

Case Study 11: Berg Water Project

Background

The Berg Water Project (BWP) was the first large, water resources infrastructure development project in South Africa to be designed, constructed and operated within the framework of the National Water Act (No. 36, 1998), requiring that water be provided for human needs and ecological Reserve (Case Study 4), and in accordance with the guidelines of the World Commission on Dams¹. It represents the culmination of a detailed options analysis carried out by the Department of Water Affairs and Forestry (DWAF) over a 14-year period to identify appropriate measures to address the water requirements of the Western Cape of South Africa. Impounded on July 26, 2007, it is the first bulk water resource development project directly linked to water demand management in South Africa.

The Berg River is the only major river within the Berg Water Management Area (Berg-WMA), an area of 13 000 km² in the south western corner of South Africa that supports a strong and diversified economy. The Gross Geographic Product of the Berg-WMA was R63,8 bn in 1997, 12 billion of which came from the Berg River catchment (2.5% of GDP of the Republic of South Africa). Economic activities are dominated by industrial and other activities in the Cape Town Metropolitan Area, intensive vineyards and fruit growing under sophisticated irrigation in mountain valley's and foothills, and dryland wheat cultivation in the lower reaches.

The Berg-WMA is situated within the Cape Floral Kingdom, recognized in 2004 as a World Heritage Site due to its incredible diversity and levels of endemism. Comprising only 6% of the area of southern Africa it has more than 9,000 plant species, 70 percent of which are endemic, accounting for half the species on the subcontinent and almost one in five of all plant species in Africa. This makes it the smallest yet most diverse of the world's six plant kingdoms. Similar levels of endemism are observed among other groups. Of the 19 indigenous fish species in the Cape, 16 are endemic and four are historically found in the Berg River catchment. The Berg-Breede White Fish (*Barbus andrewi*) is now extinct in the catchment, while the Berg River redbfin (*Pseudobarbus burgi*) is critically endangered, and the Cape galaxias (*Galaxias zebratus*) and Cape kurper (*Sandelia capensis*) are near threatened. The upper reaches of the Berg River along with a limited number of tributaries are the last refuge areas where indigenous fish are still relatively abundant.

An assessment of the State of the River (River Health Program, 2004) as part of the River Health Programme shows that although the river is moderately modified (Table 1), the overall condition is 'Good'. Since the 1980's cumulative impacts associated with encroachment of alien vegetation, urban and agricultural development and a number of diversion weirs have resulted in deteriorating water quality, elevated summer flows, and increasing degradation of the Berg River Dam ecosystem. The Berg River estuary is the second most important in South Africa in terms of national conservation importance, providing important recreational and tourism opportunities.

¹ World Commission on Dams. 2000. *Dams and Development: A New Framework for Decision-Making*. The Report of the World Commission on Dams. London and Sterling, VA: Earthscan Publications Ltd.

Although constituting only 7 % of the WMA, the Berg River catchment contributes 14% of the estuarine flows.

INDEX	CONDITION RATING					
	Above Dam	Below Dam	Jim Fouche	Paarl	Hermon	Lower Berg
Habitat integrity	Natural to Fair	Good to Poor	Fair	Poor to Poor	Fair to Poor	Fair to Poor
In-stream geomorphology	Natural	Good	Fair	Poor	Fair	Fair
Riparian vegetation	Poor	Poor	Poor	Poor	Fair	Poor
Invertebrates	Natural	Good	Fair	Poor	Fair	Fair
Fish	Good	Fair	Fair	Poor	Poor	Poor
Water quality	Natural	Good	Good	Poor	Fair	Fair
Desired health (overall)	Natural	Good	Fair	Fair	Fair	Fair

Table 1. Condition Ratings for the Berg River²

The Berg Water Project

The Berg Water Project (BWP) is considered essential if the Greater Cape Metropolitan and adjacent farming areas continue to experience strong economic and population growth and predicted water shortages are to be avoided. The yield of all existing sources within the Western Cape Water Supply System (WCWSS) is 475 Mm³/a. The ZAR1.55 billion BWP (including the Dam), located in the upper reaches of the Berg River, is designed to capture winter rainfall and store it for supply to the City of Cape Town (CCT) during the dry summer months augmenting the available yield in the WCWS by 81 Mm³ (18%) to 523 Mm³/a. Total unrestricted water use in the 2005/06 year was estimated to be 465 Mm³/a and predicted to grow to 560 Mm³/a by 2011 under a high growth scenario.

