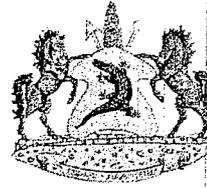


Lesotho Highlands Water Project



*Chris
Review Release
11/20/06*



**CONTRACT LHWC 001
CONSULTING SERVICES FOR THE FEASIBILITY
STUDY FOR PHASE II
STAGE 1 SUPPORTING REPORT
HYDROPOWER**

MAY 4 2006

STAGE I SUPPORTING REPORT

HYDROPOWER – EXECUTIVE SUMMARY

1. INSTRUCTION

A: Scope

As outlined in the RFP, the Consultant shall review previous studies and formulate a range of conventional hydropower and pumped storage arrangements including the Oxbow site and incorporate them in the preliminary layouts of the Development Options.

B: Main alternatives and basic data

The hydropower alternatives which have been identified include:

1. Katse route: Increased yield from Katse reservoir, due to diversion into the Katse reservoir see Fig. 1-1
2. Polihali to Muela route see Fig. 1-2, with diversion through a new tunnel running from Polihali reservoir to an extension of the Muela power plant.
3. Lebelo to Mohale: Increased generation capacity at Muela due to 6.75 m³/s pumped from Lebelo into Mohale reservoir, see Fig. 1-3.
4. Power plant at storage dams: At the toe of storage dams, with open river d/s calling for IFR releases; thereby creating a potential for power and energy production up to 210 GWh/a.
5. The Oxbow plant would make use of 742 m net head, and a regulated flow of 3.5 m³/s. In the Monenco FS it was suggested to install 80 MW, as a peak power plant, running ~ 6 h/day which is typical for high head hydropower plants. Due to higher head going into Muela the installed capacity would increase to 90 MW, generating 200 GWh/a.
6. Reversible turbines: Instead of installing pumps at the pumping plants of Taung, Tsoelike, Ntoahae or Lebelo, reversible turbines/pumps may be installed. This concept would make use of cheaper power for pumping during weekends and at night (from Muela rather than from ESKOM), while generating higher rate/kWh power for some 6 h/day to meet daily peak demand.

Accumulated yield from the various storage dams is shown on Fig. 1-4, while Fig. 1-5 shows a profile along the river in terms of elevation, while the distances are measured along the waterway routes. Location of dams and reservoirs are also shown.

Figure 1-1 Alternative A-1-A-3; Polihali into Katse, with development down to Malatsi

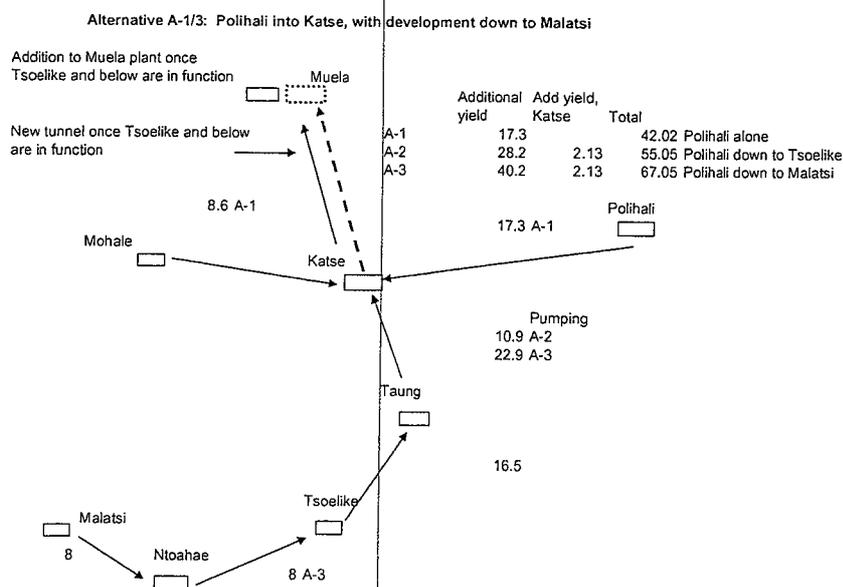


Figure 1-2 Alternative B-1 to B-3; Polihali into Katse, with development down to Malatsi

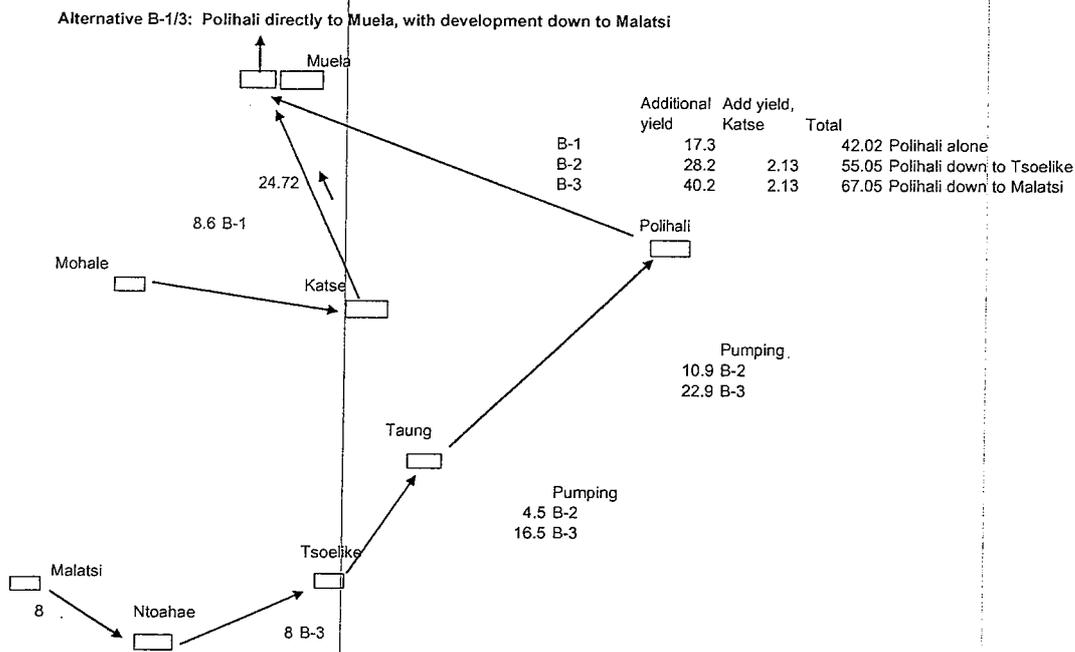


Figure 1-3 Alternative Polihali into Katse, Lebelo to Mohale and Oxbow to Muela

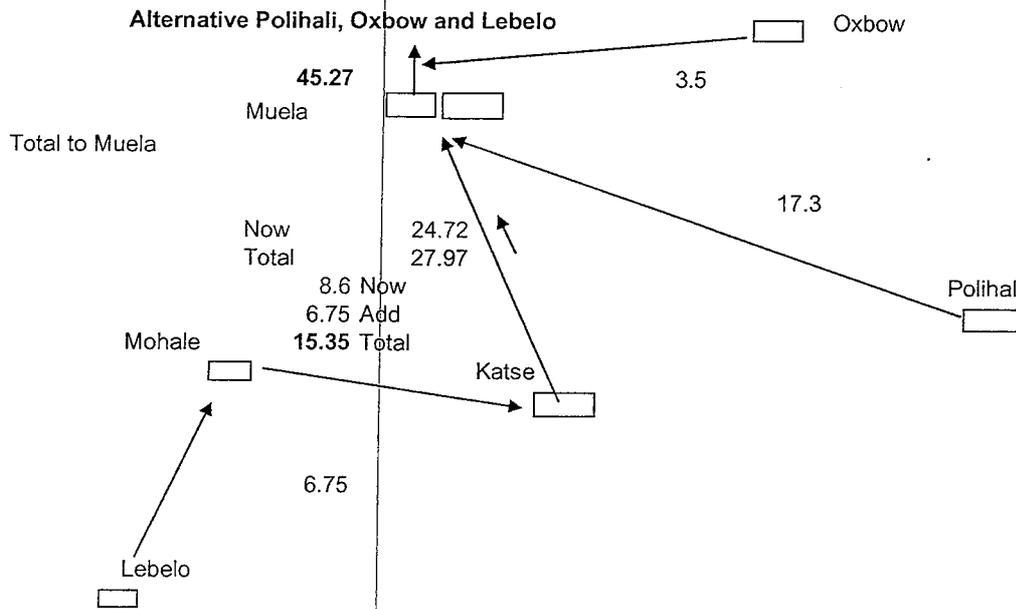


Figure 1-4 Summary from yield analyses showing yield from various storage reservoirs

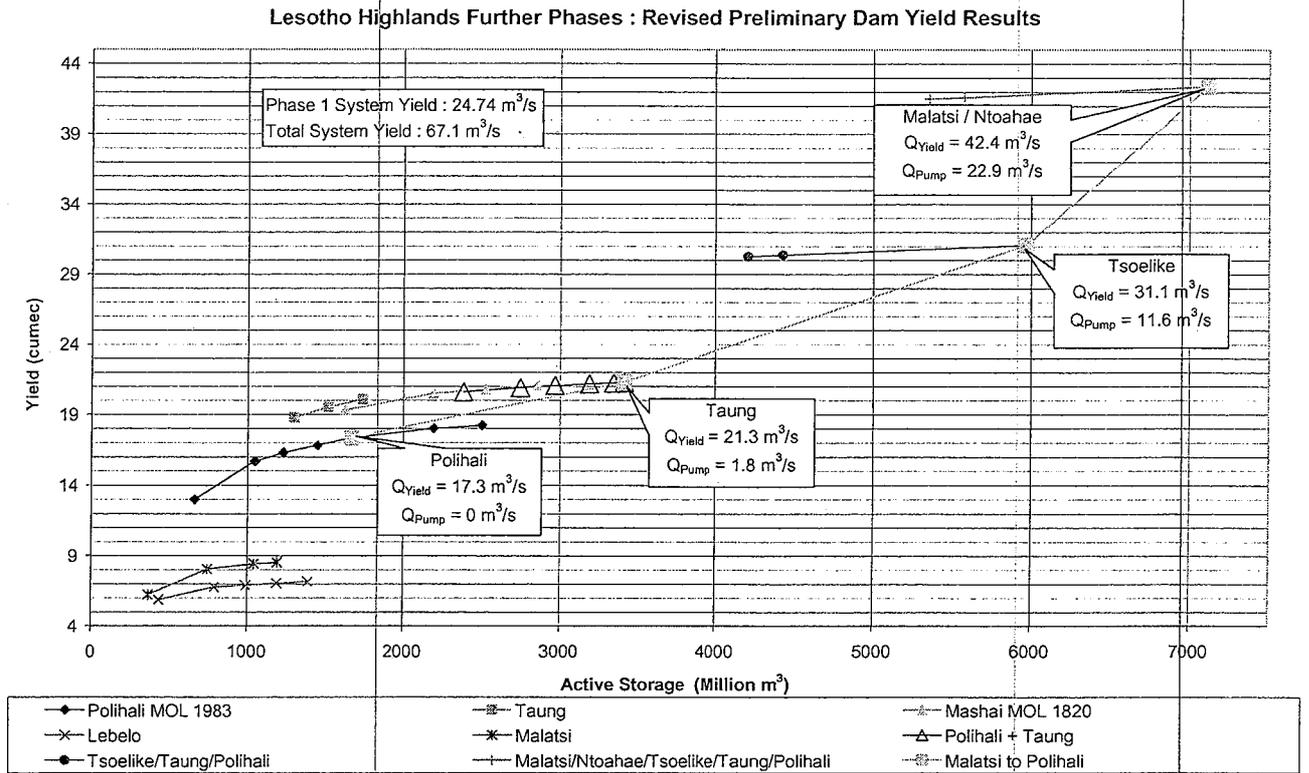
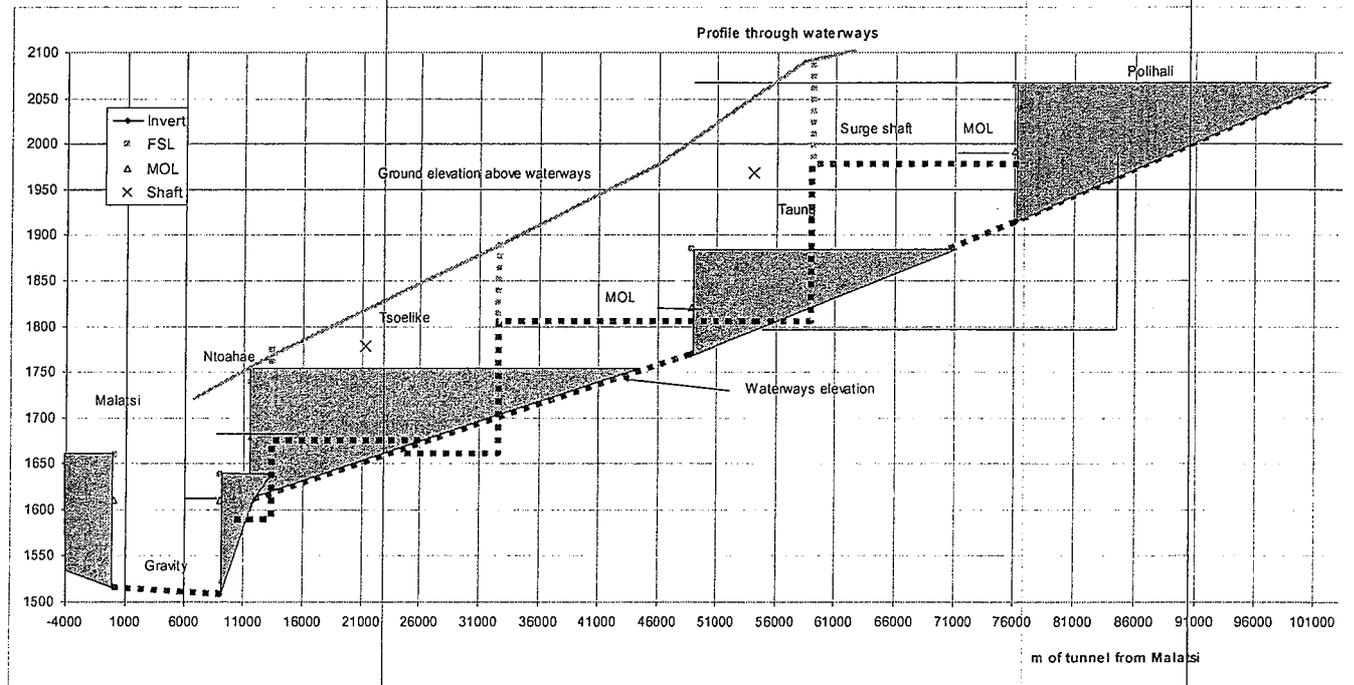


Figure 1-5 Profile along waterways, showing invert levels at dams, FSL, MOL, dam and reservoir locations.



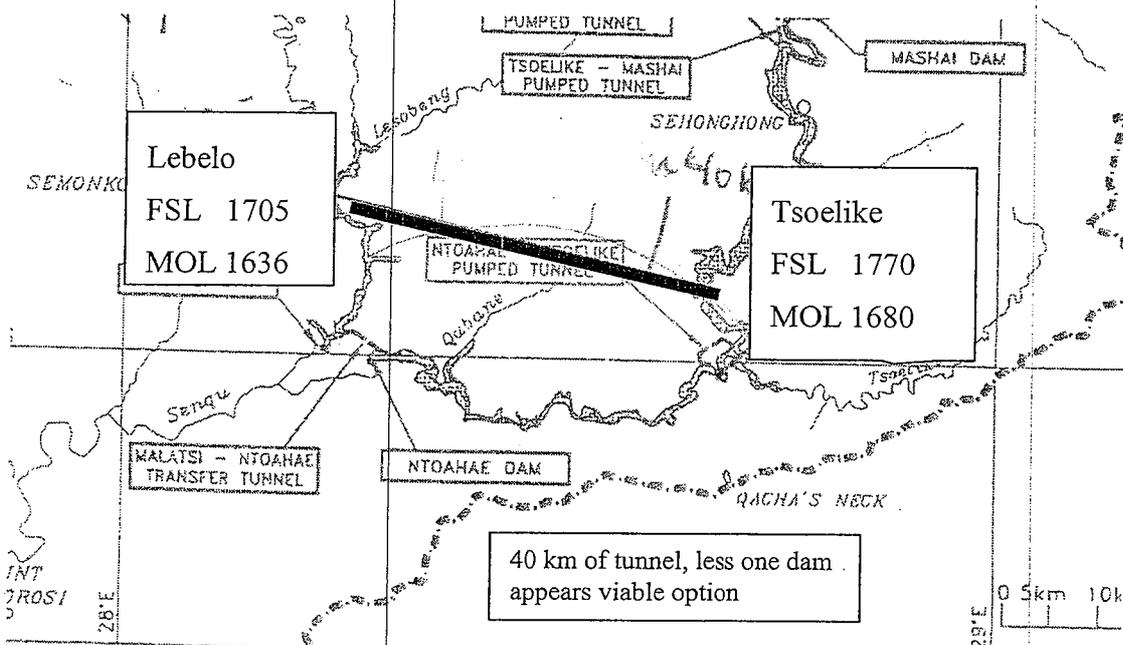
C: Lebelo to Tsoelike option

This alternative includes replacing the “Malatsi to Ntoahae to Tsoelike” alternative with Lebelo to Tsoelike. Tentative cost comparison is presented in Table 1-2, while the tunnel route is shown in Fig. 1-6.

Table 1-2 Cost comparison of Malatsi-Ntoahae to Tsoelike vs Lebelo to Tsoelike

	Lebelo to Tsoelike alternative	Malatsi to Ntoahae to Tsoelike		
Malatsi dam with auxiliaries		88,864,698		
Ntoahae dam with auxiliaries		71,278,340		
Lebelo dam with auxiliaries	59,022,152			
Malatsi to Ntoahae tunnel		62,062,500		
Ntoahae to Tsoelike waterways		50,140,625		
Lebelo to Tsoelike waterways	326,153,846		GWh	Rate
Pumping cost Ntoahae to Tsoelike		94,501,385	262	0.038462
Pumping cost Lebelo to Tsoelike	9,366,472		25.968	0.038462
Total	394,542,471	366,847,547		
Ratio		1.08	1	

According to the above rough estimate, it appears economical to develop the Lebelo to Tsoelike link. The above is based on civil and pumping cost alone. Once EIA aspects will be added, it is believed that the difference will be more significant.

Figure 1-6 Possible tunnel route from Lebelo to Tsoelike

2. POWER AND ENERGY GENERATION

A: System power and energy usage and forecast

The Muela HPP is Lesotho's first major generation plant, with installed capacity of 81 MW. Transmission to Maseru is through a 132 kV line from a surface switchyard with an intermediate substation at Maputsoe. Before the Muela plant, electricity generation was in the form of mini-hydropower plants built by the Government of Lesotho and operated by the Lesotho Electricity Corporation (LEC) including:

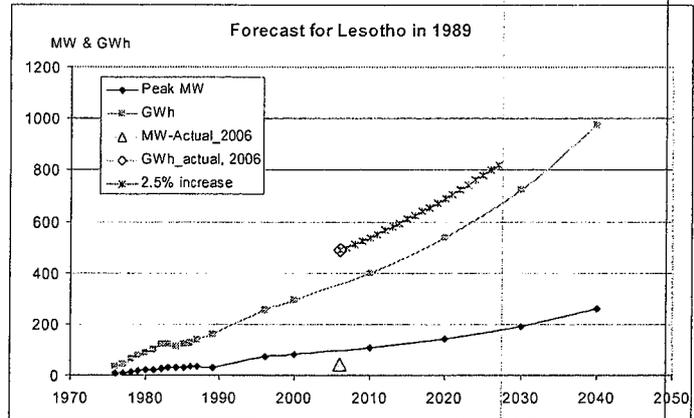
- Mantšonyane Mini-Hydro with an installed capacity of 2 MW

- Semonkong Mini Hydro with an installed capacity of 180 KW which has a diesel generator as a standby, capacity of 120 kW
- Tlokoeng with an installed capacity of 670 KW
- Tsoelike with an installed capacity of 400 KW
- Katse mini-hydro with installed capacity of 540 kW which forms part of Lesotho Highlands Water Project, hence being operated by LHDA.

Of the above noted mini-hydro plants currently only Semonkong and Mantsouyane are in operation. At Mphahlele, provisions have been made for future installation of a mini-hydro.

Fig. 2-1 shows power and energy forecast prepared by Moneco in 1989. Prevailing values are also shown.

Figure 2-1 Monenco 1989 forecast of power and energy needs for Lesotho



B: Monthly load Characteristics

The electricity consumption shows a typical winter peak during May to September due to high electrical consumption during winter months, mainly due to use of electrical heaters.

Fig. 2-2 shows typical monthly average power (MW) and energy (GWh) needs in Lesotho, while Fig. 2-3 shows average monthly Lesotho load curve vs what is obtained from Muela, indicating shortage in winter, which is purchased from ESKOM.

Figure 2-2 Typical present operation of the Muela power plant, MW and GWh production

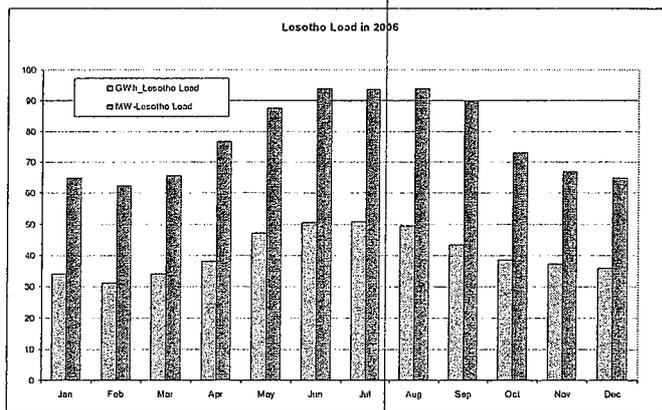
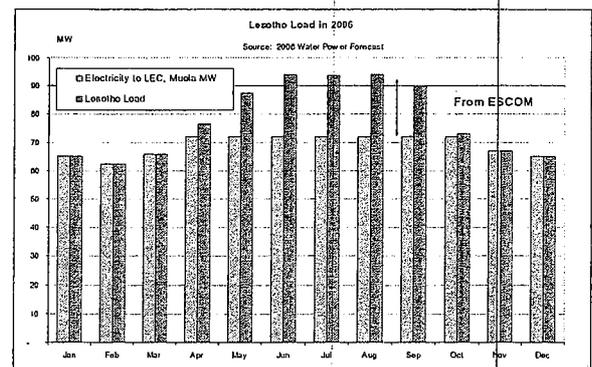
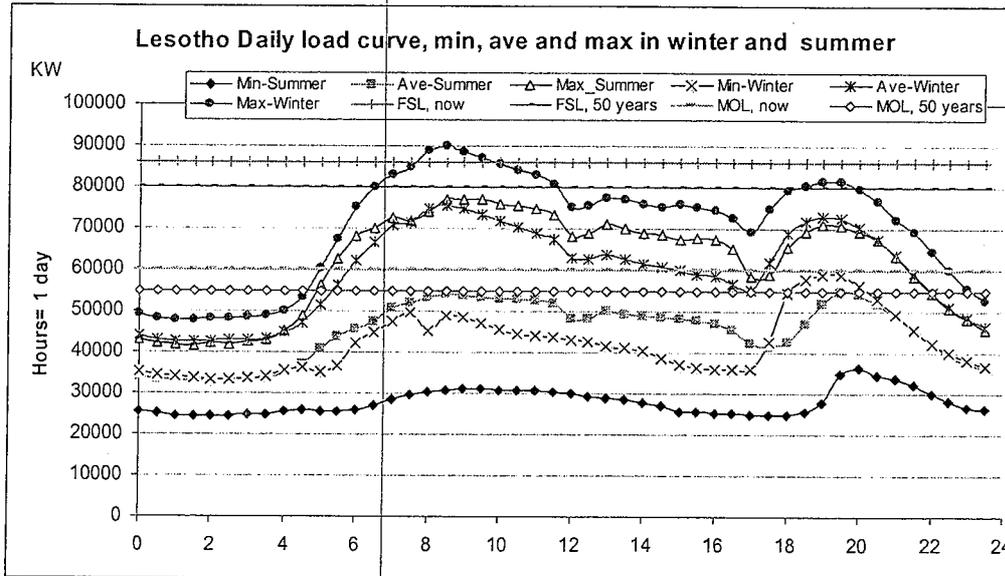


Figure 2-3 Muela generation vs Lesotho monthly demand



Typical daily load curves for Lesotho during summer and winter, respectively, for 2005/2006 are shown on Fig. 2-4. Added to this plot is the max power generation corresponding to Katse FSL and MOL, for existing conditions as well as for assumed conditions to apply 50 years from now, once the roughness of the tunnel lining may have increased from 0.9 mm to 2.1 mm. In view of the manner in which the plant has been operated, during winter peak load hours, power must be obtained from ESKOM.

Figure 2-4 Lesotho daily load curve, min, average and max KW load



C: Base cost of thermal plant generated energy

The following rates have been derived and used:

- pumping on weekends 15 c-R/kWh
- pumping at night 15 c-R/kWh
- base power during day 25 c-R/kWh
- peak power, 6 h/day 35 c-R/kWh.

The 35 c-R/kWh have been confirmed by cost values obtained from a pumping plant presently under construction in RSA. Regarding capitalized worth of water and power sales, 6% rate of return calculated over 50 years has been applied.

3. MUELA POWER PLAN

Main data are as follows:

- MW installed 81 MW
- Q(rated) 12*3 m³/s
- FSL, Katse 2053 masl
- MOL, Katse 1989 masl
- TWL 1761 masl.

Historic reservoir levels at Katse reservoir from start of operation and until end of 2005 are shown on Fig. 3-1, while Fig. 3-2 shows flow and accumulated volume diverted from Katse and Matsoku through Muela.

