At the Goodenough Weir construction site and then talking about it during the question and answer session bottom left and the debriefing session bottom right.

Some observations from the site & debrief session

In response to the field visit, key discussions were held around various issues and imperatives related to dam and in-river structure removal, accountability, responsibility and impact management, as well as around knowledge, research and monitoring. These raised several associated points of consideration:

- It is important to consider responsibility for water resource management, with a river connectivity lens, including legal obligation, policy and regulation, funding, land ownership; resource management obligations; riparian zone management.
- There are many obstacles to the design and implementation of efficacious river connectivity activities, including land ownership and access, design, river rehabilitation, deep evidence gathering and ongoing monitoring.
- There is a need for a strategic and innovative approach in championing river restoration especially addressing Department of Water & Sanitation (DWS) and Department of Forestry, Fisheries and the Environment (DFFE) policy and regulatory obligations as well as issues related to water security and livelihoods protection. How can the requirements of the National Water Act, 1998 (NWA) and those of National Environmental Management Act, 1998 (NEMA) be aligned with each other and with the Bill of Rights embedded in the South African Constitution.
- The need to align ecological, economic, social and governance imperatives in common cause of river restoration and river connectivity.
- Need for much more information and evidence gathering through sustained monitoring to inform new barrier design or decisions around barrier removal:
    - Need to find ways of actually measuring the extent of water security that a dam can provide. Often assumptions drive decisions, rather than evidence and facts.
    - Need to ensure that studies are in place to track and trace fish movement to measure efficacy of new weir design, in respect of fish movement.
    - Need to know more about the particular species and what their migratory behaviours are, and how these are impacted. In addition, to understand more about the various species requirements in relation to migration. For example how and when to they move – is it related to seasons? Other factors like size, endurance, temperature and flow of water, moon phases all impact species behaviour.
    - Need to understand more about how barriers work positively in some instances e.g. preventing spread of invasive species.
    - Need to monitor fishways for a sustained period to be able to make predictions about efficacy, and impact on design.
    - Need to investigate the possibility of adaptation – might the river have achieved a new equilibrium, with the weir in place?
    - Need to understand better what the impacts of weir removal and non-removal.
- Funding for investigations, monitoring of all aspects and dissemination of information is always a challenge.
- Funding for decommissioning / removal of instream infrastructure is difficult to mobilise. Dam removal is expensive. Who can pay? Who should pay? What mechanisms can be employed?
    - In the USA, NGOs champion river rehabilitation despite that the state is responsible. NGOs can raise resources, where state is limited by budget constraints.

  - It was noted that in some European countries, decommissioning is mandatory, and regulated. Permits are given for the establishment of barriers and apply finitely to a specified end-of-life duration, after which they must be decommissioned by the owner. A fund exists resourced by levies specifically to fund decommissioning. Insurance companies are also leveraged.
  - There are international funds designed around river connectivity that could be accessed.
  - If removal of barriers were to be embedded into catchment management strategies, maybe tariffs and levies can be rationalised and raised. It would need to be strategically packaged and expressed as a resource management and protection strategy, and linked to a broader water resource management imperative. It is possible to describe instream structure removal as a Nature-based Solution[9] to challenges such as biodiversity loss.
  - There are legal obligations that can be used to rationalise pressure on government to assist, including the "public duty" that DWS has to exercise responsibility for ecologic/aquatic biota. For example, if a weir can be proved to be hazardous then DWS must exercise the duty of care clause of NEMA (Section 28).
  - It is important to do proper cost-benefit, evidence-based motivations that objectively analyse impacts and then devise a strategy, backed by evidence, and preferably with the identification of easier and doable "low-hanging fruit".
- Research and knowledge can inform best practice, but enforcement mandate is separated from information. How can the case study weir DWS U1H006 and others barrier be managed? There should be a dynamic and cyclical relationship between research, implementation, monitoring (formal and experiential by interested and affected parties) and regulation.
  - Need to find ways of bringing community knowledge and citizen science into the monitoring and learning process.
  - Ongoing long-term monitoring of instream structures, especially those that have been modified to include fishways is necessary to understand efficacy. It is not clear who would be responsible for this function.
- River barriers need to be considered case-by-case. There are multiple factors that impact of barrier removal (priority, cost, barrier ownership, extent of barrier impact, etc). What different approaches can be taken in different situations?
  - Can innovations be employed to simplify barrier removal?
  - Can barriers/weirs be partially removed?
- Ownership of the infrastructure is a key factor in addressing river rehabilitation through dam removal: The State owns the water body, and has regulatory mandate over location (riparian stewardship) of the water as defined by the National Water Act, 1998.
- It was noted that there is an asset register regarding state-owned dams and weirs. Is there a similar database of privately-owned infrastructure? This speaks also to weir monitoring, management and maintenance.

[9] This was illustrated by Navashni Govender in her description of ecosystem rehabilitation through dam removal in the Kruger National park.

- River connectivity needs to be understood in its broadest terms, so that an informed, holistic, but site-specific motivation is prepared. Multiple factors must be considered in instream structure removal:
    - Species migration (fish, macrocrustaceans, and others.)
    - Biodiversity protection and restoration.
    - Sediment reduction and sediment movement as a natural part of the river ecosystem.
    - Adaptation of species to weir impacts.
    - Impacts of climate change, including flooding was recognised.

> "The natural disturbances associated with sediment are integral to river ecosystems, and even fine-grained sediment can be beneficial to the river condition." (Wohl, E et al, 2015)

- It was noted that more information is required about the aquatic species using this river, including how they are using it (or would use it). All aquatic species require some movement to complete biological processes. The extent of movement requirements differ-some exercise long distance migration such as the African freshwater eels; others like the yellowfish species partake localised and seasonal movement.

Day 2: Presentations and discussions

The main purpose of Day 2 was to bring to the assemblage multi-perspectives regarding the integration of river connectivity restoration into river basin management strategies through expert input and facilitated discussions into key themes. A booklet was distributed to facilitate discussion and detail the two day workshop (Appendix 2).

Expert key messages

Several presentations were made on Day 2 addressing a range of key issues relevant to the debate around dam and weir decommissioning. As part of the World Fish Migration Foundation, and the organising committee, Burnett gave context to the event and described the outcomes of Day 1, with some useful visuals of the old Goodenough Weir and its upgrade. He was followed by an official welcome address by Rocha from World Fish Migration Foundation and then followed by a short presentation from successful dam removals in Kruger National Park by Govender from South African National Parks.

Together, these presentations outlined the contextual issues facing the sector, providing a sound basis for the table breakaway discussions and expanding the lens through which to consider a way forward for a South African decommissioning initiative. Some key observations that came out from the presentations included:

- Healthy rivers derive from sustaining the river ecosystem in its most natural state.
- Healthy and unobstructed river ecosystems provide the maximum ecosystems services, especially in a time of climate threat.
- Legislation is improving to protect biodiversity, which can support decommissioning.
- Instream obstruction decommissioning has a powerful impact on biodiversity protection.
- There are many redundant dams and weirs in rivers everywhere, doing no good at all.

Key messages of the presentations are presented below.

Matthew Burnett, World Fish Migration Foundation, University of KwaZulu-Natal, Institute of Natural Resources: Day 1 Field Trip report

Burnett used the opportunity of welcoming expert speakers and event participants to reiterate the purpose and process of the workshop. He also provided some visual contextualisation of the Goodenough Weir. The aerial photograph maps the uMkhomazi River in its catchment and indicates three weirs (owned by DWS) upstream of Goodenough Weir and one downstream, owned by Sappi (Figure 7).

Figure 7. The uMkhomazi River Catchment, showing the river, and the various weirs, including the new Goodenough Weir with the fishway.

The photographs (figures 8 and 9) below show the DWS upstream weir in relation to Goodenough Weir, showing the proximity as 500m.

Figure 8. DWS-owned weir just upstream of Goodenough, visible in the foreground.

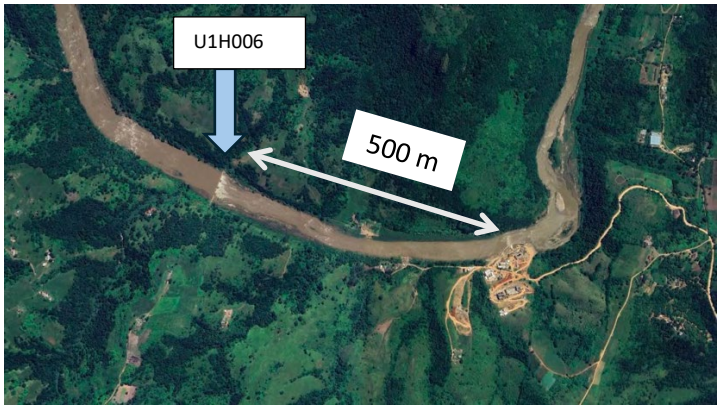


Figure 9. The upstream weir (U1H006) in relation to the new Goodenough Weir - 500m apart.

Burnett explained that the Goodenough Weir was modelled almost exactly on the Lower Thukela River Bulk Water Supply Scheme Weir, including the design of the fishway. The fishway below is from the uThukela Weir (Figure 10), and this demonstrates the same design as will pertain at the Goodenough Weir. The fishway is a vertical-slot fish ladder. This design is a pool and slot design, where fish are able to rest in pools after swimming through fast flowing water until the fish has moved through the fishway and upstream. Without a fishway, fish would not be able swim upstream past the barrier. Included in the design is the rock-way or rock-ramp, which provides a wetted surface for crawling organisms, like crabs and freshwater prawns, that use these structures to move upstream.

Figure 10. The uThukela Weir and fishway as a model for the Goodenough Weir and the fishway on the left.

Mr Ruben Rocha, Programme Manager, World Fish Migration Foundation

Extending the welcome from the World Fish Migration Foundation, Rocha reminded the gathering that although barrier removal was one part of river restoration, in Europe alone there are more than 1,000,000 barriers. So far 150 000 have been described as redundant, i.e. are serving no useful purpose, and indeed, contribute to dangers for people and other living animals. They contribute to increased greenhouse effect, increases in water temperature and evaporation and loss of water. Mr Rocha spoke of the growing awareness of the need to remove dams and barriers, noting that 8000 had been removed in Europe in the past five years, with 500 of these in 2023.

Navashni Govender, Senior Manager, Conservation, Kruger National Park Mpumalanga, South Africa: Water Management in KNP

Govender has been involved in a critical demonstration of the transformative power of both the installation of water course barriers, or artificial waterpoints, and the decommissioning of these same structures. Her data-driven and evidence-based presentation clearly illustrated the impacts of the installation and decommissioning for the land and the animals, and provided important lessons for sustainability in the face of growing climate threats. Govender presented her data in the context of long-term rainfall trends. She explained that during the years of reduced rainfall in the 1960s and 1970s, the prevailing practice was to install a large number of artificial waterpoints in the form of dams, reservoirs, weirs and troughs to ensure that the animals had access to water. In the drought years of the 1990s, it was noted that despite the availability of waterpoints, there was a radical increase of animal deaths.

From careful monitoring and evaluation of explanations for the phenomena, it was realised that animal mortality was not from too little water but rather from too little grazing and foraging material. The creation of multiple artificial water points created a false habitat for animals, resulting in the homogenisation of the landscape. Animals kept close to waterpoints, and overgrazed the surrounding land, resulting in the denuding of large areas and food shortages.

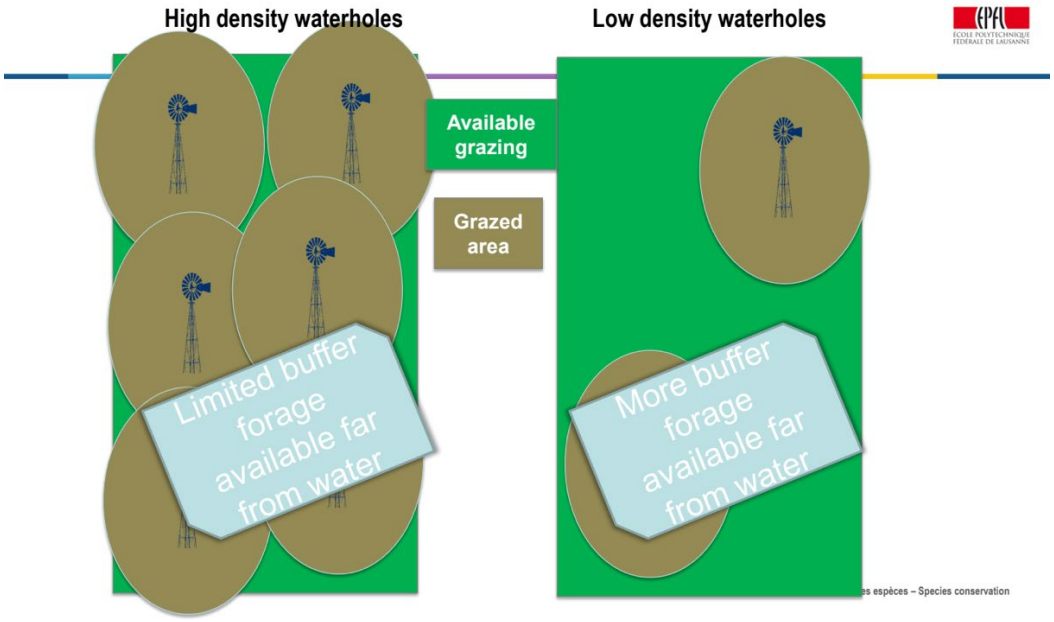


Figure 11.Comparison of high and low density waterpoint impacts on grazing.

Govender pointed out that, “Artificial water provision should limit the suppression of the natural spatial and temporal patterning in water availability. This implies that:

- Water should not be provided in areas that are naturally dry.
- Water should not be provided too evenly across the landscape, thus unnaturally increasing the water availability during droughts and spreading the effects of droughts over larger landscapes.

