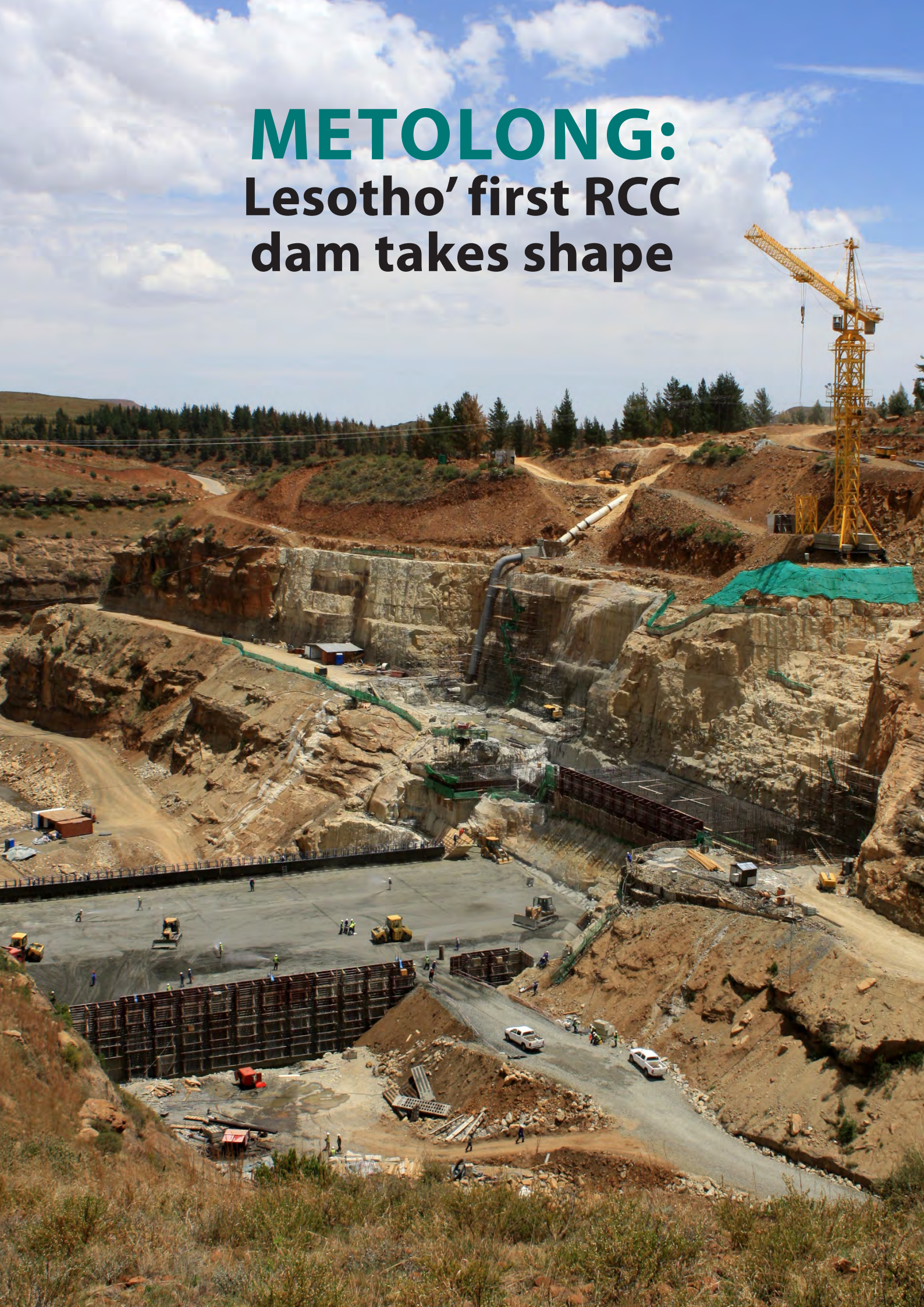
METOLONG:
Lesotho' first RCC dam takes shape



With Arab funders, South African consultants, a Chinese contractor and a Basotho workforce, the Metolong Dam, currently under construction in Lesotho, is the embodiment of how cosmopolitan water resource development has become. Lani van Vuuren visited the site.

When entering the Metolong Dam site, one is immediately struck by the bilingual signboard outside the gate advertising vacancies – one side English, the other Basotho. It is perhaps symbolic of the challenges of working on an international job site where different cultures – neither of whom speak hardly anything besides their mother tongue – have to work together to build a much needed dam for Lesotho.