Figure 3-1 Historic Katse reservoir levels

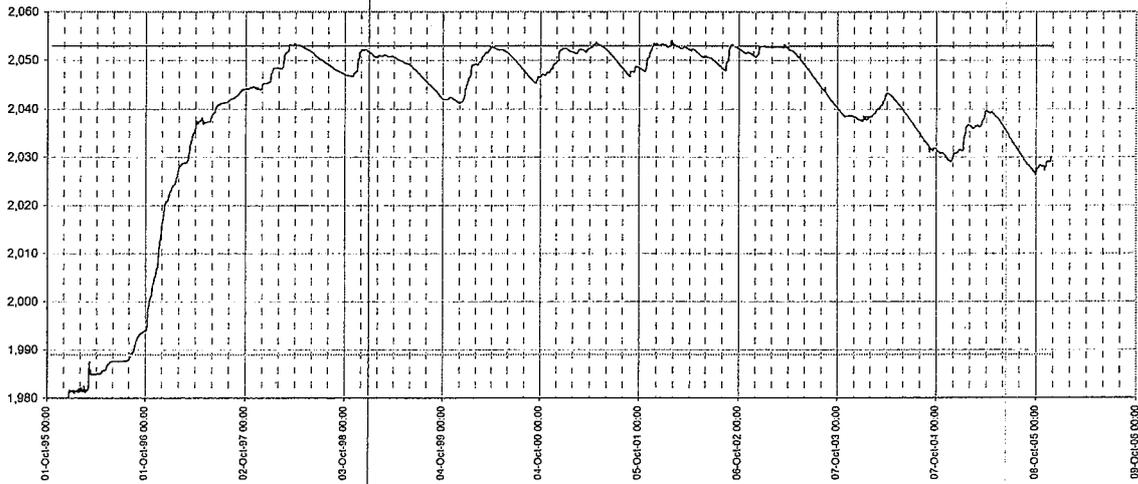
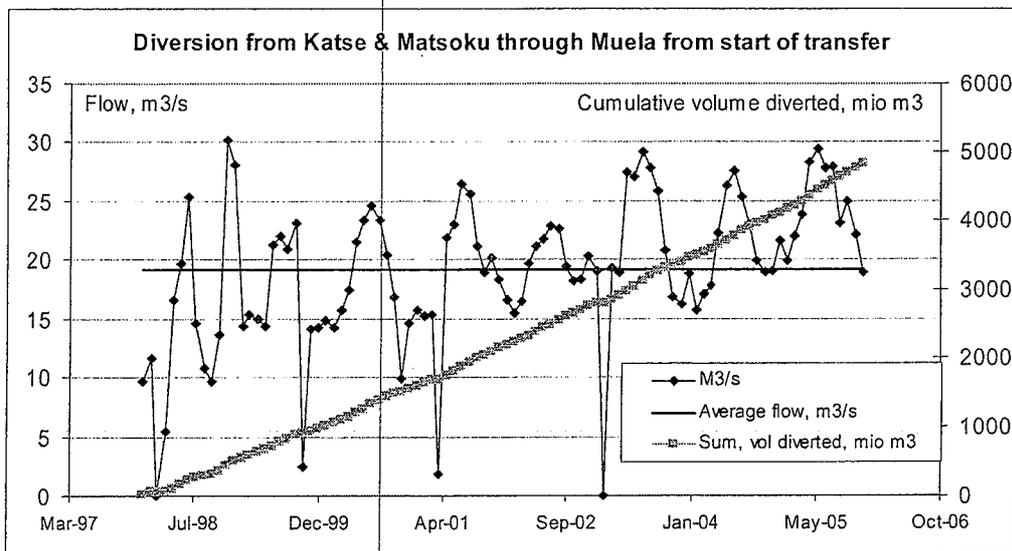


Figure 3-2 Transfer from Katse and Matsoku through Muela plant from start



In the hydraulic calculation of energy in terms of MW and GWh/a, Ka value of 0.9 for the present conditions was assumed, while a Ka value of 2.1 mm was assumed to apply 50 years from now.

For closure and startup of the turbines, the following is understood to be valid:

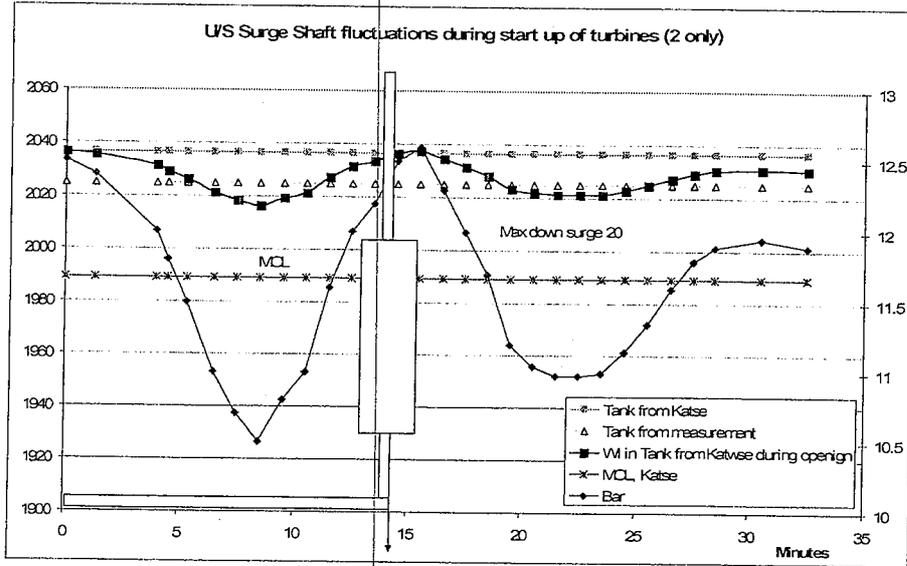
- Emergency closure occurs in 15-30 seconds
- Startup: 3 minutes to synchronize; 0 to max load in 10 seconds.

Fluctuations upon closure and start up of the turbines amount to:

- 10 m drawdown during startup
- 18 m up-surge and 12 m down-surge during closure.

This must be added to/ deducted from head loss, to assess possible up/down-surge at the power plant during emergency closure. The critical conditions apply at MOL and plant emergency closure, see Fig. 3-3.

Figure 3-3 Water level fluctuations in u/s shaft during turbine start up (2 units)



Applying the above noted existing and 50 years Ka value for the concrete lined headrace and tailrace tunnel and an “n” value of 0.0115 for the steel lined penstock, head losses in the waterways down to the surge shaft/ elbow and overall have been calculated as plotted on Fig. 3-4. Adding some 10 to 20 m due to down surge as above noted, maximum flow at MOL reservoir level of:

- 40 m³/s applies for present conditions of Ka = 0.9 mm, while flow may decrease to
- 37 m³/s for assumed conditions 50 years from now, for Ka = 2.1 mm.

For FSL the max flow amounts to some 52 m³/s. For present conditions it is assumed that the generators and auxiliaries can handle some 15% overload conditions, which for FSL allow generation of 86 plus MW, which may be reduced for conditions assumed to apply 50 years from now to 80 MW. The above is an indication of how much flow can go through the plant without any modification or added cost. Fig. 3-4 and Fig. 3-5 show the limitation set by the high setting of the elbow and of the surge tank at Muela.

Figure 3-4 MW vs flow through turbines for FSL and MOL with limitations at shaft

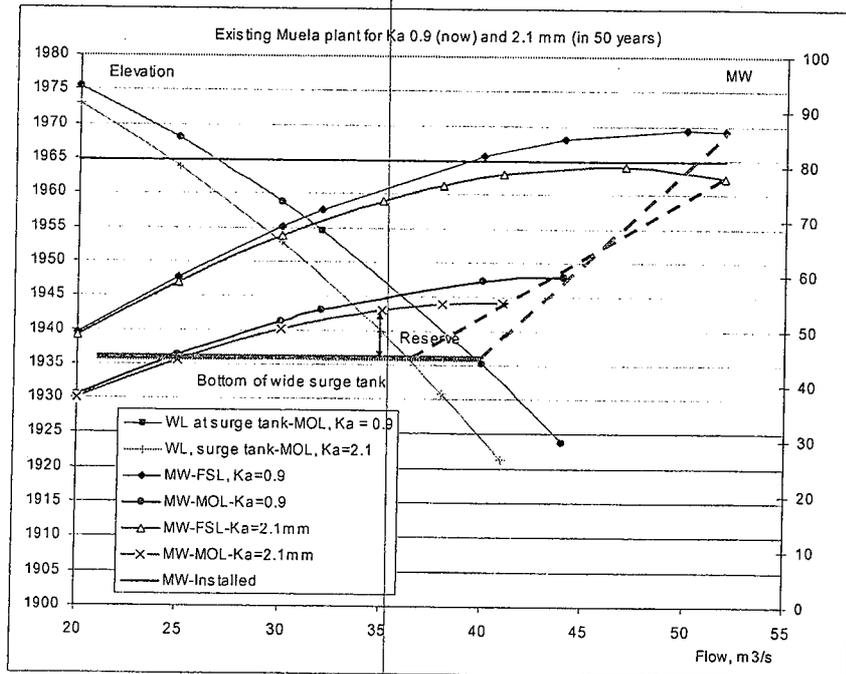
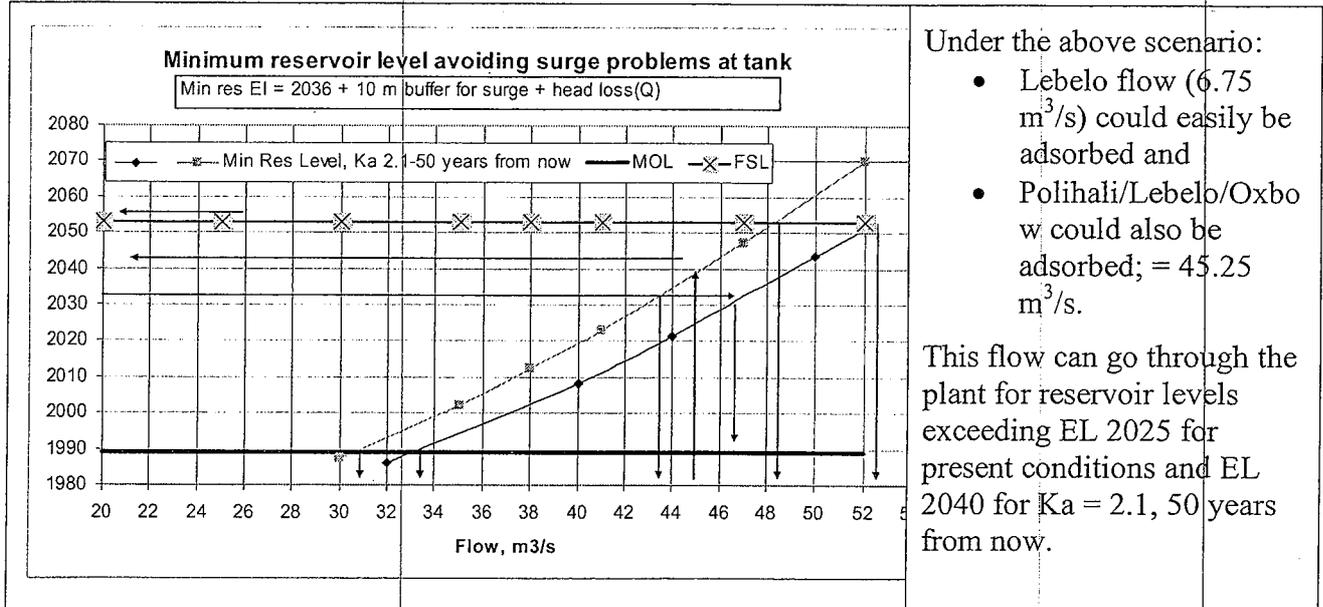


Figure 3-5 Minimum reservoir levels at Katse considering shaft and elbow limitations

For diversion beyond above noted values, e.g. in case Taung & Tsoelike are constructed, then a second tunnel from Katse to Muela must be constructed. The addition to the Muela plant would make full use of existing plant facilities such as ventilation, air conditioning, crane, station power, etc.

4. OXBOW HYDROPOWER PROJECT

A Feasibility Study was carried out by Monenco Consultants Limited of Montreal, Canada for the Oxbow Hydroelectric. The Monenco 1989 FS indicated that a 92 m high dam at the Oxbow site would permit the most favorable exploitation of the Oxbow water resource, with full supply elevation of 2525 masl and a live storage of 72.8 million cubic meters. This would allow the diversion of an average of 3.5 m³/s to the powerhouse.

With the revised layout, Oxbow waterways run into the Muela afterbay dam as shown on enclosed drawings. Peak production would run for 6h a day at Q(peak) ~ 14 m³/s, producing 200 GWh/a.

The transmission line would be 8 km long 132 kV line, connecting to Muela.

5. HYDROPOWER PROJECTS AT D/S TOE OF DAMS HARNESSING IFR FLOW

A: General

It is presently assumed that at all storage dams approx 15% of the inflow has to be released in the form of d/s release. This is significantly more than the d/s (IFR) releases specified for Katse and Mohale, which makes it sensible to harness this flow.

Furthermore, at each dam site, waterways will be customized to handle IFR flow with intakes, pipe work and outlet facilities, allowing a turbine to be hooked up to this system at a minimal civil-work cost and at a minimal hydro-mechanical cost. At these large reservoirs, sedimentation will not be an issue, as it was at some of the mini-hydro plants mentioned above. At each site, transmission and switchyard will be at hand to provide construction power, which means minimal additional cost on this sector as well.

The above makes it very economical to install turbines to harness some 140-150 m of head and the IFR-flow. The turbine would be of Francis type, with simple butterfly valve installed u/s of it, discharging into a "tailrace tank" to secure submergence. Details are listed in Table 5-1. The

generation is significant, considering that in 2006 Lesotho usage amounted to 244 GWh/a. In fact, the entire surrounding rural population could be electrified from these units.

Cost and an economical assessment are presented in Table 5-2. Based on this preliminary assessment it is highly economical to harness IFR flow. Note that risk of cost overruns is essentially nil. No carbon credit has been included in values listed below.

Table 5-1 IFR flow and potential power and energy production at storage dams

	Q(IFR)	MW	GWh	Cumulative GWh
Turbine at Polihali	3.31	5.3	46.5	46.5
Turbine at Tsoelike, if no d/s development	8.6	8.6	75.3	121.8
Turbine at Ntoahae	9.34	14.4	126.4	
Turbine at Malatsi	6.89	4.4	38.8	211.8
Turbine at Lebelo, assuming Ntoahae and Malatsi are not constructed	2.5	3.2	28.0	

Table 5-2 Cost of turbines installed

	MW	El-Mech	Civil	Total	Capitalized revenue	B/C ratio
		Mio \$	Mio \$	Mio \$	Mio \$	
Turbine at Polihali	5.3	3.9	4.31	8.23	15.11	1.83
Turbine at Tsoelike	13.8	6.8	7.45	14.23	39.17	2.75
Turbine at Ntoahae	14.4	7.0	7.66	14.62	41.08	2.81
Turbine at Malatsi	4.4	3.5	3.89	7.43	12.62	1.70

Electrification of the rural population is of significant environmental and social benefit. Providing electricity to the local household will reduce burning of biomass (reduce de-forestation) which is one of the main contributors to global warming. Night electricity could be used for pumping for irrigation of nearby agricultural fields, and for other similar improvements.

B: Generation capacity vs pumping needs

Table 5-3 through 5-5 provide an overview over generating capacity and pumping needs as well as balance of generation vs pumping GWhs. As noted in column 5 in Table 5-5, in general, surplus of GWhs prevails

Table 5-3 Pumping details, including MW installed and GWh generated

	From	To	Q-yield	H-pumping	MW*1.1	GWh-pumping	GWh-added generation
15	Ntoahae	Tsoelike	8.05	103	10.7	85.0	-
14	Tsoelike	Taung	16.50	154	32.9	261.8	-
7a	Taung	Polihali	22.90	193	57.0	454.3	-
10	Lebelo	Mohale	6.75	377	32.8	261.6	149.8
Total without Lebelo						801.1	Pumping

Table 5-4 Generation details for the various stages

Generating capacity	Q	H	MW generated	MW installed	GWh generated
Polihali to Muela along	17.3	272	41.5	54.0	363.9
Polihali, Taung and Tsoelike	30.33	259	69.4	81.0	607.6
Polihali to Malatsi, into Muela	42.33	241	90.1	108.0	789.0
			-		(1): -
Oxbow added	2.5	742	16.4	90.0	-56.5

Table 5-5 Summary of generation vs pumping requirements for the various stages

	Pumping	Generation	Shortage of generation to cover pumping needs	
Polihali	-	363.94	-363.94	Surplus
Polihali to Tsoelike	272.40	607.56	-335.15	Surplus
Polihali to Malatsi	801.07	789.01	12.06	Shortage
Including Oxbow		87.01		
Polihali to Malatsi including Oxbow	801.07	876.02	-74.95	Surplus

6. COMBINING PUMPING PLANTS WITH REVERSIBLE TURBINES

Potential hydro-sites and pumping plants best suited for installation of reversible turbines/pumps are listed in Table 6-1.

Table 6-1 Potential sites suited for installation of reversible pumps

	H/L	Rating
Any hydro unit located at toe of storage dams	0.3-0.4	NA
Oxbow	764/16100=0.05	1
Lebelo to Mohale	0.09	2
Ntoahae	0.039	3
Taung to Katse	0.007	4

Once all civil works have been provided, large unit reversible turbines/pumps may replace many small pumps, without additional space requirements.

An assessment is presented in Table 6-2, indicating that it is very economical to install reversible turbines at pumping plants, with increased benefit where the tunnel size is set by minimum construction related diameter, rather than by flow. It is also economical to install reversible turbines at Oxbow.

Table 6-2 Benefit of installing reversible turbines at pumping stations and at Oxbow

PRELIMINARY ASSESSMENT IF IT PAYS OFF TO INSTALL REVERSIBLE PUMPS/ TURBINES

Site	Q(ave)	U/s FSI	D/s FSI	L, Tunnel	D(i.d.)-use	L_shaft	D_shaft	Head loss(Qfir m used)	MW	h/day	GWh/a	Rate, \$/ kWh	Cost civil	El-Mech	Capitalized pumping cost and generation	Plant and generation cost	
																	Money saved over the lifetime of the project
Lebelo to Mohale	Pumping all the time	6.75	2075	1,705	41.04	4.5	70	2.70	1.51	27.11	24	237.5	0.032	19.9	11.4	120.94	152.23
	Pumping, weekends and nights	20.67	2075	1,705	41.04	4.5	70	2.70	14.15	80.16	18	526.7	0.023			191.56	
	Peak power generation, 6 hours/ day	35.00	2076	1,705	41.04	4.5	70	2.70	40.58	102.10	6	223.6	0.054	51.1	29.2	189.8	82.2
Taung-Malatsi to Katse		22.9	2053	1,885	24.95	4.5	168	3.14	10.77	39.25	24	343.8	0.032	24.6	14.1	175.07	213.76
		50.53	2075	1,770	24.95	4.5	168	3.14	52.43	139.12	18	914.0	0.023			332.46	
		60.00	2076	1,770	24.95	4.5	168	3.14	73.92	122.94	6	269.2	0.054	61.1	34.9	228.5	199.9
				V =	3.77		7.76										13.53
Tsoelike to Taung		16.5	1885	1,770	37.26	4.5	115	2.20	9.10	19.05	24	186.8	0.032	16.3	9.3	84.90	110.51
		33.00	1885	1,770	37.26	4.5	115	2.20	36.39	28.28	18	185.8	0.023			67.57	
		33.00	1805	1,770	37.26	4.5	115	2.20	36.39	22.90	6	50.2	0.054	24.5	14.0	-42.6	83.5
				V =	2.07		8.68										>>>
Oxbow																	
	Generation, peak	14	2525	1,761	16.079	4	764	3.00	5.67	93.73	6	205.3	0.054	40.6	23.2	(174.22)	(110.46)
	Pumping	12.00	2525	1,761	16.08	4	764	3.00	4.16	99.39	18	653.0	0.023			237.51	
	Generation, peak	50.00	2525	1,761	16.08	4	764	3.00	72.30	305.35	6	668.7	0.054	95.9	54.8	567.6	-179.3
			V =	3.98		7.07										Revenue	68.87

7. COST ESTIMATION OF OPTIONS AND RATING

A: Escalation

In 1988 1 US\$ was 2.25 Rand/ Maloti. Escalating the US\$ by 4.5% to 2006 and applying current rate of 6.5 to the US\$, this corresponds to 11% escalation of the Rand from 1988; i.e.

$$1 * 1.045^{(2006-1988)} = 2.21 \text{ US\$}; 2.21 * 6.5 = 14.4 \text{ Rand}$$

$$2.25 * 1.11^{(2006-1988)} = 14.72 \text{ Rand} \sim 14.4$$

This means that while it is appropriate to escalate the foreign portion by 4.5%, the local portion should be escalated by some 10-11%/a. This approach is being used in all hydro cost assessments.

B: Consideration related to tunnel cost

Overall cost values used in the tunnel cost estimate are listed Table 7-1. It is not common to excavate a 70-80 km long water tunnels without vehicular access (all through shafts). In view of this and very high rock cover, relative to other Phase tunnel costs, the cost of the Taung to Muela tunnel is found low and the Erlands tunnel as well, although to a lesser degree. This affects hydro-installations, as gravity flow may be favored. In view of the dominating cost of the waterways, it is suggested this be carefully looked into.

Table 7-1 Cost comparison of Phase II tunnels, all included

	D (m)	km	Mio Rand per Tunnel report	Rand/m	US\$/m	Ratio	Comments
Taung to Polihali	4.5	27.2	1,935	71,132	11,114	1.68	High
Tsoelike to Taung	4.5	37.3	2,265	60,724	9,488	1.44	OK
Ntoahae to Tsoelike	3	2.6	321	123,423	19,285	2.92	Very high
Oxbow to Muela	3.6	16.08	1,000	62,189	9,717	1.47	High
Polihali to Muela, gravity	5.1	72.1	4,400	61,026	9,535	1.44	Internally not in balance. Compared to Kárahnjúkar, OK.
Polihali to Erlands	5.1	66.65	4,779	71,695	11,202	1.70	Internally not in balance. Compared to Kárahnjúkar, OK.
Kárahnjúkar	5.5	13					Much larger tunnel, very expensive country
	7.4	> 42			6,602	1	

Comparison of lined tunnel cost, including adits and auxiliaries, using Mohale and Icelandic recent data in a basaltic setting vs the above noted Phase II estimate is shown on Fig. 7-1. The difference in cost seems to warrant that tunnel and auxiliary cost be looked into more carefully. If these tunnel layouts are being compared to canal or pipeline projects, skewed comparison may result.

C: Cost of Electro Mechanical equipment, valves and gates

Cost curves shown on Fig. 7-2 were used assessing the cost of electro mechanical equipment, both turbines and pumps. Cost is escalated to 2006. The el-mech cost of alternatives under study is also plotted, being higher than the envelope curves would give. These cost values should be looked carefully into in the next phase of this study.

The pumping plant cost, affecting reversible turbine alternatives, is shown below, as well as cost curves of gates and valves. Cost curves of substations, both civil and el-mech, are also shown.

D: Detailed cost assessment

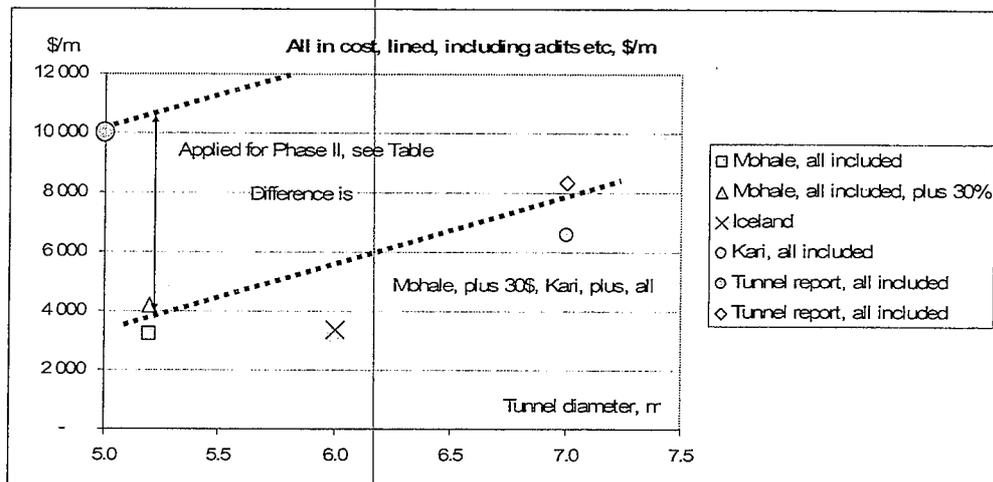
Summary of data entering the cost estimate, as well as calculation of power (MW) and energy (GWh) for these alternatives under study are shown on Table 7-2. Estimated development cost, capitalized revenue from power sales and B/C ratios are also shown, including on Fig. 7-3.

E: Oxbow – peak generation plant, including carbon benefits

As long as water revenue may carry the cost of the Oxbow dam and the waterways, it is beneficial to install generating units at Oxbow waterways, with:

- B/C ratio of 1.26 for generation alone, with ~ 90 MW installed for peak generation, or
- B/C ratio of 1.47 if reversible turbines are installed.

Figure 7-1 Cost/ m of lined tunnel, including adits and auxiliaries



F: Summary of Benefit/Cost assessment

Details of the cost estimate are given in Appendix F of the Main Report. Figure 7-3 A and B show cost, capitalized revenue and the B/C ratio for the generation alternatives studied, while Fig. 7-3 C and D address cost, sales revenue and B/C ratio of a few alternatives with reversible pump installed.

The project component which rates highest is:

- Diversion of water from Polihali into the Katse reservoir, with no additional turbines installation at Muela.

With this arrangement Muela becomes essentially a base plant. This alternative is, however, only actual if water transfer is limited to:

- Polihali, and/ or
- Polihali, Lebelo and Oxbow.

As Oxbow will take $3.5 \text{ m}^3/\text{s}$ out of the Katse tunnel, the Muela power plant can handle more flow, however, not the Tsoelike yield of $31.1 - 3.5 + 24.4 = 52 \text{ m}^3/\text{s}$ (possible at high reservoir levels, but not for reservoir levels close to MOL).

If the entire system will be developed, it appears that the highest benefit comes from:

- The Polihali – Taung – Tsoelike – Ntoahae – Malatsi alternative, with up to 4 x 27 MW units installed; see Fig. 7-3 B
- The situation is improved still if reversible turbines/pumps are installed at say Tsoelike or Ntoahae, See Fig. 7-3 D.

As most of the RSA plants are “base plants” it appears worthwhile to install peak power/ pumping plants, under the assumption that peak power is sold to RSA as well as used during winters in Lesotho.

To mention a free market similarity, Norway, with its hydro plants, sells peak to Europe at high rate and purchase base from France at a much lower rate. This is how hydro power plants are used in general, in particular high head plants.