- Artificial water should only be provided or condoned if human-induced constraints affect the availability of drinking water in the park (e.g. deteriorating quality and quantity of rivers flowing into Kruger)."

Heterogeneous landscapes are much more supportive of biodiversity. These realisations have led to a systematic decommissioning of two thirds of the artificial waterpoints over the past 40 years. This work has been accompanied by dam removal to support river connectivity. It was noted that in addition to protection of fauna and flora biodiversity, the decommissioning has been a game changer in respect of flood management.

Mr Nkosinjani Mkhize, DWS Deputy Director, Catchment Management Sub-directorate, Pongola to Mzimkulu Catchment Management Agency (PUMCA): Catchment-Based Water Resource Protection in the Pongola-Mtamvuna Water Management Area

Mkhize is a key roleplayer in the formation of the Pongola-Mzimkulu Catchment Management Agency (PUCMA) in South Africa. As Deputy Director within the newly-established PUCMA, all eyes are upon him and his colleagues to see how best catchments can be managed at a time when water security and the protection of water sources is at an all-time high. Catchment Management Agencies (CMA) have been in place for some time, but the mandate has been reviewed and the imperatives are now much more urgent, requiring reviewed approaches and bold leadership.

Mkhize pointed out that all our river catchments "are currently stressed". He noted that the primary water users are agriculture at over 60%, while municipal urban and rural users are at 24% and 3% respectively. Mkhize described the legislative and regulatory landscape as progressive and designed to address equitability and sustainability, requiring careful management to balance ecology with usage, defining responsible Resource Quality Objectives (RQOs). Legislation is premised on the understanding that South Africa exists within a water-scarce environment. The mandate of the CMA is to facilitate responsible water resource management within a defined Water Management Area (WMA). The CMA aims to:

- Take into account the classification of water resources and water resource quality objectives and the requirements of the Reserve and international obligations.
- Set out strategies, objectives, plans, guidelines and procedures for the overall management of water resources within the water management area.
- Contain a water allocation plan according to a set of principles.
- Take into account national and regional plans (prepared under any other law) including the water services development plans (WSDPs) of municipalities.
- Enable public participation in managing the water resources in the water management area.
- Take into account the needs and expectations of current users and potential users.

Mkhize described the approach and strategy of the PUCMA as being collaborative, participatory and stakeholder-driven and designed around seven key themes (*Figure 12*).

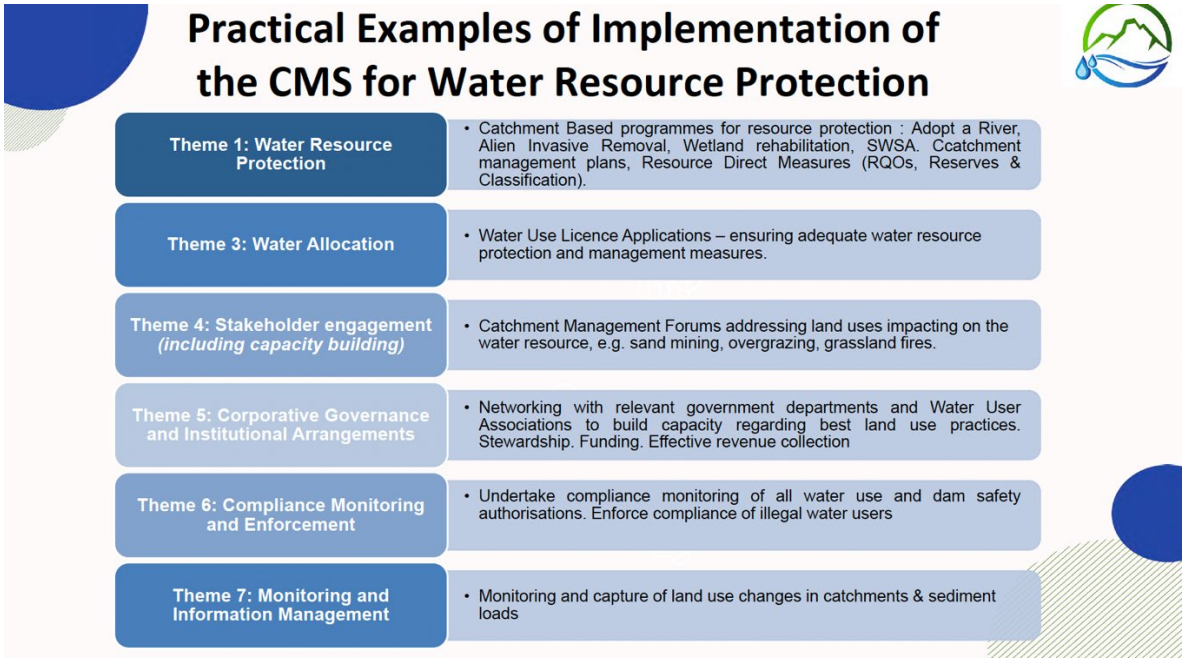


Figure 12. The seven themes of PUCMA.

In respect of dam and weir removal, Mkhize reminded the assembly that decommissioning is new, has not been done to any significant degree in South Africa, and is also subject to regulation. Motivations would need to address ecological issues, economic imperatives and "The serious consequences for life, property and ecosystem function". Any removal "Would trigger the need for authorisation in terms of the NEMA regulations … It is likely that a full Water Use Licence Application (WULA) would need to be submitted to DWS for the activity in terms of the National Water Act".

In response to questions, Mkhize indicated that PUCMA will be "the first CMA to put river connectivity into the strategic plan". He acknowledged the need to build an arsenal of information, techniques and methods to improves river functionality and to guide improved and best practice. He also indicated the need to work closely with agencies like UUW, as the CMA has powers of enforcement that UUW does not have, but UUW has the capacity to monitor and identify non-compliance. He noted that there are special challenges related to ensuring or enforcing compliance of other government entities, such as municipalities, although there is at least one case in process currently.

Ms Futhi Vilakazi, Senior Manager: Catchment Management, UMngeni-uThukela Water: Source Water Security Challenges and UUW Catchment Based interventions

The impact of the challenges on water storage infrastructure such as dams was also presented in the form of a map and three-year dam quality index data that clearly indicated water resources in crisis: "dams and rivers are mostly in poor condition" (*Figure 13*). Vilakazi named the range of key challenges in rural, peri-urban and urban contexts, including:

- Sedimentation and siltation at various points along catchments, especially in dams.
- Problems associated with extensive sugarcane and commercial afforestation.
- Agricultural runoff including feedlot impacts.
- Catchment degradation (terrestrial and aquatic invasive alien species infestation, erosion, wetland dysfunction).
- Sandmining.

- Industrial and sewer overloads and illegal discharging into water courses.
- Solid waste clogging systems.
- Non-operational and malfunctioning waste water treatment works.
- Eutrophication and consequent algal blooms in dams.

In describing how UUW aims to address these issues, in order to deliver on their core mandate which is sustainable and equitable water provision, Vilakazi emphasised UUW's commitment to an integrated, collaborative, whole-catchment approach, addressing problems from source to symptom, and using Nature-based solutions as much as possible both as preventative and as curative responses. She presented some of the interventions that UUW is implementing such as conducting catchment assessments/inspections and reporting polluters of all kinds to mandated authorities; developing and implementing integrated catchment management plans; supporting the implementation of Nature-based Solutions (wetland rehabilitations, constructed wetlands, soil conservation and restoration interventions) in various locations; and collaborating with a wide range of stakeholders and role players operating in the research as well as catchment rehabilitation space to learn about and build best practice.

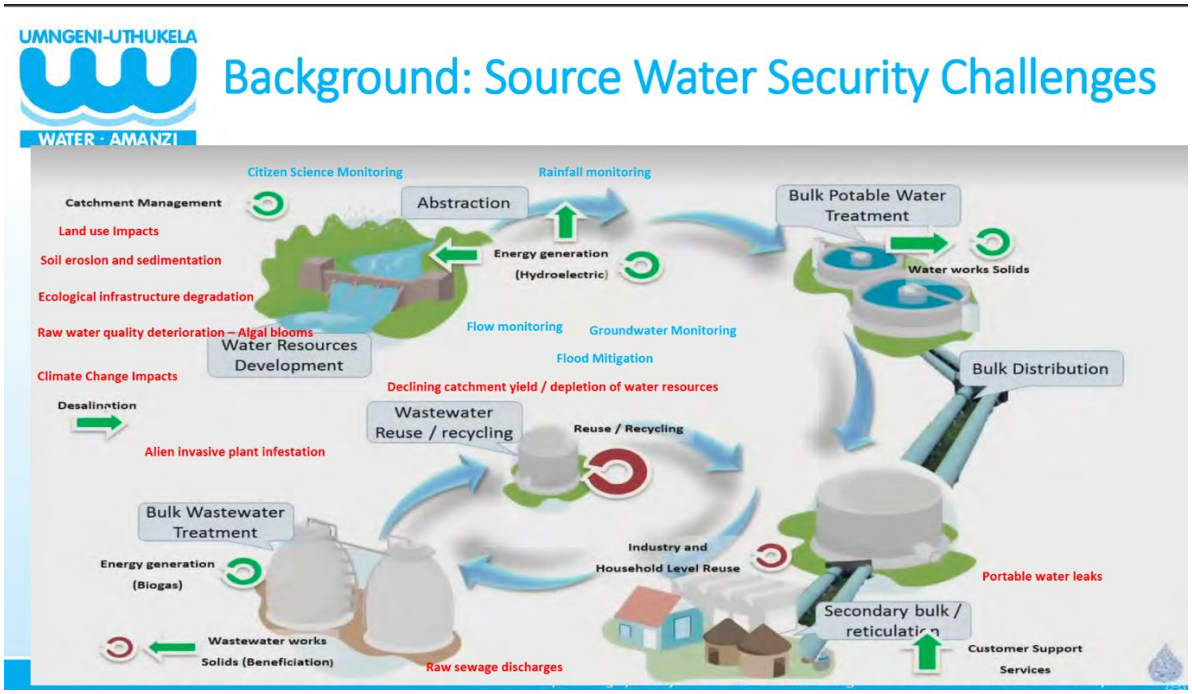


Figure 13. The lifecycle of water provisioning.

Vilakazi pointed out two key limitations: The scale and magnitude of the challenges are sometimes beyond the reach and mandate of the organisation, given limited resources and impact management control, and lack of authority to enforce compliance. There are involved mandates over which UUW has no jurisdiction, such as municipal departments. UUW also has a geographic mandate, and does not have control of upstream impacts from outside the area. Interventions that are carried out are often long-term in nature and do not address immediate problems. Vilakazi ended her presentation by inviting all parties present to collaborate with UUW.

Mr Geoffrey Goll, President, Princeton Hydro, US: Sediment Management Before, During, and After Dam/Weir Removal

Goll's presentation focused on the crucial issue of sedimentation in the context of river ecosystems, pointing out that "rivers are conveyor belts of sediment" (*Figure 14*). He noted that watershed sediment is a "normal and critical part of ecosystem functionality", as it provides habitat and substrates for a various organisms. It is part of the hydrologic cycle linking terrestrial, freshwater and marine ecosystems. Sediment plays a large role in coastline protection. Likewise, disrupted sediment movement can result in many challenges.

In unobstructed and obstructed river systems, the sediment movement is directly related to the landscape, including to landuse and land cover.

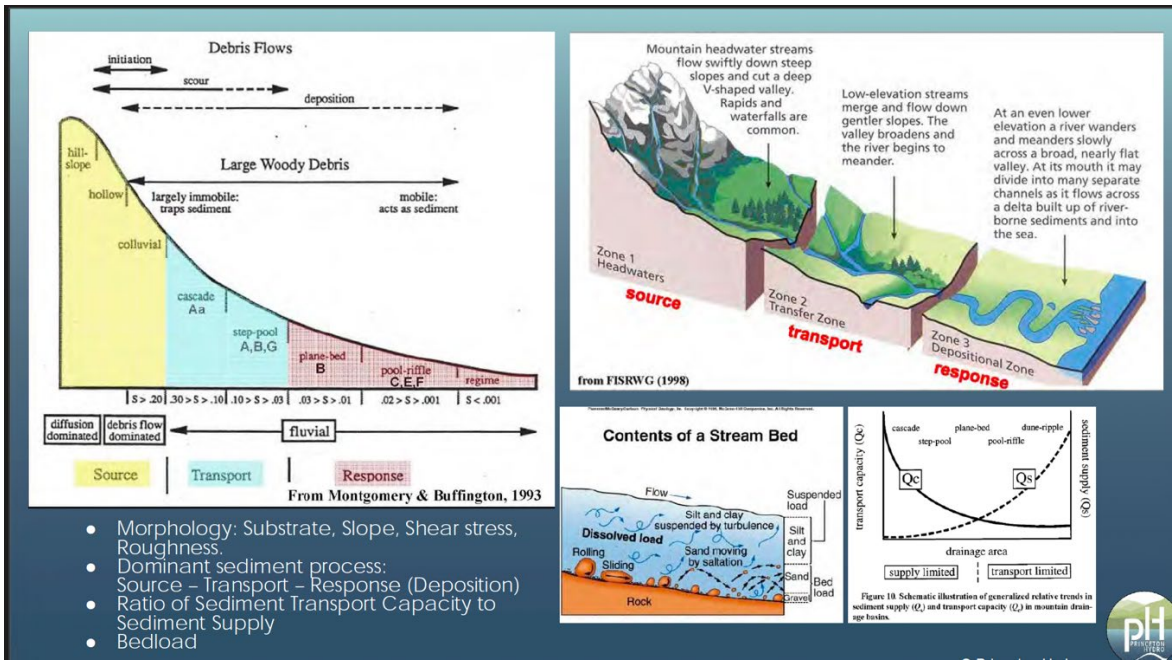


Figure 14. Understanding the morphology of the river.