The BWP includes the Berg River Dam, a 2.5 km pipeline from the dam to the Dasbos inlet, allowing water to be pumped from the dam into the Riviersonderend Tunnel System, and the supplement scheme. The dam's design also includes a 63m high multi-level inlet tower that allows for environmental releases of up to 200m³/s to mimic floods and the management of downstream water quality. The streams and run-off flowing into the Berg River Dam provide a sustained yield of approximately 56 Mm³/a. The supplement scheme will increase this yield from 56 to 81 Mm³/a through a weir, 4ha balancing dam and pump station that allows pumping of a portion of the winter flows to the Berg Dam via a 10km pipeline through the inter-basin transfer into the Theewaterskloof Dam in the Breede River catchment, where it can be gravity fed to the CCT.

The process of identifying appropriate measures to address the water requirements of the Western Cape of South Africa started in 1989 when the DWAF initiated the Western Cape Systems Analysis (WCSA) to determine future needs, water resources availability and appropriate measures to address water shortages. The options identified underwent public consultation in 1996 from which 12 additional schemes were identified for further investigation. One of the options considered was the development of the Berg River Dam (then called Skuifraam Dam) and the Supplement Scheme.

² Taken from River Health Programme (2004). State-of-Rivers Report: Berg River System. Department of Water Affairs and Forestry Pretoria ISBN No: 0-620-32075-3.

Environmental Impact Reports were completed for the Berg River Dam in November, 1996 and for the Supplement Scheme in October, 1997. These included a preliminary Reserve determination for the river downstream of the dam but not for the estuary. On the basis of these submissions a Record of Decision was issued by the Department of Environmental Affairs and Tourism in May 1999 with a seven year authorization period. The RoD provides authorization subject to three sets of conditions. These include six general conditions, seven relating to the Environmental Management Plan (EMP) and six relating specifically to the Ecological Reserve, defined in the RoD in accordance with the National Water Act (Act No. 36, 1998). This included a requirement that the design did not foreclose the option of releasing floods in excess of the “damage control” Instream Flow Requirements³ (IFR), that any changes in the magnitude of the IFR require the authorisation from the DEAT and the DEAT’s approval of the detailed water release patterns. Further provisions were included in the RoD to accommodate any subsequent revisions of the Reserve based on the findings of the monitoring programme.

In April 2002, the Cabinet approved the implementation of BWP. The original proposal had been withheld while the national government assessed water conservation, demand management, and alternative supply options. The decision to augment supply was conditional upon the CCT reducing the demand for water by 20% by the year 2020 and the BWP Raw Water Supply Agreement between the DWAF and the CCT specifically commits the CCT to achieving the “Low Water Demand Curve”.

In response, the CCT has been implementing a Comprehensive Water Conservation and Water Demand Management Programme. This includes the reuse of effluent from wastewater treatment works, water conservation and demand management measures, restructuring of water tariffs, and bans and restrictions on nonessential water uses. As part of the demand measures, the TCTA awarded a ZAR21 million, eight-year contract to the Working for Water Programme to facilitate the removal of alien vegetation from the Berg River catchments. This is expected to significantly increase the amount of run-off available for storage in the dam. In 2005/6 the targets established by the DWAF in terms of the “Low Water Demand Curve” were exceeded by 13%. Continued success in implementing water demand measures could delay any further interventions until 2015.

In May 2002, the Minister of Water Affairs and Forestry directed the Trans Caledon Tunnel Authority (TCTA) to fund and implement the BWP as an implementing agency of the DWAF (Box 1).