Figure 7-2 Cost curves for el-mech/hydro, pumping plants, gates & valves and substations

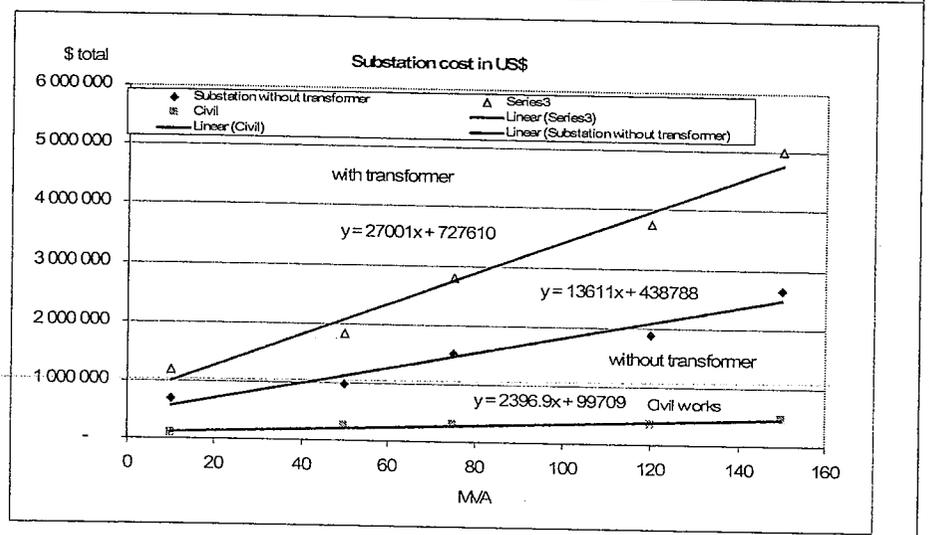
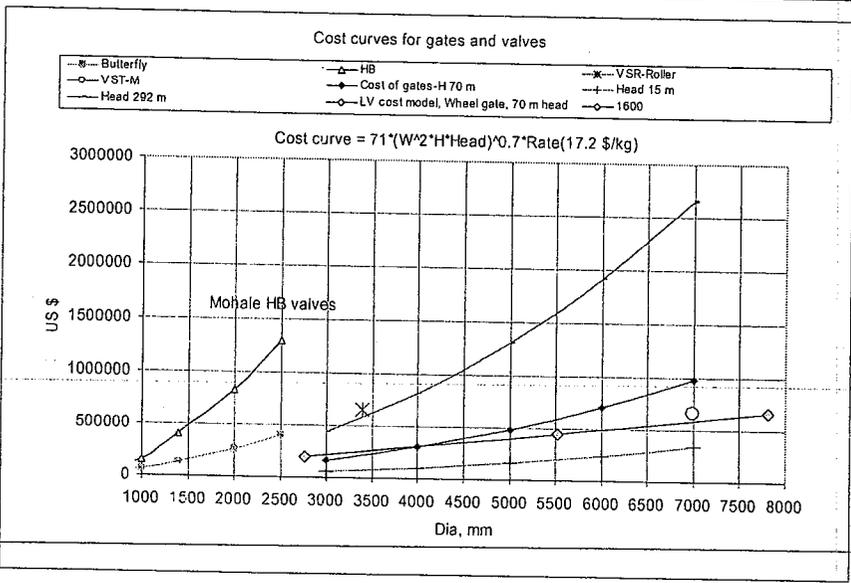
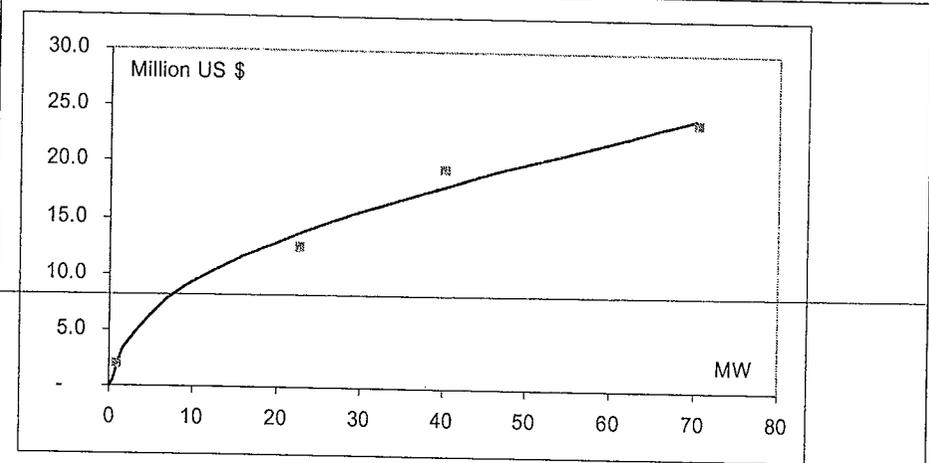
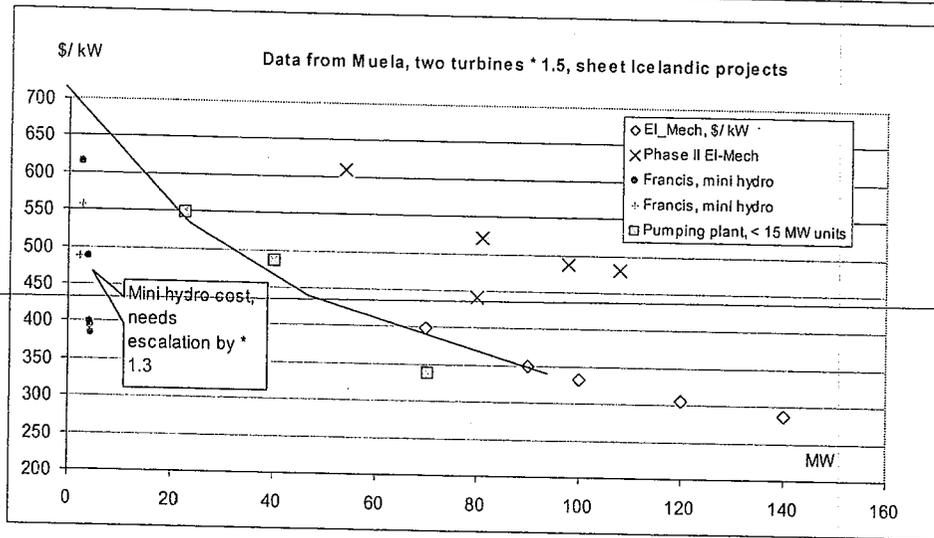
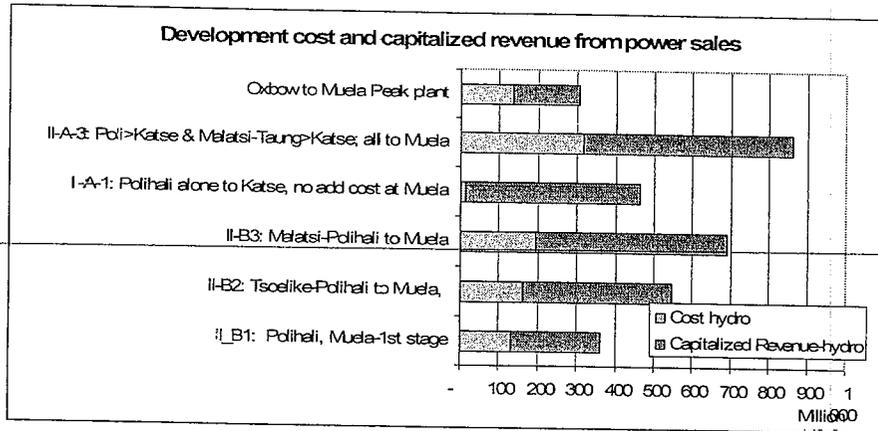
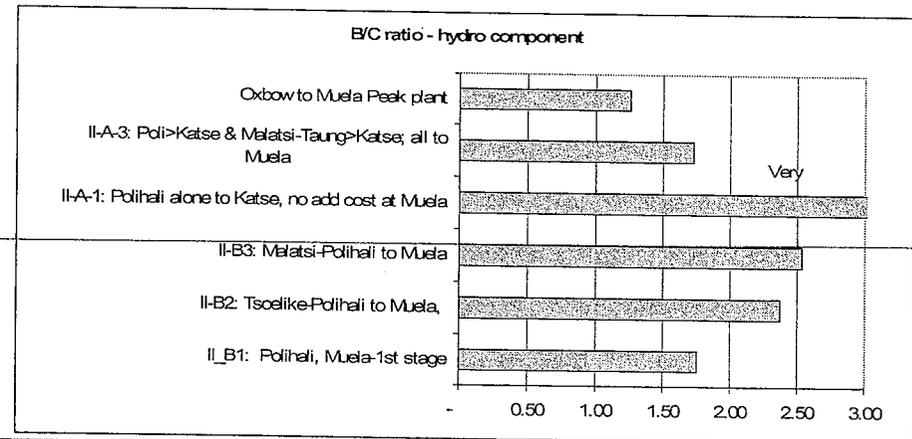


Figure 7-3 Cost and B/C ratios of hydro generation units, including for reversible turbine alternatives

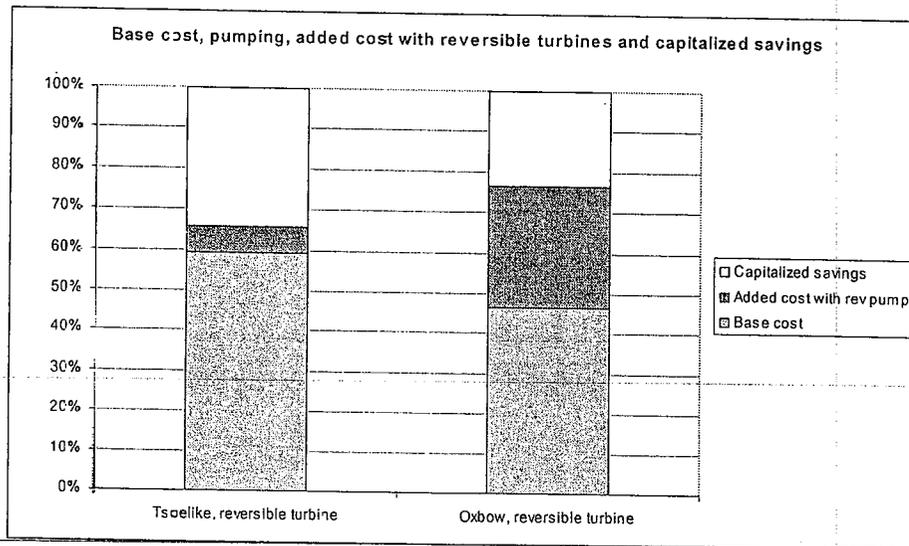
A: Generating unit cost and capitalize revenue



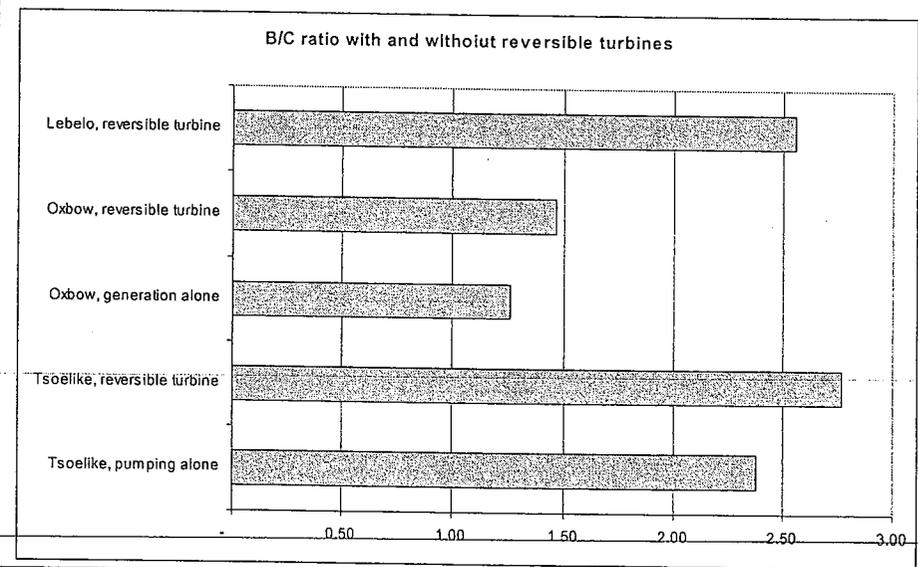
B: Generating unit B/C ratio



C: Reversible units, cost and capitalize revenue



D: Reversible units, B/C ratio



**STUDY FOR PHASE II
STAGE 1 SUPPORTING REPORT**

HYDROPOWER

APPENDIX B

OXBOW DRAWINGS

MAY 2006

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**STUDY FOR PHASE II
STAGE 1 SUPPORTING REPORT**

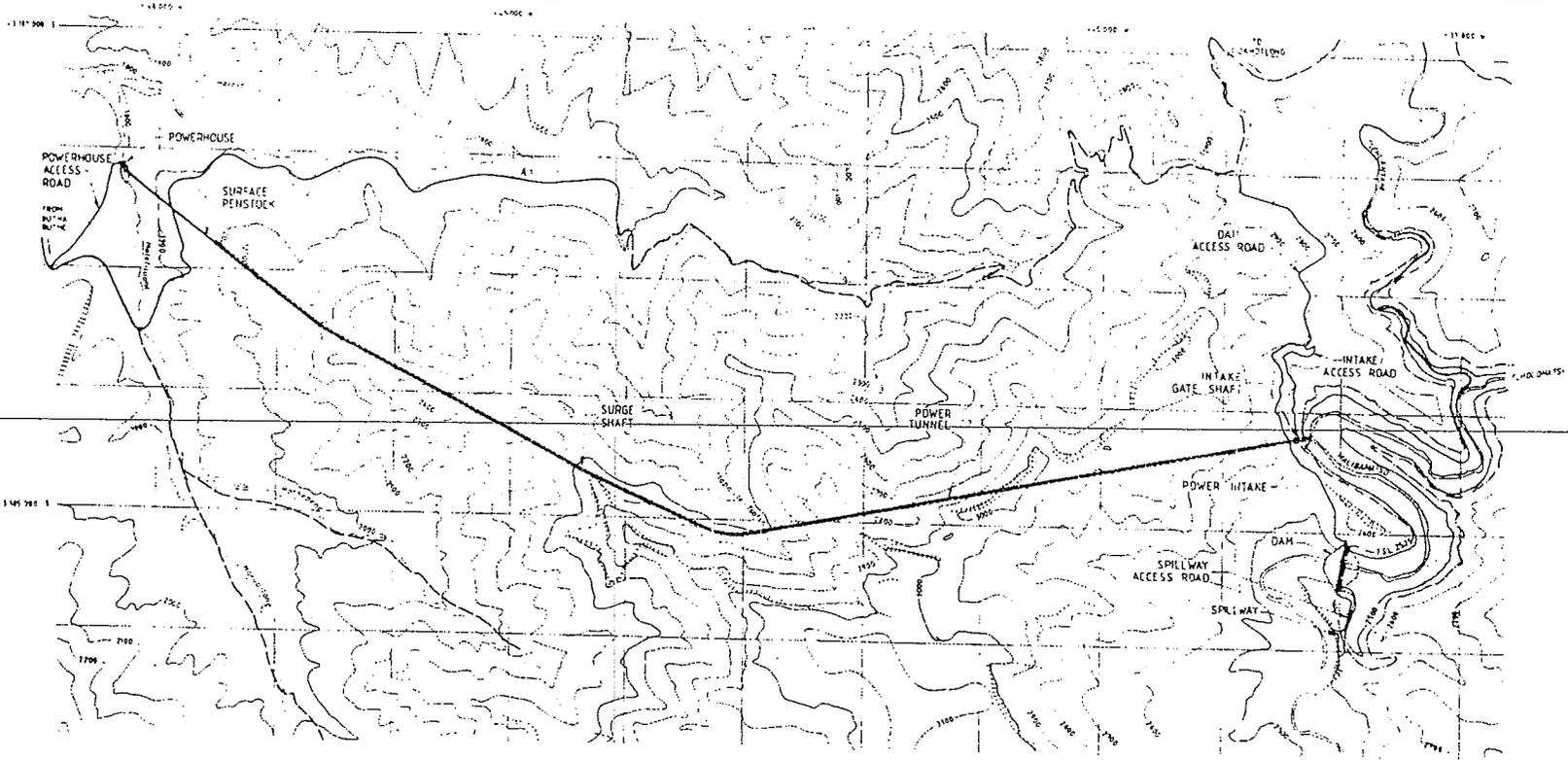
HYDROPOWER

APPENDIX B1

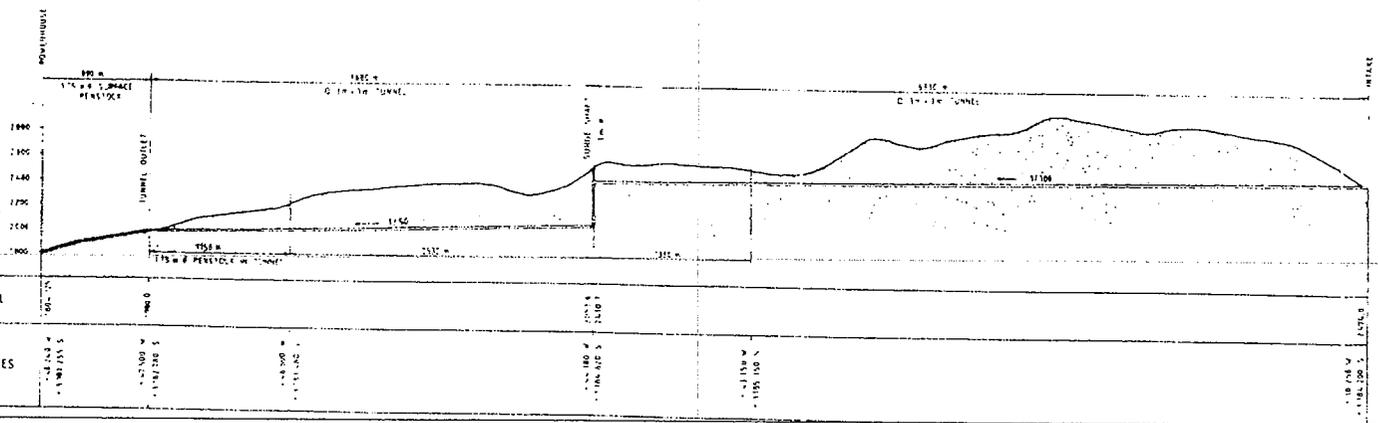
MONENCO - OXBOW DRAWINGS

MAY 2006

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PLAN



PROFILE

LEGEND

- Bitumen Surfaced Road
- Gravel Road
- Cliff
- Stream
- River

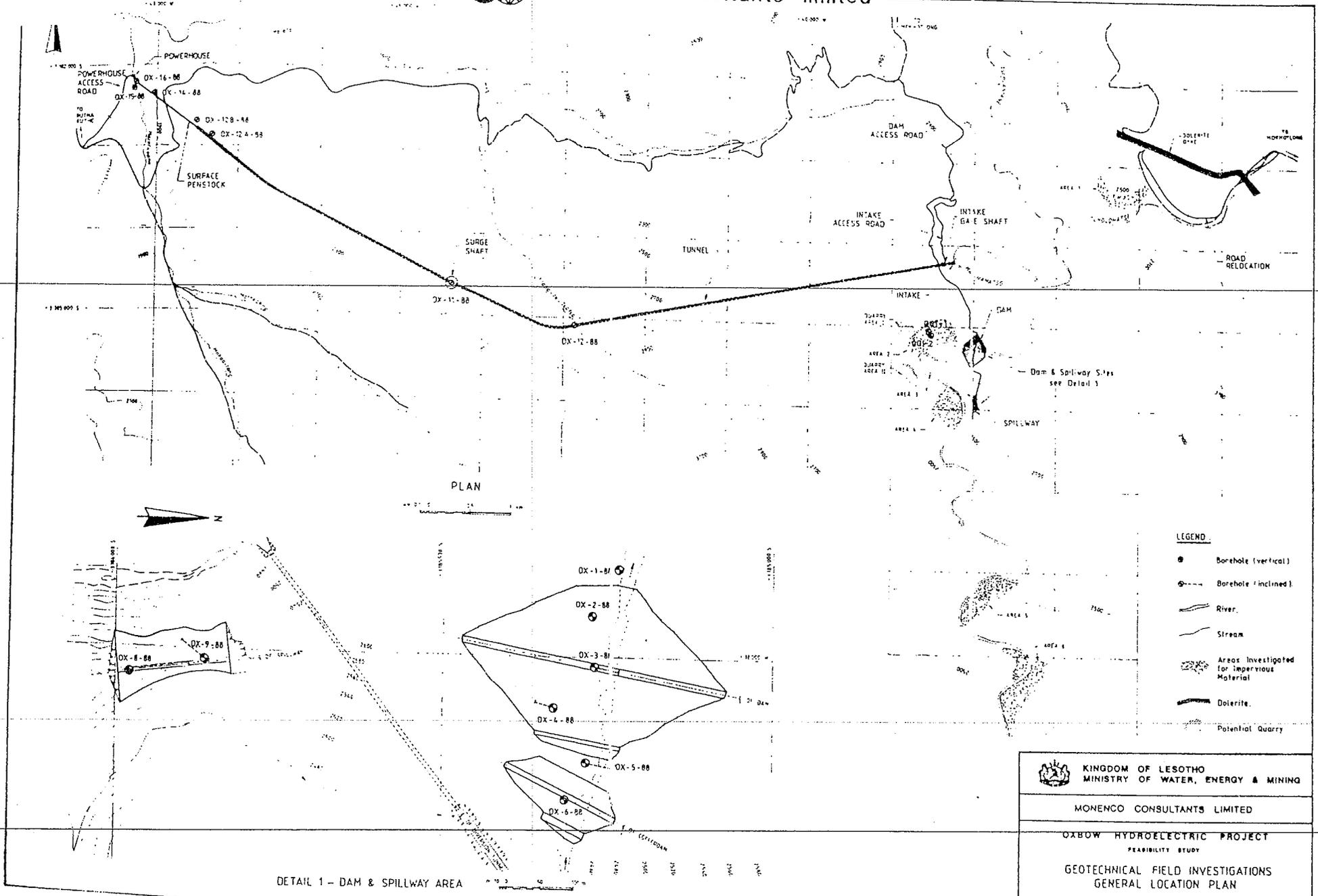


KINGDOM OF LESOTHO
MINISTRY OF WATER, ENERGY & MINING

MONENCO CONSULTANTS LIMITED

OXBOW HYDROELECTRIC PROJECT
FEASIBILITY STUDY

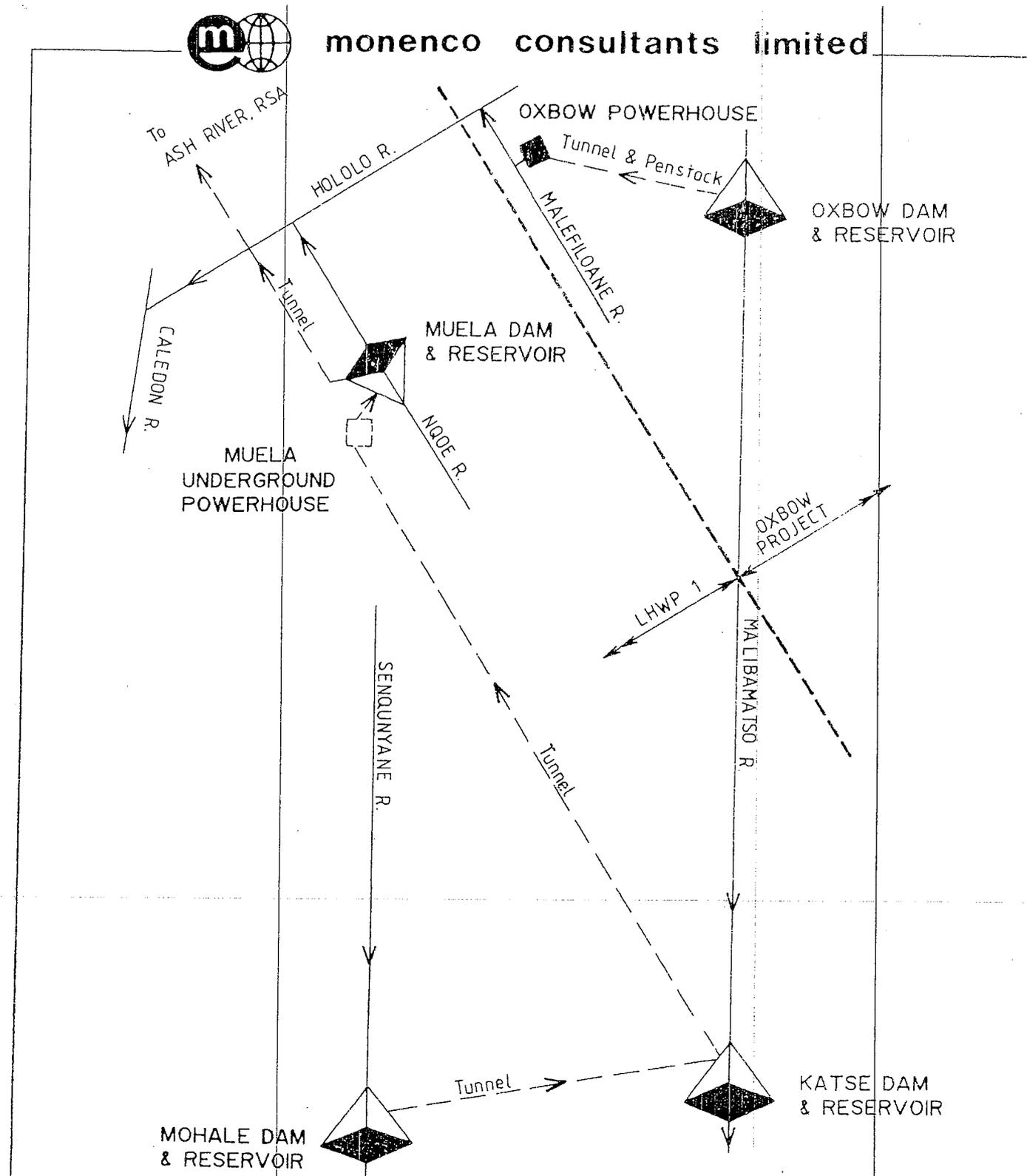
TUNNEL/PENSTOCK PLAN & PROFILE



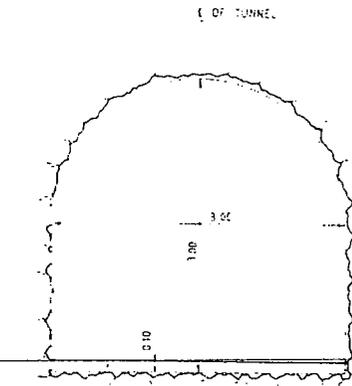
- LEGEND**
- Borehole (vertical)
 - Borehole (inclined)
 - River
 - Stream
 - ▨ Areas Investigated for Impervious Material
 - Dolerite
 - ▨ Potential Quarry

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OXBOW HYDROELECTRIC PROJECT FEASIBILITY STUDY	
GEOTECHNICAL FIELD INVESTIGATIONS GENERAL LOCATION PLAN	
FIGURE 4-2	

DETAIL 1 - DAM & SPILLWAY AREA



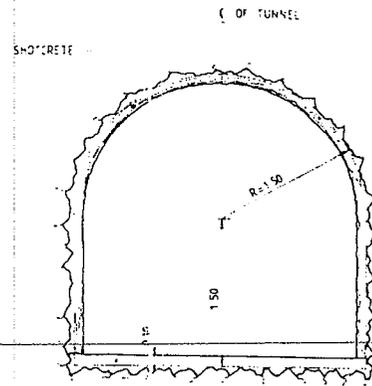
	KINGDOM OF LESOTHO MINISTRY OF WATER, ENERGY & MINING
MONENCO CONSULTANTS LIMITED	
OXBOW HYDROELECTRIC PROJECT FEASIBILITY STUDY	
OXBOW & LHWP 1 SCHEMATIC PLAN	
FIGURE S-2	



SUPPORT
NO ROCK SUPPORT EXCEPT SPOT ROCK BOLTING

CONDITION
DENSE BASALT WITH WIDELY SPACED TIGHT JOINTS.

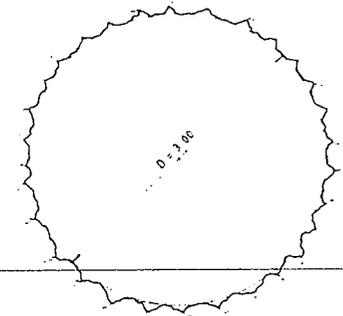
CONCRETE ---
TUNNEL SECTION 1
UNLINED



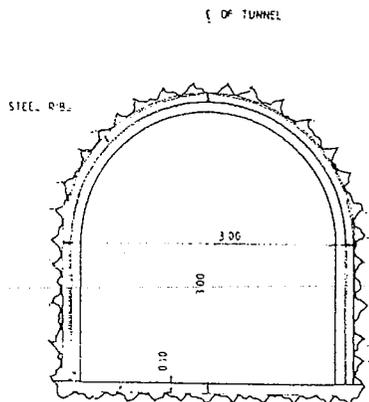
SUPPORT
NO ROCK SUPPORT EXCEPT SPOT ROCK BOLTING AND 5-10 cm SHOTCRETE LAYER.

CONDITION
AMYGDALOIDAL BASALT, UNALTERED WITH WIDELY SPACED TIGHT JOINTS.

