WATER RESOURCE MANAGEMENT

What's to be done about that dam silt!

Water storage and hydroelectric dams across the world are running out of water as they become increasingly gummed-up with sand and silt. The Water Research Commission (WRC) has been appointed to develop a new siltation management strategy for South Africa's large dams, writes Tony Carnie.

Dredging Africa

The Nqweba Dam was built in 1925 to provide irrigation. But over the last 96 years the dam has lost more than 40% of its water storage capacity due to siltation and currently has very low water levels.

More than 60% of the world's original dam water storage is likely to be lost within just three decades due to the growing accumulation of mud, sand and fine silt pouring into dams across the globe. That was the warning sounded by top hydrologists during the recent National Siltation (NatSilt) Symposium hosted by the WRC.

"We currently lose more storage than we build, and climate change will reduce water yields further due to increased sediment loads," said World Bank independent consultant, Dr Nikolaos Efthymiou, pointing to the threat of more severe storms and hotter temperatures that are expected to accelerate the erosion of soils in many parts of the world.

Efthymiou said the heyday of dam building was between 1960 and 1990, with most dams being built in the 1970s. This meant that the majority of the world's dams were about 50 years old, and the building of new dams had slowed significantly because of economic factors and a shortage of suitable locations.

Though siltation rates vary widely according to local conditions and land care, dams silt up at the rate of about 0.8% per year at a

global scale – but in many cases the siltation rate is much higher and this means that billions of dollars in dam construction costs go to waste due to rapid siltation.

In South Africa, the mean annual loss in storage capacity is lower, at around 0.4% per year – but several local dams are nevertheless seriously affected already. The Welbedacht Dam in the Free State, for example, has lost more than 90% of its storage capacity.

Prof Gerrit Basson, one of South Africa's foremost sedimentation scientists, suggests that future population growth and land clearance/degradation will exacerbate the sedimentation problem further, especially in Africa. Basson, the head of hydraulic engineering at Stellenbosch University's civil engineering department, notes that the current total large dam reservoir storage capacity for the world is 6 100 km^3. In 2006, the storage capacity left free of sediment was 4 100 km^3, which means a build-up of sediment of 2 000 km^3 (33%), which – if left unchecked – could potentially increase to a volume of sediment of 3 900 km^3 by the year 2050 (based on current storage capacity).

"This means that by 2050 roughly 64% of the world's current reservoir storage capacity could be filled with sediment," says Basson, who is also a former chairperson of the reservoir sedimentation committee of the International Commission on Large Dams (ICOLD) and a member of the World Bank-UNESCO Task Group on reservoir sedimentation management.

ICOLD assessments suggest that several countries – almost one third of them in Africa – could therefore experience critical sedimentation volumes by 2050.

At the local level, Basson has also been closely involved in several studies to assess the sediment levels of South Africa's major dams. He notes that sediment research and daily suspended sediment sampling of rivers in South Africa started in the 1920s. By the 1970s, with many new dams constructed, most of the river sampling programmes were stopped and replaced by reservoir surveys by the Department of Water and Sanitation (DWS), which are recorded in the so-called 'Dam List'.

These early sediment yield maps for South Africa were updated in 2010, and earlier this year the WRC developed a shortlist of 20 dams believed to contain some of the highest silt levels and which may be priority dams for further investigation for possible dredging.

Some dams of concern include Lake Arthur Dam on the Tarka River (52% silted), and the Darlington, Nqweba, Lubisi, Grassridge and Bospoort dams (all above 40%). In KwaZulu-Natal, the Hluhluwe Dam is estimated to be 25% silted up, while the Gariep

Dredging Africa

Sediment removal at Oliphantskop dam

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The business end of a cutter suction dredger at Mvunyane dam.

Dam on the Orange River, South Africa's largest dam, was nearly 20% silted up.

At a global level, several options have been explored to combat the inevitable siltation of dams.

Basson says this includes soil erosion and land care management measures to reduce the problem at source, by focusing on land care on the worst 20% of the catchment which contributes most of the sediment yield. Other options include building expensive upstream check dams to trap sediment from large floods; by-passing sediments via tunnel schemes; flushing and sluicing; raising the height of dams or building brand new dams at enormous cost.

Because South Africa is a largely arid and water-scarce country, Basson says the option of sluicing and flushing dams is unlikely to be feasible, as most dams don't have enough excess water. "Dredging costs have come down in recent years with the use of the latest cutter suction dredgers from Europe. But it is important to note that dredging of all of the reservoir sediment is not required and that the aim should be to dredge the original river channel only, for the best firm yield increase."

"In conjunction with dredging, we are proposing that water from the deposited sediments in reservoirs could be used during droughts and from the aquifer formed by the original river beneath the reservoir, by retrofitting pumps at the dam wall."

He notes that by-passing sediment via tunnels or canals in South Africa is not new, and many dams were designed in KwaZulu-Natal such as Nagle Dam, Henley Dam and Shongweni Dam, more than 70 years ago, with sediment bypass facilities.