Box 1: The Trans-Caledon Tunnel Authority (TCTA)

The TCTA is a public entity established in October 1986, with the signing of the Treaty between Lesotho and South Africa, to facilitate ancillary developments in South Africa associated with the Lesotho Highlands Water Project (LHWP).

³ The term Instream Flow Requirement (IFR) is commonly used in South Africa, while other international terms such as environmental flow and ecological flow are also used. All these terms are used synonymously and refer to the collective amount of water needed to sustain healthy, natural ecosystems based on scientific studies.

TCTA was legislatively incorporated into the National Water Act in 1998 as a body established under Section 103(2) to implement international agreements in respect of the management and development of water resources shared with neighbouring countries, and on regional co-operation over water resources. Under the Act, the Minister of Water Affairs and Forestry can allocate additional functions insofar as these do not compromise the ability to discharge primary functions, including, but not limited to, management services, financial services, training and other support services. A Revised Establishment Notice published in March 2000 amended the TCTA's mandate to assume responsibility for all additional projects in the water sector. In May 2002 TCTA was directed in terms of Section 103(2) of the National Water Act to fund and implement BWP as the agent for the DWAF.

In 2004 TCTA was further directed to fund and implement the ZAR2.5 billion Vaal Pipeline Project to meet the rising water demands of Eskom and Sasol in the Mpumalanga Highveld Region. In August 2005, Cabinet approved the creation of an agency for the management and development of national water resource infrastructure. This will lead to the merger of TCTA with the DWAF's National Water Resource Infrastructure Branch to form the National Water Resource Infrastructure Agency. The NWRIA will have responsibility for the operations and maintenance of South Africa's major national dams and water transfer schemes and the implementation and funding of social and economic bulk water infrastructure.

The issue of environmental flows was addressed at various stages during design, construction and operation of the dam. Preliminary assessments of the environmental flow requirements were carried out in 1992/93 as part of pre-feasibility investigations for the Skuifraam Dam and again in 1996 as part of the feasibility studies. These initial approaches were based on early versions of the Building Block Method (Case Study 7) and relied on specialist studies to explore the impact of flow reductions on the riverine environment. A series of workshops and specialist meetings during the following decade focussed on more detailed specialist inputs and the assessment of different scenarios undertaken by a range of stakeholders.

This process resulted in the recommendation of a Reserve determination based on a high confidence, preliminary determination for the Upper Berg. The preliminary ecological category was set as Category C. This represents a moderately modified state where a loss and change of natural habitat and biota have occurred, but where the basic ecosystem functions are still predominantly unchanged. Preliminary determination of the Reserve was set at 37.1 % of the Mean Annual Runoff of 141.683 Mm³. A comprehensive determination of the Reserve, including that for the estuary, is expected following finalization of the three-year monitoring program.

Drivers

Professional drivers were important in both the early and later stages of planning for the Skuifraam Dam. During the late 1980s and early 1990s, there had been an increasing recognition among water resource planners and ecologists of the need for scientifically based approaches to determining environmental flows (Case Study 4) and this had led to the initial estimates of instream flow requirements for the dam.

The political transition in South Africa provided a unique opportunity for translation of these professional drivers into legislative provisions that provided stronger

protection for aquatic ecosystems. Thus the 1998 National Water Act gave legal standing and legitimacy to the professional judgement and methodologies developed over the previous decade. The legal framework along with progressive leadership was central to maintaining the momentum and ensuring compliance with environmental water requirements during the design, construction and operation.

The global significance of the Cape Floral Region has also been an important indirect driver in the development agenda of the Western Cape region. Although the development of the Berg River dam did not directly threaten the Floristic Region, the public awareness of the importance of good environmental management produced an enabling environment for conservation oriented measures such as those contained within the environmental flow assessments. Government authorities, local and international conservation agencies, water resource professionals and local NGOs have invested significant efforts into providing a solid scientific basis that highlights the importance of Cape region, including its rivers and estuaries, and the benefits that these have at the community level through tourism and natural resource based activities. Recognition of these important linkages has increased public awareness, both locally and internationally, on the need to ensure environmentally sustainable solutions to development needs and an enabling framework for environmental flows.