CONCRETE ---
TUNNEL SECTION 2
SHOTCRETE LINING



SHAFT SECTION

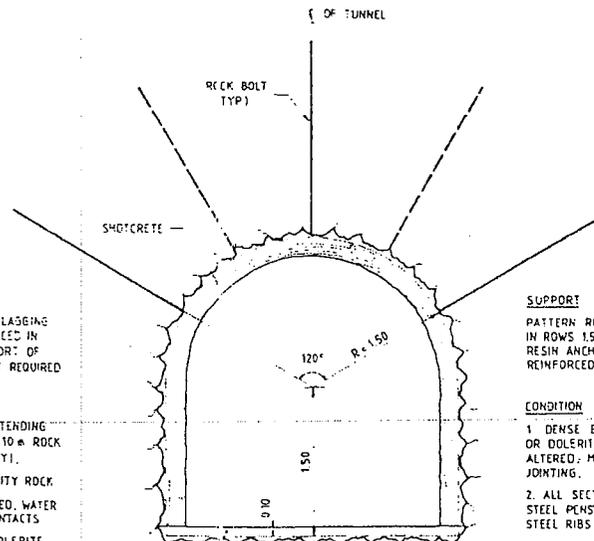


SUPPORT
STEEL RIBS LINER PLATE AND/OR LAGGING ENCASED IN 20 cm CONCRETE, REINFORCED IN EXTREME CONDITIONS INITIAL SUPPORT OF ROCK BOLTS & SHOTCRETE POSSIBLY REQUIRED

CONDITIONS

1. ALL PORTALS FOR A DISTANCE EXTENDING TO LOCATION IN TUNNEL HAVING 5-10 m ROCK COVER (DEPENDENT ON ROCK QUALITY).
2. FAULTED OR SHEARED POOR QUALITY ROCK.
3. VERY CLOSELY FRACTURED ALTERED, WATER BEARING ROCK ALONG LAVA FLOW CONTACTS.
4. FRACTURED, ALTERED, BASALT - DOLERITE CONTACTS.

CONCRETE ---
TUNNEL SECTION 3
STEEL RIBS AND CONCRETE



SUPPORT
PATTERN ROCK BOLTS, 2 m LONG, STAGGERED, IN ROWS 1.5 m APART, ALONG TUNNEL AXIS, RESIN ANCHORED & GROUTED, SHOTCRETE, FIBRE REINFORCED, 10-20 cm THICK LAYERS

CONDITION

1. DENSE BASALT, AMYGDALOIDAL BASALT OR DOLERITE, UNALTERED TO MODERATELY ALTERED; MODERATE TO CLOSE, TIGHT JOINTING.
2. ALL SECTIONS OF TUNNEL CONTAINING STEEL PENSTOCK EXCEPT THAT SUPPORTED BY STEEL RIBS AND CONCRETE.

CONCRETE ---
TUNNEL SECTION 4
ROCK BOLTS AND SHOTCRETE

NOTES

1. ALL ROCK SUPPORT SHOWN FOR TUNNEL SECTIONS ALSO APPLY FOR SHAFT.
2. PRESSURE RELIEF HOLES IN CONCRETE AND SHOTCRETE AS REQUIRED DEPENDING ON GROUND WATER CONDITIONS.
3. OCCASIONAL SECTIONS OF WEAK OR PERMEABLE ROCK STRATA MAY REQUIRE GROUT STABILIZATION AHEAD OF TUNNEL FACE.



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TYPICAL TUNNEL AND SHAFT SECTIONS	
FIGURE 5-10	

**STUDY FOR PHASE II
STAGE 1 SUPPORTING REPORT**

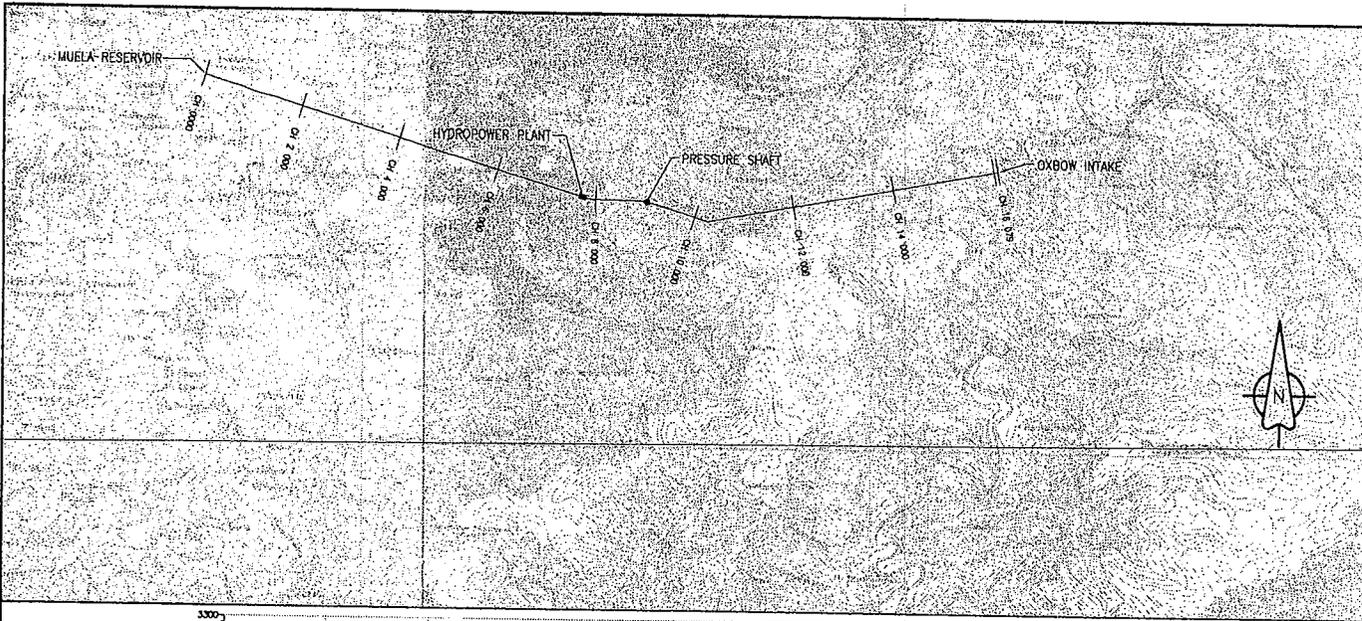
HYDROPOWER

APPENDIX B2

REVISED - OXBOW DRAWINGS

MAY 2006

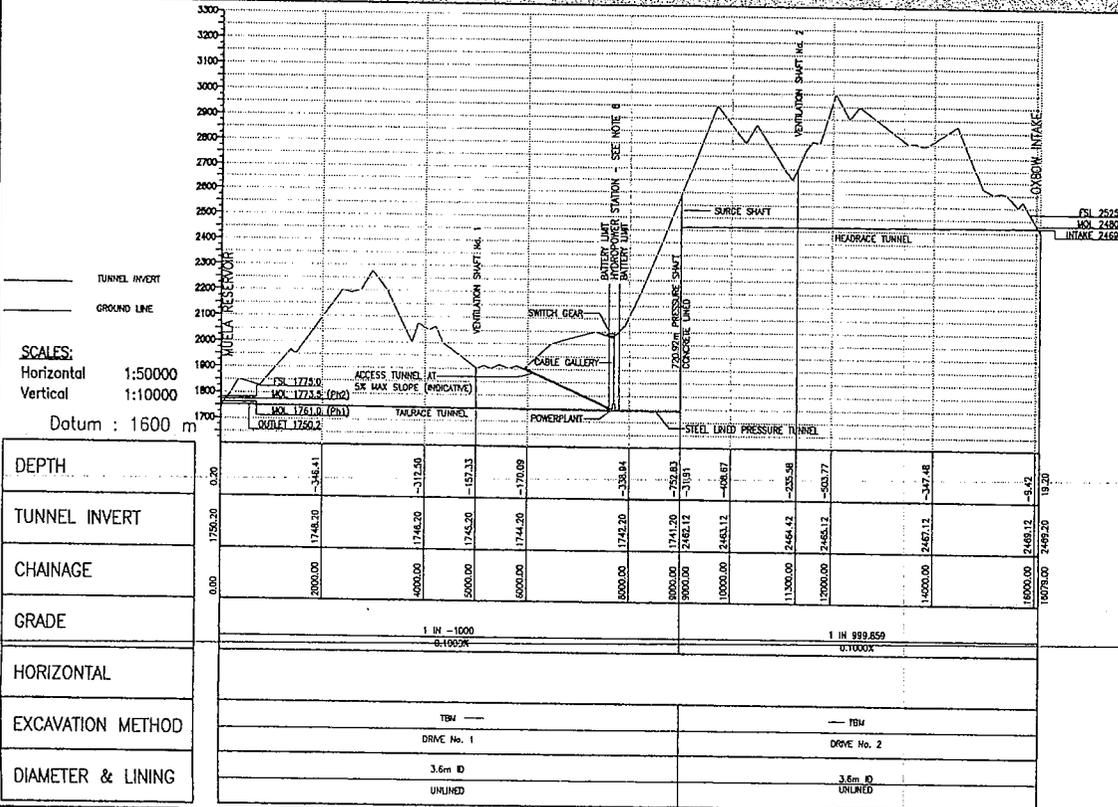
DRAFT



- NOTES:**
- ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE SHOWN.
 - ALL LEVELS IN METRES ABOVE SEA LEVEL (M.A.S.L.)
 - SLOPE OF TUNNELS TO BE MODIFIED AT A LATER STAGE TO PROVIDE GRAVITY DRAINAGE DURING CONSTRUCTION, WHERE POSSIBLE.
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 - FOR DETAILS OF HYDROPOWER COMPONENTS SEE HYDROPOWER STAGE 1 SUPPORTING REPORT.

DRAFT

Date	Rev.	Revision	Drn	Chkd	Appd
SCALE 1:50 000					



Designed: B. C. VILJEN Initial:
 Drawn: J. H. BADEHORN Initial:
 Checked: P. WARDLELL Initial:

SCALES:
 Horizontal 1:50000
 Vertical 1:10000
 Datum: 1600 m

1-OX02-100-002		DRAWING TITLE			
DRG. NO.	RELATED DRAWINGS				

LESOTHO HIGHLANDS WATER COMMISSION

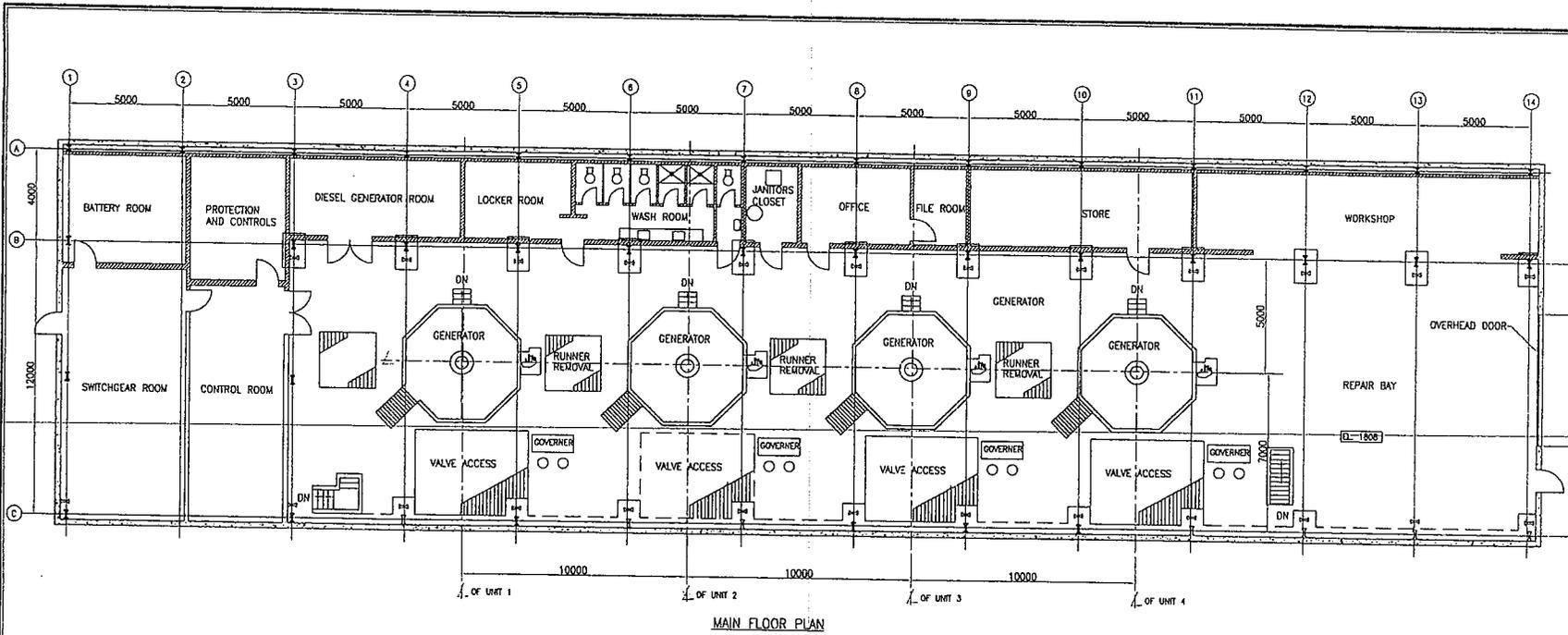
Approval: _____ Date _____
 Chief Executive Officer

**LESOTHO HIGHLANDS WATER PROJECT
 FEASIBILITY STUDY FOR PHASE II - STAGE 1**

**OXBOW - MUELA TUNNEL
 GENERAL ARRANGEMENT AND LONGSECTION
 SHEET 1 OF 1**

	SEED Sensu Engineering, Environment and Development Consultants	ECL Africa South West International CCSA SNC
--	---	--

Project Manager		Date	
Date	Drawing No.	Date	Rev.
24/03/2006	1-0B02-100-001		P01



- NOTES:**
1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE SHOWN.
 2. ALL LEVELS IN METRES ABOVE SEA LEVEL (M.A.S.L.).
 3. THIS PROFILE AND SECTION IS BASED ON DESIGN BY MOWENCO FEASIBILITY STUDY 1989.
 4. TO REDUCE LENGTH OF CURVED RUNNER SHALL BE TAKEN OUT THROUGH TUBE AND NOT BETWEEN UNITS.
 5. THIS AND OTHER SIMILAR IMPROVEMENTS WILL BE DONE IN STAGE II, IF DECIDED TO ADVANCE THIS ALTERNATIVE FURTHER.
 6. SIZE OF UNITS TENTATIVELY SET AT 22.5 MW x 4 IN FURTHER STUDIES. ASSESS IF LARGE UNITS MAY BE INSTALLED (LESOTHO GRID STABILITY ISSUE)

DRAFT

Date	Rev.	Revision	Des.	Chkd.	Appr.

SCALE 1:100

DRG. NO. _____ DRAWING TITLE
 RELATED DRAWINGS

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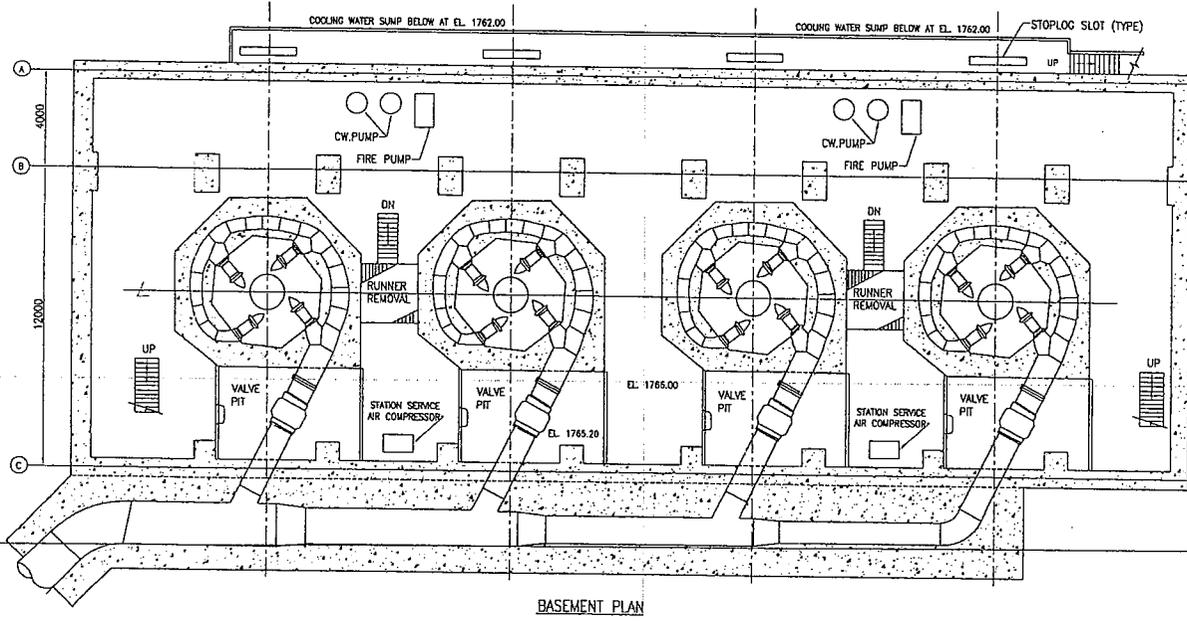
Approval: _____

Chief Executive Officer _____ Date _____
LESOTHO HIGHLANDS WATER PROJECT
FEASIBILITY STUDY FOR PHASE II - STAGE 1

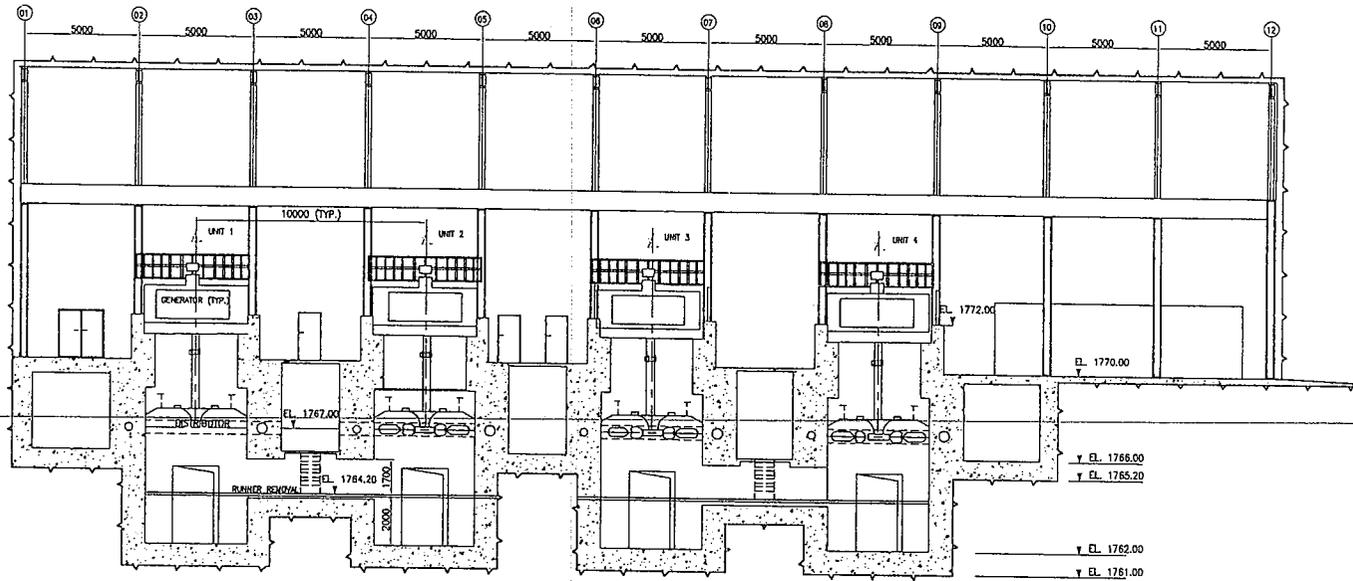
OXBOW HYDROELECTRIC PROJECT
BASEMENT PLAN AND
MAIN FLOOR PLAN

C4-SEED CONSULTANTS SEE: Sengu Engineering, Equipment and Development Consultants. ED: Wilson Shand, WE International, 0206 506

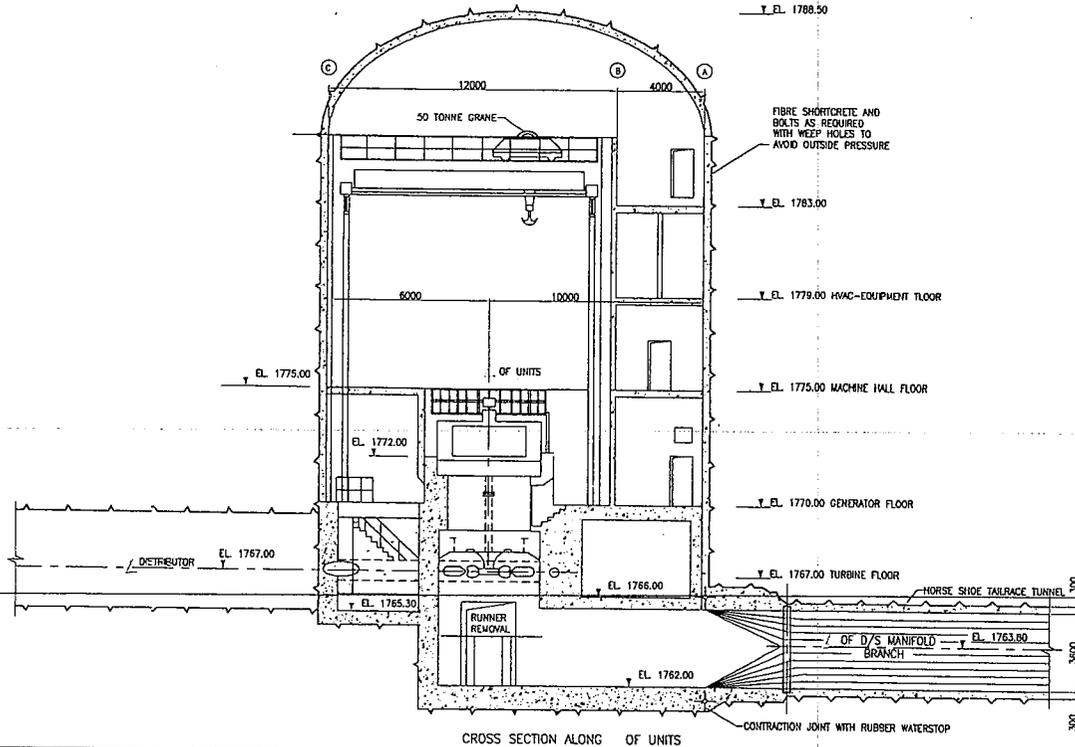
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 Date 22/03/2006 Drawing No. 1-0B02-610-001 Rev. P01



Designed: LP Initial: Drawn: MJA Initial: Checked: PJ Initial:



LONGITUDINAL SECTION ALONG \angle OF UNITS

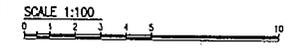


CROSS SECTION ALONG OF UNITS

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	RELATED DRAWINGS

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Chief Executive Officer _____ Date _____

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FEASIBILITY STUDY FOR PHASE II - STAGE 1

OXBOW HYDROELECTRIC PROJECT

POWER HOUSE

PROFILE AND SECTION

C4-SKEW SERVICES

SEED: Sengiso Engineering, Environment and Development Consultants

EC: Mtham Sheng and International COE

Approval: _____

Project Manager _____ Date _____

Design: LP Initial: ... Drawn: MJK Initial: ... Checked: PJ Initial: ...

