



The Zimbabwe Water Forum provides a platform for Government and Development Partners to share international best practices in the water sector between Zimbabwe and other countries. The forum was formed through a partnership between the Ministry of Water Resources Development and Management, the Multi-Donor Trust Fund and the World Bank and is hosted by the World Bank's Zimbabwe Country Office and the Urban WSS Thematic Group.

Zimbabwe Dam Safety Study

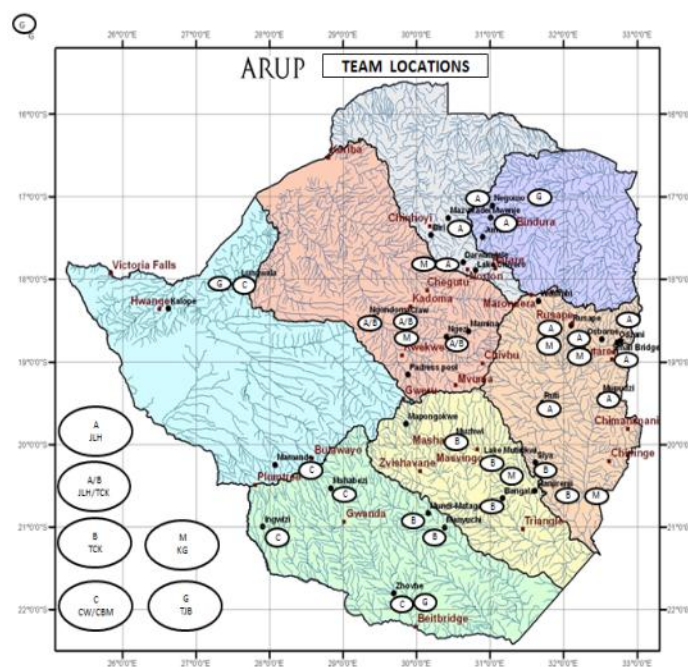
In 2011, the Zimbabwe National Water Authority (ZINWA) requested technical assistance from the World Bank to undertake a review of the safety of dams in Zimbabwe; consultants from Arup Pty were appointed to complete the task. The project's objectives were to assess the overall condition of dams in Zimbabwe in order to make recommendations for a Dam Modernization and Operation Improvement Program (DMOIP), and to identify urgent dam safety measures for quick implementation while the longer-term DMOIP was being prepared. In December 2011 and January 2012, three teams of experienced dam engineers visited the 25 dams to be assessed in the study; two specialist teams (led by a geologist and a mechanical and instrument engineer) were then asked to visit selected dams for further assessment. The results of this review are summarized below. The full study is available at the World Bank.

Assessing the dams

Three teams of experienced dam engineers visited 25 dams in Zimbabwe in December 2011 and January 2012. The teams included engineers James Hampton, Chamu Mhuka, Terry Kabell, Chris Watermeyer, John Hart, Kozanai Gurukumba, and Tim Broderick. Each team was accompanied by a ZINWA staff engineer (C.T. Maruvenje, T. Maurikira, B. Rungano, and P. Makwarimba) together with relevant catchment managers and water bailiffs. Mechanical engineer Kozanai Gurukumba and engineering geologist Tim Broderick then visited eight selected dams for further assessment in February 2012. The teams reported that dam staff were extremely cooperative and helpful during these visits.

Evaluations of urgency, importance, and cost

The primary objective of the dam assessment teams was to identify and evaluate the measures that would be needed for the dams to meet



safety standards. These needs were then classified by the urgency of the required repairs. All but one dam required significant repairs

beyond normal maintenance, and many of the dams posed a risk to human life and health or to major assets of the system.

	Classification	Number of dams (total 25)	Percentage
	Emergency – human life in immediate danger; major asset loss (including operational loss)	5	20%
	Urgent – likely to pose risk to human life; major asset risk (including operational loss)	10	40%
	Significant - Rehabilitation beyond meaningful maintenance	9	36%
	Normal Maintenance Required – Site staff to carry out without additional resources	1	4%

The dams were also ranked according to their importance to the economic and well-being of their communities using the following criteria which were scored from 1 (lowest priority) to 5 (highest priority):

- Economic value of the water resource (weighting 25%) (for example, the main source of supply for irrigators)

Dam name (color=urgency)	Priority ranking	Quick fix index	Cost Range US\$	
			Low	High
Osborne	3.25	3.0	100,000	500,000
Ruti	2.00	2.5	100,000	500,000
Rusape	3.00	3.5	1,500,000	3,000,000
Odzani	NA	0	NA	NA
Smallbridge	3.75	1.5	20,000	100,000
Siya	2.25	2.0	100,000	500,000
Mupudzi	2.50	2.0	100,000	500,000
Manjirenji	2.00	4.0	1,500,000	3,000,000
Muzhwi	3.25	3.0	100,000	500,000
Bangala	1.75	2.0	100,000	500,000
Mutirikwi	3.50	2.0	100,000	500,000
Manyame	3.50	3.5	1,500,000	3,000,000
Mazvikadei	1.75	1.0	20,000	100,000