Assessment

Recognition: Although there was broad recognition of the need to provide water for downstream environments, agreeing on the Reserve has not been easy. Using a scenario based approach to facilitate discussion among principal stakeholders, the preliminary Reserve reflects a negotiated agreement among the principal stakeholders on the allocation of water to ensure sustainable allocation among competing demands. This agreement included reductions in the recommended peak flood flows and increases in summer low flows intended to facilitate a compromise among prior established uses.

Downstream irrigators have historically held riparian water rights and have had to adapt to the changing legal framework governing water use and primacy of the ecological Reserve. Transition within the DWAF to re-orient itself in line with the rights based approach that recognizes the Reserve as a primary right, while continuing to ensure the development of water resources in support of social and economic growth, has also posed significant challenges. The initial motivations from the ecologists for the proposed peak flood flows were deemed by the DWAF to be unsatisfactory. Similarly, the ecologists have been forced to re-enforce the methodologies for determining environmental flows. This is acknowledged through the adoption of scenario based approaches that allow weighted consideration of the options to address sometimes competing social needs and economic demands.

Participation: Arrival at the decision to proceed with the BWP, and the project itself, has been through a detailed consultative process. This was initiated through the WCSA and the BWP has since established a number of participatory mechanisms to include a wide range of stakeholders. An Environmental Management Committee (EMC) was established to encourage participative monitoring of the conditions specified in the RoD and the performance and implementation of the EMP. The EMC

includes representatives from the DWAF, TCTA, civil society, water users, local communities and consultants for the project.

Broad-based participation in the Reserve determination itself was limited. The initial process of determining the Reserve through the BBM based approach focussed only on water for the environment and involved specialist inputs facilitated through a series of workshops. These were limited to professionals within the DWAF, water resource engineers and ecologists. However, as methodologies for Reserve determination developed and scenario based approaches were adopted these came to reflect negotiated agreements among a larger number of stakeholders on the allocation of water. This wider participation was also facilitated by the increased recognition of the Reserve following the provisions of the Act and the explicit requirement to address the social component within the same planning framework.

The increased participation of a range of diverse stakeholders has often been complicated by the exclusionary nature of professional dialogue. Engineers and ecologists have had to adapt to different terminology and approaches, accept differences in the resolution of the respective science and reach agreement on the principles encapsulated in the provisions of the legislation. This process has often been facilitated by one, or a small number of, professionals who are key to bridging the disciplinary divide and facilitating a mutual understanding. For example, ecological arguments for flood flows to maintain important ecosystem processes within the system were more successful once translated into more engineering orientated, sediment transport models and associated with sedimentation and the frequency and magnitude of flood risks, as well as the incorporation of weirs to act as sediment traps in urban areas such as Paarl.

Assessment Technique and Scientific Data: Preliminary determination of the ecological Reserve was built on a number of earlier estimates of environmental water requirements. The method for determining the IFRs in the early 1990s was based on an early version of the Building Block Methodology that was under development in South Africa at that time (Case Study 3). The recommended flow regime from that assessment included three freshets per annum and four controlled floods. However, the IFR was only determined for one “critical reach” and lacked hydraulic data that had been specifically designed to help determine the IFR.

A workshop was undertaken at the feasibility stage in 1996 to re-assess and/or refine the recommended IFRs. Three characteristic reaches were identified, although only two were assessed due to extreme degradation of the third. Determination of the Reserve was based on specialist studies undertaken for vegetation, fish, macro-invertebrates, water quality and geomorphology. Data inputs to the determination process were also provided on the hydrology, habitat integrity and nature conservation importance. While the recommended flow regime was similar to that previously recommended, it proposed slightly higher flood requirements, with a medium-sized flood of 70-100 m³/s in June and a larger release of 100-220 m³/s between July and September.