**STUDY FOR PHASE II
STAGE 1 SUPPORTING REPORT**

HYDROPOWER

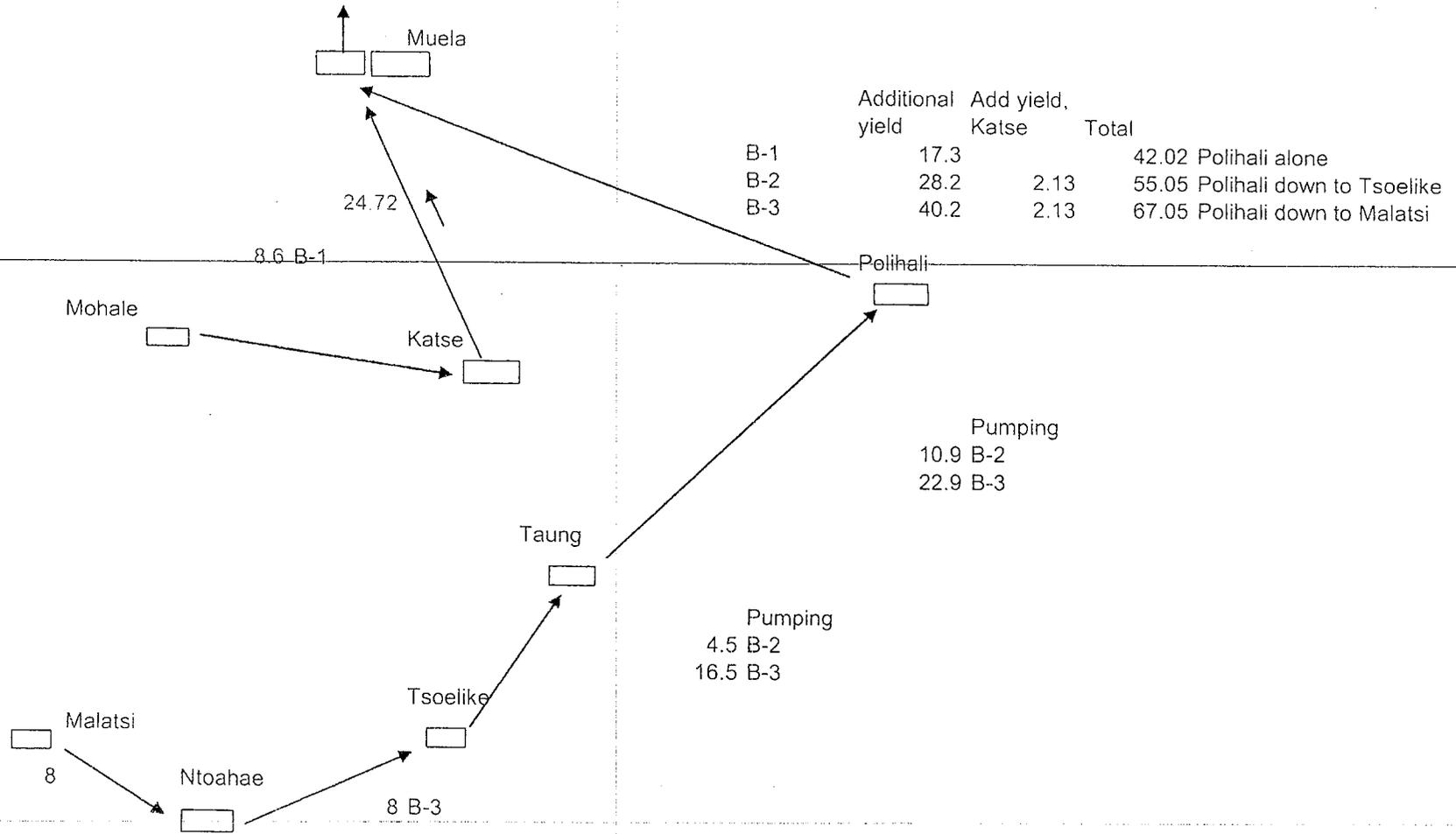
APPENDIX C

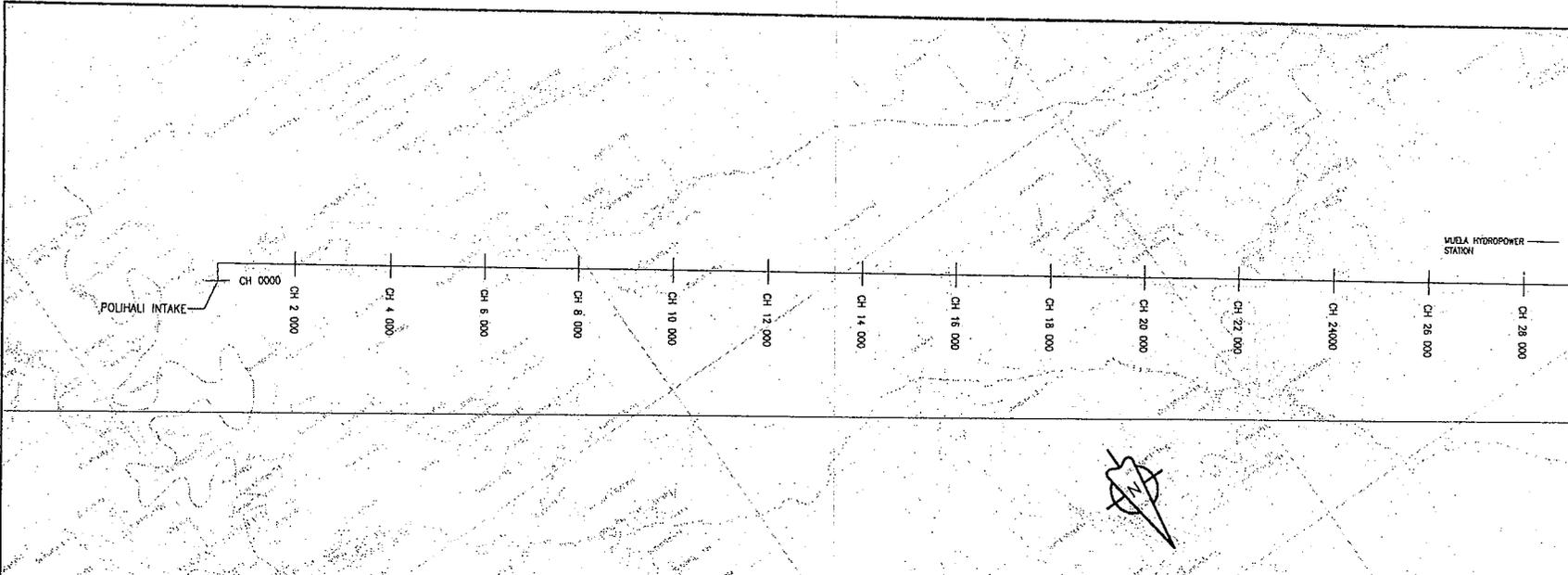
MUELA – POLIHALI – MALATSI LAYOUTS

MAY 2006

DRAFT

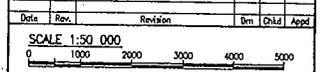
Alternative B-1/3: Polihali directly to Muela, with development down to Malatsi





- NOTES:**
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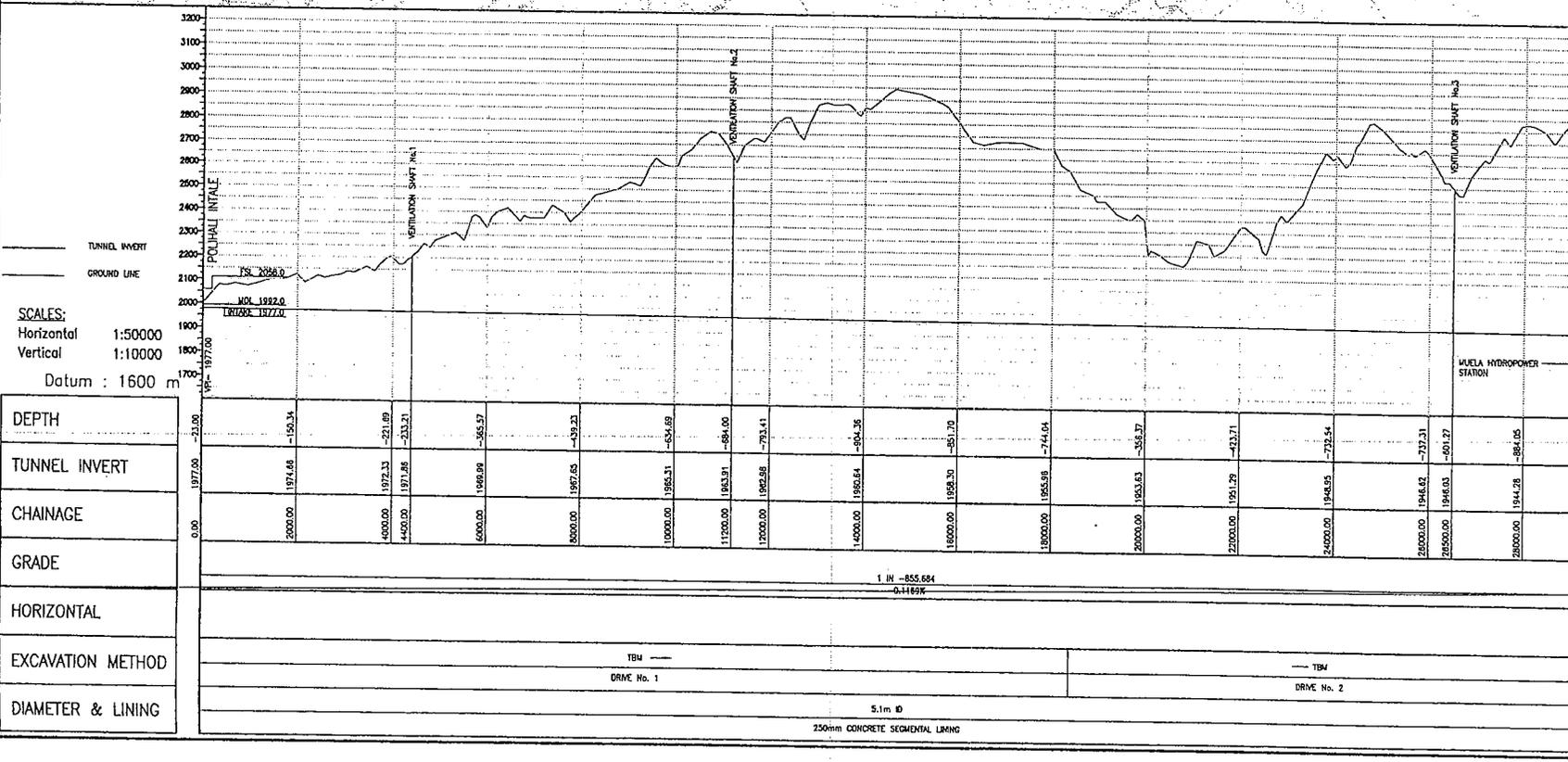
LESOTHO HIGHLANDS WATER PROJECT
FEASIBILITY STUDY FOR PHASE II - STAGE 1

POLIHALI - MUELA TUNNEL
HYDROPOWER OPTION
GENERAL ARRANGEMENT AND
LONGSECTION - SHEET 1 OF 3

C4-SEED CONSULTANTS
SEED: Survey Engineering, Environment and Development Consultants
KS: Khamiso Shone VTC International
Approval: _____

Project Manager _____ Date _____

Date 24/03/2006 Drawing No. 1-POQ2-100-001 Rev. P01

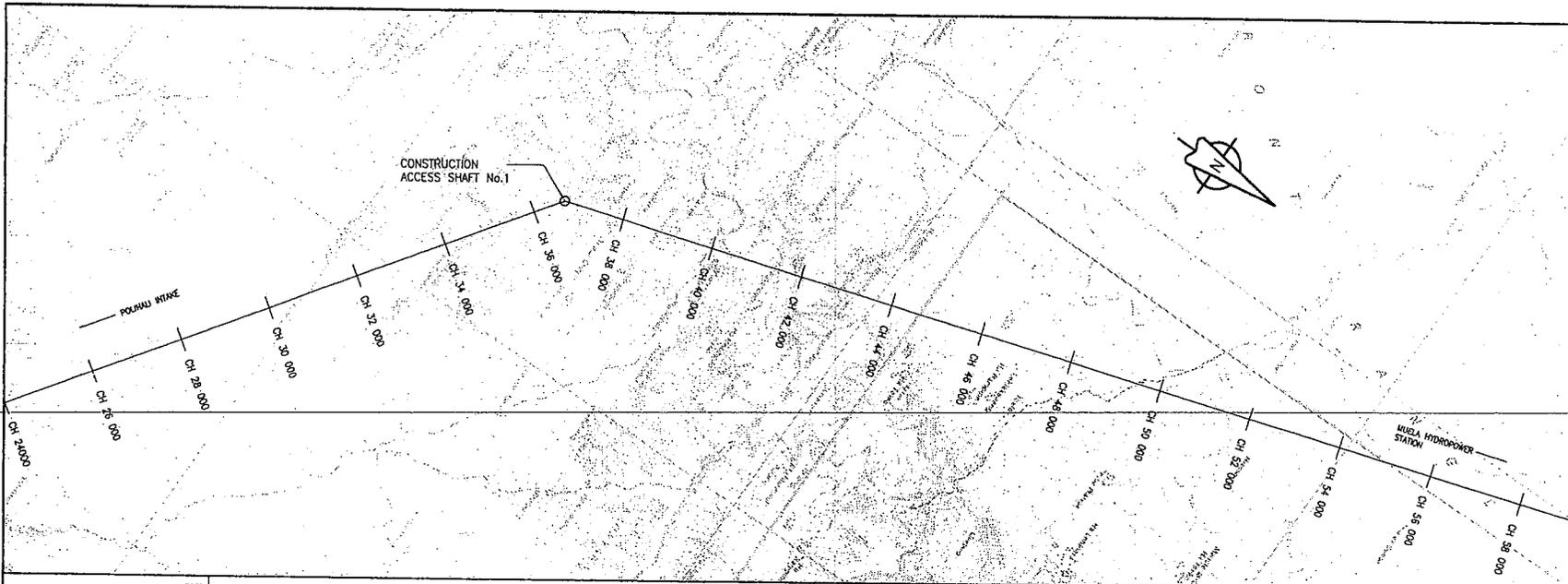


DESIGNED: B. C. VILJOEN Initial:
DRAWN: J. H. BAENHORS Initial: Checked: P. WARDLELL Initial:
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Vertical 1:10000
Datum: 1600 m

TBM
DRIVE No. 1

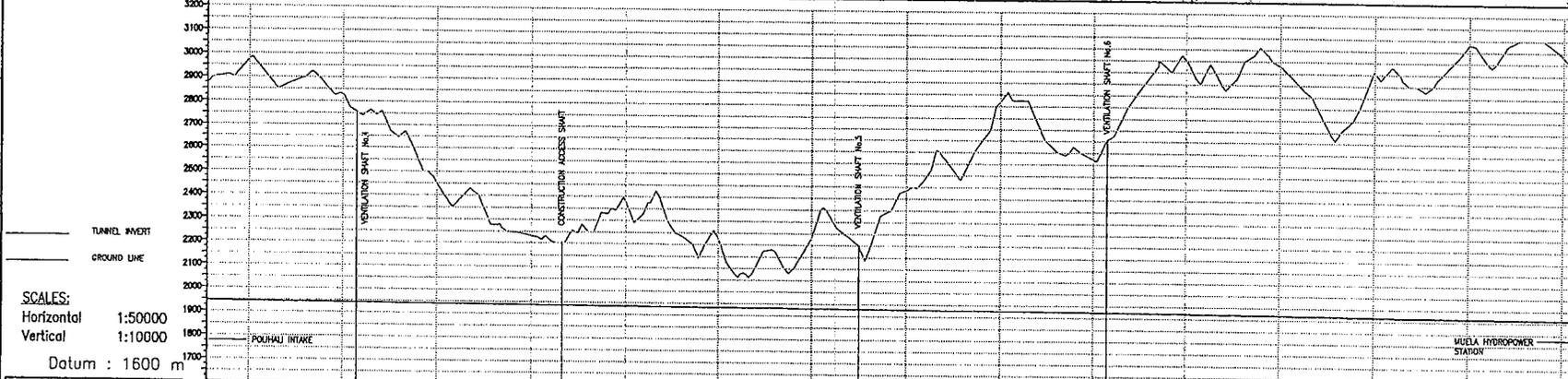
TBM
DRIVE No. 2

5.1m Ø
250mm CONCRETE SEGMENTAL LINING



- NOTES:**
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DRAFT



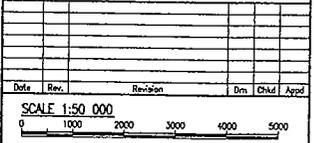
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 Vertical 1:10000
 Datum : 1600 m

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TUNNEL INVERT	1911.54
CHAINAGE	3000.00
GRADE	1911.54
HORIZONTAL	1911.54
EXCAVATION METHOD	1911.54
DIAMETER & LINING	1911.54

3000.00	1911.54	-1333.06
3050.00	1928.60	-885.15
3100.00	1938.75	-815.40
3400.00	1927.27	-512.73
3600.00	1924.93	-295.07
3650.00	1924.17	-285.83
3800.00	1925.58	-146.34
4000.00	1930.25	-254.75
4200.00	1927.82	-302.08
4300.00	1926.75	-270.38
4400.00	1925.58	-508.42
4600.00	1923.24	-855.76
4650.00	1920.91	-851.19
4650.00	1920.55	-735.40
5000.00	1918.57	-1081.43
5200.00	1916.33	-1083.34
5400.00	1913.89	-1041.11
5600.00	1911.55	-1106.44
5600.00	1909.22	-1120.78

1 IN = 855.884
 0.1169X

5.1m ID
 250mm CONCRETE SEGMENTAL LINING



DRG. NO. DRAWING TITLE
 RELATED DRAWINGS

LESOTHO HIGHLANDS WATER COMMISSION

Approval: _____
 Chief Executive Officer Date

LESOTHO HIGHLANDS WATER PROJECT
 FEASIBILITY STUDY FOR PHASE II - STAGE 1

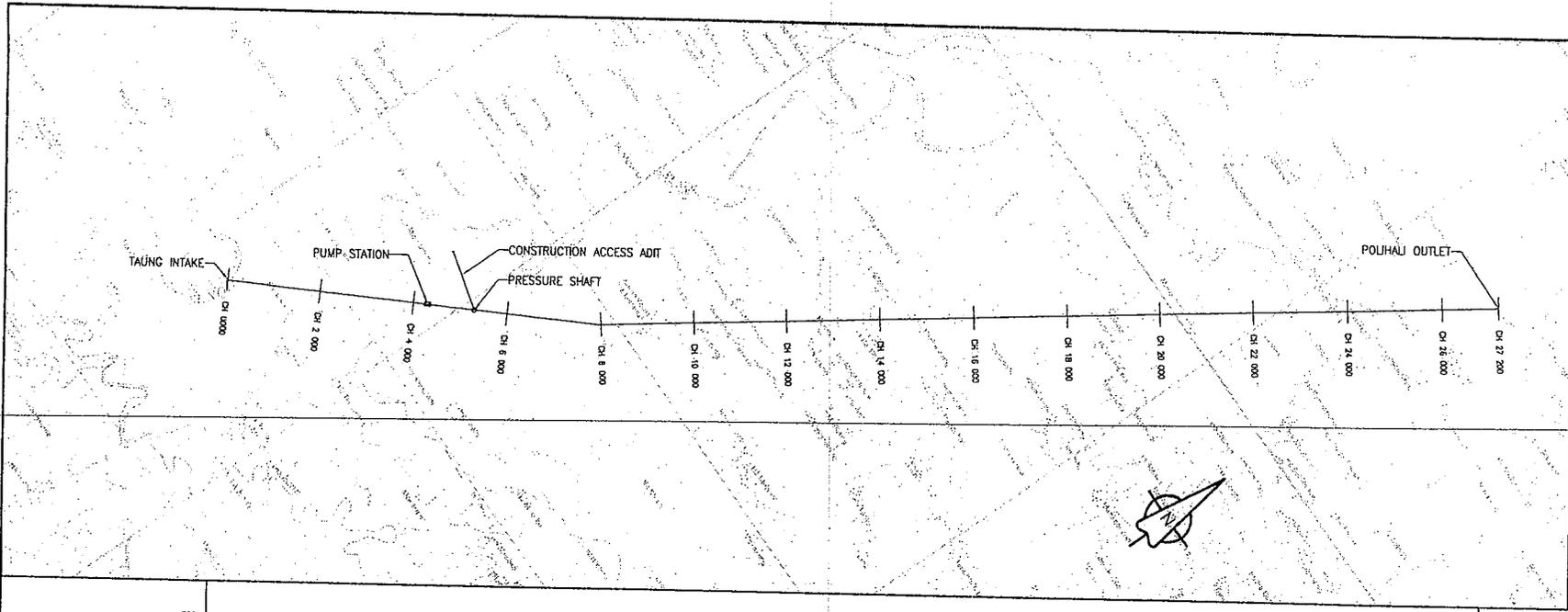
POLIHALI - MUELA TUNNEL
 HYDROPOWER OPTION
 GENERAL ARRANGEMENT AND
 LONGSECTION - SHEET 2 OF 3

G4-SEED SEED: _____ E.S.: _____
 WATER VENTURE Senior Engineering, Environment and Development Consultants VWE International (Pty) Ltd

Approval: _____
 Project Manager Date

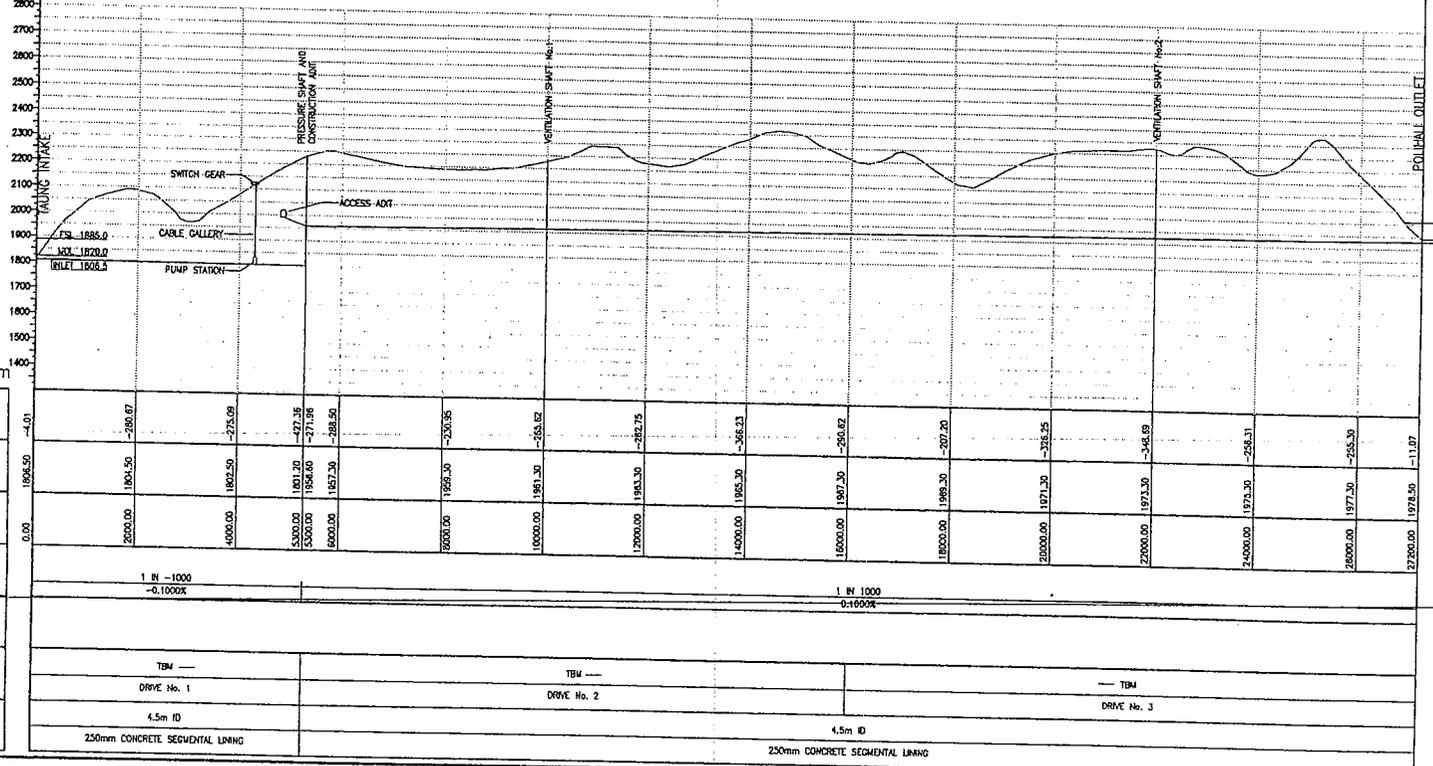
Date Drawing No. Rev.
 24/03/2006 1-P002-100-002 P01

Designed: B. C. VILJOEN Drawn: J. H. BOENHORS Initialed: Checked: P. WARDLELL Initialed:



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DRAFT



Designed: B C VILJOEN
 Drawn: J H BAUEHORS/Initial:
 Checked: P WARDLELL
 Initial:
 SCALES:
 Horizontal 1:50000
 Vertical 1:10000
 Datum : 1300 m

DATE REV. REVISION

SCALE 1:50 000
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DATE REV. REVISION

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Approval: _____
 Chief Executive Officer Date

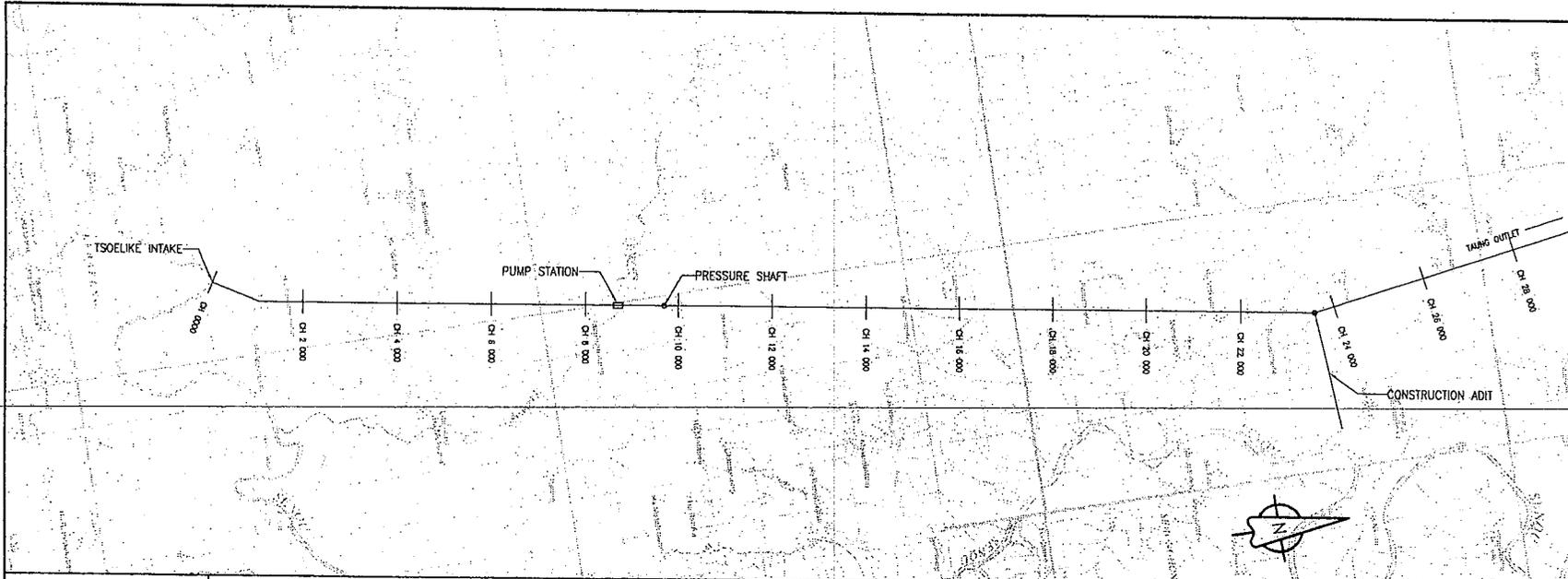
LESOTHO HIGHLANDS WATER PROJECT
 FEASIBILITY STUDY FOR PHASE II - STAGE 1

TAUNG - POLIHALI TUNNEL
 GENERAL ARRANGEMENT AND
 LONGSECTION
 SHEET 1 OF 1

G.A. SEED CONSULTANTS
 SEDI: Senu Engineering, Environmental and Development Consultants
 ECI: Krom Sheng PEE International SPC

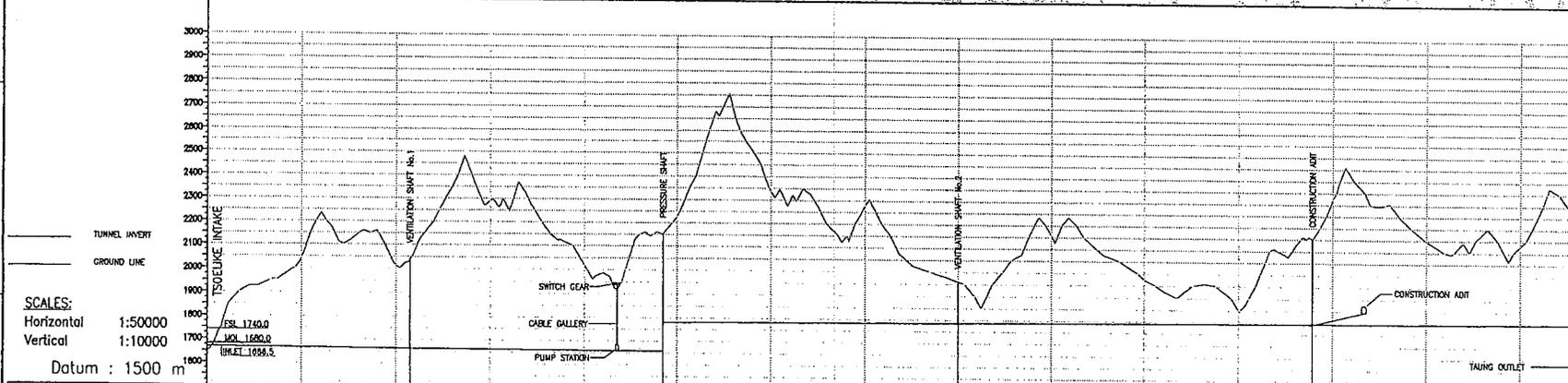
Project Manager _____ Date _____

Date 24/03/2006 Drawing No. 1-TU07-100-001 Rev. P01



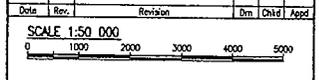
- NOTES:**
1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE SHOWN.
 2. ALL LEVELS IN METRES ABOVE SEA LEVEL (M.A.S.L.)
 3. SLOPE OF TUNNELS TO BE MODIFIED AT A LATER STAGE TO PROVIDE GRAVITY DRAINAGE DURING CONSTRUCTION, WHERE POSSIBLE.
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 5. THE FINAL HORIZONTAL AND VERTICAL ALIGNMENTS, AND THE POSITIONS OF THE INTAKES, OUTLETS AND OTHER STRUCTURES WILL BE DEPENDENT ON GEOLOGICAL CONDITIONS.