Unlike the other large dams in the Mountain Kingdom this one will not be supplying water to South Africa. Lesotho's first roller compacted concrete (RCC) dam is meant to bring welcome relief to the capital of Maseru and surrounding villages of Roma, Mazenod, Morija and Teyateyaneng, which have been suffering severe water shortages in recent years due to rapid urban growth.

Recent studies have shown that current urbanisation rates in Lesotho lie around 5.5%. Moreover, the dynamics of rural water supplies are changing dramatically with the shift to urbanised neighbourhoods. Lesotho has also experienced a boom in export growth through light industries, particularly the textile and apparel sector, which has placed increasing pressure on existing water supplies.

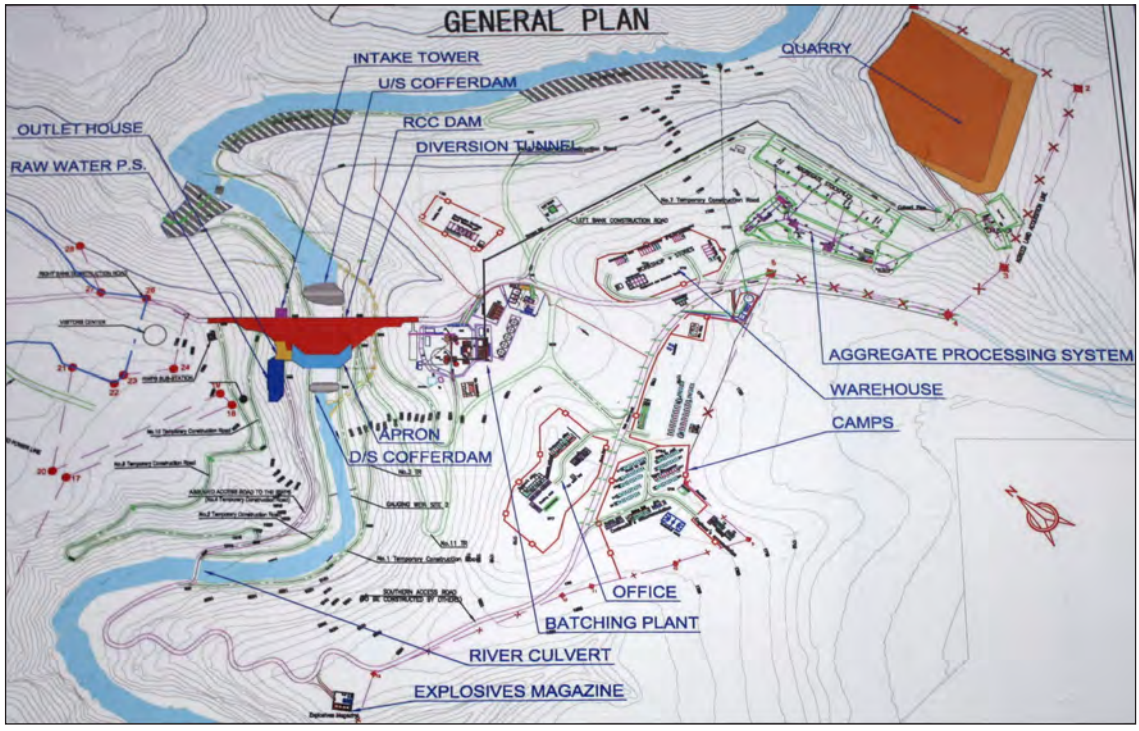
A DAM FOR LESOTHO

The Metolong and associated infrastructure forms part of a broader programme of donor support to improve water and sanitation supply in Lesotho. The dam is being constructed in the South Phuthiatsana River in the lowlands of western Lesotho, about 35 km from Maseru. The river is a tributary of the Caledon River, and sources its water in the highlands of Lesotho. The Metolong Dam and Water Supply Programme, as the project is known, comprises a dam and raw water pump station, associated water treatment works and conveyance systems to support domestic and industrial water supply.

The dam construction is funded by five Middle Eastern funders, namely the Saudi Fund for Development, Kuwait Fund for Arab Economic Development, Arab Bank for Economic Development in Africa, OPEC Fund for International Development and the Abu Dhabi Fund for Development. Additional funders of the larger programme include the South African government, the World Bank, the Millennium Challenge Corporation and the European Investment Bank. The Metolong Authority has been established by the Lesotho government to implement the project.

LOCATION AND DESIGN

South African consulting engineering firm GIBB has been appointed in joint venture with Consolidated Consultants for Engineering and Environment from Jordan to undertake the engineering



Sinohydro

Left: *An upstream view of the Metolong Dam, intake tower, outlet and pump station currently under construction.*

Right: *A general layout of the dam site.*

Lani van Vuuren

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The aggregate processing system has a capacity of 400 t/h. On-site basalt rock is being used as concrete aggregate, while sand is crushed from the basalt stone due to the limited availability of natural sand sources.