In river systems that are obstructed, the natural movement of sediment results in multiple problems that require various scales of interventionist management. The build-up of sediment reduces water volume and storage in weirs and dams. It requires the use of complex and expensive dredging to clear, with associated challenges of sediment disposal. High sedimentation in water courses leads to an increase in water temperature and quality. It creates substrates that inhibit habitability. Highly sedimented areas are typically devoid of biodiversity.

In the context of dam removal, sediment management is necessary and can be handled in multiple ways depending on the situation. Sediment management can be passive (allowing sediment to be carried downstream, subject to riverine processes); active (involving dredging, moving, offsite disposal and/or stabilising sediment); or it could be a combination of passive and active sediment management. Assessments and sediment surveys are necessary to determine method and timeframes. Dam removal programmes often will use an adaptive planning approach, based on morphology assessments, surveys, decisions around sediment transport, monitoring, informed predictions about possible outcomes. Typically, 10% of dam removal funds are allocated to a post-removal monitoring process.

In relation to sediment management, dam removal guidelines should address relative sediment volumes, estimating average annual sediment loads; sediment transport from dam removal, at all stages of the planned process; and analysis of stream power and other rough estimates of risk (*Figure 15*). Goll noted the importance of predicting impacts and ongoing sediment maintenance post removal; and determining best dredging processes, whether hydraulic or mechanical. Guidelines should enable making sound decisions about phasing the process, in relation to the ecosystem. Finally, taking into account the different characteristics of impoundments at different parts of the river system.

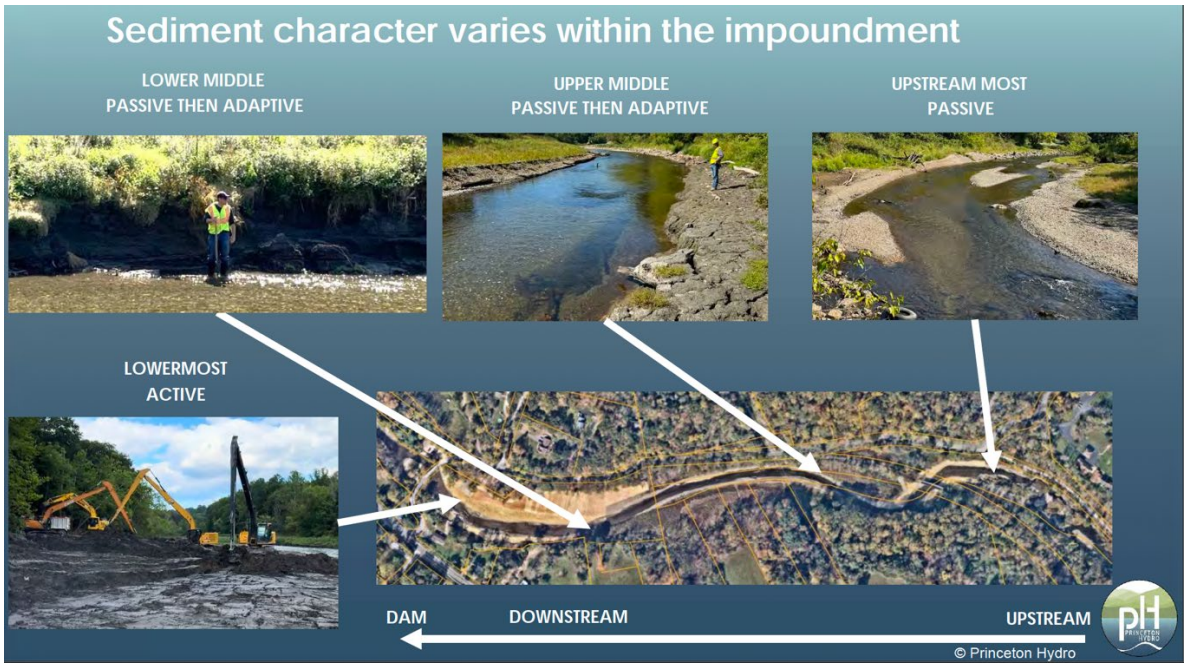


Figure 15. Sedimentation at different points.

In response to questions, Goll indicated a number of strategies to manage and limit negative impacts from disrupted sedimentation flows such as:

- Taking the approach to keep sediment moving by all means possible. Scouring increases where sediment is not moving. Accepting that high levels of continuous management are required.
- Ensuring that land use near rivers does not result in sand infiltration into the river, such as leaving riverine areas pristine, or in the case of agricultural lands, encouraging no-till practices.
- Encouraging the planting of groundcovers and water plants close to rivers for bank stabilisation.
- Introducing systems and mechanisms for increased aeration.
- Enabling slow water release practices.

Goll shared that legislation in the US is similar to that in South Africa, and that there is space to ensure sustainability. He pointed out that dam removal is often cheaper and easier to achieve than dam retrofitting. He encouraged participants to advocate for fishway installation and sediment movement systems in the context of instream structure repair and design of new installations.

> "I would love to live like a river flows, carried by the surprise of its own unfolding" John O'Donohue

Hamish Moir, Business Development Director and Principal Designer, cbec eco-engineering, UK: Designing with nature

The subtitle of Moir's presentation was "The sustainable 'nature-based' management of sediment at dam structures: case studies from Scotland, England and Iceland", underscoring the preference for using Nature-based Solutions. He presented four different case studies, making the point that the morphological processes and constraints of any single case needs to be understood before deciding on an intervention design. He noted issues such as channel stability, biodiversity and ecological conditions, size and scale of structures and sediment continuity. He emphasised that risk management is the key design factor. Moir described a series of case studies of building river connectivity through instream structure removal where possible and modification were it was not possible to fully remove the structure.

River Leven (Burn Mill Dam) and Bronie Burn, which entailed a full removal, and which was relatively simple, restoring river connectivity and yielding relatively quick returns in terms of ecological restoration. It was noted that morphodynamic modelling identified channel instability resulting from simple weir removal, requiring channel reprofiling upstream and downstream, which provided significant additional biodiversity benefits.

Bowston Weir, entailed partial removal (full removal and rock ramp replacement). This case involved the application of 'morphodynamic' modelling of channel bed evolution resulting from the removal of the large weir structure and rock ramp replacement.

With the River Leven (Kirkland Dam), removal could not happen due to the unexpected discovery of a sewerage pipe in the weir, but a rock ramp was installed (*Figure 16*). The design in this case entailed a 'nature-based' mitigation approach, including a nature-like rock ramp to facilitate unhindered fish passage and allow of sediment continuity, as well as contribute to the overall aesthetic appeal of the intervention. The process required a significant amount of river engineering and land restoration to achieve the end result.

Figure 16. Stages of the weir mitigation on the River Leven.

The case study of Andakílsá River and dam in Iceland involved the retrofitting of a dam structure including sediment management. To address the main zone of sediment accumulation, a retrofitted spillway structure was installed to permit the natural transport of coarse sediment downstream. This enabled increased water surface slope/energy gradient and transport of coarse sediment over spillway crest and downstream. In addition, the strategy entailed re-naturalisation of the upstream catchment to manage sedimentation, as well as decreased bank erosion through channel stabilisation achieved through re-establishment of native vegetation in river corridor; and increased (natural) in-channel sediment storage managed through implementation of large wood structures, also providing significant ecological improvement (*Figure 17*).

Figure 17. Channel stabilisation through re-establishment of native vegetation in river corridor graphically depicted for visualisation on how nature-based solution can contribute to river connectivity restoration.

The following are some key observations:

- It is possible that the impoundment sedimentation issue is artificially enhanced.
- Nature-based sustainable approach through reinstating natural river/ riparian process across broader scale.
- Managing the cause of sedimentation issues rather than the symptom (longer-term approach).
- Riparian condition/processes significantly impacted on Andakilsa River resulting in elevated sediment yields.
- Significant additional benefits were achieved including improved flood risk management, as well as ecological and socio-economic benefits

In concluding his presentation, Moir made the following recommendations in respect of ensuring a carefully planned process of instream structure removal and river rehabilitation:

- Ideally, remove entire dam/ weir structure.
- Important to have careful consideration of physical process and constraints to determine best course of action.
- Sediment continuity should be a fundamental consideration (sustainable management).
- Nature-based approach – avoid concrete!
- Consider wider reasons for high sediment yield.
- Retrofit existing and sustainably design structures.

In response to questions about the kinds of rocks that can be used to build rock ramps, Moir encouraged local sourcing as transport costs can be prohibitive.

Andy Blackmore, Manager Integrated Environmental Management & Protected Area Planning, Ezemvelo KZN Wildlife: Removing instream barriers in South Africa – An overview of the legal challenges

Blackmore provided an overview of the legislative framework governing dam and instream structure decommissioning. He noted the importance of ensuring that the range of laws in various policies and regulations needed to be understood together, and that this enabled actions to be justifiable in some cases and not in others. The provisions of one Act may be supported or challenged by another.

He noted that the transboundary nature of several of Soth Africa's bigger rivers required that we acknowledge some international legislation along with our own, including:

- UN Watercourses Convention (1997) which addresses the equitable and sustainable use of international watercourses.
- UNECEWater Convention (1992), requiring protection and sustainable use of transboundary watercourses and international lakes.
- Ramsar Convention (1971) which promotes the "wise use" of wetlands, including maintaining their ecological character through sustainable practices.
- Helsinki Rules (1966): Guidelines for the use of international rivers and drainage basins. They focus on equitable utilization and prevention of harm.

Blackmore also referenced a range of multinational treaties, agreements, policies, guidelines and action plans applicable to the Southern African Development Community (SADC) countries, noting that they promote environmentally sound development and management practices, require measures to prevent harm and degradation and promote mitigation measures, as well as the protection of aquatic environments.

The main South African laws that must be considered in respect of instream barrier removal are the following, all of which govern slightly different legal specifics, but all of which need to be factored into processes aimed at building river connectivity through instream barrier removal.

- National Water Act 36 of 1998 (NWA), which addresses aspects such as any alteration of the bed, banks, course, or characteristics of a watercourse, and considerations for issuing water use licenses, including the need to protect water resources, promote equitable access, and ensure sustainable use.
- National Environmental Management Act 107 of 1998 (NEMA), focusses on wide-ranging environmental protection including defining permission processes such as Environmental Impact Assessments (EIA) and other factors that could result in disturbance of ecosystems and loss of biological diversity are avoided, and degradation of the environment are avoided. NEMA contains three Listing Notices specific to dams and weirs. Listing Notice 1: Activity 31 refers to the closure of existing facilities, structures, or infrastructure. Listing Notice 2 specifies the height of dam walls. Listing Notice 3 specifies the development of-(i) dams or weirs where infrastructure and water surface area exceeds $10m^2$.
- National Environmental Management: Biodiversity Act 10 of 2004 (NEMBA), provides for the management and conservation of South Africa's biodiversity, including through the control of alien or listed invasive species. It also references the duty of state organs to implement legislation applicable to biodiversity, that they must manage, conserve and sustain South Africa's biodiversity.

- National Heritage Resources Act 25 of 1999, states that a person may alter or demolish any structure or part of a structure which is older than 60 years without a permit issued by the relevant provincial heritage resources authority. This potentially places a heavy administrative burden on dam decommissioning.

Blackmore concluded by reminding event participants that there exists a complex legal environment for decommissioning weirs and dams that may require Water Use Permits or Certificates, Environmental Impact Assessment and Authorisation, Biodiversity Permitting and Conservation Authority involvement, and could even require Preliminary Heritage Assessments and even full Heritage Impact Assessments.

Table discussion key findings

The second session of Day 2 was designed to encourage deep discussion on several relevant focus areas. Workshop participants were invited to choose two topics of interest (*Figure 18* and *Figure 19*). They would spend half the time at a table of one topic, and half the time discussing their second topic choice. The groups were provided with two river maps with condition cards: one to show the current state of rivers; the other to show an ideal condition. The task was to explore each of the topics and use the insights generated to populate the two river maps. The developed ideal river map would provide insight into a way forward in relation to the focus areas.

The focus areas of the tables were:

- Interests and roles of stakeholders (community, land-owners, NGOs, specialist practitioners, researchers, government, others)
- Are current governance mechanism conducive to dam restoration yes/no? Why?
- Balancing water scarcity and biodiversity protection (water abstraction and storage, dams, risks and mitigations)
- Socio-economic and socio-ecological considerations, including local livelihoods and ecosystem derived services
- Funding for the entire process from mapping to removal

Interests and roles of stakeholders

Instream infrastructures are built for various reasons. They are located on different land holdings, under different ownership and / or stewardship. The catchments within which rivers flow may be long and wide, or they may be small. The ecosystems services offered by rivers and catchments are equally varied. The beneficiaries of the ecosystems services can be local or distant. The conditions of the catchments and river systems are variable. Water usage from catchments varies. Efforts to manage, conserve and rehabilitate catchments involves yet another set of people. All these variations imply that there is a wide range of role players and stakeholders related to any river system and catchment (*Table 3*). This wide range of stakeholders implies a complex web of interests, complicated further by the reality that some stakeholders are engaged, others not; some are aware of their interests, others not, and few are aware of the interests of other stakeholders. Finally, some interests are in direct conflict with others. Table 3 describes the range of stakeholders and their respective interests.

Any intervention that involves change, will raise the concern of affected stakeholders – either positively or negatively. This needs to be understood by the champions of change.

