DWA/eWISA

The inlet/outlet works in Rockview Dam comprise a reinforced/pre-stressed concrete tower, 68 m high. To ensure the tower's stability in the event of an earthquake it was necessary to provide 32 anchors, each of 3 000 kN capacity, anchored 20 m into the rock.

PALMIET – An environmentally sound example

Long before the passing of formal environmental management legislation, the Palmiet Pumped Storage Scheme proved that infrastructure development can be sensitive to the needs of the environment. Article by Lani van Vuuren.

Numerous large water engineering projects in the 1950s, such as the raising of the Steenbras Dam and the completion of the Wemmershoek Dam, proved to be inadequate to meet Cape Town's insatiable demand for water. All eyes turned to the Palmiet, a short river (only about 74 km) which rises in the Hottentots-Holland mountains and winds south-west to its estuary near Kleinmond.

The river had actually been identified as a possible water source as far back as the 1900s. A Mr St V Erskine, learning that the Town Council of Cape Town was investigating potential water supplies, looked to purchase land around one such a possible river and acquiring the water rights. (His plan was to sell the land and water rights back to the municipality for a profit). He passed by the Steenbras River 'a mere dribble he could jump over' and settled on the Palmiet River, which he had to cross by using a punt and wire rope.

With financial backing of a London firm and some local investors Erskine started acquiring land in the catchment. However, the distance of the Palmiet River to Cape Town at that stage completely put off the municipality (it would have to be pumped 130 km – quite a task at that time). Erskine then offered to build the infrastructure himself, selling the water to the municipality at 7½ d per 1 000 gallons (4 546 ℓ), but even that did not persuade them. Instead Cape Town chose to develop the Steenbras scheme.

We do not know what happened to Erskine, but 70 years later the Department of Water Affairs (DWA) conducted investigations to survey possible dam sites in the Palmiet River to further augment Cape Town's water supply. Initially it was assumed that a long tunnel would be needed to convey the water from such a dam north-westwards under the Kogelberg and Hottentots

ENGINEERING FEATURES OF THE ROCKVIEW DAM

- **Type**: Rockfill with clay core (main embankment), and earthfill and rockfill with clay core (northern embankment)
- **Height above lowest foundation**: 48 m (main embankment), 33 m (northern embankment)
- **Gross storage capacity**: 16,8 million m^3
- **Crest length**: 1 300 (main embankment), 670 m (northern embankment)
- **Material content of dam wall**: 3,1 million m^3 (main embankment), 450 000 m^3 (northern embankment)
- **Type of spillway**: None
- **Surface area at full supply level**: 77 ha

ENGINEERING FEATURES OF THE KOGELBERG DAM

- **Type**: Mass arch gravity concrete with separate earth embankment
- **Height above lowest foundation**: 54 m
- **Gross storage capacity**: 17,3 million m^3
- **Crest length**: 182,5 m
- **Material content of wall**: 72 000 m^3 (concrete)
- **Earth embankment**: 202 000 m^3
- **Type of spillway**: Ogee (uncontrolled)
- **Surface area of reservoir at full supply level**: 142,6 ha

