

The Palmiet Pumped Storage Scheme
 Summary description of civil works

Section of works	Brief description	Principal dimensions or quantities	Methods of construction
Headworks - Tower - Access bridge	Control and access tower in upper Rockview reservoir with emergency stoplogs and maintenance gate to the inlet/outlet bellmouth at bottom, leading to headrace Vehicular access from Rockview Dam crest to permit gate loads	<ul style="list-style-type: none"> - Excavation 6 000m³ - 70m high prestressed tower - 11m x 14m elliptical section comprising wet and dry wells - 50m bellmouth tapering from 2 x 14m x 7m rectangular to 6,2m dia - 4 x 20m deck spans - Piers up to 50m high 	Excavation: As for headrace (below) Tower: Climbing shutter Bellmouth: Conventional RC construction Deck: Precast beams and launch girder Piers: Conventional climb
Headrace	Trapezoidal section cut-and-cover trench to accept welded in situ steel liner later encased in concrete	<ul style="list-style-type: none"> - 500m long - Depth variable 8m to 22m - Excavation 35 000m³ - Steel liner dia 6,2m - Gradient 1:225 	Conventional surface drill and blast and rock support techniques Conventional RC encasement followed by void grouting
Surge tank	Circular tank in open excavation off-line but connected to the end of the headrace by a 60° Y-piece	<ul style="list-style-type: none"> - Excavation 32m wide, depth 22m - Tank 21m ID, 78m high, prestressed 	Excavation: As for headrace (above) Conventional climbing shutter to prestressed structure
Inclined shaft	Underground circular inclined shaft and bends connecting headrace/surge tank to pressure	<ul style="list-style-type: none"> - 125m long inclined - Excavation dia 7,8m - Steel liner dia 6,2m 	Raise-bore to pressure tunnel, D&B widen, muck out through pressure tunnel

	tunnel steel liner as headrace	- Gradient 1:0,7 (55°)	Mass concrete type backfill with three-stage grouting of rock and voids
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Pressure tunnel	Underground horseshoe section tunnel with steel liner as headrace	- 500m long - Excavation dia 7,8m - Steel liner dia 6,2m - Gradient 1:10	Conventional drill, blast and support: 1. Pantafort – drilling (two-boom jumbo) 2. Heading and bench (hardness of rock and short length precluded TBM excavation) Concrete and grouting as for inclined shaft
Penstock and bifurcation	Similar to headrace, with bifurcation at lower end	- 560m long - Depth variable 8m to 18m - Excavation 45 000m ³ including bifurcation - Steel liner dia 5,4m - Gradient 1:15	As for headrace (above)
Penstock shafts	Twin circular inclined shafts and bends connecting bifurcation to base of machine shafts, via a horizontal section in each	- About 92m long inclined - Gradient 1:1 - 4,7m dia excavation for liner - 3,9m dia - 37m long horizontal excavation tapering to 3,4m dia for liner tapering to 2,6m dia	As for inclined shaft, except raise-bores and mucking were done to the horizontal drives from machine shafts

<p>Machine shafts and services shaft, drainage and services galleries</p>	<p>Twin vertical shafts to accept pump turbines, motor generators and ancillaries. Services shaft and galleries located between two main shafts. Base of main shafts to accept draft-tubes to tailrace</p>	<ul style="list-style-type: none"> - Main shafts <ul style="list-style-type: none"> • Excavated dia 26m • Concrete lined dia 23m incorporating lift-shafts • Depth 70m • Concrete embedment and support framework to pump turbines and motor generators with access floors and galleries at shaft base, 30m high and 23m dia - Ancillaries <ul style="list-style-type: none"> • Services shaft 6m dia • Galleries about 6m dia horseshoe sections 34m long 	<p>Excavation</p> <ol style="list-style-type: none"> 1. Spiral D&B excavation by segments 2. Drilling by crawler rigs 3. Mucking by crane to surface loader and trucks 4. Rock support by bolts, anchors and mesh-reinforced shotcrete to designed parameters <p>Concrete machine-embedment with RC operation temperature controlled Concrete wall lining by climbing shutter</p>
<p>Tailrace shafts</p>	<p>Two asymmetrical inclined shafts and bends connecting draft-tubes to lower Kogelberg Dam and tailworks control structure, lined with reinforced concrete</p>	<ul style="list-style-type: none"> - 93m and 68m long - Gradient 1:1,9 and 1:0,9 - 6,0m dia excavated - 5,0m dia lined 	<p>As for inclined shaft, but no raise bore possible to 1:1,9 gradient where full-face D&B was used. Concreting to collapsible steel shutter specials to bends</p>
<p>Tail works - Tower</p>	<p>Twin control and access towers in lower Kogelberg reservoir surmounted by common control house for maintenance gates to twin intake/outlet bellmouths at bottom, leading to tailrace shafts</p>	<ul style="list-style-type: none"> - Excavation 36 000m³ - 7m square tower sections - 33m high towers - 28m x 7m x 12m high control house 	<p>Excavation: As for headrace (above) but rock support as for machine shafts Bellmouth: Conventional RC construction</p>