In respect of the workshop focus, looking at promoting river connectivity through limiting especially instream barriers, it was important to consider the interests that are embedded in the river systems. The focus group used the following questions to assist them to unpack how to think about stakeholders:

- Who benefits from ecosystems services provided by rivers? What are their respective interests? What drives their interest?
- Who are the key stakeholders involved in river rehabilitation and dam management? What are their interests? Do they have specific roles related to their interests?
- How should stakeholders be engaged?

In the South African context, the typical range of catchment stakeholders include those from various spheres of government, including the different mandates; those from various scales of private sector interests; and a range of actors broadly from civil society. The complexity of the stakeholder profile links to respective interests and mandates. The following table unpacks some of the complexity.

Understanding stakeholder mandates, interests and concerns enables a strategic approach to engagement. The table discussants suggested that to achieve an ideal river connectivity outcome, it would be necessary to:

- Build collaboration and partnerships across catchments and across stakeholder groupings, for collective advocacy. Key questions remain: who will be responsible for bringing stakeholders together and to common cause? How to mobilise resources for effective and meaningful, bottom-up, whole-catchment stakeholder engagement.
- Build knowledge and understanding about the multiple benefits of river connectivity such as fish migration, biodiversity protection, sedimentation management, river functionality, coastal ecosystem protection, flood risk management. Do this with all categories of stakeholder in multiple ways appropriate to the stakeholder grouping. This is important for understanding and reconciling different / opposing views and understanding trade-offs associated with different choices.
- Align to and promote the development of catchment management strategies of all catchments, not only big ones.
- Engage CMA specifically to facilitate stakeholder discussions and information sharing, including through Catchment Management Forums, as well as to communicate stakeholder issues to DWS and national government policy makers.
- Referencing local mythology, the group agreed to beware of angering Nkanyamba[10]!

[10] The Nkanyamba is a legendary serpent that is said to live in the deepest bodies of water, often near waterfalls, in South Africa. The amaZulu people are said to believe the Nkanyamba to be a giant, tall serpent with the head of a horse, who is the 'river guardian' protecting water from inappropriate use.

Figure 18. Talking about the stakeholders to the stakeholders.

Taking the discussion to the riverscape visualisation exercise, the group noted the present and ideal conditions.

Figure 19. Stakeholder engagement - present and ideal conditions.

Table 3. Stakeholders and their interest

Stakeholder		Interest / Mandate in respect of catchments and rivers	Likely issues of concern in respect of river connectivity
National Government	DWS	Responsible for governing all water resources. It "owns" all water resources, managing them on behalf of the people. Ensure policy governs practice. Ensure water and sanitation infrastructure for service delivery Monitoring and compliance.	Aligning water security with environmental impacts of disconnected rivers
	DFFE	Responsible for governing all environmental resources	Ensuring instream barriers do least environmental harm through legislative controls, e.g. EIAs. Protecting biodiversity
	SANBI	Research and development on all matters impacting biodiversity	Research, monitoring, advocacy for best practice outcomes for protecting biodiversity
Provincial / Regional/Local Government	Catchment Management Agencies	Responsible for governing all catchments on behalf of DWS	Ensuring the sustainable management of catchments in the interests of protecting ecosystems services delivered by catchments while also ensuring equitable water supply.
	Economic Development, Tourism, Environment & Agriculture (or other provincial equivalents)	Responsible for enforcing policy and regulation at a provincial level within the focus areas	Governing and supporting interests of livelihoods development at all scales. Managing regulation and compliance. Responsible for limiting pollution / degradation impacts of environment, agriculture, other activities
	Umngeni-Uthukela Water (and other regional water boards)	Water Services Provision of potable water to municipalities and some end users; increasingly infrastructure management	Require water security - supply but also quality for cost-effective on-selling. Catchment management and river quality protection are key to mandate
	District / Metro / Local Municipalities	Water authority purchases water from Water Services Provider and sells to consumers. Responsible for water and sanitation infrastructure	Indirect interest in water quantity and quality. Responsible for water and sanitation infrastructure. Currently unable to deliver on preventing contamination of water sources.
Traditional Authorities	Ingonyama Trust Board in KZN; systems of chiefs / amakhosi and headmen/izinduna	Stewardship of land in some rural areas; hold authority over landuse and land allocation. Act on behalf of the state according to traditional practices	Mostly disconnected from water provision services, they depend on local rivers and streams, hence are interested in clean rivers.
Private sector	Commercial agriculture (various kinds large-scale production). Rural	Access to constant & reliable water resources for irrigation/livestock purposes	Quantity and quality of water. Constant and reliable supply. Likely to challenge barrier removal in interests of securing own access to water. They are often polluters of water resources.

	Small-scale agriculture (various kinds of production). Rural	Access to constant & reliable water resources for irrigation/livestock purposes	Quantity and quality of water. Constant and reliable supply. Likely get water from rivers and streams.
	Urban & peri-urban industry	Access to constant & reliable water resources for processing purposes	Quantity and quality of water. Constant and reliable supply. Likely to challenge barrier removal in the interests of securing own access to water. They are often polluters of water resources.
	Rural businesses (e.g. tourism; recreational)	Access to constant & reliable water resources for various purposes - domestic use, recreation	Quantity and quality of water. Constant and reliable supply. Likely to resist barrier removal in the interests of securing own access to water, rivers and dams.
Civil society	NGOs / NPOs / CBOs	Access to constant & reliable water resources for various purposes - domestic use, recreation, aligned to environmental protection and equitable access.	Research, monitoring, advocacy for best practice outcomes for protecting biodiversity; environmental sustainability. Implementation of projects / activities to reduce negative impacts on water resources. Likely to support managed decommissioning efforts.
	CBOs	Advocate for access to water resources for local community use.	Quantity and quality of water. Constant and reliable supply. If knowledgeable, may support barrier removal to secure unpolluted water.
	Water User Associations	Advocate for access to water resources for commercial use (in practice). In principle, they manage water allocations within designated areas to ensure equitable allocation among registered water users.	Quantity and quality of water. Constant and reliable supply. Likely to challenge barrier removal to secure own access to water.
	Research / learning Institutes	Research and development on all matters impacting social and environmental sustainability	Research, monitoring, advocacy for best practice outcomes for protecting biodiversity; environmental and socioeconomic sustainability
	Residents (differentiated)	Access to constant & reliable water resources for various purposes - domestic use,	Access to constant & reliable water resources for various purposes - domestic use, subsistence agriculture Likely to be less knowledgeable about decommissioning
	Rural communities	Access to constant & reliable water resources for various purposes - domestic use, subsistence agriculture	Access to constant & reliable water resources for various purposes - domestic use, subsistence agriculture Likely to question decommissioning

Governance

The table discussants unpacking issues of governance considered the range of key policies and mechanisms currently in place to inform river and dam management (*Figure 20* and *Figure 21*). They explored who the role players are in these processes. They debated whether the activities of current mechanisms address river restoration adequately, especially with the sometimes competing pressures

of water security and environmental protection, and what gaps need to be addressed to build a more holistic and sustainable approach, in respect of policy, practice and participation. Given that governance refers not only to legislation but also to how various role players govern, or manage, the water resources including rivers, dams, and other channels of water that ultimately derive from rivers, the issue cannot be understood aside from issues affecting role players and stakeholders.

It was agreed that there are several policies and regulations that impact in one way or another on instream structure removal and dam management, as was clearly explained by Blackmore in his presentation of the current legislative framework. Some aspects of this legislation is specific, describes specific mandates and requires specific actions. Others are indirect. Some aspects of one law can challenge aspects of another. It was agreed that this legislative and accountability landscape was not well understood within the stakeholder community. The government has taken some steps in some areas to help people understand water laws, but much more education is needed. Key to ensuring good governance is ensuring that *all* stakeholders – to the greatest degree possible - are aware of:

- Legislation from all angles that directly or indirectly impacts management of instream infrastructures (e.g. NWA, NEMA, NEMBA, NHRA, and others).
- What mandates and mechanisms pertain when, where and how; who the mandate holders are, and how should, and do, they deliver on their mandates.
- The range of possible impacts of instream infrastructure on river functionality and river connectivity, with a broad lens including issues of long-term sustainability and threats such as climate change.
- How best to offset and / or mitigate impacts of instream infrastructure in any and every way possible.

The mechanisms of governance are largely in the hands of government agencies and associated forums that include private sector and civil society interests. However, these mechanisms and their mandates require some refinement. The respective roles and responsibilities of the different levels of the DWS, including the CMAs, water boards and municipalities are not always clear, even within these organisations. There is a question about which agency should lead river management and the extent to which understand their responsibilities, roles and limitations. Further, there needs to be a clearer line of accountability and compliance management within the state mechanisms. A clear and diligent system of Compliance, Monitoring and Enforcement (CME) will assist improved governance of water resources, and associated activities such as river rehabilitation and dam management.

As well as the legislative landscape, a key factor that impacted on governance issues related to ownership, responsibility and accountability. It was noted that although all water resources are “owned” by the National DWS, often the river runs through privately-owned land, or land that is under non-state jurisdiction. This immediately implies a necessary partnership arrangement, and justifies the need for controls and authorisations on state and private land. Effective river management and water resource protection requires a collective approach to best practice. This requires ongoing engagement. The politics around this is clearly experienced in forums such as catchment management forums and water user associations. In some places, there is no engagement and accountability can be profoundly compromised.

Another aspect that this group considered was the lack of Water Quality Data. It was noted that currently there is no official data on water quality or river management in South Africa. Further it is unclear as to who is or should be he responsible agency for collecting this data.

In respect of instream infrastructure removal and dam management, the discussants acknowledged that specialist knowledge and expertise was critical, at all stages from assessment and planning, to removal, to post-removal rehabilitation, and ongoing monitoring. With such available expertise and a requirement for such, the rationale for instream structure or dam removal (or installation) would be thoroughly assessed, and deeply informed decisions would be made about whether removal was the best option, and how best to proceed.

An associated conundrum was considered. For old and redundant infrastructure such as weirs and dams, it was noted that there is uncertainty as to what agency is responsible for maintenance or removal, and there appears to be limited recorded information on these structures, despite that apparently DWS has a register of all instream infrastructure. Questions were raised as to the currency of this register, and whether monitoring actually took place. The riverscape visualisation was used to consider a way forward.

Figure 20. Discussing governance issues and using the riverscape to guide discussion.

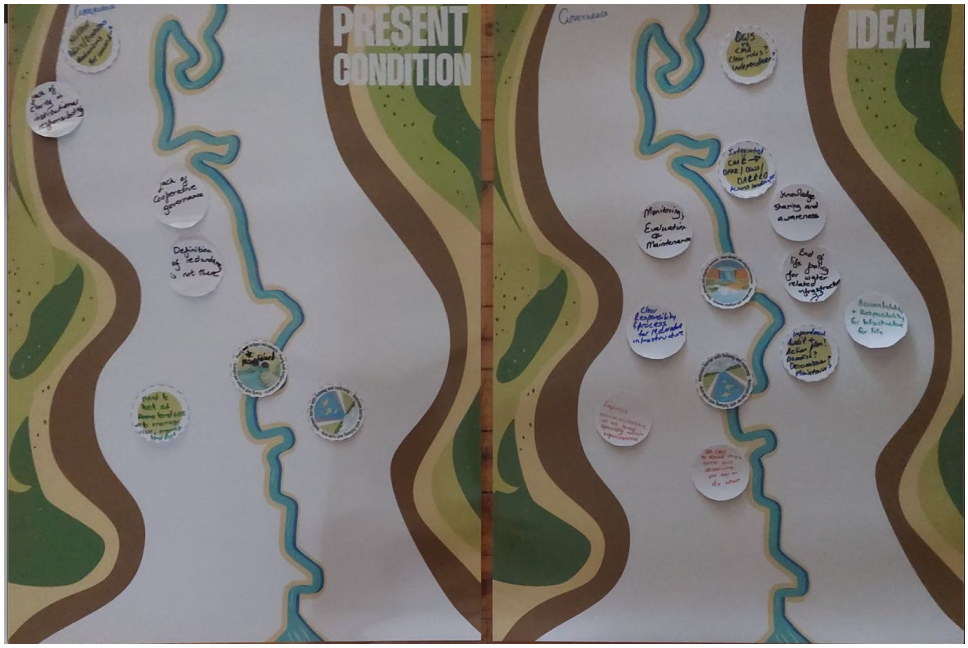


Figure 21. Governance - present and ideal conditions.

Looking forward, the governance team agreed that there were several actions that could be taken forward in the short to medium term that would result in better practice, including the following:

- In a framework of cooperative governance, there needs to be a process to ensure that key stakeholders have the knowledge and understanding of policies and imperatives to plan how to navigate a rational dam decommissioning and river rehabilitation process.
- The roles and responsibilities of the different role players within and outside government need to be more clearly defined, and made known.
- Need to develop a strategy for the prioritisation of river restoration and sustainable dam management given the urgency of water security issues as well as the need to protect rivers as critical water sources, and the need to prevent biodiversity loss.
- A wide-ranging audit could be carried out around governance issues: what is working and what is not? Which management actions are effective and which are not? Where are the disconnects between the various mandates?
- An audit could be done of all instream infrastructure, by catchment, by region, by province. This could include all that are documented, including location, land ownership, installation date, purpose, current status, recommended actions, including whether old structures should be allocated heritage status. It could extend to checking if the databases are up to date including those on private property.
- A facilitated discussion specifically focussing on instream infrastructure could be convened with all relevant and involved / mandated government entities to straighten out issues of responsibility and accountability, and address questions such as whether or not CMAs should take responsibility for instream structures within the catchments they manage. This should include all different interested and affected departments / mandates at all spheres of government, to foster cooperative governance practices.
- A similar facilitated discussion could be convened between different sector stakeholders: government, private sector, and civil society.