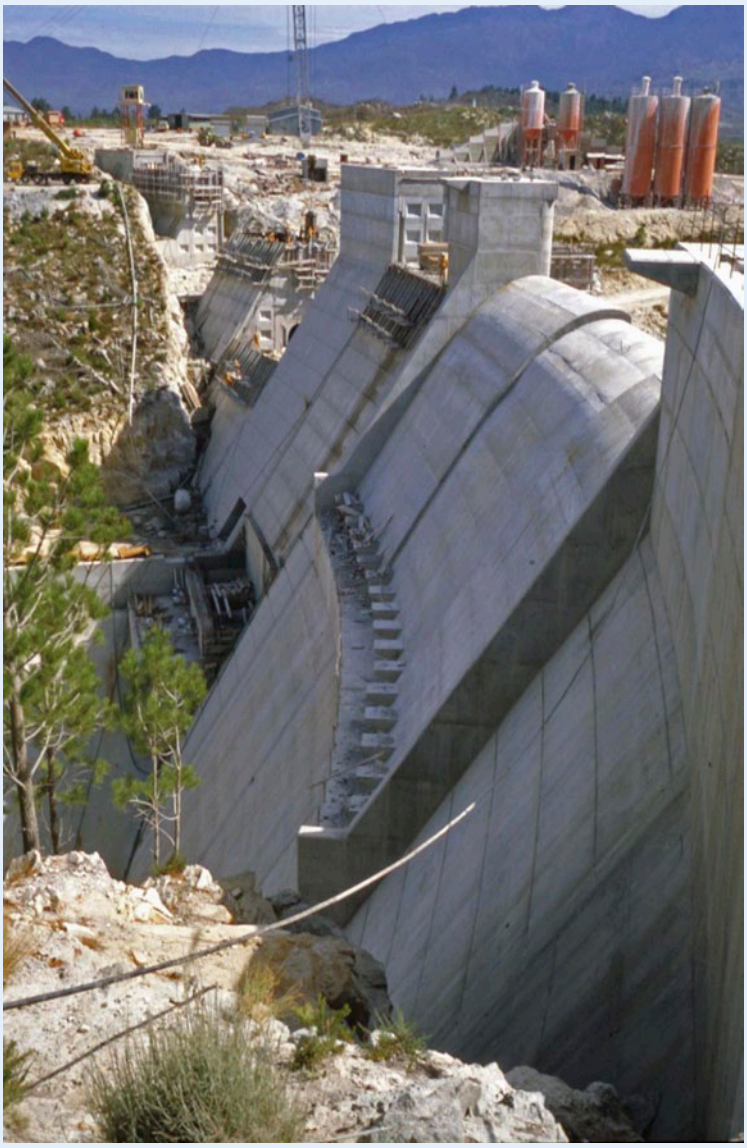
Mountain ranges towards the city (both economically and environmentally unsound), however, the construction of the Steenbras Pumped Storage Scheme in 1978 opened up a new avenue.

By incorporating this scheme to convey Palmiet water towards Cape Town the length of the conduit could be shortened. If the new scheme could be developed as another pumped storage scheme this would even make it more economical as pumping cost would be reduced by using the cheaper off-peak power. So the idea of the Palmiet pPumped Storage Scheme was born.

Eskom undertook the initial feasibility study into the viability of such a scheme, which was completed in 1979. Between 1978 and 1979 initial geological investigations were also conducted. Among others, this involved mapping of the geology from aerial photographs, ground surveys and the examination of borehole longs. A complex geology was uncovered, and it was realised that much more geological data would be required in critical areas before a final feasibility study and cost estimate could be undertaken.

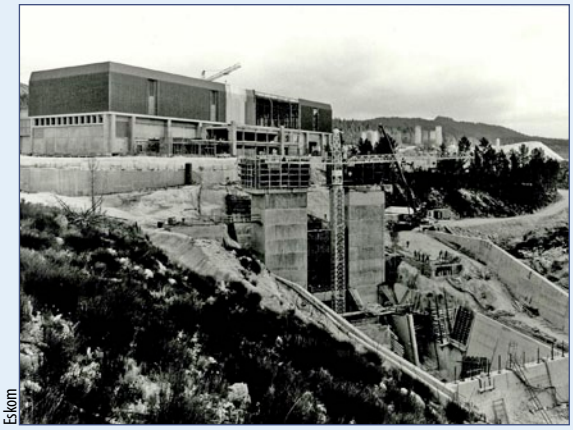
Thus, a second geological study was undertaken between 1979 and 1980. Together these two studies produced 47 boreholes recovering 2 452 m of core material upon which the final feasibility study and cost estimate were based. As the scheme developed, it was found that Eskom's need for peak power generating capacity was more urgent than Cape Town's need for additional water and that the required generating capacity far outweighed the pumping capacity required for the transfer of the available water. As a result, the project took the form of a major hydroelectric pumped storage facility, with provision for the water transfer facility to be brought into use when required.