A truck waits to be refilled with RCC. Metolong's two batching plants have a total rate capacity of 300 m³/h of RCC and 200 m³/h of conventional concrete.

services of the detailed design, preparation of tender documents for construction and construction supervision of the Metolong Dam. According to Johann Geringer, GIBB Chief Design Engineer: Heavy Engineering Sector, Metolong Dam is located in a deeply-incised gorge. The dam site and type was established during the feasibility study preceding the design stage. The site was determined at a location where it not only offered a sizeable storage capacity for a dam, but also offered a high-lying surrounding topography from where water can be supplied mostly by gravity with the minimum amount of pumping.

"The deep steep-sided gorge and the lack of suitable soils ruled out the possibility of considering embankment-type dams, which left a concrete dam as the only option for the site," Geringer explains. The latter is further enhanced by the presence of suitable concrete aggregate borrow areas being available both on and close to the dam site.

"Since it was important to supply water as early as possible from the dam, fast construction of the dam was a great consideration. This finally culminated in the decision to recommend the construction of a RCC dam."

Several studies were undertaken to optimise the location and design of the dam, including topographical surveys, seismic hazard analysis, hydrological studies, and water quality modelling, among others. Feasibility investigations also included detailed social and environmental studies to mitigate potential impacts of the dam.

Interestingly, a study was also undertaken to determine the potential impacts of climate change on the long-term dam yield of Metolong Dam. This study, undertaken by Jeffares & Green, found it 'highly unlikely' that the available long-term yield of the dam will decrease in the intermediate future (30 to 50 years from now). As a result no adaptation measures

will be required to account for the impacts of climate change on the yield of the dam.

Sedimentation has been found to be more of a threat to the long-term sustainability of the dam. The upstream catchment of the Phuthiatsana River is severely degraded, resulting in extensive erosion due to the high population density and high usage of land. At the time of writing the Lesotho government was investigating catchment management plans to reduce human impacts on the catchment.

Metolong Dam will ultimately be 83 m high with a crest length of 280 m, and a reservoir that can impound up to 63.7 million m^3. The dam will incorporate a 75 m-long, uncontrolled spillway in the central section. The dam has a non-overspill crest width of 7 m.

A popular design feature in South Africa for RCC dams (think of latter constructed dams such as De Hoop), Metolong will also feature a stepped downstream face, which will have a slope of 0.8:1 (H:V). The steps will be constructed 1.2 m high and 0.96 m in width, such that each step is constructed by placing four lifts of RCC each of compacted thickness of 300 mm. The steps on the ogee crest of the spillway will have smaller and varying dimensions to suit the curvature of the spillway cap. The spillway has been designed to pass a flood of 2 000 m^3/s.

Geringer explains that it was difficult to fit an uncontrolled central spillway in the dam that would have the desired discharge capacity within the constraints provided by the narrow gorge. "Various configurations were investigated and a hydraulic model study conducted at Stellenbosch University. The latter confirmed the design with best hydraulic performance to be one that comprises a 75 m-long spillway at the crest followed by a straight chute to finally end on a 20 m-wide flat apron with a width of 45 m and a length of 20 m."

With regards to outlet works, Metolong Dam will have a dry intake tower containing two independent outlet systems to ensure that there is a backup system in case one system is out of operation for either maintenance or failure of some components. The outlet system will comprise two independent 1 200 m-diameter vertical pipes. The intake tower will be situated on the right bank where the lowest intake will be below the 50-year silt level. Geringer notes that the valves of intakes will be sealed off once they become covered with sediment.

The dam design also includes a pump station with an initial pumping capacity of 1.2 m^3/s, to be located on the right bank. The pump station has been designed for five 0.6 m^3/s pumps with variable speed drive motors. For phase 1, three pumps will be installed with two being on duty and one on standby. From the pump station the water will be taken to the 75 Mℓ/day Metolong Water Treatment Works situated on the high ground above the gorge from where the water will be conveyed to Maseru and nearby villages.

DAM CONSTRUCTION

Chinese firm, Sinohydro, one of the contractors on the gigantic Yangtze Three Gorges Project, was appointed to construct the Metolong Dam and pump station in August, 2011. Unfortunately, several delays prevented site establishment to occur shortly thereafter, such as funding shortfalls, challenges in obtaining visas and work permits for the Chinese labour force as well as the contractor's unfamiliarity with local conditions and requirements.

Construction eventually started in 2012, with excavation work for the dam and diversion tunnel commencing in June of that year.

