# The Palmiet Pumped Storage Scheme
## Summary description of civil works

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<th>Section of works</th>
<th>Brief description</th>
<th>Principal dimensions or quantities</th>
<th>Methods of construction</th>
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<td><strong>Headworks</strong></td>
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| - Tower          | Control and access tower in upper Rockview reservoir with emergency stoplogs and maintenance gate to the inlet/outlet bellmouth at bottom, leading to headrace | - Excavation 6 000m$^3$  
- 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 | Excavation: As for headrace (below)  
Tower: Climbing shutter  
Bellmouth: Conventional RC construction |
|                  |                  |                                    |                         |
| - Access bridge  | Vehicular access from Rockview Dam crest to permit gate loads | - 4 x 20m deck spans  
- Piers up to 50m high | Deck: Precast beams and launch girder  
Piers: Conventional climb |
| **Headeace**     |                  |                                    |                         |
|                  | Trapezoidal section cut-and-cover trench to accept welded in situ steel liner later encased in concrete | - 500m long  
- Depth variable 8m to 22m  
- Excavation 35 000m$^3$  
- 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 | - 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 | - 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 |
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<td><strong>Pressure tunnel</strong></td>
<td>Underground horseshoe section tunnel with steel liner as headrace.</td>
<td>- 500m long&lt;br&gt;- Excavation dia 7.8m&lt;br&gt;- Steel liner dia 6.2m&lt;br&gt;- Gradient 1:10</td>
<td>Conventional drill, blast and support:&lt;br&gt;1. Pantafort – drilling (two-boom jumbo)&lt;br&gt;2. Heading and bench (hardness of rock and short length precluded TBM excavation)&lt;br&gt;Concrete and grouting as for inclined shaft</td>
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<td><strong>Penstock and bifurcation</strong></td>
<td>Similar to headrace, with bifurcation at lower end.</td>
<td>- 560m long&lt;br&gt;- Depth variable 8m to 18m&lt;br&gt;- Excavation 45,000 m³ including bifurcation&lt;br&gt;- Steel liner dia 5.4m&lt;br&gt;- Gradient 1:15</td>
<td>As for headrace (above)</td>
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<td><strong>Penstock shafts</strong></td>
<td>Twin circular inclined shafts and bends connecting bifurcation to base of machine shafts, via a horizontal section in each.</td>
<td>- About 92m long inclined&lt;br&gt;- Gradient 1:1&lt;br&gt;- 4.7m dia excavation for liner 3.9m dia&lt;br&gt;- 37m long horizontal excavation tapering to 3.4m dia for liner tapering to 2.6m dia</td>
<td>As for inclined shaft, except raise-bores and mucking were done to the horizontal drives from machine shafts</td>
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| Machine shafts and services shaft, drainage and services galleries | 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 | - Main shafts  
  - 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  
  - Services shaft 6m dia  
  - Galleries about 6m dia horseshoe sections 34m long | Excavation  
 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  
Concrete machine-embedment with RC operation temperature controlled  
Concrete wall lining by climbing shutter |
| Tailrace shafts | Two asymmetrical inclined shafts and bends connecting draft-tubes to lower Kogelberg Dam and tailworks control structure, lined with reinforced concrete | - 93m and 68m long  
- Gradient 1:1.9 and 1:0.9  
- 6.0m dia excavated  
- 5.0m dia lined | 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 |
| Tail works  
- Tower | 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 | - Excavation 36 000m³  
- 7m square tower sections  
- 33m high towers  
- 28m x 7m x 12m high control house | Excavation: As for headrace (above) but rock support as for machine shafts  
Bellmouth: Conventional RC construction |
| - Access bridge | Vehicular access from power station platform to permit gate loads | - 1 x 11.5m span  
- 1 x 20.0m span  
- Single pier 9m high | Deck: Precast beams  
Pier: Climbing shutter |
|-----------------|---------------------------------------------------------------|----------------------------------|
| Tailworks       | Widened river channel and reinforced concrete training wall anchored to rock with mass concrete coffer-dam across tailrace excavation | Channel 80m long, 10m wide  
120m long, 6m high training wall  
25m long, 6m high coffer-dam | Conventional excavation, rock support and RC construction |
| - River diversion | | | |
| Power Station   | 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 | 11m x 30m x 16m high RC structure  
10m high steelwork over whole building | All conventional RC structural/building work and finishes with usual services. Trenches and box-outs as are common in power station works |
| - Main building | | | |
| - Annexes       | Two RC annexes on either side of the main building:  
- a two-tier administration annexe  
- a three-tier switchgear annexe | 12m x 73m x 9m high  
30m x 92m x 16m high | |
| - Ancillaries   | 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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Fig 2: Vertical alignment: SVE's review report

Fig 3: Final vertical and horizontal alignment