The final proposed scheme comprised two new dams with an active storage capacity of 15 million m^3 each and a level difference of 285 m to be linked by a 2 km tunnel and 400 MW hydropower station. During the night and over weekends water would be pumped from the lower reservoir (Kogelberg) on the Palmiet River, to the upper reservoir (Rockview) situated on the



DWA/eWISA

Kogelberg Dam nearing completion as part of the Palmiet Pumped Storage Scheme. The dam features a two-level spillway that is a 45 m-long uncontrolled crest in the river section.



Eskom

Eskom

***Above and top**: The Palmiet hydropower plant during construction. The plant has a total power generating capacity of 400 MW and can be brought on stream in less than 3 minutes, compared to coal-fired stations which require around eight hours to start generating power from cold start-up.*

watershed between the Palmiet and Steenbras rivers.

During hours of peak electricity demand, electricity would be generated by releasing water from Rockview through the same waterway system to the power station and returning it to Kogelberg. Additional water over and above that required for generation would be pumped to the upper reservoir and released into the Upper Steenbras Dam. In this way, Cape Town's water would be augmented by about 25 million m^3 a year.

A close working relationship was forged between members of Eskom and DWA involved in the scheme. Eskom became responsible for the design and construction of the power station and the waterways. In turn, the two dams together with the connecting canal and pipeline between the Rockview and Upper Steenbras dams became the responsibility of DWA.

The scheme was approved in 1982 and construction started soon after. The consulting engineers on the project were Ninham Shand and VKE along with Elektroconsult Engineering Services of Switzerland. The main civil works contractors were Clifford Harris-Marti Tunnelling and Philipp Holtzmann of Germany, although the dams were constructed internally by DWA, with Peter Hume and Niel van Wyk of the department acting as resident engineers.

Most of the workforce on the dams were transferred from the Jonkershoek tunnel project and, at the height of construction close to 800 people worked on the dam sites. No housing could be established on site, and so everyone had to be accommodated in nearby Grabouw.

The environment was always going to be an important consideration of the project. The Palmiet runs through the Kogelberg Nature Reserve – a particularly sensitive area endowed with a wealth of fynbos species, and the pumped storage scheme was to be situated close by. DWA carried out environmental studies during the planning stages of the project, and it was during this time that a special environmental ministerial committee was found under the chairmanship of Dr Paul Roberts to investigate the potential environmental impacts of the scheme. The committee included wide representation from key institutions and individuals using water in the catchment.

Various alternatives were investigated while the committee identified pertinent issues requiring attention. A 'construction plan' was eventually drawn up with 54 recommendations on reducing the anticipated negative environmental effects of the project. This included demarcating work areas prior to the start of any construction activities; delineating specific eating areas in order to contain the spread of exotic Argentinean ants; inspecting construction materials to eliminate the possible introduction of non-indigenous plants; providing adequate toilet facilities for workers (largely unheard of on construction sites at the time); and devising a refuse control system. In addition, all polluted and sediment-carrying water had to be controlled and directed to special ponds before being released, while all disturbed areas had to be rehabilitated by replacing the topsoil that had been removed and stored (restoration was done concurrently with construction).

Even access roads were routed to avoid scenic outcrops of rock of sensitive plant growth areas and followed natural contours thus blending in with the landscape. The Palmiet power station – as well as the waterway linking the Rockview and Kogelberg dams – was placed underground. The recommendations were accepted and a resident environmental control officer was appointed to see that they were carried out. The main approach of the environmental programme was to prevent pollution. Interestingly, this preventative approach ended up saving as much as 1,5% of the anticipated project cost.