Subsequent hydrological yield analyses identified that the IFR could not be met without affecting the yield and relative costs of the water supplied from the scheme. Consequently, scenario meetings were held to compare flow regimes more suited to

off-stream users with the recommendation IFR and assess the affects of these on the river ecosystem. A “Damage Control” scenario was adopted where environmental flows were reduced from the recommended IFR in a way that was thought to have the least impact on the river ecosystem. Changes included a reduction in the volume of the recommended flood flows and an increase in the frequency and duration of summer irrigation releases that were up to four times the capping flows, resulting in permanent flood conditions in the Berg River.

Two additional workshops were convened in 1998 and 2001 to assess the design criteria for the outlet works after it was acknowledged that additional work was required to deepen the scientific understanding of the relationship between ecological processes and a particular flow magnitude or frequency. Concerns had also been raised on the potential impact of the recommended flood releases ($200\text{m}^3/\text{s}$) on the project costs and dam safety. The Record of Decision specifically required that the design be such that it did not foreclose the option of releasing floods in excess of the “Damage Control” IFR flood regime and so this information was necessary to inform the design of the dam. Consequently, provisions were included in the design of the dam and the diversion conduit for both low flow and flood releases. A 5.5m diameter tunnel through the dam wall, which was used during construction, is now used to facilitate environmental releases. The operating rules provide for the required volumes of water to be released from the dam to maintain the flow and integrity of the Berg River downstream of the dam.

Consultations conducted in 1996 also recognised the need for a detailed monitoring program to provide the basis for an adaptive management framework to facilitate implementation of the Reserve. This was reflected in the conditions outlined in the RoD, which required sufficient baseline information to be collected prior completion of the dam to assess the effectiveness of the environmental flows. If the monitoring demonstrates that the BWP has an unacceptable ecological affect on the river or estuary, the RoD requires that the environmental flows be revised.

The baseline monitoring programme, initiated in 2002, included eight specialist studies for the riverine environment, nine specialist studies for the estuary and a series of general catchment reports that included groundwater elements. The aim was to monitor the effects of the artificial flow regime imposed downstream of the dam as required under the conditions laid forth in the RoD. The objectives of this programme were to:

- confirm compliance with the IFR;
- verify the nature and accuracy of the changes to the ecosystem that were predicted as a result of the dam;
- determine the effectiveness of the environmental flow releases in terms of their predicted effects on ecosystem processes; and,
- facilitate implementation of adaptive management where undesirable and/or unpredicted changes in ecosystem characteristics are detected. Such adaptive management would seek to minimise the impacts of these changes.

Data collection was completed in 2005 and a conceptual model was developed for determining and managing changes brought about by the BWP. The programme focused on the flow regime and the physical, chemical and biological characteristics that the environmental flow is intended to support. Amongst other elements, the

programme included sediment transport monitoring and hydraulic and salinity modelling of the Berg River estuary. This comprehensive monitoring provides the baseline against which the projects environmental allocations are assessed and will be used to establish a comprehensive Reserve for both the river and the estuary. The issue of appropriate flood releases is now under discussion in the light of advances in environmental flow assessment methodologies, the information available from the three-year baseline monitoring programme, and concerns over water quality, especially salinity.

Integration: The environmental flow determinations were integrated with the environmental assessments during the feasibility stage and the RoD issued by the Department of Environmental Affairs and Tourism in 1999 covers implementation of the EMP and the Reserve determination. Following initial determinations there was a protracted process of reaching agreement on integrating the recommended flow regime in to the design parameters for the dam.

The preliminary freshwater requirements for the Berg River estuary were investigated at a workshop in 1993 as part of the Western Cape System Analysis. While it was acknowledged the estuary was an important and integral part of the Berg River, it was not included in the preliminary determination because of inadequate baseline data and information available and because the workshop concluded that the contribution of flows from the dam to the estuary was low enough for the BWP not to impact on the estuary significantly. Subsequent concerns have seen the estuarine environment included under the broader monitoring program and included in the comprehensive determination which included estimates of the estuarine reserve in 2008.