Safety signs dotted around the site remind visitors and employees to be vigilant and stay safe.

Lani van Vuuren

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Above: *A closer view of the RCC laying process. The dam will eventually have a total concrete volume of around 315 000 m³ of which 280 00 m³ will be RCC.*

Below: *Several villages are located around the dam site.*

Excavations were used to remove the weathered and bladed basalt down to sound rock. Excavation in the bladed basalt at the top of the left abutment reportedly proved a difficult exercise to determine a suitable founding level, as the individual rock shards interlock to provide the appearance of a firm founding, but unravel upon the removal of a few interlocking rock shards.

This necessitated the application of shotcrete to the downstream portion of the left abutment excavation to provide stability, prevent fallout of the rock and to provide a safe working area. Once the sandstone horizon was reached, about 20 m to 30 m below the upper basalt, drill and blast methods were employed to excavate the harder intact sandstone rock.

River diversion was accomplished through a 244 m-long tunnel through the sandstone on the left bank. The tunnel will later be plugged with a permanent concrete plug that will prevent water from seeping through it once pressurised. Diversion was achieved in February 2013.

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The contractor employs a single jaw crusher of 400 t/h capacity for aggregate crushing and screening. All drilling is limited to daylight hours in consideration of the three surrounding villages. Crushing and screening operations are, however, performed around the clock as this does not generate excessive noise pollution. Two batching plants, each with a capacity of 150 m³/h are also in use on site.

A major milestone was reached at the dam site on 5 August when the first RCC was placed into the dam foundation. By the end of that month 36 595 m³ of RCC had already been placed to a height of 10 m. At the time of writing, 83 557 m³ RCC had been placed using a fleet of 20 t dump trucks. Interestingly, in order to ensure that the wheels of the trucks were cleaned of contaminants prior to entering onto the freshly placed RCC layer works, a wheel washing station was established about 60 m upstream of the dam. Metolong will eventually have a concrete volume of around 315 000 m³ of which 268 000 m³ is anticipated to be RCC.

The contractor was confident that the halfway mark would be reached around year-end at the start of Lesotho's rainy season to enable impoundment to take place. According to Metolong Dam Coordinator, David Bosshart, it is critical to impound the reservoir during the current rainy season. "Lesotho has a distinct seven-month rainy season in which about 85% of annual rainfall occurs. If we miss this opportunity, there could be an additional seven-month delay waiting for the next rainy season."

In order to impound, the dam should be up about halfway (i.e. 40 m) to be above the intake/outlet pipes. In addition, the lower dam instrumentation, grouting and drainage systems need to be

operational. Workers are currently working in two 12-hour shifts, seven days a week to meet this target. Placing of RCC is routinely exceeding 1 000 m^3 per shift, with the best placing rate for a 24-hour period being 3 179 m^3.

CHALLENGE OF WORKING TOGETHER

Lesotho has a large unskilled and semi-skilled workforce, however, experience in dam construction is limited. Sourcing skilled construction personnel has therefore proved a challenge for the contractor, and on-site training of unskilled personnel has been required.

Unfortunately the problems with unions and labour strikes – now so prevalent in South Africa, have also occurred in Lesotho. In June 2012, the site was marred by violent strikes which left property destroyed and personnel injured. Order was only restored following the personal intervention by Lesotho authorities, and the Chinese Ambassador to Lesotho.

The Metolong Authority has since arranged for the establishment of a satellite site office, however, further unrest occurred in May 2013, which also saw work stoppages. "Although some issues of the labour dissatisfaction still remain to be resolved, the debilitating effect of prolonged strikes by the labour force appears to have been averted," notes Bosshart.

As with all international projects, differences in language and culture play an important part in effective communication. According to GIBB Resident Engineer, Michael Neumann, the site has its fair share of communication problems. "Many of the Chinese expatriates are not conversant in English, while the labour force predominantly speaks Sesotho. In order to bridge the language barrier, extensive use is made of sketches, annotated photographs, daily ad hoc meetings, or even literally taking relevant parties to site and demonstrating what is required."

It is hoped that the team can overcome their differences to complete this necessary infrastructure for Lesotho citizens. The project is expected to be completed in 2015. ❑

General characteristics of the Metolong Dam

Planned year of completion	2015
Purpose	Domestic, industrial
River	Phuthiatsana River
Type	Roller compacted concrete (RCC)
Storage capacity	63.7 million m^3
Wall height above lowest foundation	83 m
Crest length	280 m
Material content of dam wall	315 000 m^3 of which 268 000 m^3 RCC
Type of spillway	Uncontrolled, stepped

Source: GIBB

One of the access roads that have been constructed to the dam site.

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