DRAFT



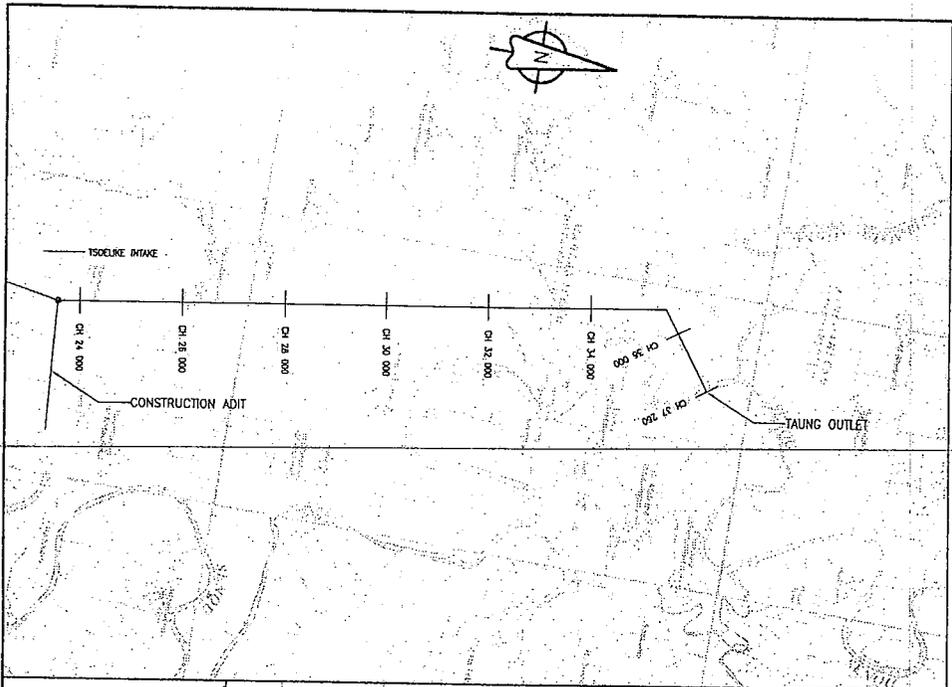
DEPTH	
TUNNEL INVERT	
CHAINAGE	
GRADE	
HORIZONTAL	
EXCAVATION METHOD	
DIAMETER & LINING	

DEPTH	1600	1700	1800	1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000
TUNNEL INVERT	1666.50	1864.50	1865.50	1865.50	1866.50	1868.50	1868.50	1868.50	1868.50	1868.50	1868.50	1868.50	1868.50	1868.50	1868.50
CHAINAGE	0+000	2+000.00	4+000.00	5+000.00	6+000.00	8+000.00	9+000.00	10+000.00	11+000.00	12+000.00	14+000.00	16+000.00	18+000.00	20+000.00	22+000.00
GRADE		-375.23	-351.79	-374.50	-250.98	-358.81	-405.50	-370.98	-426.70	-558.77	-486.76	-174.78	-376.84	-185.76	-271.15
HORIZONTAL	1 IN 1000 0.1000%														
EXCAVATION METHOD	TBM DRIVE No. 1					TBM DRIVE No. 2					TBM DRIVE No. 3				
DIAMETER & LINING	4.5m ID 250mm CONCRETE SEGMENTAL LINING					4.5m ID 250mm CONCRETE SEGMENTAL LINING					4.5m ID 250mm CONCRETE SEGMENTAL LINING				



DATE	REV.	REVISION	DRN	CHKD	APPD
SCALE 1:50 000					
DRG. NO.					
DRAWING TITLE					
RELATED DRAWINGS					
LESOTHO HIGHLANDS WATER COMMISSION Approval: _____ Chief Executive Officer Date					
LESOTHO HIGHLANDS WATER PROJECT FEASIBILITY STUDY FOR PHASE II - STAGE 1					
TSOELIKE - TAUNG TUNNEL GENERAL ARRANGEMENT AND LONGSECTION SHEET 1 OF 2					
 G4-SEED SEED: Seng Engineering, Environmental and Development Consultants E4: VVE International S&E: S&E					
Project Manager _____ Date _____ Date Drawing No. Rev.					
24/03/2006 1-TS05-100-001 P01					

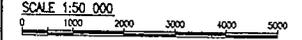
Designed: B. C. VILJOEN
 Drawn: J. H. BADEHORST
 Checked: P. WARDLELL
 Initial:



- NOTES:**
1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE SHOWN.
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DRAFT

Date	Rev.	Revision	Dim	Chgd	Appd



DRG. NO. _____ DRAWING TITLE _____

RELATED DRAWINGS

LESOTHO HIGHLANDS WATER COMMISSION

Approval: _____ Date _____

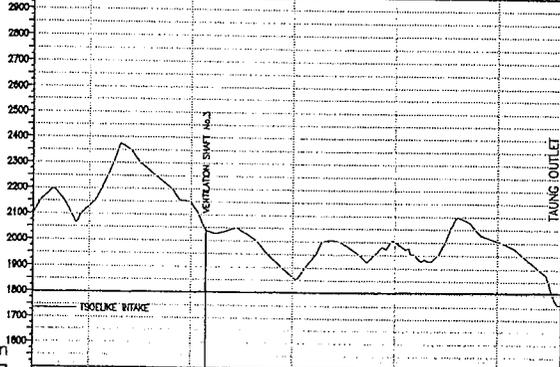
LESOTHO HIGHLANDS WATER PROJECT
FEASIBILITY STUDY FOR PHASE II - STAGE 1

TSOELIKE - TAUNG TUNNEL
GENERAL ARRANGEMENT AND
LONGSECTION
SHEET 2 OF 2

G.I. SEED CONTRACTORS SEED: Sewer Engineering, Equipment and Development Consultants EC: Kinam Seana VEE International SCS INC

Approval: _____ Project Manager _____ Date _____

Date **24/03/2006** Drawing No. **1-TS05-100-002** Rev. **P01**

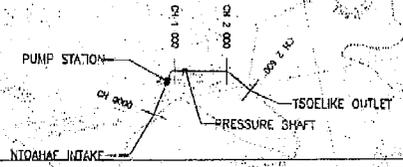


SCALES:
Horizontal 1:50000
Vertical 1:10000
Datum : 1500 m

DEPTH
TUNNEL INVERT
CHAINAGE
GRADE
HORIZONTAL
EXCAVATION METHOD
DIAMETER & LINING

28000.00	1787.24	-331.44	30000.00	1798.24	-344.62	30300.00	1798.40	-340.01	30000.00	1861.24	-82.18	3+000.00	1803.24	-188.78	36000.00	1885.24	-199.28	37260.00	1885.56	46.50
1 IN 1000																				
0.1:10000																				
— TBM																				
DRIVE No. 3																				
4.5m ID																				
250mm CONCRETE SEGMENTAL LINING																				

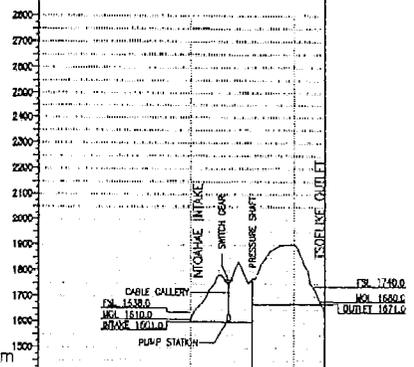
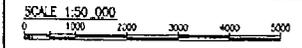
Designed: B C VILJOEN Drawn: J H BADENHORST Checked: P VARNBELL Initial:



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DRAFT

Date	Rev.	Revision	Dn	Chgd	Appd



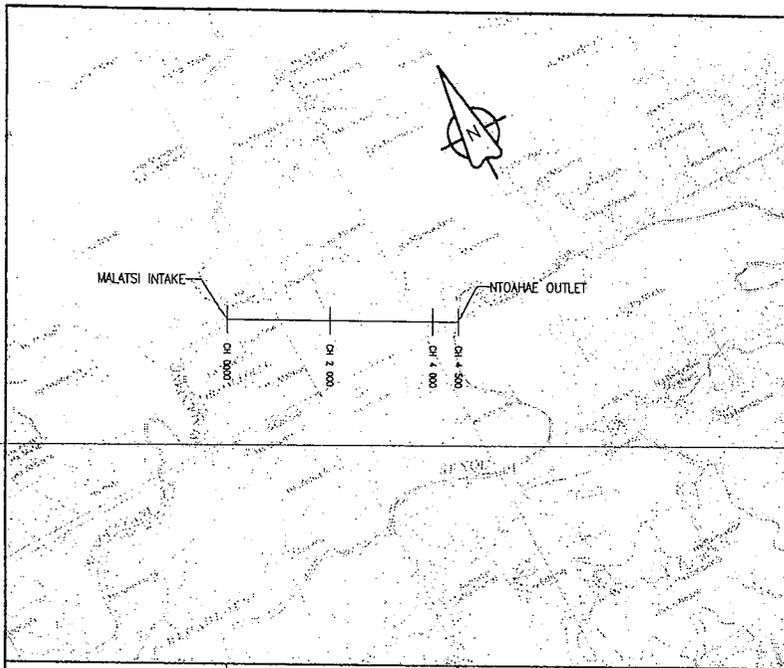
SCALES:
 Horizontal 1:50000
 Vertical 1:10000
 Datum : 1400 m

DEPTH	
TUNNEL INVERT	
CHAINAGE	
GRADE	
HORIZONTAL	
EXCAVATION METHOD	
DIAMETER & LINING	

	1.00	162.52	-97.72	-230.30	-46.00
	1631.00	1699.04	1881.00	1971.00	1671.00
	0.00	0000.00	0000.00	0000.00	2600.00
		1 IN = 1000	1 IN = 992.899		
		0.1000X	0.1000X		
		D&B	D&B		
		DRIVE No. 1	DRIVE No. 2		
		3.0m ID	3.0m ID		
		250mm CONCRETE IN SITU LINING			

Designed: B. C. VUKIĆEN Drawn: J. H. BENEHROŠTIČIĆ Checked: P. WARDLELL Initial:

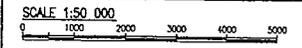
SAC. NO.	DRAWING TITLE	
RELATED DRAWINGS		
LESOTHO HIGHLANDS WATER COMMISSION		
Approval: _____ Date _____		
Chief Executive Officer		
LESOTHO HIGHLANDS WATER PROJECT		
FEASIBILITY STUDY FOR PHASE II - STAGE 1		
NTOAHAE - TSOELIKE TUNNEL		
GENERAL ARRANGEMENT AND LONGSECTION		
SHEET 1 OF 1		
SEC. S.E.D. C.D. Senior Engineering Senior Engineer Chief Engineer Supervisor Supervisor Supervisor 2008 2008 2008		
Approval: _____		
Project Manager Date _____		
Date	Drawn by No.	Rev.
24/03/2008	1-NT06-100-001	P01



- NOTES:**
1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE SHOWN.
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DRAFT

Date	Rev.	Revision	By	Chk'd	App'd



DRG. NO. _____ DRAWING TITLE _____

RELATED DRAWINGS _____

**LESOTHO HIGHLANDS
WATER COMMISSION**

Approval: _____
 Chief Executive Officer _____ Date _____

**LESOTHO HIGHLANDS WATER PROJECT
FEASIBILITY STUDY FOR PHASE II - STAGE 1**

**MALATSI - NTOAHAE TUNNEL
GENERAL ARRANGEMENT AND
LONGSECTION
SHEET 1 OF 1**

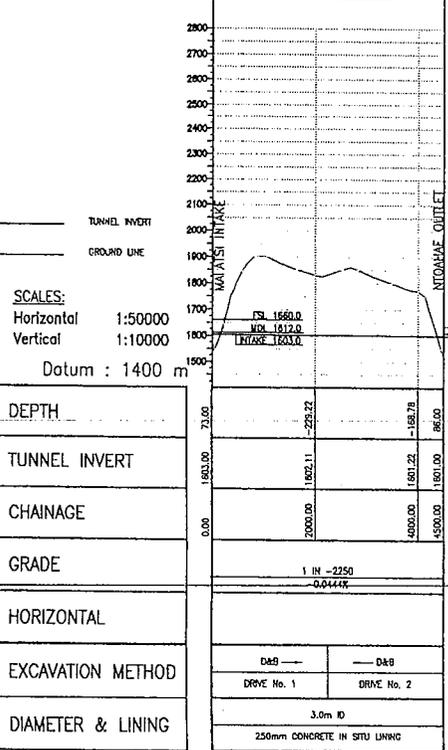
G-4-SEED HELP FUTURE **SEED** SEED Engineering, Construction and Development Consultants **CL** Minawa Sand & M&E International

Approval: _____

Project Manager _____ Date _____

Date: 24/03/2006 Drawing No. 1-ML08-100-001 Rev. P01

Designer: B. C. VILJOEN Drawn: J. H. BADEHORST/initial: Checked: P. WARDLELL Initial:



**STUDY FOR PHASE II
STAGE 1 SUPPORTING REPORT**

HYDROPOWER

APPENDIX D

MUELA – POLIHALI – MALATSI LAYOUTS

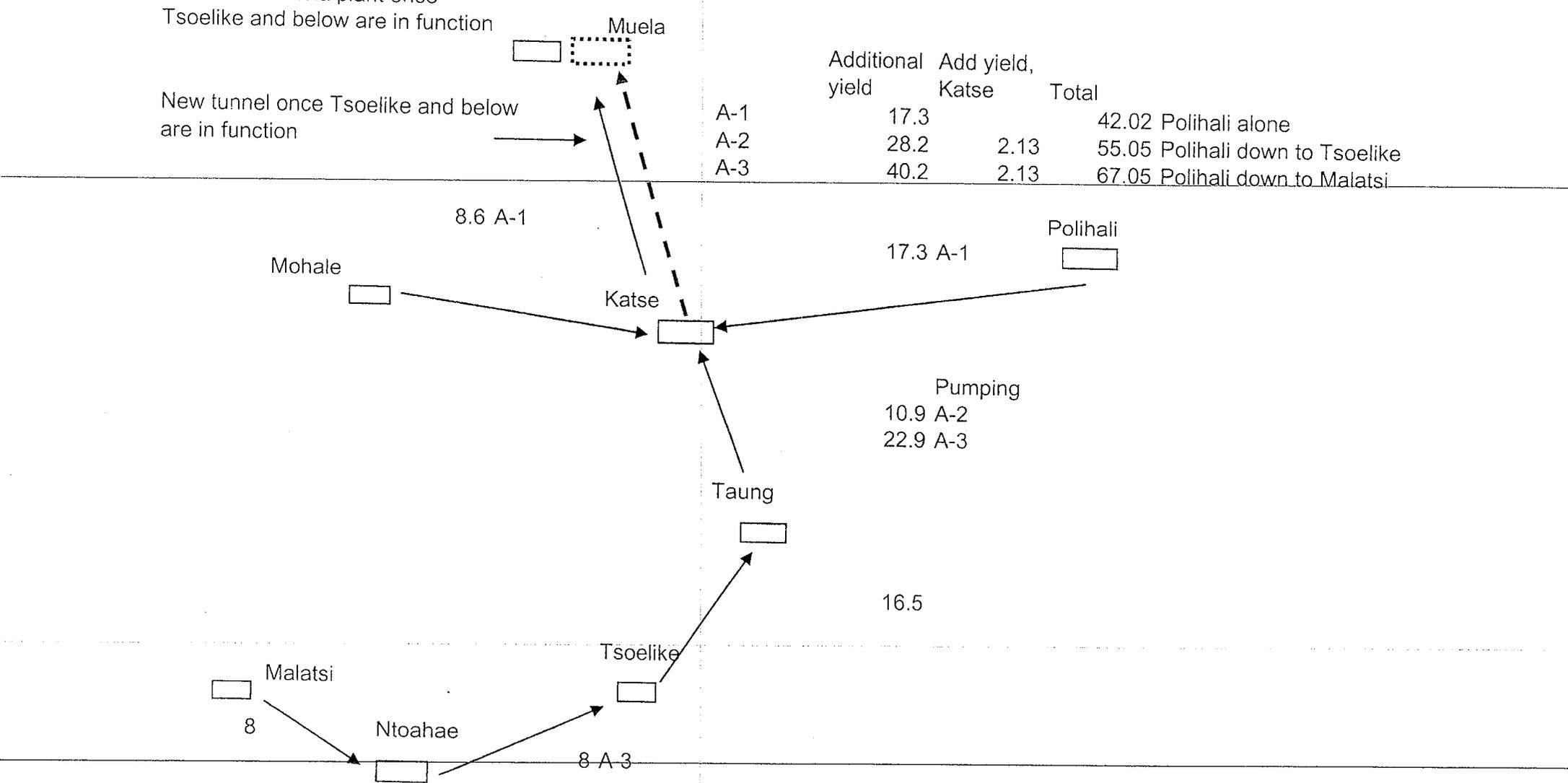
MAY 2006

DRAFT

Alternative A-1/3: Polihali into Katse, with development down to Malatsi

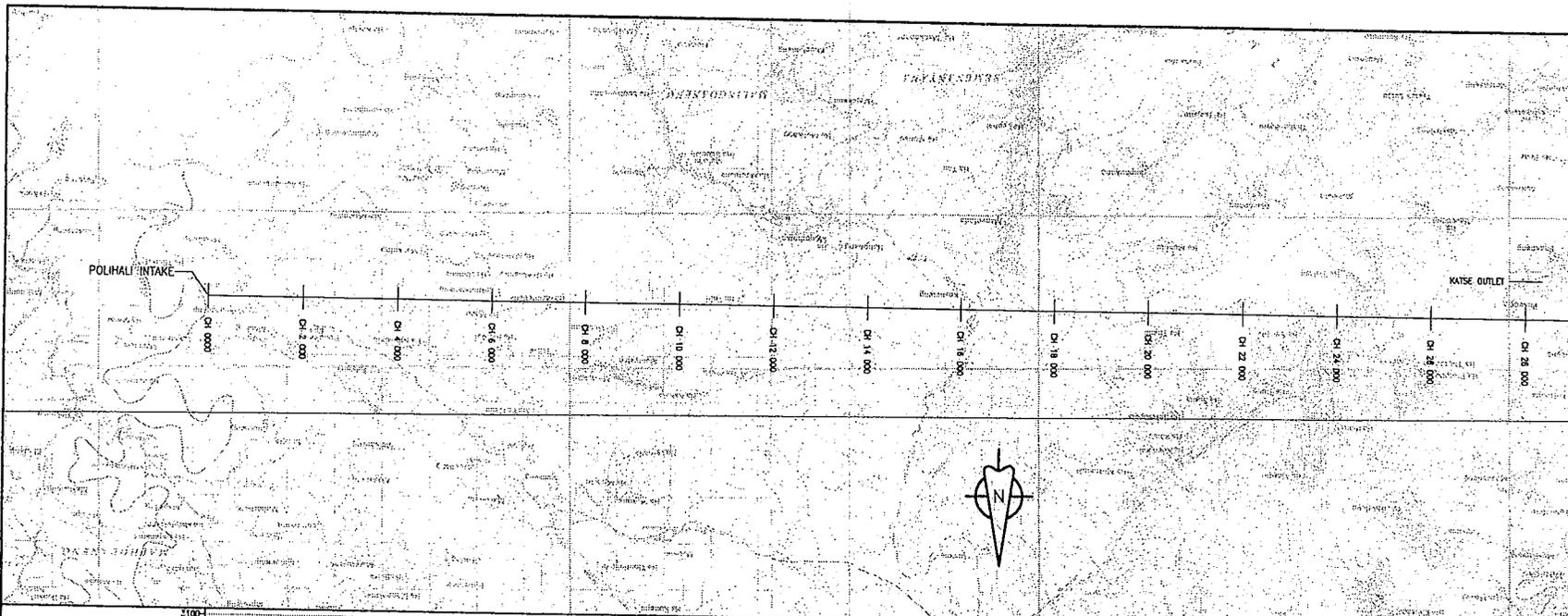
Addition to Muela plant once Tsoelike and below are in function

New tunnel once Tsoelike and below are in function



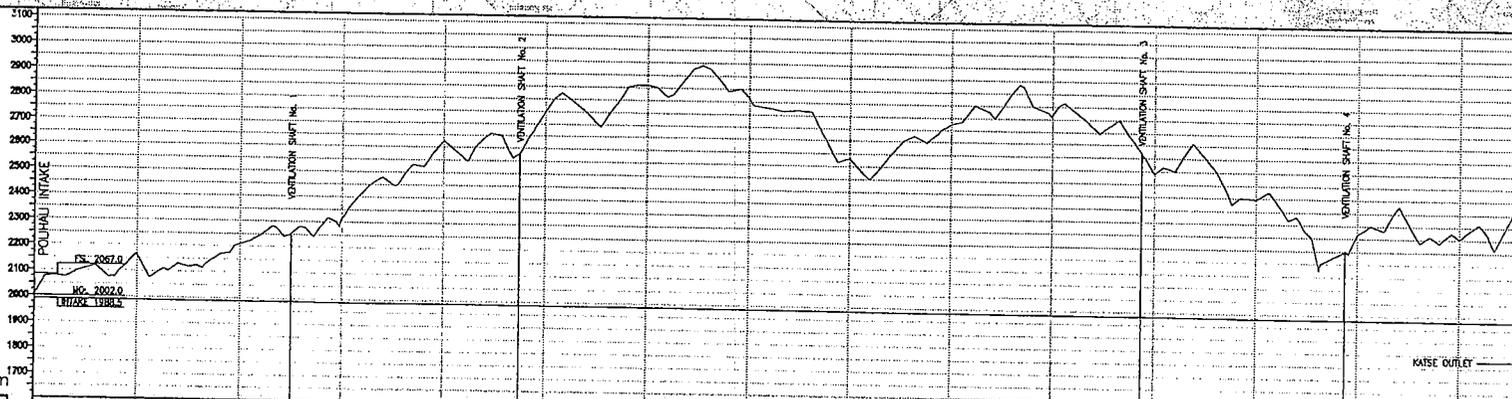
	Additional yield	Add yield, Katse	Total	
A-1	17.3		42.02	Polihali alone
A-2	28.2	2.13	55.05	Polihali down to Tsoelike
A-3	40.2	2.13	67.05	Polihali down to Malatsi

Pumping
10.9 A-2
22.9 A-3



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DRAFT



SCALES:
 Horizontal 1:50000
 Vertical 1:10000
 Datum : 1600 m

DEPTH
TUNNEL INVERT
CHAINAGE
GRADE
HORIZONTAL
EXCAVATION METHOD
DIAMETER & LINING

1988.50	1987.53	1987.15	1986.82	1986.48	1985.90	1985.30	1984.13	1984.46	1983.79	1983.11	1982.43	1981.76	1981.08	1980.41	1979.66	1978.94
2000.00	4000.00	5000.00	6000.00	8000.00	9500.00	10000.00	12000.00	14000.00	16000.00	20000.00	21750.00	22000.00	24000.00	23750.00	28000.00	

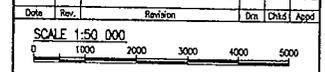
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0.0337x

TBM
DRIVE No. 1

TBM
DRIVE No. 2

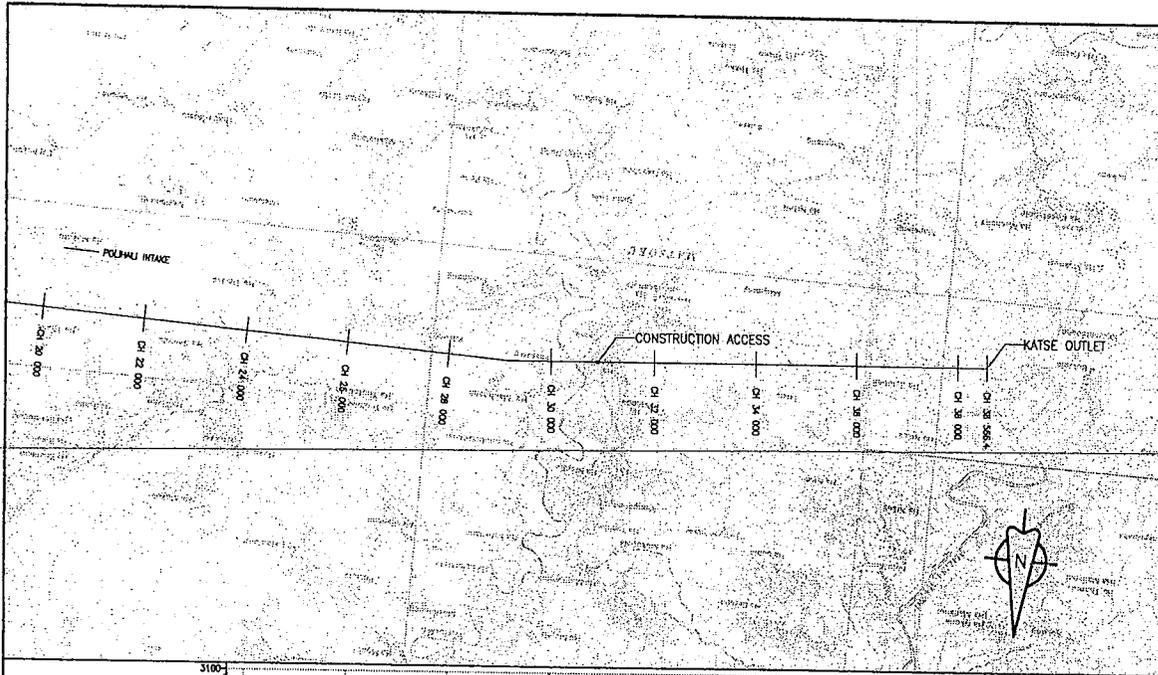
4.5m ID

250mm CONCRETE SEGMENTAL LINING



DRG. NO.	DRAWING TITLE
	RELATED DRAWINGS
LESOTHO HIGHLANDS WATER COMMISSION	
Approval:	
Chief Executive Officer	Date
LESOTHO HIGHLANDS WATER PROJECT	
FEASIBILITY STUDY FOR PHASE II - STAGE 1	
POLIHALI - KATSE TUNNEL	
GENERAL ARRANGEMENT AND LONGSECTION	
SHEET 1 OF 2	
Approval:	
Project Manager	Date
Date	Drawing No.
24/03/2006	1-P001-100-001
Rev.	P01

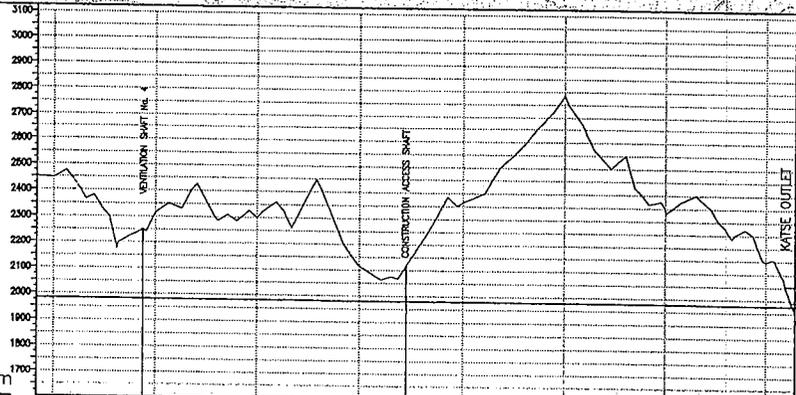
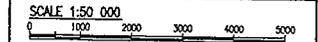
Designed: B C VILJOEN Initial:
 Drawn: J H BAOENHOF Initial:
 Checked: P VARNDELL Initial:



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DRAFT

Date	Rev.	Revision	Drn	Chkd	Appd



FSL 2053.0
 NOL 1889.0
 LOUITLET 1975.3

SCALES:
 Horizontal 1:50000
 Vertical 1:10000
 Datum : 1600 m

DEPTH	TUNNEL INVERT	CHAINAGE	GRADE	HORIZONTAL	EXCAVATION METHOD	DIAMETER & LINING
464.59	1980.41	24000.00				
286.17	1980.19	24720.00				
333.28	1979.74	25000.00				
220.84	1979.05	25950.00				
138.81	1978.39	30000.00				
138.53	1978.08	30900.00				
307.29	1977.71	32000.00				
807.95	1977.04	34000.00				
308.53	1976.37	35000.00				
109.31	1975.69	36000.00				
25.33	1975.50	38556.40				
1 IN = 2966.615 = 0.03371						
4.5m ID 250mm CONCRETE SEGMENTAL LINING						
			TBW DRIVE No. 2			
			TBW DRIVE No. 3			

Designed: B C MILJEN Initial:
 Drawn: J H BADENHORST Initial:
 Checked: P VARNDELL Initial:

DRG. No.	DRAWING TITLE
----------	---------------

**LESOTHO HIGHLANDS
 WATER COMMISSION**

Approval: _____
 Chief Executive Officer Date _____

**LESOTHO HIGHLANDS WATER PROJECT
 FEASIBILITY STUDY FOR PHASE II - STAGE 1**

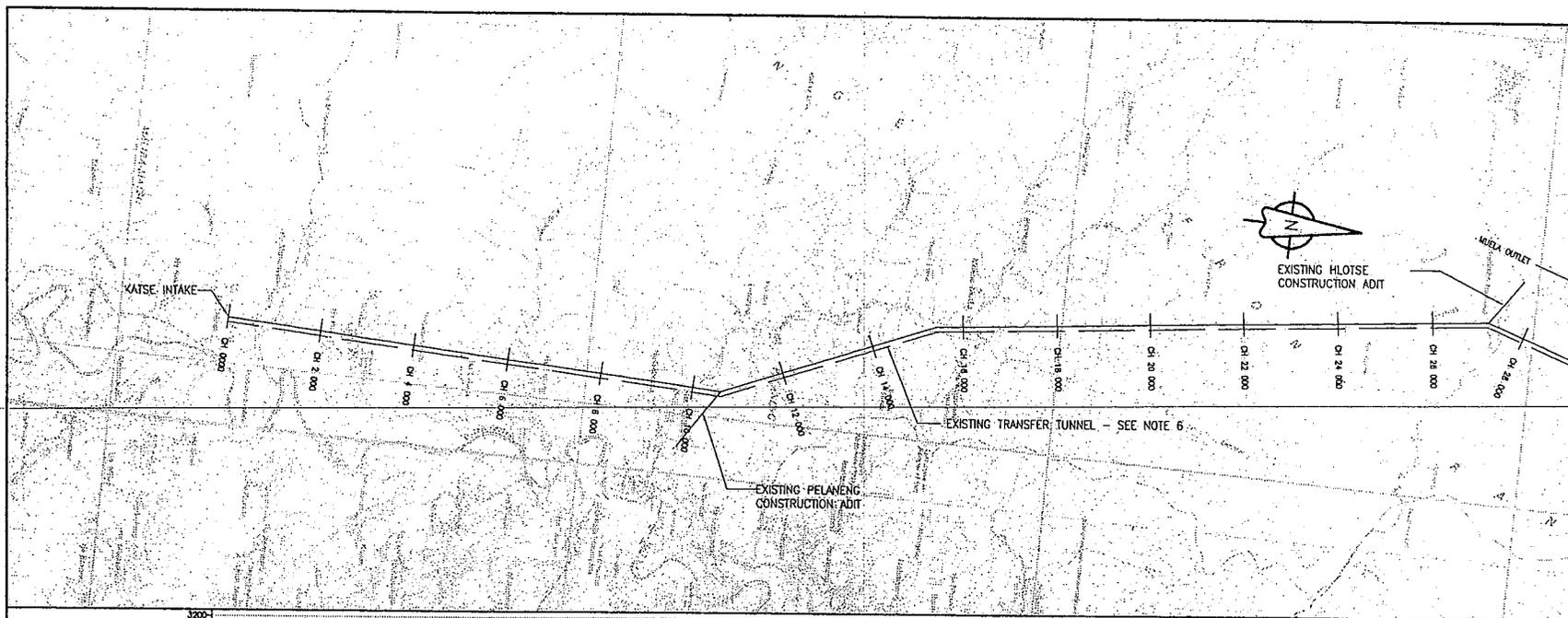
**POLIHALI - KATSE TUNNEL
 GENERAL ARRANGEMENT AND
 LONGSECTION
 SHEET 2 OF 2**

SET: Sengiso Engineering, Environment and Development Consultants
 CL: Graham Stead VEE International 2004 SEC

Approval: _____
 Project Manager Date _____

Date	Drawing No.	Rev.
24/03/2006	1-P001-100-002	P01

Designed: B C VILJOEN Drawn: J H BAUCHHORN Checked: P VANDERBELL Initial:
 Initial: Initial: Initial:

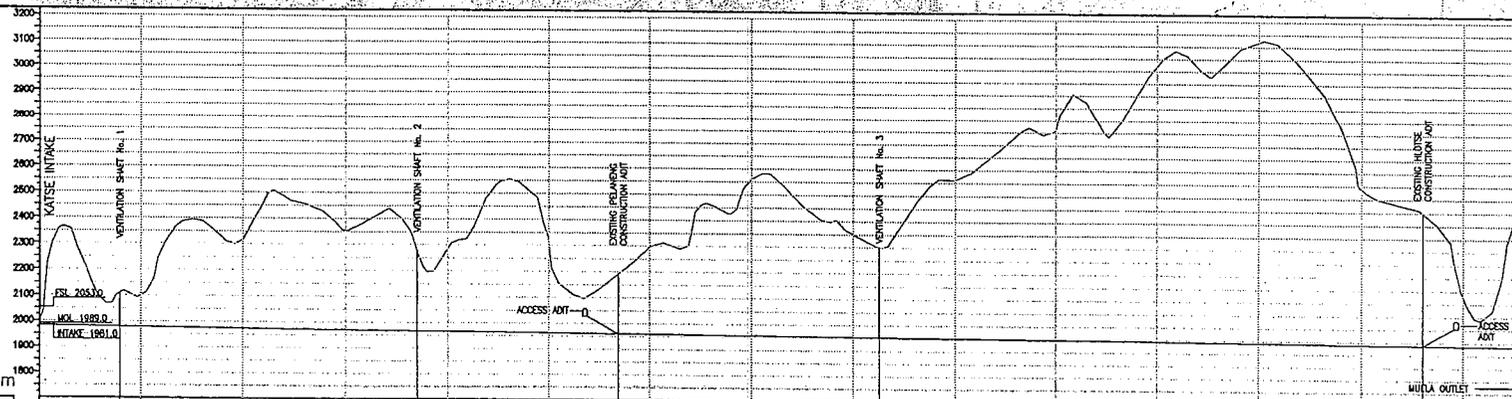


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 6. THE POSITION OF THE EXISTING TRANSFER TUNNEL IS INDICATIVE ONLY.
 7. FOR DETAILS OF HYDROPOWER COMPONENTS SEE HYDROPOWER STAGE 1 SUPPORTING REPORT.

DRAFT

Date	Rev.	Revision	By	Check	Appr.

SCALE 1:50 000
 0 1000 2000 3000 4000 5000



DEPTH	TUNNEL INVERT	CHAINAGE	GRADE	HORIZONTAL	EXCAVATION METHOD	DIAMETER & LINING
0.00	1981.00	0.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
0.00	1981.00	1590.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
0.00	1981.00	2000.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
0.00	1981.00	4600.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
0.00	1981.00	6000.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
0.00	1981.00	7350.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
0.00	1981.00	8000.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
0.00	1981.00	10000.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
0.00	1981.00	11365.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
0.00	1981.00	12000.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
0.00	1981.00	14000.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
0.00	1981.00	16000.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
0.00	1981.00	16512.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
0.00	1981.00	18000.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
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0.00	1981.00	27200.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING
0.00	1981.00	28000.00	1 IN -495 -0.20204		TBM	4.35m ID 250mm CONCRETE SEGMENTAL LINING

DRG. NO. DRAWING TITLE
 RELATED DRAWINGS

LESOTHO HIGHLANDS WATER COMMISSION

Approval: _____
 Chief Executive Officer Date

LESOTHO HIGHLANDS WATER PROJECT
FEASIBILITY STUDY FOR PHASE II - STAGE 1

KATSE - MUELA TUNNEL
HYDROPOWER OPTION
GENERAL ARRANGEMENT AND
LONGSECTION - SHEET 1 OF 2

G4-SEED SEED: Sengiso Engineering, Environment and Development Consultants CE: Khomo Shano VEE International SOC

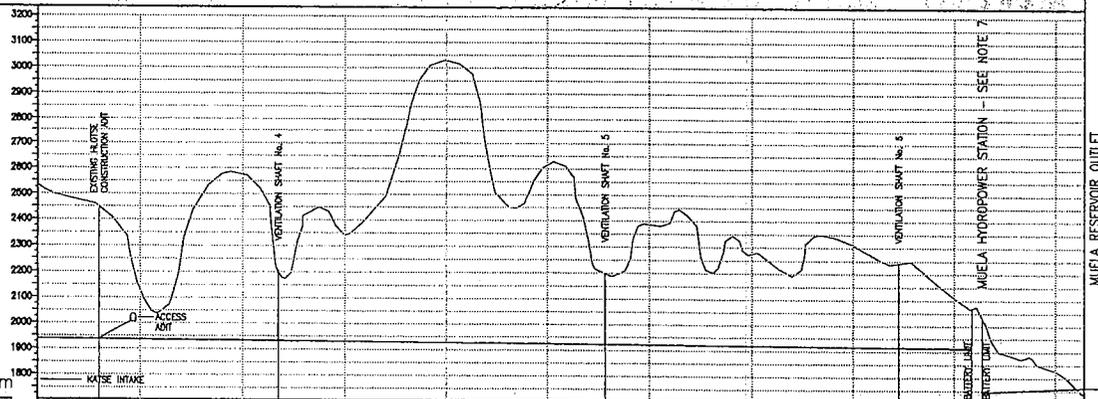
Approval: _____
 Project Manager Date

Date Drawing No. Rev.
 24/03/2006 1-KT02-100-001 P01

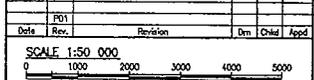


- NOTES:**
1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE SHOWN.
 2. ALL LEVELS IN METRES ABOVE SEA LEVEL (M.A.S.L.)
 3. SLOPE OF TUNNELS TO BE MODIFIED AT A LATER STAGE TO PROVIDE GRAVITY DRAINAGE DURING CONSTRUCTION, WHERE POSSIBLE.
 4. THE HORIZONTAL AND VERTICAL ALIGNMENTS AND THE POSITIONS OF CONSTRUCTION ACCESS, VENTILATION SHAFTS, INTAKES AND OUTLETS TO BE MODIFIED AND/OR DETERMINED WHEN HIGHER RESOLUTION SURVEY DATA IS OBTAINED AND DAM OPERATING LEVELS ARE FINALISED.
 5. THE FINAL HORIZONTAL AND VERTICAL ALIGNMENTS, AND THE POSITIONS OF THE INTAKES, OUTLETS AND OTHER STRUCTURES WILL BE DEPENDENT ON GEOLOGICAL CONDITIONS.
 6. THE POSITION OF THE EXISTING TRANSFER TUNNEL IS INDICATIVE ONLY.
 7. FOR DETAILS OF HYDROPOWER COMPONENTS SEE HYDROPOWER STAGE 1 SUPPORTING REPORT.

DRAFT



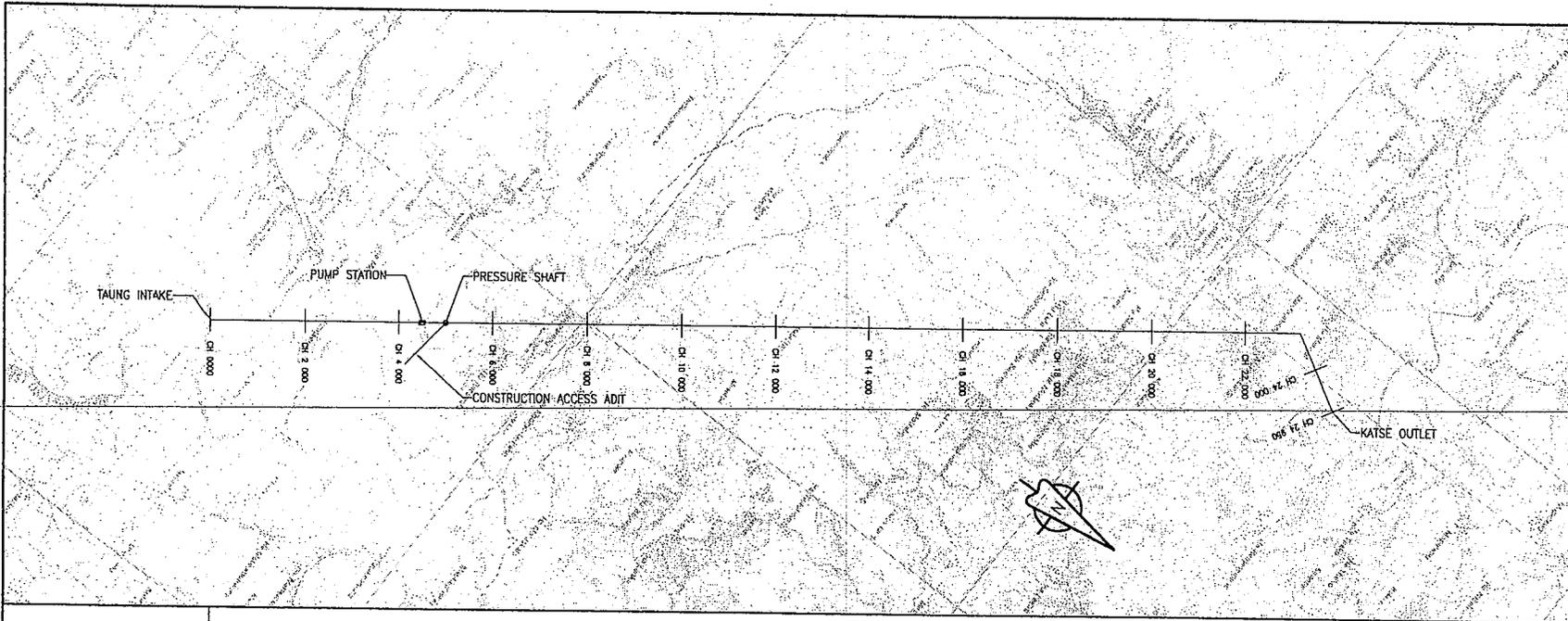
DEPTH	TUNNEL INVERT	CHAINAGE	GRADE	HORIZONTAL	EXCAVATION METHOD	DIAMETER & LINING
-513.31	1933.59	27500.00	1:100000	0.14568	TBW	4.35m ID 250mm CONCRETE SEGMENTAL LINING
-193.20	1933.81	28000.00	1:100000	0.14568	DRIVE No. 3	
-543.77	1936.00	30000.00	1:100000	0.14568	TB4	4.35m ID 250mm CONCRETE SEGMENTAL LINING
-270.50	1939.39	30991.00	1:100000	0.14568	DRIVE No. 4	
-415.24	1977.99	32000.00	1:100000	0.14568	TB4	4.35m ID 250mm CONCRETE SEGMENTAL LINING
-1103.33	1925.08	34000.00	1:100000	0.14568	DRIVE No. 4	
-697.38	1922.17	36000.00	1:100000	0.14568	TB4	4.35m ID 250mm CONCRETE SEGMENTAL LINING
-776.08	1921.18	37100.00	1:100000	0.14568	DRIVE No. 4	
-666.30	1916.25	38000.00	1:100000	0.14568	TB4	4.35m ID 250mm CONCRETE SEGMENTAL LINING
-356.83	1915.34	40000.00	1:100000	0.14568	DRIVE No. 4	
-395.87	1915.43	42000.00	1:100000	0.14568	TB4	4.35m ID 250mm CONCRETE SEGMENTAL LINING
-395.31	1914.22	43000.00	1:100000	0.14568	DRIVE No. 4	
-197.81	1910.52	44000.00	1:100000	0.14568	TB4	4.35m ID 250mm CONCRETE SEGMENTAL LINING
-132.35	1910.00	44356.00	1:100000	0.14568	DRIVE No. 4	
-298.84	1772.50	44550.00	1:100000	0.14568	TB4	4.35m ID 250mm CONCRETE SEGMENTAL LINING
-702.28	1755.33	46000.00	1:100000	0.14568	DRIVE No. 4	
31.00	1751.00	46575.00	1:100000	0.14568	TB4	4.35m ID 250mm CONCRETE SEGMENTAL LINING



Drawn: J. H. BODENKORS; Checked: P. VANDELLE; Initial:
 Designer: B. C. VILJOEN; Initial:

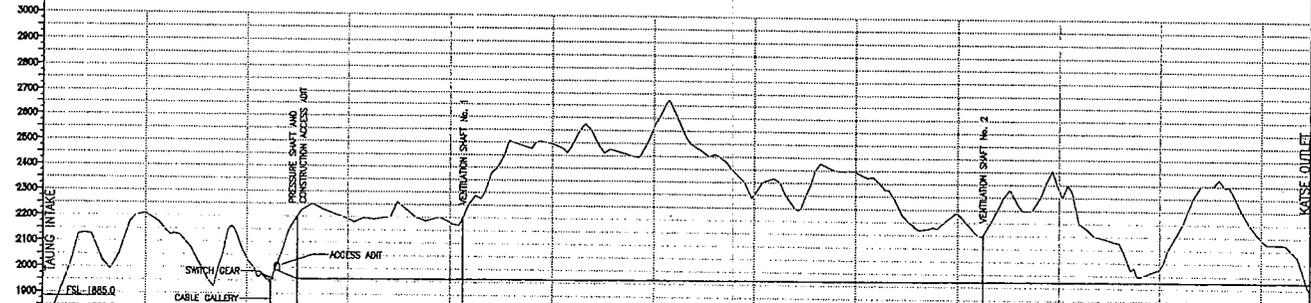
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DRG. NO. _____ DRAWING TITLE _____
 RELATED DRAWINGS _____
LESOTHO HIGHLANDS WATER COMMISSION
 Approved: _____ Date _____
 Chief Executive Officer _____ Date _____
LESOTHO HIGHLANDS WATER PROJECT
FEASIBILITY STUDY FOR PHASE II - STAGE 1
KATSE - MUELA TUNNEL
HYDROPOWER OPTION
GENERAL ARRANGEMENT AND LONGSECTION - SHEET 2 OF 2
C4-SEED SFD: Senzo Engineering, Design and Development Consultants; ES: Wahan Shand WE International; 0004 584
 Approved: _____ Date _____
 Project Manager _____ Date _____
 Date 24/03/2006 Drawing No. 1-KT02-100-002 Rev. P01



- NOTES:**
1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE SHOWN.
 2. ALL LEVELS IN METRES ABOVE SEA LEVEL (M.A.S.L.)
 3. SLOPE OF TUNNELS TO BE MODIFIED AT A LATER STAGE TO PROVIDE GRAVITY DRAINAGE DURING CONSTRUCTION, WHERE POSSIBLE.
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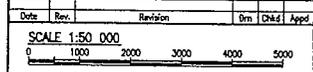
DRAFT



SCALES:
 Horizontal 1:50000
 Vertical 1:10000
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DEPTH	TUNNEL INVERT	CHAINAGE	GRADE	HORIZONTAL	EXCAVATION METHOD	DIAMETER & LINING
34.50	1806.50	0.00	1 IN -1000 0:1000%		TBM	4.5m ID 250mm CONCRETE SEGMENTAL LINING
102.50	1894.50	2000.00			DRIVE No. 1	
234.31	1862.50	4000.00			DRIVE No. 2	
297.90	1817.50	5000.00			DRIVE No. 3	
343.05	1762.50	6000.00				
333.45	1766.50	8000.00				
221.45	1904.50	8000.00				
236.06	1904.50	8000.00				
258.46	1902.50	10000.00				
508.56	1902.50	12000.00				
335.45	1964.50	14000.00				
676.46	1904.50	16000.00	1 IN 1000 0.1000%			4.5m ID 250mm CONCRETE SEGMENTAL LINING
262.36	1904.50	18000.00				
187.60	1904.50	18000.00				
359.82	1970.50	20000.00				
50.45	1972.50	22000.00				
116.45	1974.50	24000.00				
65.50	1975.50	24500.00				

FSL 1885.0
 MSL 1920.0
 UNLT 1826.6
 UNLT 1825.5



DATE, NO., REV., REVISION, DRWG TITLE, RELATED DRAWINGS

LESOTHO HIGHLANDS WATER COMMISSION

Approval: Chief Executive Officer Date

LESOTHO HIGHLANDS WATER PROJECT
 FEASIBILITY STUDY FOR PHASE II - STAGE 1

TAUNG - KATSE TUNNEL
 GENERAL ARRANGEMENT AND LONGSECTION
 SHEET 1 OF 1

G4-SEED (ENVIRONMENTAL)
 SEDI: Seng Engineering, Environmental and Development Consultants
 ICI: Waram Shani WE International COBA SPC

Approval: Project Manager Date

Date 24/03/2006 Drawing No. 1-TU01-100-001 Rev. P01

Designed: B. C. MUMDEN
 Drawn: J. H. BADENHORST
 Checked: P. VARDIPELL
 Initial:

**STUDY FOR PHASE II
STAGE 1 SUPPORTING REPORT**

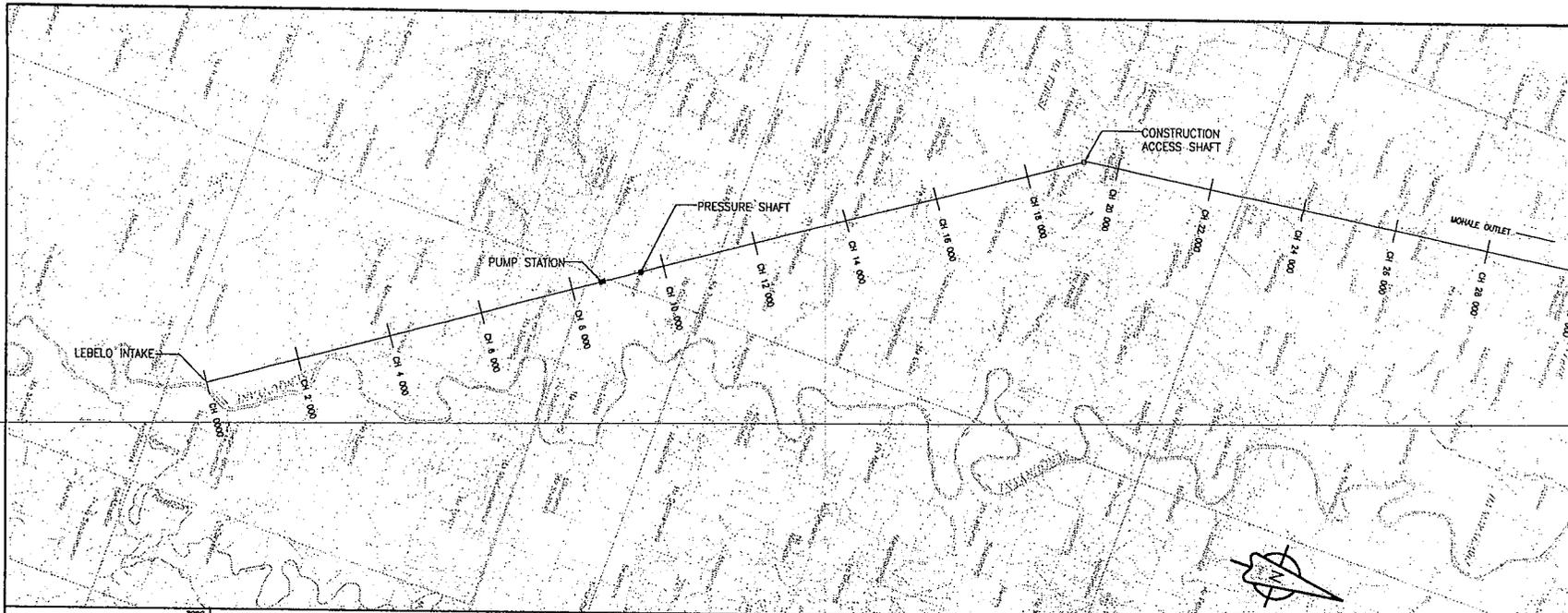
HYDROPOWER

APPENDIX E

LEBELO TO MOHALE LAYOUTS

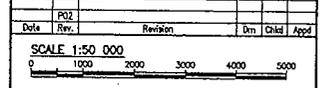
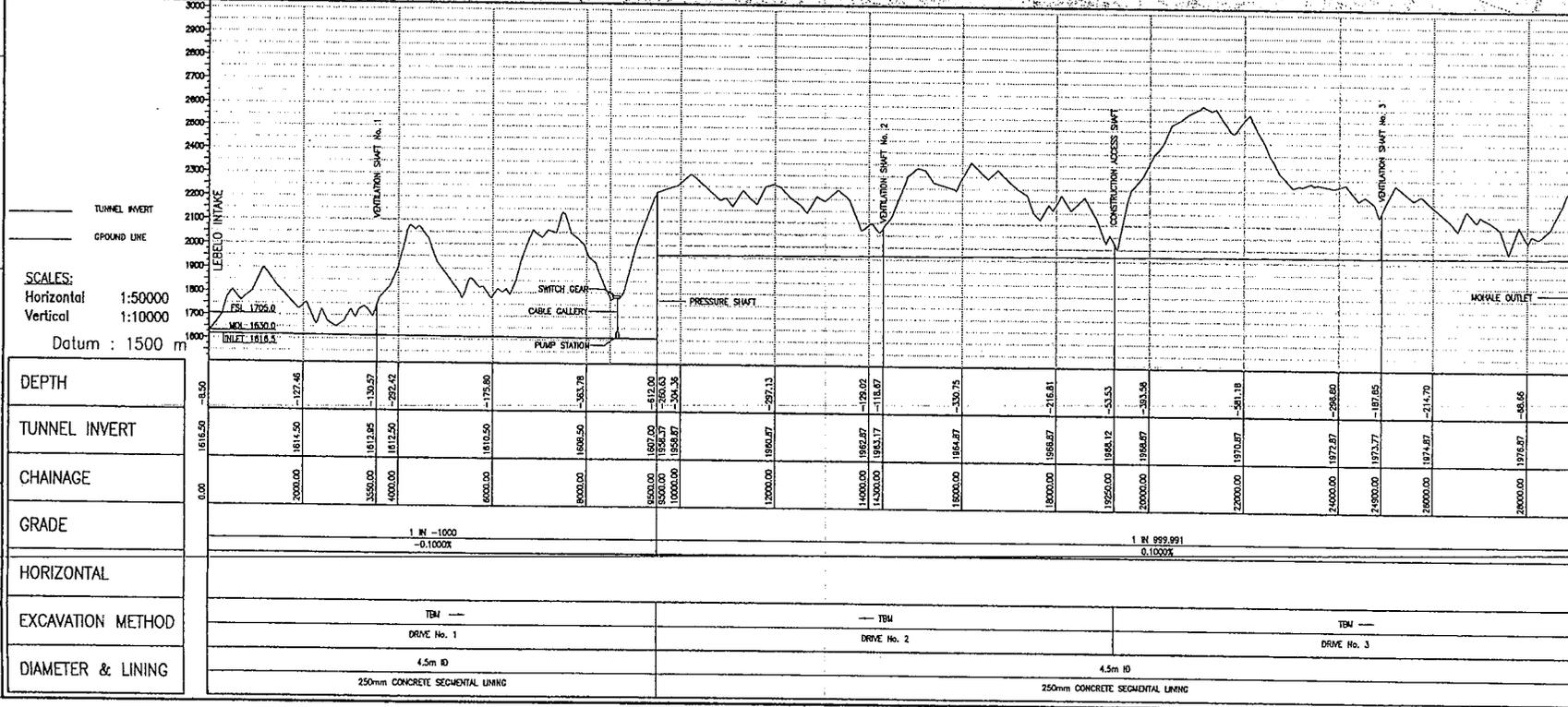
MAY 2006