ROCKVIEW DAM

Situated 285 m above Kogelberg Dam, Rockview Dam being situated on a watershed virtually has no catchment area and is solely dependent on pumping to fill it. The dam basin consists of two natural depressions, with the larger one located on the southern side. These depressions are linked by an excavated channel. The main embankment, which is about 1 300 m long and has a maximum height of 48 m, was constructed mainly along the southern perimeter of the basin. This main wall was constructed of rockfill with a central clay core, and has a material content of 3,1 million m^3.

The secondary (or northern) embankment is about 670 m in length, and has a maximum height of 33 m. The natural topography borders the remainder of the basin. The northern embankment also has a clay core and rockfill outer zones but, in order to make use of the sandy overburden material within the dam basin, relatively large sandy

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- Thanks to eWISA for photographs

transition zones were also incorporated. This embankment also houses the outlet system which comprises two pipes each able to discharge the required flow of 6 m³/s at the lowest drawdown level. Each outlet pipe is of 1 500 mm internal diameter, and is provided with a hydraulically controlled slide gate for isolating purposes at its inlet and is terminated by a 1 400 mm sleeve valve. The outlet pipes are encased in concrete over the full length and the concrete encasement is founded on rock.

The quarry needed to provide the rockfill was the biggest ever established by DWA at that time and, when completed, Rockview dam was the largest rockfill dam (by volume) in the country. By constructing a rockfill dam DWA was ensured of a larger capacity structure created by the removal of material for the embankment from the dam basin. An estimated 2,5 million m³ additional capacity was created by excavation of rockfill from the basin. At full supply capacity the water area within the dam basin is about 77 ha and the live storage capacity is 15 million m³. Construction of Rockfill Dam kicked off in 1983 and was completed in November 1986.

KOGELBERG DAM

The lower storage unit, Kogelberg Dam, is situated on the Palmiet River some 2 km downstream of the power station. It consists of a concrete arch/gravity wall in the river section with a separate earth embankment on a saddle on the eastern flank. The concrete wall has a total length of 182,5 m with a maximum height of 54 m above its lowest foundation level and contains 72 000 m³ of concrete. The earth embankment is 850 m long, with a maximum height of 17 m, containing about 202 000 m³ of earth. A 45 m-long ogee crest spillway permits passage of a 1 360 m³/s flood, the energy generated being dissipated by a splitter-and-step system that aerates the nappe. A concrete apron protects the riverbed from erosion. River outlets were provided to permit the passage of compensation water to downstream riparian owners. All material for the construction was obtained from the Rockview reservoir basin.

Initially, access to the dam site was difficult, and a 5 km permanent road had to be constructed before construction could start. Eventually building started in May 1983. A 6 t luffing cableway was used to construct the main concrete wall. The cableway towers were 263 m apart and 60 m high. Concrete was transported from the mixer to the cableway in two 2,25 m³ buckets on an electrically-driven trolley. The cableway was able to reach 18 m to each side of its centreline, and was able to cover most of the dam wall. Concrete for the apron was placed by mobile crane.

Work in the riverbed was executed during the summer months when the flows were low and easily diverted. To stop the dam from impounding and thereby flooding the power station works in the basin, a temporary opening of 6 m by 6 m was left in the dam at a low level. This opening was successfully closed in April 1987 by constructing a 2,4 m-thick reinforced concrete wall at the upstream end. The dam was completed in July 1987, and overspilled for the first time on 10 July that year. The entire project was officially inaugurated on 14 October 1988 and in that year won a SAICE Award for 'Most Outstanding Civil Engineering Achievement'. ❑

DWA/eWISA

DWA/eWISA

Below: *Work is undertaken on the bottom of the Kogelberg Dam, the lower storage unit of the Palmiet pumped storage scheme.*

Bottom: *Rockview Dam during construction. At the time, Rockview was the largest rockfill dam in the country by volume.*