- Developing a guideline resource for removal that identifies relevant legislation, required authorisations; assessment protocols and checklists; options for removal, partial removal, impact mitigation, like different kinds of fishways, or sediment management; as well as general information about the benefits and challenges of removal.
- Developing educational resources and mechanisms of information sharing for different kinds of stakeholder, using different kinds of mechanisms.
- There needs to be a way to effectively distinguish between public and private water storage assets, and how these should be governed.
- River connectivity is a new thrust in South African water resource management discourse, and still needs to find its way into dam management.

Balancing water scarcity and biodiversity protection

This was by far the most popular theme of the workshop showing a strong desire to try get this balance right (*Figure 22* and *Figure 23*). There is a perception that water security, or even water availability, can be solved by damming rivers and creating abstraction facilities at key points along these rivers. There is wide-ranging research that posits the need to protect water sources, namely rivers, by supporting their natural functionality. Then there are the impacts to biodiversity that come with creating dams and other instream structures. The event that that has spawned the discussion is championing the need to remove instream barriers specifically so that migratory aquatic species can migrate along river systems as per their biological need. The debate quickly broadened from crabs and fish to include all species, fauna and flora: “It’s not only about the fish”, emphasised Burnett!

Water needs to be valued much more than it is. Catchments must be valued part of the ecosystem. Biodiversity of fauna and flora impacted by catchment systems need to be valued. A lot of rivers do not have reserve values set up for them. Defining river value must include biotic values, as well as those associated with “river hydrology, geomorphology, instream processes, and landscape functions”. If greater value was placed on our natural assets then the political will to protect them is likely to be more forthcoming. Water and biodiversity protection are intertwined and part of one whole system upon which humans are dependent.

The table discussants attempting to balance water scarcity and biodiversity protection agreed that there should be no conflict between these two issues. They agreed that the only way to address both requirements is to look for points of consensus and collaboration to minimise negative impacts through careful and informed planning, taking all aspects into consideration, at the most local and detailed level.

They agreed that legislation may need to be reformulated to bring issues into alignment, so that it was not a case of one or the other, but rather premised on balancing needs with actions to the least harm. Naturally, water and biodiversity co-exist. However, industrialisation, population growth and urbanisation require that storage capacity like dams must enable access of people to water at the source. There is a growing demand for water, which is intensified by climate change impacts. It was noted that when there is informed and correctly designed infrastructure coupled with effective management, there is likely to be minimal negative impacts. Currently, in South Africa policy and practice are not well aligned, hence we see extensive negative impacts. This is compounded by the

politicisation of commodities such as water which are understood in terms of service delivery. Political leaders get more votes for building dams than taking away. The ignorant public pressurises ignorant politicians who have a narrow focus.

The discussion turned to the need to clearly understand the apparently competing imperatives underpinning the two "sides" in order to seek balance. People want constant and plentiful supplies of quality water; nature works seasonally, and in cycles of ebb and flow, flood and drought. Dams are needed to store large volumes of water; dams cover land mass denuding biodiversity. Dams need depth to hold water; feeder rivers deposit sediment into dams shortening their lifespans. Weirs are also necessary for small-scale abstraction for farmers and others; migratory species cannot pass these barriers. Water providers are responding to immediate needs for constant water supply; biodiversity protection requires a long-term sustainability lens.


Figure 22. Balancing water security and biodiversity.

Questions were raised about the acceptable limits to which biodiversity loss can be pushed? What should be considered, and factored into developments such as dam commissioning or even decommissioning? It was agreed that ecosystem services tools should be used; that scales of protection must be understood based on data; that a sustainable development lens should support decision-making; and that even off-site information should be taken into account.

It was agreed that the many conflicting factors were more apparent than real, and that to achieve a compatible balance between the need for (short- and long-term) water security and (long-term) biodiversity protection, a different mindset was required. There is a way to ensure both. The following recommendations were put forward:

- Dams and instream structures must be designed with equal ends in mind, water pooling and biodiversity protection. This should be reflected in all legislation and in permissions and authorisations. It should also be embedded in professional skills development – there are insufficient ecological engineers being trained. By way of illustration, the negative impacts of weirs would be greatly reduced if they placed in the best place. All instream structures should be required to facilitate migratory species passage.
- Authorisation processes such as EIAs and Water Use Licenses should be amended to be more specific about ensuring that impacts of instream structures cause least harm to biodiversity.

Impact assessment practitioners should be required to examine issues much more carefully than they currently are.

- Special consideration should be given to proposed benefits of dams and instream structures aside from the basic impact assessments. Social impact assessments should include an examination of where the benefits are going. Especially in the case of dam installations, the local community may lose land, biodiversity, quality of life, while the benefits are piped 500kms away.
- Long-term professional monitoring should be a requisite for authorisation, accompanied by mandatory data-sharing with relevant authorities, as well as CMAs. Monitoring should happen at all stages of the installation's life cycle from the site identification and planning stage, during the build and for years after to understand the impact, from baseline to transformation.
- Additionally, there should be a mandatory decommissioning requirement for all dams and instream structures as part of an EIA authorisation. Currently, there are redundant dams and weirs all over the place, providing no benefit, but still compromising biodiversity. Decommissioning should be prioritised as part of the process, controlled, informed and monitored, as per existing legislation.
- Improved policy formulation, description, implementation, monitoring and compliance systems should be guided first by a strong commitment to ecological sustainability, of all biomes and natural resources. Such an approach would require diligent data collection and evidence-based consideration for responsible and sustainable decision-making. Data should include a commitment to alternatives thinking. Decisions should not be reactive, addressing narrow interests but rather should seek alternatives first before committing to one course of action, such as building a large dam in a time of water scarcity.
- Better management will require better resourcing, higher budget allocations.
- Deeply considered decision-making requires the aggregation of multi-faceted information. Lack of knowledge causes us to not look for solutions – we are looking for a quick fix and not a hard fix.
- Alternatives thinking around water provision includes bringing effective water management into the discussion. All over South Africa, massive volumes of water are lost to leaks and wastage. It is said that in Durban alone, more than 50% of piped water is lost due to damaged infrastructure. In fact, many municipalities are exceeding water use licences due to unmanaged water losses. What would efficiently-managed and maintained infrastructure do for water demand? In addition, the contamination of water sources by malfunctioning sewer and sanitation systems places an unnecessarily high burden on water services providers. If existing water resources were carefully managed, would there be such a need to obstruct rivers for water abstraction?
- At a level of governance, there needs to be much more integrated thinking, planning, implementation, monitoring, compliance enforcement. Different mandates at the most local level need to see the connection between their mandates and those of their colleague departments. The water and sanitation manager and teams should be aware of the environmental protection teams, and vice versa. This will require special education programmes within systems at all spheres of government, so overcome a powerful practice of siloisation.

- At a public level, there should be a massive awareness building drive to bring people to the practice of real water conservation. Campaigns that inform and encourage people to understand that water does not come from taps, and to understand the journey of water from the source to their coffee cup. Citizen science is a growing practice that can be amplified easily. Science needs to be taken to the people and to be incorporated into environmental education.
- A multi-stakeholder approach should be adopted to champion river rehabilitation including strategic rethinking the need and value of dams and instream structures, drawing together different perspectives as well as different knowledge and skills.
- At the level of conservation efforts, a regional and catchment approach may be more effective.

Groundwater restoration programmes could be championed by government and non-governmental organisations.

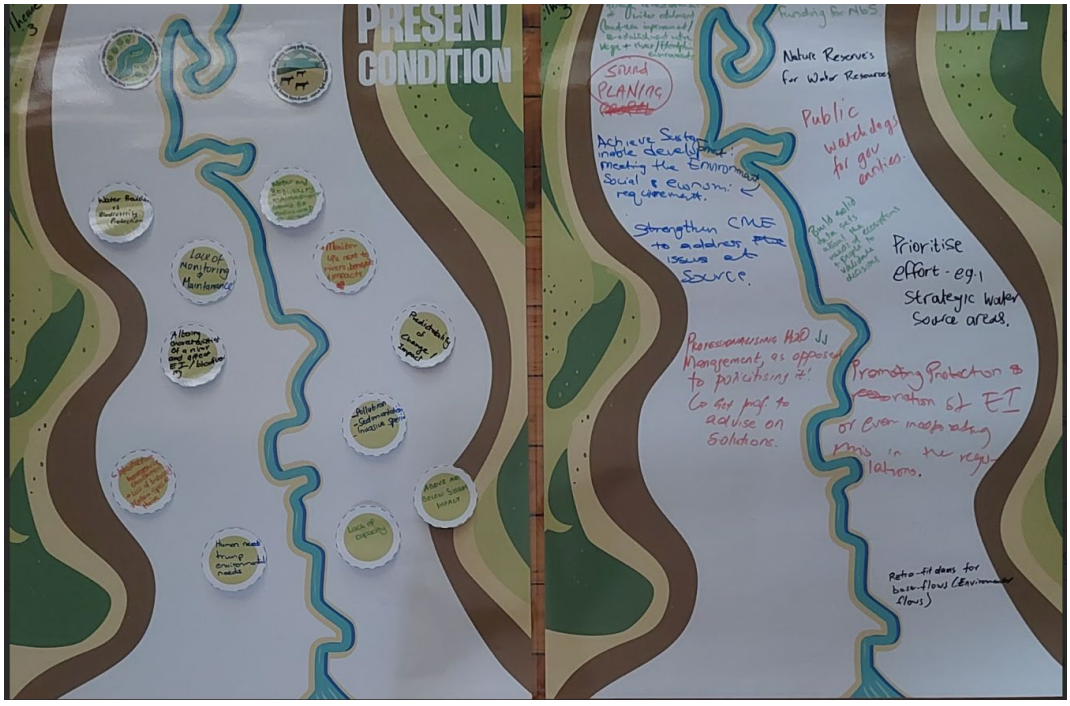


Figure 23. Balancing water security and biodiversity - present and ideal conditions.

Socio-economic and socio-ecological considerations

There are multiple socioeconomic and socioecological considerations in both the building and decommissioning of dams, especially if they are associated with additional benefits that flow from ecosystems rehabilitation, which is the driving notion behind the river connectivity movement (*Figure 24*). The table discussants considered economic impacts and related issues, in respect of river connectivity and dam decommissioning, and related ecosystems rehabilitation broadly. They tied this into socioecological factors. All of the table topics are integrally connected. All have internal complexities and complexities related to aligning the focused imperatives, however, all discussions need to align to each other to leverage the greatest positive impact.

The table discussants engaging with socioeconomic and socioecological issues related to dams and other instream obstructions spent much time unpacking what the respective benefits and challenges, having to overlay this discussion with questions about who benefits and how? In which instances does

one person's benefit result in another's loss. Ultimately the discussion aimed to see how to maximise benefits and minimize losses.

In unpacking the benefits of dams and other instream structures installation, the discussants agreed that installations are usually to support economic gain of one kind or another.

The benefits include:
Water extraction for local, regional or national benefit for potable use. In a water scarce country such as South Africa, this is a major rationale for dam construction.

- Dams enable easier water management for water services providers.
- Water for agriculture and industry is a critical input. The biggest users of water are agriculture which uses about 70% of available water, the fashion industry, the energy industry, the meat industry, the beverage industry and the construction, mining, and car industries. Water supply for these large-scale user's needs to be constant, predictable and of an appropriate quality. Most commercial users of water rely on water service providers to ensure their needs are met. Water service providers need to create reliable mechanisms to facilitate this supply. Dam storage is a large part of this system
- Water for household use is equally critical. In a modern urbanized context, most users expect their water to flow from the tap every time they turn it. Like their industrial counterparts, they rely of water storage systems, which include dams and weirs.
- Rural users (including farmers) are closer to water sources, often abstracting from the rivers directly or indirectly through building various scale dams and weirs. Uses are varied from agricultural, to fishing, to personal to cultural and even craft.
- Dams and weirs also create opportunities for tourism-related activities – recreational use of bodies of water for sailing, or fishing. For stakeholders in this sector, dams can play a measurable income generating role. A new dam in an area can transform the tourism potential of the area with multiple benefits in respect of enterprise and job creation, increased trade traffic for shops, restaurants, hospitality establishments, and even stimulate new opportunities such as fish farming and processing.
- Building dams, especially large storage dams, can create short- and long-term job and enterprise opportunities.
- From an ecological perspective, dams can play several beneficial roles. They do create their own ecosystems. As water levels rise in a dam they reflect as a wetland system. They can hey help reduce greenhouse gas emissions including carbon dioxide. Dams can mitigate flood threats by limiting water flow. They can assist in cooling an area.
- Instream structures can prevent invasive fish species from travelling upstream.
- Combining economic and ecological benefits, there are livelihoods opportunities related to dam and weir management, and to rehabilitation projects that may arise from problems caused by dams.
- Dams on private property are difficult to monitor.

Just as there are socioeconomic and socioecological benefits to dams and weirs, so there are very real problems caused by these installations. Those mentioned include:

- Dams and other instream structures reduce biodiversity, both aquatic and terrestrial. Migratory species are prevented from reaching their spawning grounds. Vast tracts of flora are drowned by dams.
- Dams are not always beneficial to everyone, with mostly downstream users benefitting.
- Dams take up land used for human settlement and cultural purposes such as gravesites, grazing and agriculture.
- In the case of the Vaal-Thukela Transfer scheme, local people who are aware that the benefits of the dam are "exported" elsewhere, have protested vociferously. This unrest can and has resulted in damage to infrastructure and has posed operational risks. A similar situation happened with the Inanda Dam where people lost land and gravesites. Compensation was handled poorly resulting in many people only experiencing the loss.
- Dams require careful design, and ongoing management. As they are fundamentally vulnerable to sedimentation, this results either in extremely expensive dredging operations, or abandonment. Likewise, dams are vulnerable to contamination and algal blooms which are expensive to resolve in large bodies of water.
- In as much as dams can assist to manage flood risk, in themselves they pose a flood risk if they fail and water breaches dam walls, allowing massive bodies of water to descend downstream.
- Dams create barriers for people and animals. Communities can be split by dams. They can prevent free migration of animals (for example, in Pongola, the Jozini Dam restricts animal movement significantly).
- Dams attract vectors such as mosquitoes.
- Another unique challenge that may need addressing in South Africa relates to land claims and how these affect dams. Post successful land claims, new owners typically do not have the skill or capacity to maintain them[11].