- Importance as a potable supply (weighting 25%) (for example, the sole potable source for a sizable population)
- The risk of failure if issues are not addressed (weighting 50%)

This ranking rated the Ngezi dam as the highest priority for repairs, primarily because the construction of a wave wall is critical to prevent flooding in the event of a severe flood. The Ingwezi Dam was ranked as the lowest priority since there is no risk of the dam failing if issues are not addressed, and the dam doesn't provide drinking water. At the same time, however, the very fact that the Ingwezi dam is in relatively good condition means that it will take little investment in time and money to bring it up to standards.

To further help decision-makers create priorities and plans for dam repair, the consultants devised a "quick fix" index that weighed both the effort and cost of making the necessary repairs. For just under a third of the dams (7 dams), safety standards could be met with repairs costing less than US\$100,000 and requiring relatively little effort. The most expensive and difficult repairs are needed to the Lungwalala dam, as severe seepage there requires major civil engineering works to repair. Another 5 dams will also be costly to bring up to standards, with potential costs of up to US\$3 million each in rehabilitation works.

Dam name (color=urgency)	Priority ranking	Quick fix index	Cost Range US\$	
			Low	High
Zhove	2.00	2.0	100,000	500,000
Mundi-Mataga	2.00	1.0	20,000	100,000
Mtshabezi	2.25	1.0	20,000	100,000
Manyuchi	2.50	2.0	100,000	500,000
Ingwizi	0.75	1.0	20,000	100,000
Lungwalala	3.25	5.0	3,000,000	10,000,000
Mananda	3.00	1.5	20,000	100,000
Mwenje	3.00	1.5	20,000	100,000
Negomo	2.75	3.5	1,500,000	3,000,000
Ngondoma	1.50	3.5	500,000	1,500,000
Ngezi	4.75	3.5	500,000	1,500,000
Claw	3.50	3.0	1,500,000	3,000,000

Dams are structurally sound, but repairs are needed

Overall, the assessments found that the dam structures themselves are generally in good repair, but some significant refurbishment is needed for most dams to meet all safety standards. Common issues include outlet works that have not been maintained and dropped or jammed service gates. Mechanical and electrical repairs are also needed at most dams. Although these repairs frequently involve only the replacement of small inexpensive parts, at some sites more extensive fixes are needed, sometimes urgently. At many dams, standard safety requirements, such as lighting and access roads, should be upgraded.

Routine maintenance was found to be inadequate at many sites: staffing levels were insufficient, communication systems were poor, gauges were not being monitored and analyzed, there were no clear maintenance schedules, and operation and maintenance manuals were often missing. Dam staff are usually diligent, but little regular support from ZINWA creates low morale.

Emergency Preparedness Plans were not in place at any of the dams. In some cases, water bailiffs had a verbal understanding of emergency procedures, but there were no formal written documents to follow. This is a serious deficiency in overall procedure and training that should be relatively inexpensive to correct.

Individual dam assessments

Osborne Dam: Overall, this dam is safe and most necessary repairs could be carried out as normal maintenance. However, the hydraulic works are in urgent need of repair and attention, posing an immediate risk to the operation of the dam. Although these repairs are projected to be relatively inexpensive (under \$500,000), they will be time-consuming and complex as a diving contractor will be required to assess the potential for repair.



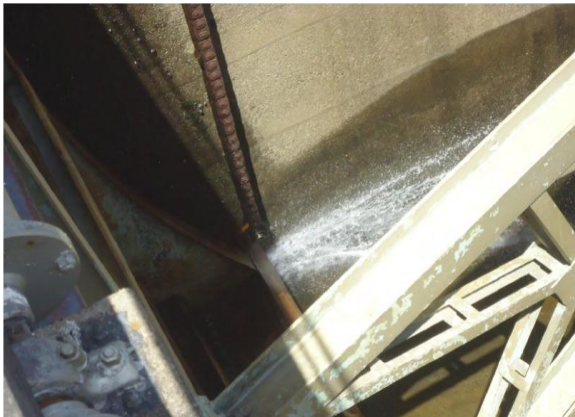
Osborne: Service gate stuck in half-open position

Ruti Dam: The Ruti dam is essentially safe, but it is not being utilized to its full potential. A large amount of potential water for the reservoir is being lost through a damaged fuse gate on the main spillway, and there is serious leakage in the saddle spillway that the dam bailiff has reported could result in a breach.