Cost Effective: Several concerns were raised during feasibility studies in 1996 that the cost of incorporating the required environmental flow requirements into the dam's design and operation would reduce the effective yield, reducing the number of users and increasing the unit cost of water. This would reduce the availability of capital to fund other social needs and bring forward the date for new schemes. However, ecologists and geomorphologists identified the deterioration of the river condition in the absence of adequate sediment-sorting floods and argued for inclusion of provisions enabling flood releases of at least 160m³/s. Estimates at the time suggested that the additional cost to address the recommended peak flood flows of 160m³/s would result in an additional 20% to the overall cost of the dam (Table 2). The incremental cost of the 60m multi-level intake included to address the environmental flows is estimated to be 50%. However, a detailed project completion report is being prepared, including a detailed cost breakdown, and will be issued by the end of 2008.

Capacity	Releases (m³/s)	Cost (ZAR M)	% of Dam Cost
Dam safety purposes	30	53.6	11
Current design for larger releases	70	63.5	13
Required IFR releases	160	100.0	20

Table 2: Estimated costs of outlet works (as at June 1998)

To facilitate determination of an agreed reserve, an economic analysis was undertaken to assess the impact of four scenarios on the yield and relative cost of water (Table 3). Final agreement on the design parameters and acceptance of the peak flood flows was facilitated by recognition that these floods would help remove sediments and therefore reduce the potential for flooding of urban and industrial areas downstream.

Env Release (Mm ³ /a)	Scenario	Effective yield (Mm ³ /a)	Equivalent hectares ¹	Urban people provided for	Years before next scheme	Additional capital expenditure (ZARm)	Illustrative water cost	Relative cost of water
0	No IFR	88	13 500	800 000	5.9	0	65	1
19	Drought IFR every year	73	11 200	667 000	4.9	50	74	1.14
43/19	Damage control IFR	61	9 400	560 000	4.0	89	85	1.30
51/19	Full maintenance IFR	54	8 300	493 000	3.6	112	94	1.45

Table 3: The yield, cost and other implications of environmental release scenarios

Reporting: The process of arriving at and then implementing the BWP has produced a large number of specialised reports covering a wide range of different topics relating to the sustainable development of water in the Berg-WMA. This process has been linked to a detailed options assessment for providing water to the CCT and developed over a unique period of political transition. This in itself has brought about significant changes in the legal framework for the management and development of water resources in South Africa. While the legal provisions providing for the access to information ensures that this is available upon request, specific reports and detailed information is difficult to track and trace and so not readily accessible. Recognizing this, and the value of the lessons that can be derived from the process for determining the Reserve, the TCTA has commissioned a detailed review to reflect on the experience and derive the lessons learned.

Influential: The determination of the environmental flows for the BWP has had a direct influence on the design and operation of the dam. However, the process of arriving at an agreed environmental flow regime has also had broader significance. First, the BWP is the first large, water resources infrastructure development project in South Africa to be designed, constructed and operated within the framework of the National Water Act. The provisions of the Act are viewed globally as being at the forefront of efforts to ensure sustainable water resources developments through recognition of the Reserve and so will have an important global impact.

Lessons

- The Berg Water Project was implemented within the framework of renewed focus on the development of bulk water supply infrastructure provided by the World Commission on Dams, and within the inclusive environment of progressive governance created by the democratic transition in South Africa.
- A strong bottom-up process, driven by the scientific community and progressive technocrats in water affairs can provide important professional

drivers. However, legislative provisions are important for maintaining momentum and ensuring commitment to the development of specific policies and procedures to ensure determination and implementation of the Reserve.

- Design parameters need to be carefully integrated into the determination of environmental flows. The process of reaching agreement on the Reserve is a data intensive, capital process that requires time, sufficient resources and a long-term commitment. Three years of data intensive monitoring followed two previous determinations to ensure adequate inputs. The results reveal additional complexity and highlight the need for adaptive measures to respond to changing context and ensure appropriate data feedback loops.
- Reaching agreement requires comprehensive analysis of the full costs and benefits associated with water use within the system. Environmental flows are an integral, legislated component of an allocation framework that should be extended to encompass a full economic analyses of the value of water and the services that it supports.

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