There are many other challenges that beleaguer dam commissioning, not least of which is the lack of deep due diligence in the siting and planning processes. Effective planning requires extensive technical, geophysical, economic, ecological and social planning long before the dam is commissioned. Dam commissioning, especially of large dams, is a highly politicised issue given the extent and complexity of impacts. It is key to service delivery and used by politicians to make promises. It is challenged by local communities who see little benefit for themselves, and protest the losses that they will incur.

Decommissioning of dams and instream structures is as fraught as commissioning. The benefits associated with decommissioning address many of the problems listed above.

- The biggest gain from decommissioning is ecological. River connectivity restores aquatic and terrestrial biodiversity, even if this takes time.
- It can also assist with alleviating water shortages for downstream users.

[11] An example is a dam built near a resort that is situated in eThekwini in the uMlazi river. Due to no maintenance post a successful land claim, the dam burst during a flood situation which has resulted in a massive damage impact downstream amounting to billions of rands. In addition, that same dam is silted up and full of invasive weeds, rendering it of almost no value to humans or animals.

There are challenges related to dam and weir decommissioning. Discussants raised some concerns:

- Decommissioning is expensive, technical requiring expertise, and will have consequences that will need short-, medium- and long-term attention. It is unclear currently who would or should bear these costs.
- Decommissioning could have a negative impact on livelihoods, including loss of employment, water access problems for livestock forcing farmers to make other less economical plans. Users that were benefitting from these systems will be at a loss.
- Agriculture may not be a good alternative and can negatively impact the dam. When a dam is decommissioned, it takes years for vegetation to regrow which leads to soil erosion and loss of biodiversity. Furthermore, dams are often located in floodplains and when a dam is decommissioned people will see it as land to build or settle in, only for them to be flooded.
- From a flood risk perspective, decommissioning dams could negatively affect those living around them as well as those living downstream close to the receiving river. The possibility of a dam bursting is supposed to be 1:200 years, however, there is a high risk of this occurring in the future especially as climate change impacts worsen.
- Unless carefully managed by post decommissioning river reconstruction (as was described by Hamish Moir and Geoffrey Goll), the impact of decommissioning can be negative for the downstream riverine ecosystem.
- Weirs are built for monitoring purposes. Without them, alternatives would need to be designed.

Figure 24. Discussing and presenting findings socioeconomic and socioecological aspects

Human impacts on river health offer an important segue into alternative ways of thinking about the conundrum of water scarcity and damming water as a first-choice solution. If efforts are directed to maintaining the health of catchment ecosystems, then the ecosystems services can be assured. These include provision of water, flood risk management and other socioeconomic benefits put forward by proponents of dams and weirs. Redirecting energy, efforts and resources into supporting healthy catchments can yield multiple socioeconomic and socioecological benefits, including a wide range of job creation and enterprise development opportunities including Invasive Alien Species management, river rehabilitation through ecological restoration programmes, management of other catchment degrading challenges like erosion, inappropriate rangeland management and others[12].

[12] Example of these benefits are evident in the upper uMkhomazi Catchment.

To resolve some of the dilemmas posed by this complex focus area, table discussants proposed that much greater thought, and planning needs to go into dam commissioning. A comprehensive cost-benefit analysis should include a detailed analysis of the socioeconomic and socioecological benefits and losses of the infrastructure. It was noted that EIAs, and especially Socioeconomic Impact Assessments tend to be "tick-box" exercises rather than detailed studies. The assessment should be able to define exactly how much water can be abstracted from the system before its sustainability is threatened. It should address the likely siltation trajectory, measuring the cost benefit of that. It should address how to decommission the dam.

Questions were raised about the extent to which agricultural users of river systems were understood and engaged. Farmers often restrict flow to downstream users which negatively affects them. DWS does have water use legislation, but it is possible that this system needs to be reviewed. Activities (whether dam commissioning or decommissioning) should be planned with local communities to maximise local benefits. Processes of consultation and collaboration should be initiated before and sustained during and after dam commissioning, and should even stretch into decommissioning phases. River rehabilitation efforts, including dam and instream structure removal should be aligned to socioeconomic benefits. Rehabilitation should be broadened and defined at a catchment level. Considerations of both upstream and downstream users should be made, looking at what is coming from where, when and how. This assumes a high degree of careful planning and stakeholder consultation. Continuous monitoring of impacts in construction, operational and decommissioning phases should be required by DWS.

Funding

The fifth table topic related to funding issues, asking key questions around liability (*Figure 25* and *Figure 26*). Discussions considered who needed to be part of the funding of river rehabilitation and effective dam management, and how those who should be held responsible for this funding could or should be engaged? Funding is required to carry out all aspects of decommissioning from databasing all existing dams and instream structures throughout the country; identifying and profiling redundant infrastructure; prioritising lists of redundant structures; strategizing per site with detailed plans for location-specific decommissioning and river connectivity restoration, or mitigation alternatives such as installing fishways; extensive stakeholder consultation; developing plans; implementing plans and monitoring across all phases well into the post decommissioning phase. Researching legislation as well as best practice is also of high value to inform a sound implementation.

The bottom-line realisation was that although water security and ecosystem rehabilitation is a national concern, and therefore should fall into the purview of national government, specifically the DWS and the DFFE, it is likely that they both do not have the resources to fund such activities entirely, and their procurement processes make access difficult. It was agreed that a public private collaboration was the most rational approach. This would imply a participatory management commitment would need to be part of the solution. Participatory management involves various stakeholders such as government departments at all spheres, learning and research institutes, water service providers, farmers, private companies and communities that directly or indirectly benefit from the river resources. It was noted also that there are several international bodies that would be interested.

Figure 25. Discussing and presenting about funding options

In addition to funding actual decommissioning and river rehabilitation activities, there are associated activities that impact on catchment health. Programmes and projects addressing innovative land use and land management should be drawn into a collaborative effort[13].

The discussants decided that the easiest way to address this was to consider the types of funding available for ecosystems rehabilitation. This provoked discussions about "user pays and abuser pays more" lines of debate; the need for biodiversity offsets, paid by developers (private or public); that regulators such as DWS, must charge for abstraction of water and disposal of waste in the catchment. What was not addressed was who would take responsibility for raising and managing funds.

The riverscape visualisation exercise carried out by this group identified the current challenges faced by lack of funding, and how this could be addressed by taking an innovative approach to financing river connectivity interventions. Table 4 lists a range of potential funding options that could be explored by those tasked with taking dam decommissioning further.

[13] There are several programmes implementing projects to support innovative grazing and farming strategies to mitigate soil erosion, overgrazing and nutrient run offs; as well as invasive alien species management, and restoration ecology.

Figure 26. Finance - present and ideal conditions

Table 4. List of fund and donor options

Type of funding	**Description**
Biodiversity Offsets by Large Companies	Major corporations can contribute biodiversity offsets to support environmental conservation efforts related to dam management and river restoration.
Funding for Offsets	Developers or other stakeholders responsible for offsetting environmental impacts may include governments or private companies, depending on prevailing environmental regulations.
Policy Implementation by Government	Governments can enforce policies such as the "polluter pays" principle, which requires those causing environmental harm to fund restoration and conservation activities.
Water Use Charges	The Department of Water and Sanitation can levy charges for water use, with the collected funds being allocated to government or municipal restoration projects.
Private Sector Funding for Infrastructure Maintenance	Maintenance of infrastructure related to river connectivity can be funded by private donors, companies, foundations, and landowners.
Public-Private Partnerships (Water Stewardship)	Collaborative efforts between public and private entities can drive water stewardship initiatives, promoting sustainable water management practices.
Insurance Coverage for Environmental Damage	Insurance mechanisms can be established to cover the costs associated with environmental damage, including that caused by disturbances to river connectivity.
Investment in Nature-Based Solutions	Banks, public and private investors, and other financial institutions can support investments in nature-based solutions for environmental management and restoration.
Water Usage by Golf Courses	Given the significant water consumption of golf course facilities, they could be involved in funding or contributing to water conservation and river connectivity restoration efforts.

Blended Finance Approach	A blended finance model, which combines public and private funds, could be implemented depending on the willingness of stakeholders to participate.
Decommissioning Process	A clear process for the decommissioning of dams and related infrastructure should be established to ensure proper environmental restoration once a dam is no longer in operation.
River Connectivity Offset Policy	Similar to wetland offset policies, there should be a specific policy in place for river connectivity. This policy would require those who disrupt river ecosystems to contribute to offset measures.
African Union Support	Regional cooperation through African Union initiatives can facilitate funding and policies for transnational water management and river restoration efforts.
SADC Funding Facility (TFCA)	The Southern African Development Community (SADC) can provide funding through the Transfrontier Conservation Areas (TFCA) initiative to support cross-border river restoration projects.
WWF Involvement in Catchment Management	The World Wide Fund for Nature (WWF) plays an active role in catchment management and river restoration, providing technical expertise and funding.
Private sector Corporate Social Investment (CSI) funds	Most companies have CSI funds. Identifying those companies that are water-thirsty and encouraging them to support river restoration for their own security. Sappi currently invests significant amounts in the uMkhomazi Catchment.
Interested parties such as fishing clubs, kayaking clubs, etc	Several civil society interests could be mobilised.

Key highlights from the two-day workshop

The two-day workshop was focussed mainly on dam management and the restoration of river connectivity. Aligning with a growing trend to decommission dams and other instream structures, the assemblage acknowledged the complexity of the terrain, especially in the face of a growing water security concern in a time of increasing climate threats to these resources. There were many issues raised, and the participants meandered along main trunks and tributaries of the subject, but from these conversations and from the expert contributions, some stand-out observations worth isolating for future reckoning.

- Water needs to be valued much more than it is. Catchments must be valued part of the ecosystem. Biodiversity of fauna and flora impacted by catchment systems need to be valued. A lot of rivers do not have reserve values set up for them. Defining river value must include biotic values, as well as those associated with “river hydrology, geomorphology, instream processes, and landscape functions”. If greater value was placed on our natural assets then the political will to protect them is likely to be more forthcoming. Water and biodiversity protection are intertwined and part of one whole system upon which humans are dependent.
- River connectivity protects aquatic and terrestrial biodiversity. “It’s not only about the fish!”
- Decommissioning dams and other instream structures can restore the natural order of species and habitat protection dramatically, as was demonstrated by the example of the Kruger National Park.
- Both the commissioning and decommissioning of dams and weirs is complex, and must be done with full and detailed impact assessments, site-specific planning, stakeholder consultation, ongoing monitoring.
- There should be no conflict between balancing water scarcity and biodiversity protection – they are co-dependent. Decisions should be made with meaningful consideration from all stakeholders and government sectors.

- Identification of all instream structures must be supported by diligent monitoring and continuous revaluations to support progressive decommissioning where structures become redundant.
- An up-to-date database of all dams and weirs needs to be compiled, including profiles of each and identifying those that are redundant. This should be prioritized as part of a national decommissioning strategy.
- As much as river connectivity is critical, so is human connectivity! Consultation and collaboration are critical to achieving catchment health.
- River connectivity is a catchment management concern.
- Water provisioning faces massive challenges from source to tap, but these would be improved if effective and integrated catchment management ensured that less effort was required to transform water into potability for the end user.
- Dams and weirs are a clumsy solution to water security. It may be better to concentrate on river rehabilitation at scale and less obstructive abstraction systems. Rivers do and need to carry sediment. Dams obstruct the flow of sediment, and become silted up, reducing their storage purpose.
- In relation to sediment management, dam removal guidelines should address relative sediment volumes, estimating average annual sediment loads; sediment transport from dam removal, at all stages of the planned process; and analysis of stream power and other rough estimates of risk.
- Using Nature-based Solutions to river rehabilitation as part of instream structure decommissioning can be more effective than artificial installations.
- The legislative framework governing decommissioning is complex and the range of laws in various policies and regulations need to be understood together, which will enable actions to be justifiable in some cases and not in others.
- The stakeholder and role player landscape is surprisingly broad, and includes those from all spheres of government, including water boards; the private sector (various water-dependent industries, commercial agriculture, water user associations) and civil society (end users of abstracted water, rural communities, NGOs, research institutes). Consultation and collaboration are critical.
- Governance is not only the purview of the government. Current governance practices (and failures) are a large part of the dependence on dams.
- There is currently a lack of accountability in the systems of governance.
- Legislated requirements such as EIAs are loosely applied, and need to be much more comprehensive and rigorous.
- A decommissioning requirement for all dams and instream structures should be part of a dam commissioning EIA authorisation. The decommissioning process should be accompanied by an EIA that is equally diligent and thorough.
- There is insufficient monitoring to make evidence-based decisions on the efficacy of mitigation measures.
- Dams and instream structures must be designed with equal ends in mind: water pooling and biodiversity protection.
- Alternatives thinking around water provision includes bringing effective water management into the discussion, especially at a municipal level. This could reduce the need for dam-based water storage.