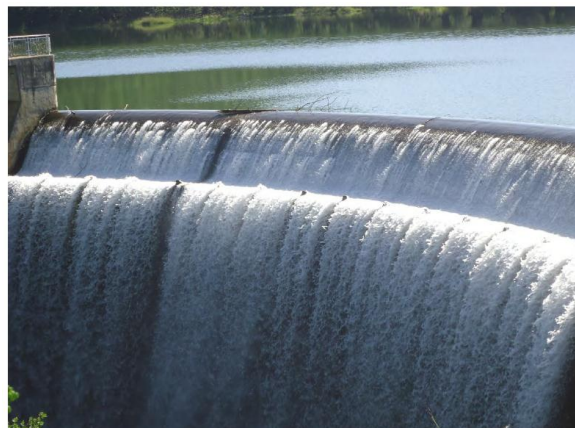
Ruti: Gap left by tipped fuse gate

Rusape Dam: This dam needs significant refurbishment to both its electrical and mechanical systems, although its major structural components are sound and are considered safe. A lack of routine maintenance has caused failures in the mechanical equipment. Total repairs to the dam could be relatively costly with estimates up to \$3 million.



Rusape: Leak in right gate

Odzani Dam: The Odzani dam is well designed and maintained. It is the only dam in the study that requires no major repairs beyond routine maintenance. The biggest operational issue at the dam is the lack of a boat so that the bailiff, who is also in charge of the Smallbridge dam approximately 2 kilometer upstream, has no easy way of commuting between the dams.



Odzani: Spillway

Smallbridge Dam: The dam is safe, but needs emergency maintenance to control leaking outlet valves. These repairs are projected to be relatively inexpensive (under \$100,000), but the emergency gate system must be replaced before these repairs are undertaken. Without a functioning emergency gate, the water level could need to be dropped for repairs to be possible. This could result in a total loss of storage, which would pose a serious threat to the water security of the City of Mutare.



Smallbridge: Water gush from a jammed valve in the outlet

Siya Dam: There are many issues requiring significant work at this dam. The outlet works are in very poor condition, the water supply system should be repaired or replaced, and the turbine/generator should be repaired and re-commissioned. Staff need further support such as reliable transportation and communications.

Mupudzi Dam: The full potential of this dam for irrigation is not being utilized. Urgent repairs are needed to the valve house which is currently flooded, preventing adequate control and maintenance of the valves. The lack of a boat means that the bailiff needs to swim to the intake tower to perform general maintenance.



Mupudzi: Flooded valve house

Manjirenji Dam: Routine maintenance at Manjirenji Dam is satisfactory, but there are many significant repairs needed including to the valve chamber, dam embankment, wave wall, and the spillway gates. These repairs could be expensive

(up to US\$3 million). The access road to the site also requires urgent repairs.

Muzhwi Dam: The situation at the dam is critical and needs addressing urgently. Emergency attention should be given to the full refurbishment (or part replacement) of the outlet works—service gates and all valves—and operating mechanisms. The design for the mechanical works needs to be re-evaluated as previous maintenance has altered some design features.



Muzhwi: Spillway return channel

Bangala Dam: Staff levels and facilities at this dam should be improved, and routine maintenance carried out to a better standard. Significant repairs need to be performed on the outlet works.



Bangala Dam

Mutirikwi Dam: The structure of this dam is in good condition, but significant refurbishment of the entire outlet system is necessary, and would best be undertaken by a specialist contractor. Monitoring should be resumed on deflection targets, crest level studs, and strain meters, and on a large horizontal crack.



Mutirikwi: Manually operated dam gate mechanism

Manyame Dam: Significant problem areas involve the dam outlet works and leaking spillway gates. Non-functioning electrical equipment means that mechanical components, such as the heavy spillway gate, must be manually operated. The dam surveillance system also requires complete upgrading.



Manyame: Leakage in the radial spillway gate

Mazvikadei Dam: This dam was constructed to supply irrigation water, but at present there is no significant demand. Repairs are needed to the outlet system; these could be achieved quickly and cheaply.

Zhove Dam: The difficulty of establishing accurate data on seepage is critical in monitoring this dam. Divers will be needed to inspect and repair damage to the upstream isolating gate and valves.

Mundi Mataga Dam: Required repairs to this dam are minimal, with work on the outlet works the only significant rehabilitation needed. These repairs should be straightforward and relatively inexpensive.

Mtshabezi Dam: The dam wall is in good condition, but steel handrails must be installed along the dam wall crest as soon as possible as there is considerable risk to the public. Divers will need to be hired to locate and recover the isolating gate which has fallen into the reservoir (a seemingly common occurrence at ZINWA dams); these repairs are projected to be relatively inexpensive.