- Access bridge	Vehicular access from power station platform to permit gate loads	<ul style="list-style-type: none"> - 1 x 11,5m span - 1 x 20,0m span - Single pier 9m high 	Deck: Precast beams Pier: Climbing shutter
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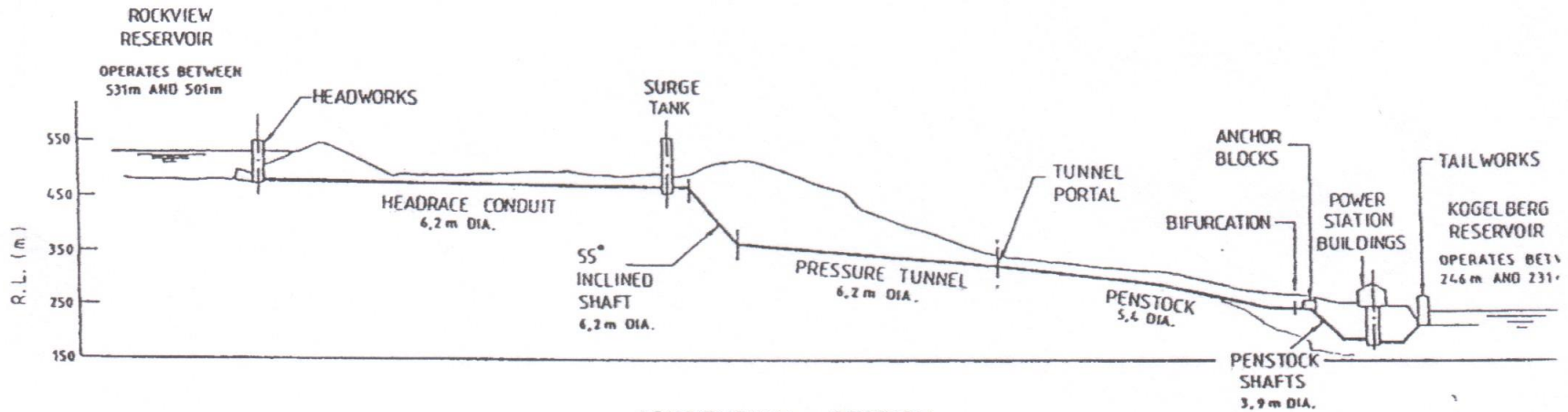
Tailworks - River diversion	Widened river channel and reinforced concrete training wall anchored to rock with mass concrete coffer-dam across tailrace excavation	<ul style="list-style-type: none"> - Channel 80m long, 10m wide - 120m long, 6m high training wall - 25m long, 6m high coffer-dam 	Conventional excavation, rock support and RC construction
Power Station - Main building - Annexes - Ancillaries	Reinforced concrete rectangular layout two-tier structure surrounding the machine shafts with crane beam to carry 360t traveling crane. Superstructure in structural steel and cladding Two RC annexes on either side of the main building: <ul style="list-style-type: none"> - a two-tier administration annexe - a three-tier switchgear annexe 	<ul style="list-style-type: none"> - 11m x 30m x 16m high RC structure - 10m high steelwork over whole building - 12m x 73m x 9m high - 30m x 92m x 16m high 	All conventional RC structural/building work and finishes with usual services. Trenches and box-outs as are common in power station works
All conventional civil engineering and building work, details too various to mention (switchyard, roads, stormwater and sewerage, security fences, retaining walls and minor buildings).			

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LONGITUDINAL SECTION

Fig 2: Vertical alignment: SVE's review report



LONGITUDINAL SECTION

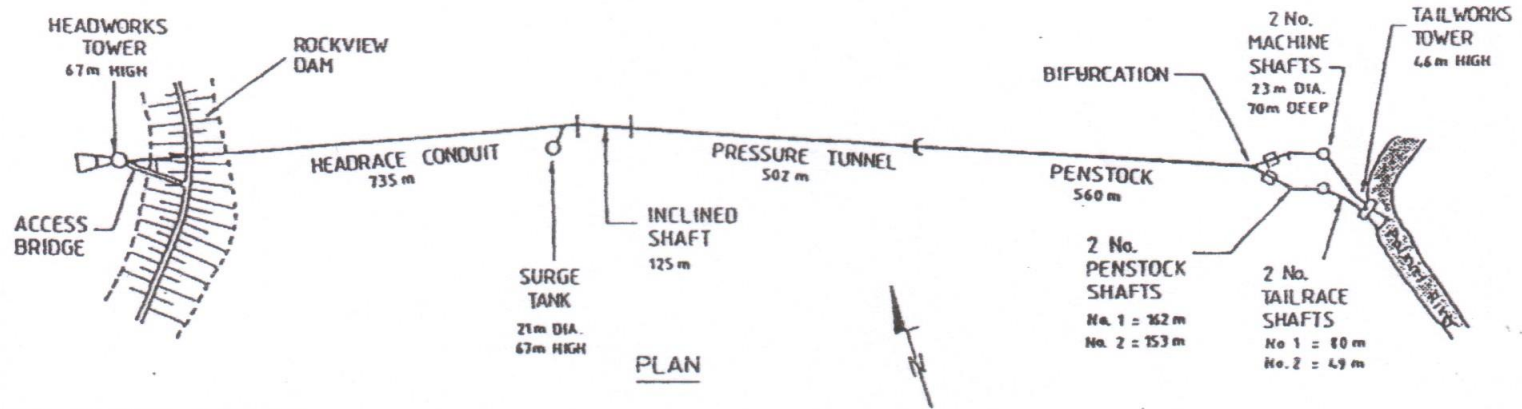


Fig 3: Final vertical and horizontal alignment