- At a public level, there should be a massive awareness building drive to bring people to the practice of real water conservation.
- If efforts are directed to maintaining the health of catchment ecosystems, then the ecosystems services can be assured, along with biodiversity protection. These include provision of water, flood risk management and other socioeconomic benefits put forward by proponents of dams and weirs. Redirecting energy, efforts and resources into supporting healthy catchments can yield multiple socioeconomic and socioecological benefits.
- Funding is necessary. Although water security and ecosystem rehabilitation is a national concern, and therefore should fall into the purview of national government, specifically the DWS and the DFFE, it is likely that they both do not have the resources to fund such activities entirely, and their procurement processes make access difficult. Public private collaboration is the most rational approach to funding.
- There are many national regional and international funds that could support a dam decommissioning and river restoration drive.

Conclusion: Issues for future consideration

The way forward after the two-day workshop is wide open. The event highlighted a network of issues, challenges, deficits, opportunities for taking the conversations further and even defining potential actions. An illustrative tool using a riverscape visualisation exercise was used in all the table discussions. It is a two-river visualisation – one representing the current state of the river in relation to the various focus topics; the other considering the ideal state of a river, providing a way forward, and a future scenario. The object of this exercise was to draw participants into a solutioning mindset as a way of contributing to a potential future roadmap of interventions that could be implemented.

All groups shared a basic understanding about the current condition of rivers, and there was much consensus about the ideal situation. Because the breakaway groups were thinking through the lens of a particular theme (such as governance or stakeholder interests, or finance, or balancing water security and biodiversity protection), there were important differences in emphasis. Taking all the inputs, a composite river visualisation was created to represent how river connectivity and biodiversity protection could be realised in ways that still allows for water security and livelihoods interests to also be protected, through best environmental practice and good governance, working with all stakeholders (*Figure 27*; *Table 5*).

Figure 27. Composite riverscape visualisation

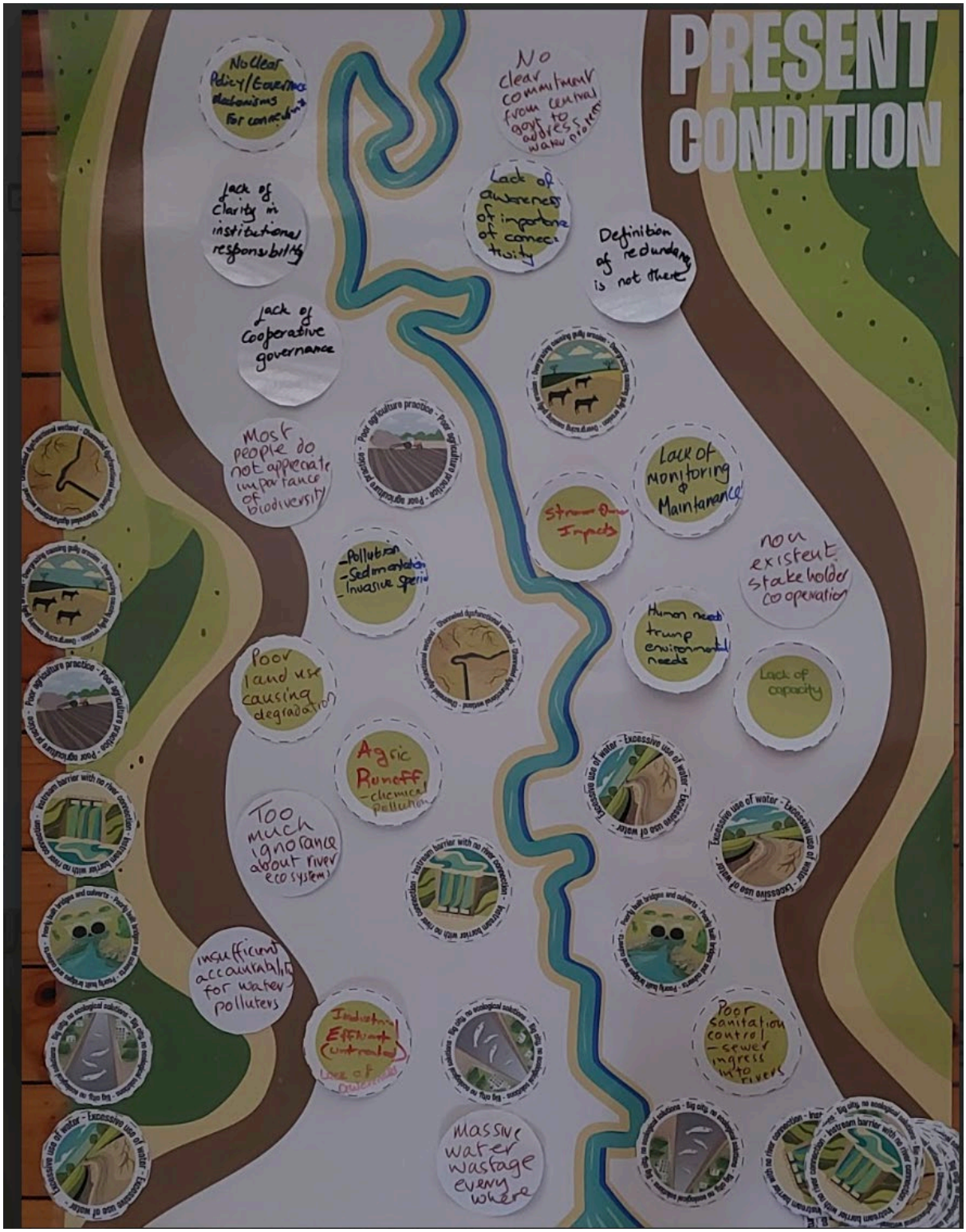
In Table 5 a provision of the issues and concerns raised both in the current condition as well as an ideal future scenario. The composite representation indicates perspectives from the range of stakeholders that participated in the process, and thus issues of governance are articulated alongside livelihoods impacts or biodiversity concerns. In this way, a more holistic picture emerges.

Table 5. Listing current and ideal river connectivity issues

Present Condition	**Ideal State**
Water and water sources are undervalued. No clear commitment from central government to address water protection. Lack of clarity regarding institutional responsibility. Human needs trump environmental needs. No clear policy / governance mechanisms for river connectivity. Definition of redundancy is absent. Lack of cooperative governance between mandates/departments. Non-existent stakeholder engagement and cooperation. Lack of awareness regarding the importance of river connectivity. Many instream barriers with no connectivity.	Committed government, appropriate policy & guideline development, based on prioritisation of water resource protection, especially strategic water source areas. Climate-smart and informed decision-making that is responsive, flexible in place. Climate change impact awareness – naturalisation of wider catchments through landuse improvement, native vegetation restoration. Water and biodiversity management harmonised. Sustainable development focus meeting environmental, economic, social imperatives. Integration of planning and CME (DFFE, DWS, DALRD, CMAs, Prov govt depts, local govt depts) – cooperative governance actually implemented. Good planning at all levels of governance. Regulatory and authorisation processes more stringent – EIAs, etc, including monitoring, maintenance, end-of-life decommissioning. Clear responsibility & accountability for all instream infrastructure for life. No dams allowed, restore river a priority. Invest in alternative storage solutions. Free-flowing rivers, no barriers in place.

Lack of knowledge/understanding of importance of biodiversity. Poor landuse practices. Overgrazing causing gully erosion. Wetland degradation – channelled, dysfunctional, drained. Agricultural runoff, causing chemical pollution of rivers. Catchment degradation through invasive alien species infestation, pollution, sedimentation. Lack of monitoring and maintenance. Lack of technical capacity. Excessive use of water. Poorly built bridges and culverts. Big City, no ecological infrastructure Industry impacts on rivers - effluent. Insufficient accountability for water polluters. Poor sanitation control – sewer ingress into waterways. Massive waste of water – carelessness, leaks. Too much ignorance about water ecosystems.	Incentives for better environmental practices. Professionalisation of water resource management (no politicisation) Extensive monitoring in place, generating solid datasets regarding ecosystem issues, socio-environmental issues, state of dams & weirs, etc to inform better decision-making. Citizen science integrated into monitoring. Maintenance of all structures in place. Effective catchment-wide stakeholder engagement – building solutions to industrial effluent. Improve communication at all levels. Increased awareness among all stakeholders. Extensive and powerful water conservation messaging in place, all the time. Farmers actively involved in solutioning. Catchment-based stakeholder management in place. Livelihoods developed through extensive catchment / river monitoring, maintenance, rehabilitation programmes. Massive drive in place to foster capacity development from professional to semi-skilled. Good grazing practice with healthy basal cover. Environmental flows sustain biological requirements. Conservation agriculture or no till. Instream barrier with fishway and rockramp. Green city with Nature-based Solutions. Municipalities proactively monitoring, maintaining waterways and sanitation infrastructure.

Subsequent to the two-day workshop, a follow-up process is planned, under the banner of “Getting the river to flow”. This will take place in early 2025. The objective is to sustain the momentum, and take the conversation deeper to forge a practical response based on the outcomes of the workshop.


PRESENT CONDITION
No clear Policy/Governance mechanisms for connectivity
No clear commitment from central govt to address water pollution
Lack of clarity in institutional responsibility
Lack of awareness of importance of connectivity
Definition of redundancy is not there
Lack of Cooperative governance
Most people do not appreciate importance of biodiversity
Poor agriculture practice - Poor agriculture practice
Lack of Monitoring & Maintanance
Stream Over Impacts
Pollution - Sedimentation - Invasive species
non existent stakeholder co operation
Human need trump environmental needs
Lack of capacity
Poor land use causing degradation
Agric Runoff - chemical Pollution
Too much ignorance about river eco system
Excessive use of water - Excessive use of water
Upstream barrier with no river connection - Upstream barrier with no river connection
Poorly built bridges and culverts - Poorly built bridges and culverts
Insufficient accountability for water polluters
Industrial Effluent (untreated)
Poor sanitation control - sewer ingress into rivers
Big city no ecological solutions - Big city no ecological solutions
Massive water wastage every where


IDEAL
Climate-smart + informed decision-making - responsive + flexible
Sound Planning
Awareness of Above and Below Stream Impact
Consistent funding for NbS
Professionalise water management - depoliticise
Co-operative governance between various mandates
Improve communication at all levels especially within organisations
Increased awareness - all stakeholders
Catchment based stakeholder management
Incentive for better environmental practices
Municipalities monitor + maintain sanitation infrastructure
Municipalities fix water leaks immediately - water wasting stopped
Accountability + Responsibility for Infrastructure for life
End of life policy for water related infrastructure??
Extensive + powerful water conservation messaging in place all the time
Massive drive in place to foster capacity from professional to semi-skilled
Farmers actively involved in solutioning
Water and biodiversity management should be harmonised to co-exist
Livelihoods built through extensive catchment rehab programmes
Strong CME addressing issues at source
Citizen Science involved in monitoring
Monitoring, Evaluation & Maintenance
Extensive catchment-based monitoring
Solid data sets re needs of ecosystems & people to inform decision-making
Impoundment audit + plan! Action? Demolish? Decommission? Maintain?

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Appendix

Appendix 1: Attendance register

Workshop 07/11

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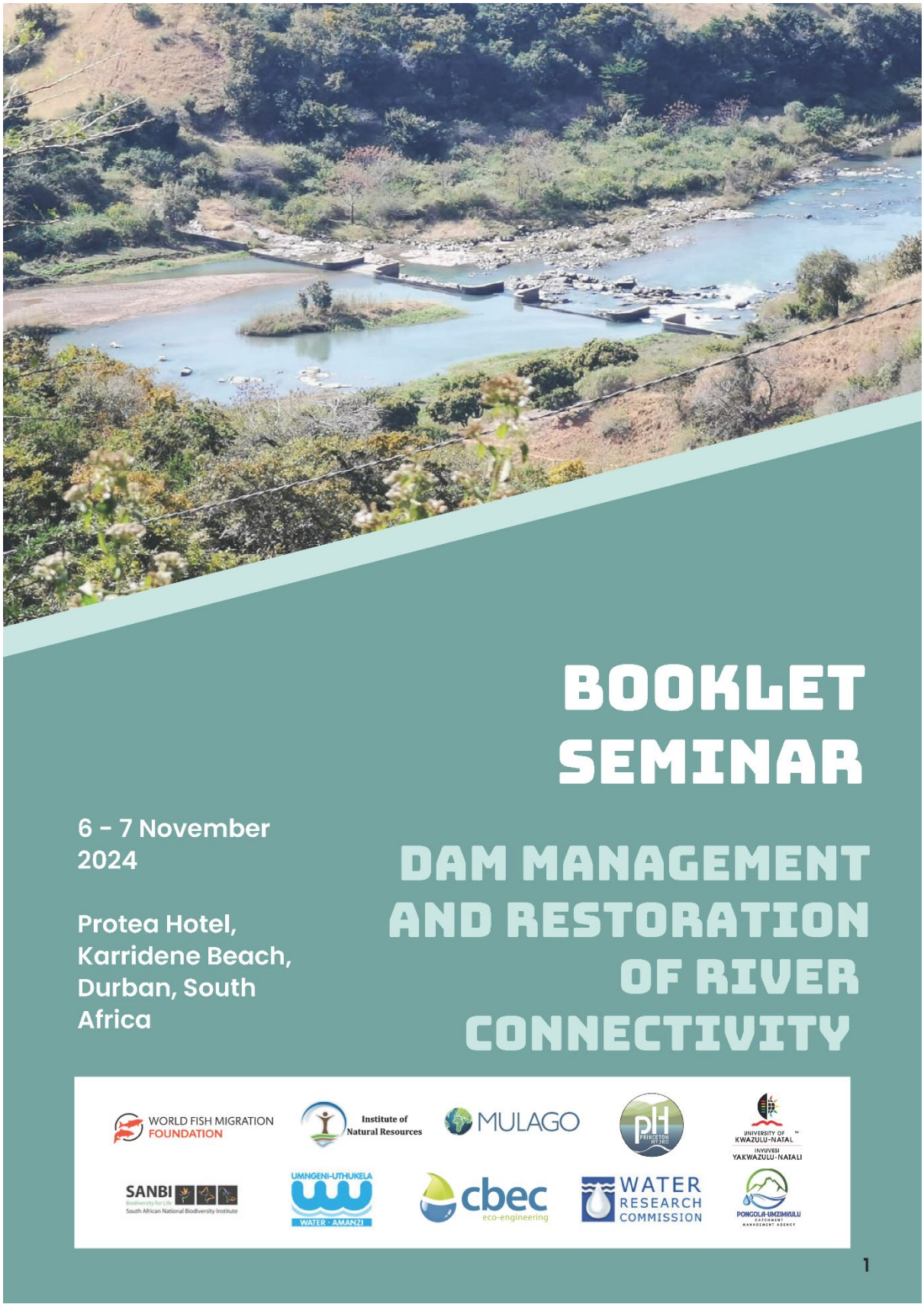
Appendix 2: Booklet compiled for the workshop



SPEAKERS

Mr Nkosinjani A. Mkhize (SA)

Nkosinjani Mkhize is the Deputy Director of the Catchment Management Sub-Directorate at the Pongola to Umzimkulu Catchment Management Agency, overseeing water resource management in the Pongola-Mtamvuna Water Management Area. He holds a BA in Development Studies, a Master's in Housing, and is currently pursuing a PhD in Hydrology, focusing on integrated water resources monitoring strategies. With 22 years of experience in the built environment and water resource management, he leads multi-sectoral stakeholder engagements and the Blue Deal Partnership for the uMngeni System, aiming to improve water quality and implement climate change interventions. He developed the first catchment management strategy for the new CMA, coordinating activities across seven strategic themes.