Manyuchi Dam: Several urgent repairs are necessary to achieve safe and efficient operations at this dam. Divers will be needed to recover the isolating gate and to repair any damage to the gate seating. The spillway basin should also be inspected and pumped out, and urgent work is needed on the access road to the dam. The dam surveillance system needs a total overhaul.

Ingwezi Dam: The dam is safe but needs methodical maintenance. Again, the isolating gate needs to be recovered from the reservoir and replaced. These repairs should be inexpensive and easily achieved.

Lungwalala Dam: The Lungwala dam will require the most expensive and complex repairs of all dams in the study with estimated costs as high as US\$10 million. The dam has urgent seepage losses on both left and right bank which need to be investigated further and addressed. Major civil engineering works will be needed to correct the problem.



Lungwalala: Leakage from the left bank

Mananda Dam: This dam is in overall good condition, but some repairs are required to ensure safety. The concrete faces of the spillway arches are severely corroded and will need refacing, and a diver will be required to investigate and repair the condition of the outlet works.

Mwenje Dam: Mwenje dam is a well designed and constructed dam and required repairs are relatively inexpensive. The outlet works will need some rehabilitation that may require a specialized contractor. Some monitoring equipment also needs replacing.



Mwenje: Rusted butterfly valve pipe



Ngondoma: Outlet pipe with a tree stump blocking a leak

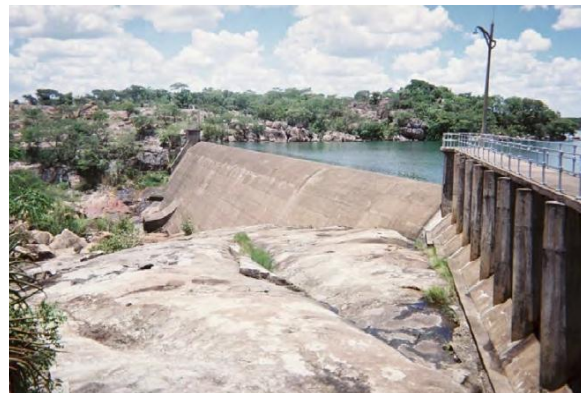
Negomo Dam: The Negomo dam is not being adequately maintained: there is excessive growth of vegetation on the upstream and down-stream slope, and there is no security fence, which leaves it accessible to both people and animals who create foot paths that later turn into gullies. The outlet exhibits signs of distress that must be investigated further on an urgent basis.



Negomo: Weed growth on rip rap

Ngondoma Dam: Immediate attention should be given to the operation of the upstream close-off to enable the refurbishment of the outlet pipe and valves controlling the releases. The spillway tilting gates need to be properly maintained and tested to ensure operation. These repairs may be relatively complex and expensive (up to US\$1.5 million).

Ngezi Dam: The Ngezi dam is a very important supplier of both irrigation and drinking water. Because the dam was designed to earlier flood estimates, the construction of a new wave wall 90 centimeters high will be urgently necessary to protect from extreme flood events. Immediate attention should be given to refurbishment (or part decommissioning) of outlet works, and a specialist contractor engaged for the refurbishment of the crest concrete of the main dam and of the auxiliary spillway.



Ngezi Dam

Claw Dam: The Claw dam is an important supplier of both irrigation and drinking water. Routine maintenance at Claw Dam is generally good and must be maintained. Some repairs to the spillway gates are urgent, including electrical maintenance and the installation of safety railing. These repairs may be relatively expensive with estimates reaching as high as US\$3 million.

Recommendations for the way forward

Extensive maintenance is needed throughout the portfolio of dams that is beyond the current day to day capacity of ZINWA. This could be addressed through two mechanisms:

- Increase the construction-related capacity of ZINWA to undertake direct heavy repair and maintenance through the establishment of in-house construction teams
- Establish an agreement with prequalified suppliers under which ZINWA would be empowered to directly instruct task orders for a standard list of operation and maintenance activities

This report recommends the second of these two options as it avoids the need for ZINWA to be responsible for the staffing and maintenance of heavy equipment.

The Zimbabwe Water Forum Policy Notes Series

Between 2011 and 2013, at the request of the Government of Zimbabwe, through the Ministry of Water Resources Development and Management, and with support from the Zimbabwe Analytical Multi-Donor Trust Fund, the World Bank has undertaken a series of analytical studies and technical assistance in the water and sanitation sector. These studies are captured in the Zimbabwe Water Forum Policy Note Series. The task team leader for the studies is Michael Webster, Sr. Water and Sanitation Specialist in Harare (mwebster@worldbank.org) with support from Priscilla Mutikani (pmutikani@worldbank.org). All notes have been edited by Rolfe Eberhard and Hilary Gopnik.

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