To tackle the problem of siltation, the WRC was appointed earlier this year to develop a National Siltation Management Strategy for Large Dams in South Africa. The three-year programme aims to develop a strategy that will guide, advise and ensure effective siltation management and related improved storage capacity for 320 large dams in South Africa, to sustain bulk water supply to the domestic, industrial and agricultural sectors.

It will also consider pilot projects for three government water schemes: Welbedacht Dam (Free State), Hazelmere Dam (KwaZulu-Natal) and Darlington Dam (Eastern Cape). It will also be linked to a major dredging project to remove at least 1 000 000 m^3 of sediment from the Nqweba Dam outside the Karoo town of Graaff-Reinet in the Eastern Cape.

The Nqweba Dam (formerly known as the van Ryneveld Pass Dam) was built in 1925 on the Sundays River to provide irrigation for farmers. But over the last 96 years the dam has lost more than 40% of its water storage capacity due to siltation and currently has very low water levels.

The Nqweba project, to be undertaken by the Pretoria-based Dredging Africa group, is one of the biggest sediment-dredging projects undertaken in the country to date – and it will also incorporate an innovative job-creation project in which the accumulated waste sediments are turned into bricks and blocks by local entrepreneurs.

Dredging Africa Director, Arend van der Wetering, says the first phase of the Nqweba project is underway, but the physical removal of silt with an imported cutter suction dredger can only commence once the dam's current low water levels are replenished by the summer rains.

The Nqweba project has an estimated price tag of €8 million (R135 million) of which €5 million will be provided as grant funding by the Dutch government and the remainder from local matching contributions.

However, major disturbance of silt deposits – whether by dredging, sluicing, flushing or venting – can cause significant environmental and problems downstream if they are not

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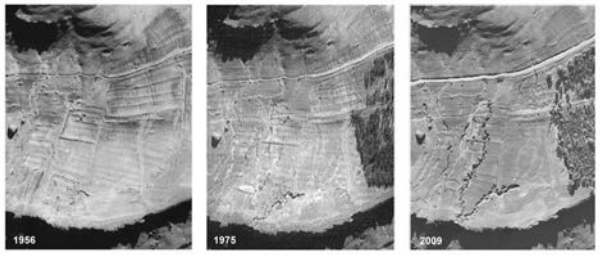

Gully erosion in the Mzimvubu River catchment.

properly planned or implemented, warned Dr Bennie van der Waal from Rhodes University's Catchment Research Group. "Released sediments can smother all the life downstream and damage the river courses. So it is vitally important to release sediment in line with environmental flow specifications."

Van der Waal also emphasised the need to tackle the sedimentation problem at source, by reducing the volume of soil erosion in the river catchments feeding major dams. In a recent research project in the catchment of Thina River and Mzimvubu Rivers in the former homeland of Transkei, van der Waal and colleague, Prof Kate Rowntree, noted that marginal agricultural areas are prone to the abandonment of cultivated fields due to economic and social shifts that make it no longer worthwhile to cultivate land.

"When agricultural land is abandoned (or a landslide has stripped a hillslope) soil can remain bare for several years before being recolonised by vegetation. Sediment yields peak after land abandonment and eventually fall if and when vegetation cover increases, possibly only after several decades. But if erosion strips the topsoil from abandoned cultivated fields they may never recover their original cover and become 'erosion hotspots'," the researchers warned.

Dr Bridget Shaddock, of the Golder Associates Research Laboratory, also cautions that care needs to be taken to avoid unleashing new problems if contaminated sediment is disturbed or released downstream during the restoration of sedimented dams. In some cases, this can include releasing some very toxic and persistent farm chemicals or heavy metals into sensitive downstream aquatic environments.

Dr Jeanine Vonkeman, a hydraulic engineer at ASP Technology (Pty) Ltd, also cautions about the need to consider the impact of dredging from contaminated sediments and negative water quality impacts from higher turbidity, reduced levels of dissolved oxygen and the release of nutrients that can result in eutrophication of dredged dams. Vonkeman said it is, therefore, imperative that proper Environmental Impact Assessment (EIA) procedures are followed prior to sediment removal.

Nevertheless, the need for action was highlighted in a recent WRC study, which suggests that almost 25% of the total number of reservoirs that were analysed in South Africa had lost between 10% and 30% of their original storage capacity. WRC CEO, Dhesigen Naidoo, noted the national desiltation programme is absolutely critical to the country's water security.

"It is a difficult option, a hi-tech option and very expensive. And we have to be quite ingenious in how we motivate that," he said, noting that siltation could also be limited at the design stage, as has been the case with designs for the Umzimvubu water project, planned for the Eastern Cape, and for example, China's Three Gorges Dam."

Jurgen Kogl, special advisor to Minister of Human Settlements, Water and Sanitation, Lindiwe Sisulu, noted that dealing with siltation was sometimes viewed as a grudge purchase, in a similar way to how consumers often viewed buying life insurance. But the problem needed to be tackled swiftly and "head on" to extend the life-span and capacity of South Africa's crucial water infrastructure, he said.

* For more information, visit: https://wrcnatsilt.org.za/ Watch a video summary of the NatSilt Programme here: https://www.youtube.com/watch?v=7BOtiQlMm6o

Dredging is one option available to physically remove decades of silt build-up from South Africa's dams.