Ms Ntombifuthi (Futhi) Vilakazi (SA)

Miss Ntombifuthi (Futhi) Vilakazi is an enthusiastic Environmental Hydrologist and Professional Scientist with a BSc Honours in Environmental Science and a Master's in Hydrology from the University of KwaZulu-Natal, South Africa. With 10 years of experience in both the private and public sectors, she has developed extensive expertise in environmental impact assessments, water use licensing, and water quality management. Futhi's skill set includes water resource planning using Geographic Information Systems and Remote Sensing, land use management, and developing climate change resilience policies and strategies. She is adept at establishing flood forecasting and early warning systems, implementing catchment and ecological infrastructure management plans, and engaging stakeholders to establish strategic partnerships for water security initiatives.

Dr Geoffrey M. Goll (USA)

Mr. Goll is a founding Partner of Princeton Hydro and licensed professional engineer with extensive experience in water resource engineering, geotechnical engineering, stormwater management, hydrology, floodplain hydraulics, environmental assessments, and environmental permitting. He has pioneered dam removals for the purposes of fish passage in New Jersey and was in charge of the state's first dam removal funded by American Rivers, NOAA, NRCS, and USFWS. To date, he has overseen 50+ dam removal designs. Mr. Goll has prepared public presentations to educate local communities regarding the benefits of restoration, stream daylighting, and fish passage. His understanding of sedimentation mechanisms and management of sediment behind impoundments has been instrumental in managing the mitigation of environmental impacts during and after demolition of river and stream obstructions. Mr. Goll regularly coordinates multiple grant sources to fund such removals as well as brings different parties together to create momentum for projects.

SPEAKERS

Dr Hamish Moir (UK)

Dr Hamish Moir has more than 25 years' experience working in the water resource industry in the UK and the US, particularly in the areas of sustainable river engineering and restoration (design and construction). He has extensive training in the fields of fluvial geomorphology and river 'eco-engineering', both in research and consultancy capacities. Dr Moir has been active in promoting more sustainable 'process-based' ('nature-based') approaches to river management/ restoration, recently co-authoring two high profile papers on the subject. His PhD and subsequent research involved the biophysical linkages in fluvial systems and river restoration and construction projects. Much of Hamish's current work involves the sustainable management of barriers (weirs, dams etc) on rivers, involving the continuum of approaches from full removal to modification to retro-fitting of hydraulic structures to broader-scale sediment management. This includes all project phases of from initial concept through detailed design, permitting, implementation and post-works monitoring.

Dr Andy Blackmore (SA)

Dr Andy Blackmore is the Scientific Manager of Conservation Planning within Ezemvelo KZN Wildlife. He is a Legal Research Fellow at the University of KwaZulu-Natal and is an Extraordinary Senior Lecturer in the Faculty of Law at the North-West University, South Africa. Dr Blackmore is a registered Professional Natural Scientist in the field of conservation science and is a member of the World Commission on Protected Areas, the World Commission on Environmental Law, and the Environmental Law Association of South Africa. His research interest lies in the interface between domestic and international law and biodiversity conservation, conservation policy and the fiducial duties encapsulated in conservation governance.

PROGRAMME

Day 1 - 6 Nov: Field visit to the uMkhomazi River
Day 2 - 7 Nov: Worskhop

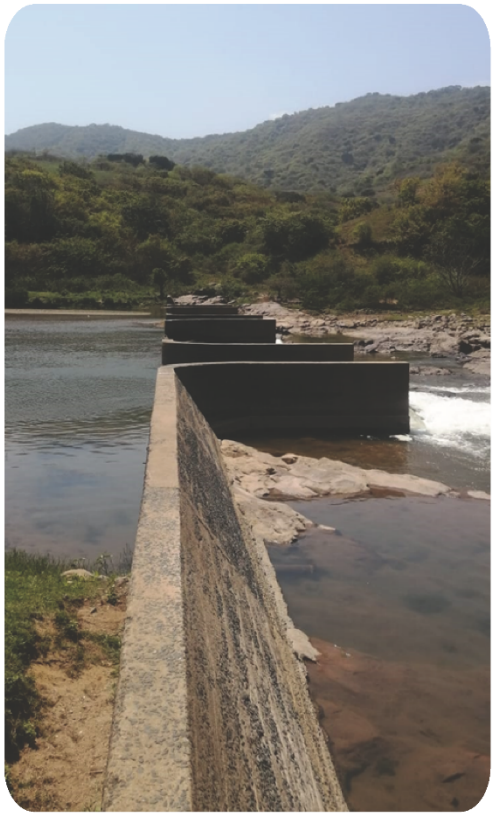
Time	Topic	Speaker
8:00	Registration	
8:30	Welcome and Introductions (WRC)	
9:00	Catchment based approach to water resource protection in the Pongola to Mtamvuna Water Management Area	Nkosinjani Mkhize (PUCMA's Governance) and Futhi Vilakazi (Water Utility - UUW) - South Africa
9:30	Engineering and Sediment Management Considerations for Dam/Weir Removal in the US	Geoffrey Goll (Princeton Hydro - USA)
9:50	Interactive Q&A Session	
10:20	Break	
10:50	The sustainable 'nature-based' management of weir and dam structures: case studies from Scotland, England and Iceland	Hamish Moir (CBEC Eco-Engeneering - UK)
11:10	Removing instream barriers in South Africa: An overview of the legal challenges	Andrew Blackmore (KZN Wildlife - South Africa)
11:30	Interactive Q&A Session	
12:00	Lunch	
13:00	World Café on Dam Removal (SANBI)	
15:30	Break	
16:00	Plenary Feedback and Conclusion	

4

A "USELESS" CASE STUDY: U1H006

Redundant instream barriers are built infrastructures that no longer serve their original purpose staying in the riverscape if not removed. This could have long-term consequences for water flow, habitat availability, migratory species, and sediment transport negatively impacting ecosystem derived services from a river, especially in the lower parts of the catchment. Instream barriers have a built life span, and what to do with them needs clear management constructs across a catchment scale to improve ecological infrastructure.

The U1H006 Department of Water and Sanitation Weir is no longer being used. It was replaced by a similar new gauging weir upstream. However, little has been done to remove its structure and rehabilitate the river, despite recent interest to investigate the possibility to do so.

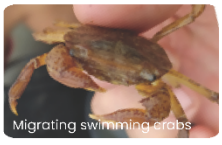


Weir U1H006

The process to removal has been met with its own barriers:

- Ownership
- Access
- Funding
- Interest
- Questioning the need for restoration
- Prioritising removal
- A pillar to post process

Migratory pathways for aquatic fauna, such as yellowfish, African freshwater eels, freshwater prawns, and swimming crabs can be disrupted by instreams barriers reducing abundances, distribution and genetic resilience threatening these species conservation status.



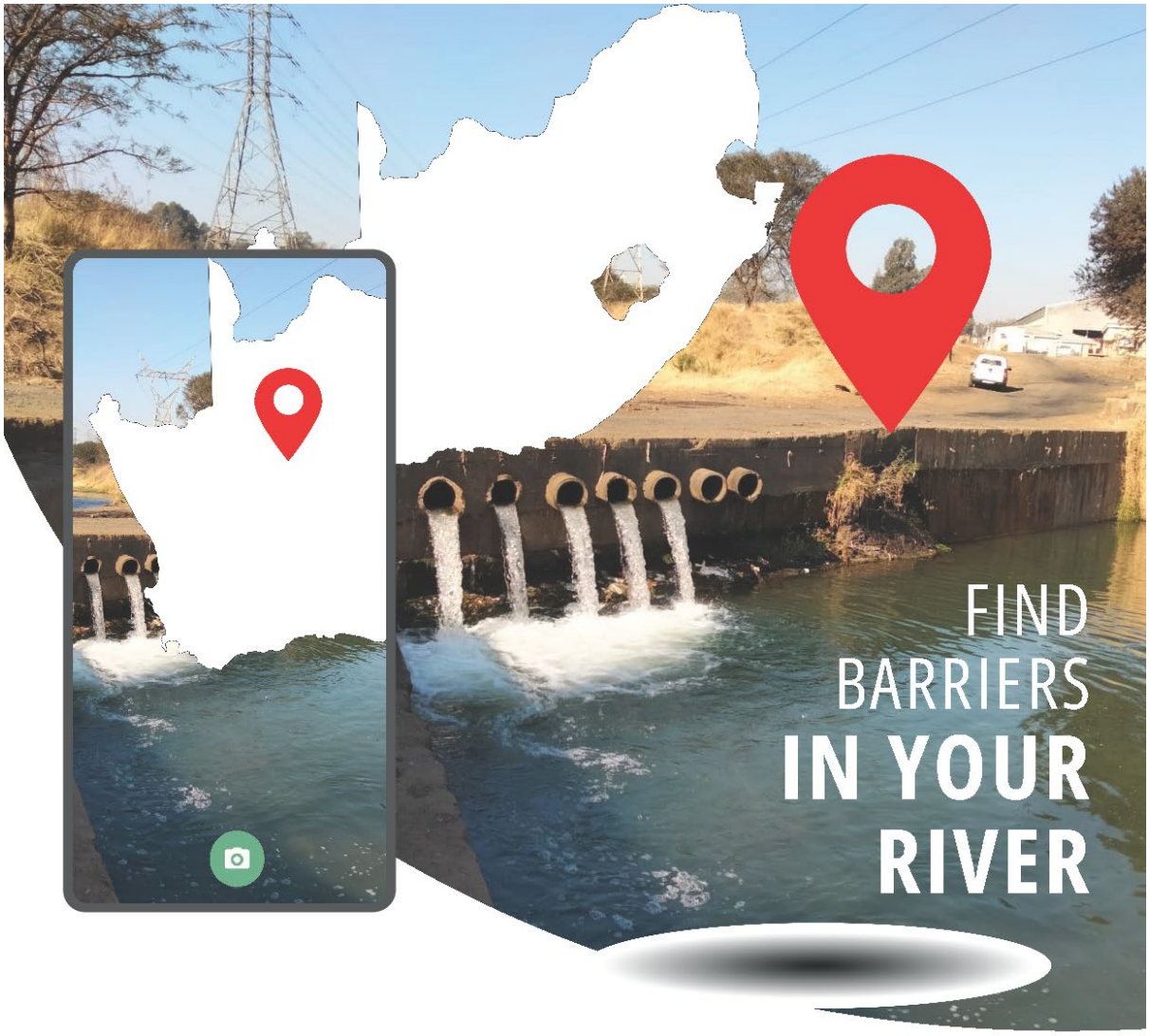
Migrating swimming crabs

Freshwater Eels

Yellowfish

5


AFRICAN FRESHWATER EELS
The Anguillids
1.6 m Long
40 + Years
25 kg
£26000/kg
Migrate Between Marine & Freshwater
5. Life Stages
Threats
Instream Barriers
Regulated Flows
Illegal Trade
Over-harvest
4. Yellow eel
Non-mature Adult
5. Silver Eel
Migratory Adult
1500 km – 4000 km
Distance Travelled
3. Elver
Juvenile
Ecological Value
Apex Predators
Nutrient Cycling
River Connectivity Indicators
2. Glass Eel
Post-Larvae
Leptocephalus
Larvae
1.
A. mossambica
NT
A. bengalensis
NT
Their Future!
Improve Conservation Status
Connect Rivers to Support Fishery
Regulate Wild-Harvest
A. bicolor
NT
A. marmorata
LC
Cultural Value
"Nkanyamba"
The River Guardian
&
ncreases fertility in livestock, aids child birth, protection, reduces infant mortality, and soap making.



LOCATE AND RECONNECT !

BECOME A BARRIER TRACKER IN SOUTH AFRICA TODAY

There are thousands of dams, weirs, culverts, and other types of river barriers around the world, preventing the continuity of life in these waters. With the Barrier Tracker App, we aim to create the first assessment of river connectivity across Africa to highlight where restoration is most needed!

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START TRACKING BARRIERS!
OR VISIT AMBER.INTERNATIONAL


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