DRAFT



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DRAFT



SCALE 1:50 000

LESOTHO HIGHLANDS WATER COMMISSION

FEASIBILITY STUDY FOR PHASE II - STAGE 1

LEBELO - MOHALE TUNNEL

GENERAL ARRANGEMENT AND LONGSECTION

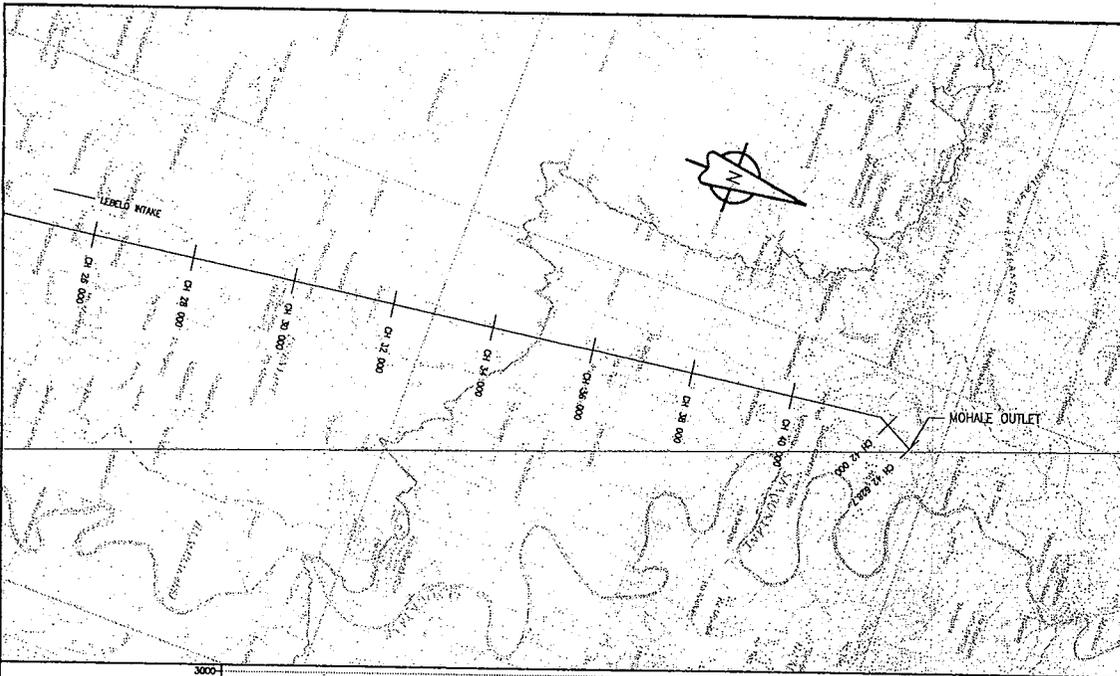
SHEET 1 OF 2

Designed: B C VILJOEN Initial: ... Drawn: J H BAEHORH/Motlo ... Checker: P VANDELLE Initial: ...

Approval: _____

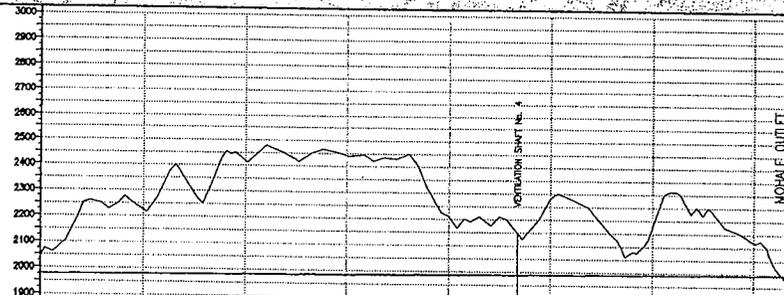
Project Manager: _____ Date: _____

Date: 24/03/2008 Drawing No. 1-LB03-100-001 Rev. P02



- NOTES:**
1. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE SHOWN.
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DRAFT

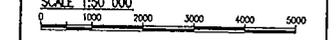


SCALES:
 Horizontal 1:50000
 Vertical 1:10000
 Datum : 1500 m

DEPTH	
TUNNEL INVERT	
CHAINAGE	
GRADE	
HORIZONTAL	1 IN 999.991 0.1000%
EXCAVATION METHOD	TBM DRIVE No. 3
DIAMETER & LINING	TBM DRIVE No. 4 4.5m ID 250mm CONCRETE SEGMENTAL LINING

	244.31	-435.48	-59.28	-225.13	-101.08	-293.13	-188.13	-128.13	1850
1976.87	1980.87	1982.87	1984.87	1986.87	1988.87	1990.87	1992.87	1994.87	1991.50
3000.00	3000.00	3400.00	3000.00	3730.00	3800.00	4000.00	4000.00	4000.00	4282.75

24/03/06 P02 ALIGNMENT REVISED		SRB	PV
Date	Rev.	Rev.	Rev.
		DR	DR



DRG. NO. _____ DRAWING TITLE _____
 RELATED DRAWINGS _____

LESOTHO HIGHLANDS WATER COMMISSION

Approval: _____
 Chief Executive Officer _____ Date _____

LESOTHO HIGHLANDS WATER PROJECT
 FEASIBILITY STUDY FOR PHASE II - STAGE 1

LEBELO - MOHALE TUNNEL
 GENERAL ARRANGEMENT AND LONGSECTION
 SHEET 2 OF 2

C4-SEED CONSULTANTS
 SEED: Siriso Engineering, Environment and Development Consultants
 CE: Mosen, Brand WE International
 G084 500

Approval: _____
 Project Manager _____ Date _____

Date 24/03/2006 Drawing No. 1-LB03-100-002 Rev. P02

Designed: B C VILJOBY Initiat: J H BAOENHISTHAB: Check: P VARNDELL Initiat:
 Drawn: J H BAOENHISTHAB:

**STUDY FOR PHASE II
STAGE 1 SUPPORTING REPORT**

HYDROPOWER

APPENDIX G

DETAILED COST ESTIMATE AND ECONOMIC ASSESSMENT

MAY 2006

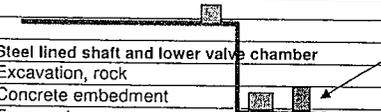
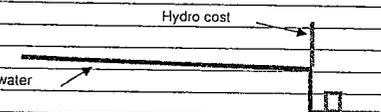
DRAFT

ANNEX COST A2: SUMMARY SHEET OF COST			II_B1: Polihali, Muela-1st stage	II-B2: Tsoelike-Polihali to Muela,	II-B3: Malatsi-Polihali to Muela	II-A-1: Polihali alone to Katse, no add cost at Muela Gravity	II-A-3: Poli-Katse & Malatsi-Taung>Katse; all to Muela	Oxbow to Muela Peak plant
No.	DESCRIPTION							
DAMS								
1	Polihali dam and appurtenant works							
2		0						
3		0						
4		0						
5		0						
6	Oxbow dam							
7	Lebelo							
TUNNELS								
9	Headrace and Tailrace Tunnel							
10	Intake at dam							
12	Surge shaft							
13	Pressure tunnel/penstock, civil and steel							
14	Powerhouse							
15	Switchyard - civil							
16	Tailrace tunnel outlet works							
17	Total mechanical equipment and turbines							
18	Total Electrical system							
19	Total transmission lines							
	Total							
Cost of tunnels, pumping stations, capitalized pumping cost (see Tunnel costing/ Pumping stations)								
	Taung (to Polihali)							
	Taung tunnel							
	Tsoelike to Taung tunnel							
	Ntoahae to Tsoelike tunnel							
	Malatsi tunnel							
	Taung to Muela, gravity							
	Polihali to Katse tunnel							
	Katse to Muela, second tunnel							
	TOTAL TENDER COST							
GE, ENGINEERING ETC								
75%	Preliminary and general	75%						
18%	Contingencies	18%						
15%	Planning, design, supervision and EIA	15%						
1%	Health and safety	1%						
10%	Cost relocations	10%						
5%	Clients administration	5%						
124%	Total multiplier	1,24	124%					
	TOTAL DEVELOPMENT COST							

ANNEX A1: GEOMETRICAL DEFINITION; COST OF HYDRO; REVENUE OF POWER SALES AND HYDRO B/C RATIO										
Alternatives >>			II-B1: Polihali to Muela	II-B2: Tsoelike-Polihali to Muela,	II-B3: Malatsi-Polihali to Muela	II-A1: Polihali to Katse, no added cost at Muela	II-A-3: Poli-Katse & Malatsi-Taung-Katse; all to Muela	Oxbow to Muela Peak plant		
A: Geometrial definition			RWL	2 065	2 065	2 065	2 053	2053	2525	
			MOL	1 983	1 983	1 983	1 989	1989	2480	
			Inv Lev	1 975	1 975	1 975	1980	1980	2470	
			TWL	1761	1761	1761	1761	1761	1761	
			L(headr.)	72200	72200	72 200	38 570	38 570	16079	
Turbine and waterway data									Incl. tailrace	
Number of turbines				2	3	4	3-no new	3,7	4	
MW installed			MW	54	81	108	81	99	92	
MW-Yield			Ka	42,0	70,3	90,7	82,8	99,7		
Hours of operation			H	18,5	20,6	19,9	24,3	24,0	6,0	
Length of waterway			f				Old tunnel			
			0,0141	L	72200	72200	72200	44954	38570	16079
Head loss, m, for 25 years Ka of 1 mm			Hloss	73,54	7,56	20,68	39,66	52,08	9,46	8,54
Net Head			Head(n)	272	259	240	221	263	742	
Tunnel flow			45	17,3	28,3	40,2	17,5	17,5	14	
Yield, m3/s (2.13 m3/s in Katse)			Qrated	33,14	17,30	30,43	42,40	42,00	42,40	2,50
Velocity in waterway			V(m/s)	0,85	1,49	2,08	2,64	2,67	0,22	
Internal diameter, all lined			Dh	5,10	5,1	5,1	4,50	4,50	3,6	
Lower pressure tunnel/ penstock diameter			Dst	3,2	3,11	3,67	2,50	3,67	0,89	
GWh	Invert intake level at dam site		River at dam	1975	1 975,0	1 975	1980	1980	2470	
B: Cost data, including general, engineering, owner's cost, etc, but not cost of financing or interest during construction										
					Base, daily	Peak. 6 h/day	Night. base. pumping	15,76		
				R/kWh	25	35,0	20			
				\$/kWh	0,038	0,054	0,031			
GWh/a				363,7	608,9	786,2	717,0	863,6	200,8	
Carbon credit									0,54	
GWH/a check				367,8	615,7	794,9	725,0	873,2	203,1	
Sales of electricity per year, mio US\$			\$/kWh	0,040	14,57	24,39	31,50	28,73	34,60	10,84
Hydro cost alone; including general, engineering and Owner's cost				130,7	161,6	195,5	11,9	315,0	135,3	
B/C hydro alone				1,76	2,38	2,54	38,18	1,73	1,26	
					11	6	7			
					0,46	0,25	0,29			

DETAILED COST ESTIMATING										
3	Dam and appurtenant works				II_B1: Polihali, Muela-1st stage	II-B2: Tsoelike-Polihali to Muela.	II-B3: Malatsi-Polihali to Muela	II-A-1: Polihali alone to Katse, no add cost at Muela	II-A-3: Poli>Katse & Malatsi-Taung>Katse; all to Muela	Oxbow to Muela Peak plant
9	Headrace and Tailrace Tunnel	Unit			72200,00	72200,00	72200,00	38570,00	38570,00	16079,00
					5,10	5,10	5,10	4,50	4,50	3,60
9,1	Tunnel excavation	m3			Detailed cost estimate deleted. For ~cost, refer to the Tunnel Report. For comments on this, refer to Section 7 of the Hydro Report			Detailed cost estimate deleted. For ~cost, refer to the Tunnel Report. For comments on this, refer to Section 7 of the Hydro Report		
9,2	Rock bolts, 3 m, 25 mm, 2 per m	nos								
9,3	Rock bolts spilling, 6 m, dia 25 mm	nos								
9,4	Clearing tunnel walls and roof	m2								
9,5	Clearing tunnel invert	m2								
9,6	Concrete lining, for Oxbow, 15%	m3								
9,8	Reinforcement	Tons								
9,9	Fiber Reinforced Shotcrete	m3								
9,10	Miscellaneous, including dewatering	%	60%							
	Total Headrace									
10	Intake at dam									
10,1	Loose excavation, incl. for ramp	m3			Detailed cost estimate deleted. For ~cost, refer to the Tunnel Report. For comments on this, refer to Section 7 of the Hydro Report			Detailed cost estimate deleted. For ~cost, refer to the Tunnel Report. For comments on this, refer to Section 7 of the Hydro Report		
10,2	Rock excavation	m3								
10,3	Shaft excavation	m3								
10,4	Rock bolts, 3 m dia 25	nos								
10,5	Rock bolts spilling, 6 m dia 25	nos								
10,6	Fiber Reinforced Shotcrete	m3								
10,7	Formwork	m2								
10,8	Concrete	,3								
10,9	Reinforcement	ton								
10,10	Intake gates	W	2							
		H								
		Head								
10,11	Maintenance, sliding gates	1500	2							
10,12	Trash racks	m2								
10,13	Miscellaneous Items	%	30%							
	Total Power Intake	Mohale HB valve								

12	Surge shaft		L	72 200,00	72 200,00	72 200,00	Nothing more	38 570,00	16079,00
				187,5	185	185,0		185,0	789,0
			At	20,43	20,43	20,43		15,90	11,53
				7703,9	4168,3	2772,1		2370,7	2370,7
			*10						
			A-shaft	118,46	140,65	153,67		945,98	0,25
			D-shaft	12,28	13,38	13,99		34,71	0,57
			Vp	6,00	6,00	6,00		6,00	11,00
			Dp	1,35	1,80	2,12		2,12	0,38
			A-orifice	1,15	2,03	2,83		2,83	0,09
			D-orifice	1,21	1,61	1,90		1,90	0,34
			*2.2						
			D_shaft_2	16,27	17,91	18,88		29,82	0,51
			0,35					0,0	35,0
			Upsurge	262,3	0,0	0,0		0,0	35,0
			Top level	2318,3	2056,0	2056,0		2056,0	2091,0
12,1	Surface excavation loose rock	m3		3 000	3 000	3 000		6 000	6 000
12,2	Galleries	m3		10.800	10.800	10.800		6.000	6.000
12,3	Shaft excavation	m3		22 217	26 020	28 429		175 007	199
12,4	Rock bolts, 2.4 m, dia 25	nos		6 392	5 605	5 605		5 605	5 710
12,5	Fiber Reinforced Shotcrete	m		473	473	473		20 372	339
	Concrete lining	m3		4 728	5 205	5 486		10 085	702
	Reinforcement	tons		284	312	329		605	42
12,6	Miscellaneous Items	%		20%	20%	20%		20%	20%
	Total Surge Shaft and galleries								
			L	New			Nothing at Muela	rom Katse to Muela called for	
13	Pressure tunnel/penstock, civil and steel								
	Water related cost in blue		L	360	150	150		42,4	2,50
	Upper tunnel valve/gate chamber or vertical shaft						L = >>>	150	150
			t(mm)-Pw	14,15	13,76	16,24		31,21	22,42
			t(min)	11,5	11,39	12,09		12,09	8,62
			t(mm)	14,15	16,24	16,24	Des for final stage	31,21	22,42
	Steel lined shaft and lower valve chamber		Powerhouse in red					In tunnel, rock half of load	
13,2	Excavation, rock	m3							
13,3	Concrete embedment	m3		942	942	942		787	262
13,4	Formwork	m2						750	750
13,5	Reinforcement	ton						47,2	15,7
13,6	Steel for penstock	ton		402,0	448,9	529,8		1017,8	177,6
13,7	Miscellaneous Items	%		25%	25%	25%		25%	25%
	Total, Steel liner, civil								
14	Powerhouse	Additional units >>		2	3	4		3 new units installed, could be two	
14,1	Loose excavation, road and platform	m2					3-no new	3	
14,2	Rock excavation, road and platform	m3							
14,3	Tailrace, loose excavation	m3							
14,4	Tailrace excavation	m3							
14,5	Underground excavation, including access tunnel	m3		10 150	15 225	20 300		15 225	97 423
14,7	Rock bolts, 3 m dia 25 mm	ea		20%	20%	20%		20%	20%
14,8	Rock bolts spiling, 6 m, dia 35 mm	ea		5%	5%	5%		5%	5%
14,9	Fiber Reinforced Shotcrete	m3		669	1 004	1 338		1 004	756
14,10	Substructure Concrete	m3	See	4 461	6 692	8 923		6 692	5 040
14,11	Structural concrete	m3		1 562	2 342	3 123		2 342	1 205
14,12	Formwork	m2	cell D116	11 377	17 065	22 754		17 065	12 852
14,13	Reinforcement	ton		332	499	665		499	336
14,14	Miscellaneous Items, superstructure, metallic	%		25%	25%	25%		25%	25%
	Total, Powerhouse								

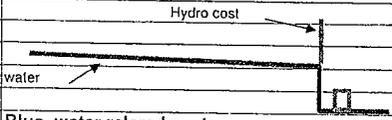
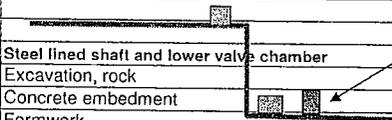


15	Switchyard - civil							
15,1								
15,2	Concrete structure			Refer to detailed estimates in the infrastructure section				
15,3	Formwork							
15,4	Reinforcement							
15,5	Miscellaneous Items							
	Total Switchyard			229 142	293 858	358 574	293 858	335 998
16	Tailrace tunnel outlet works	L		1480	1480	1480		
		D(tunnel)	1	4,1	4,10	4,10	1480	1480
	Outlet sizing	W		4,1	4,10	4,10	3,70	3,70
		H		4,1	4,10	4,10	3,70	3,70
		Vmax(m/s)		0,8	0,83	0,83	4,10	4,10
16,1	Portal rock excavation	m3					1,74	0,10
16,2	Rock support	%						
16,4	Concrete	m3						
16,5	Formwork	m2						
16,6	Draft tube gate	pcs	2	314 768	314 768	314 768		
16,7	Crane	pcs	1	112500	112500	112 500	272 631	272 631
16,8	Miscellaneous Items	%		20,00%	20,00%	20,00%	112 500	112 500
	Total, Tailrace tunnels (2) and outlet works						20,00%	20,00%
17	Mechanical equipment and turbines							
17,1	Turbine with governors			Done				
17,2	Valves			5,97	7,85	10,20	9,07	5,21
17,3	EOT cranes			2,64	3,47	4,51	4,01	2,31
17,4	Cooling system			0,86	1,13	1,47	1,30	0,75
17,5	Compressed air system			0,24	0,31	0,41	0,36	0,21
17,6	Oil treatment and transfer system			0,21	0,28	0,36	0,32	0,18
17,7	Heat, vent, A/C			0,17	0,23	0,29	0,26	0,15
17,8	Fire protection			0,66	0,87	1,13	1,00	0,58
17,9	Domestic water and sewage			0,21	0,28	0,36	0,32	0,18
17,10	Cooling system			0,12	0,16	0,20	0,18	0,10
17,11	Dewatering and drainage system			0,46	0,61	0,79	0,70	0,40
17,12	Workshop equipment			0,26	0,35	0,45	0,40	0,23
17,13	Tailrace gate and related equipment			0,18	0,24	0,32	0,28	0,16
17,13				1,22	1,60	2,08	1,85	1,06
	Total mechanical equipment and turbines			13,21	17,36	22,57	44,95	20,07
	Spherical valves			2,76	4,14	5,51	5,03	4,73
18	Electrical Equipment							
	Generator and excitation			Done				
	Generator terminal equipment			12,50	15,78	18,61	17,66	16,95
	High voltage power cables			1,67	2,10	2,48	2,36	2,26
	400 V MDC			0,17	0,21	0,25	0,24	0,23
	110 V DC system			0,73	0,92	1,09	1,03	0,99
	Diesel generator			0,33	0,42	0,50	0,47	0,45
	Control and protection system			0,15	0,18	0,22	0,21	0,20
	Power transformers			1,88	2,37	2,79	2,65	2,54
	Switchgear			2,29	2,89	3,41	3,24	3,11
	Cabling and general work			0,33	0,42	0,50	0,47	0,45
	Miscellaneous switchyard and other cost			0,79	1,00	1,18	1,12	1,07
	Total Electrical system			20,84	26,30	31,02	29,44	28,25
	Check, el mech			20,19	25,40	30,60	28,44	27,32
	Additional Substation cost, el mech			1 173 782	1 541 279	1 908 776	1 541 279	1 780 574
19	Transmission lines							
19,1	275 kV double circuit transmission > 200 MW			0	0	0	0	0
19,2	132 kV single circuit to terminal, < 100 MW			0	0	0	0	0
	Total transmission lines			0	0	0	0	8

ANNEX COST A2: SUMMARY SHEET OF COST		Unit rate	II_B1: Polihali, Muela-1st stage	II-B2: Tsoelike-Polihali to Muela,	II-B3: Malatsi-Polihali to Muela	II-A-1: Polihali alone to Katse, no add cost at Muela	II-A-3: Poli-Katse & Malatsi-Taung>Katse; all to Muela	Oxbow to Muela Peak plant
No.	DESCRIPTION							
DAMS								
1	Polihali dam and appurtenan: works							
2		0						
3		0						
4		0						
5		0						
6	Oxbow dam							
7	Lebelo							
TUNNELS								
9	Headrace and Tailrace Tunnel							
10	Intake at dam							
12	Surge shaft							
13	Pressure tunnel/penstock, civil and steel		12 631 448	13 606 906	14 568 370		77 202 187	1 869 882
14	Powerhouse		2 598 193	2 852 988	3 293 300		6 042 714	1 191 309
15	Switchyard - civil		4 714 407	7 071 610	9 428 814		7 071 610	15 839 044
16	Tailrace tunnel outlet works		229 142	293 858	358 574	293 858	335 998	319 529
17	Total mechanical equipment and turbines		512 722	512 722	512 722		462 158	462 158
18	Total Electrical system		15 971 437	21 500 120	28 089 187	2 500 000	20 066 534	11 536 480
19	Total transmission lines		21 681 140	26 302 135	31 024 575	2 500 000	29 441 368	28 245 453
	Total		58 338 489	72 140 339	87 275 542	5 293 858	140 622 569	920 000
Cost of tunnels, pumping stations, cap			Taung dam and pumping plant					
	Taung (to Polihali)							
	Taung tunnel							
	Tsoelike to Taung tunnel							
	Ntoahae to Tsoelike tunnel							
	Malatsi tunnel							
	Taung to Muela, gravity							
	Polihali to Katse tunnel							
	Katse to Muela, second tunnel							
	TOTAL TENDER COST		58 338 489	72 140 339	87 275 542	5 000 000	140 622 569	60 383 855
GE, ENGINEERING ETC								
	75% Preliminary and general							Oxbow
	18% Contingencies		43 753 867	54 105 254	65 456 656	3 750 000	105 466 927	45 287 891
	15% Planning, design, supervision and EIA		10 500 928	12 985 261	15 709 598	900 000	25 312 062	10 869 094
	1% Health and safety		8 750 773	10 821 051	13 091 331	750 000	21 093 385	9 057 578
	10% Cost relocations		583 385	721 403	872 755	50 000	1 406 226	603 839
	5% Clients administration		5 833 849	7 214 034	8 727 554	500 000	14 062 257	6 038 386
	124% Total multiplier		2 916 924	3 607 017	4 363 777	250 000	7 031 128	3 019 193
	TOTAL DEVELOPMENT COST		130 678 215	161 594 359	195 497 214	11 200 000	314 994 554	135 259 835

ANNEX A1: GEOMETRICAL DEFINITION							
	Alternatives >>						
	A: Geometrial definition	65 DelH=	2,2				
	Turbine and waterway data						
	Number of turbines						
	MW installed						
	MW-Yield			II-B1: Polihali to Muela		II-A1: Polihali to K Oxbow, Colenco	
	Hours of operation		310			89 184 645	
	Length of waterway						
	Head loss, m, for 25 years Ka of 1 mm	52,07764707					
	Net Head						
	Tunnel flow						
	Yield, m3/s (2.13 m3/s in Katse)						
	Velocity in waterway						
	Internal diameter, all lined						
	Lower pressure tunnel/ penstock diameter						
GWh	Invert intake level at dam site						
	B: Cost data, including general, engine						
	GWh/a						
	Carbon credit						
	GWh/a check						
	Sales of electricity per year, mio US\$						
	Hydro cost alone; including general, engineerin						
	B/C hydro alone						

DETAILED COST ESTIMATING			II_B1: Polihali, Muela-1st stage	II-B2: Tsoelike-Polihali to Muela,	II-B3: Malatsi-Polihali to Muela	II-A-1: Polihali alone to Katse, no add cost at Muela	II-A-3: Poli>Katse & Malatsi-Taung>Katse; all to Muela	Oxbow to Muela Peak plant
3	Dam and appurtenant works	Rate	II_B1: Polihali, Muela-1st stage	II-B2: Tsoelike-Polihali to Muela,	II-B3: Malatsi-Polihali to Muela	II-A-1: Polihali alone to Katse, no add-cost-at-Muela	II-A-3: Poli>Katse & Malatsi-Taung>Katse; all-to-Muela	Oxbow to Muela Peak plant
		1759,29	G	J	K	I	L	N
9	Headrace and Tailrace Tunnel	Now						
9,1	Tunnel excavation	90	-	-	-	-	-	-
9,2	Rock bolts, 3 m, 25 mm, 2 per m	60	-	-	-	-	-	-
9,3	Rock bolts spilling, 6 m, dia 25 mm	120	-	-	-	-	-	-
9,4	Clearing tunnel walls and roof	1,6	-	-	-	-	-	-
9,5	Clearing tunnel invert	8	-	-	-	-	-	-
9,6	Concrete lining, for Oxbow, 15%	320	-	-	-	-	-	-
9,8	Reinforcement	1 300,0	-	-	-	-	-	-
9,9	Fiber Reinforced Shotcrete	380	-	-	-	-	-	-
9,10	Miscellaneous, including dewatering		-	-	-	-	-	-
	Total Headrace	Raised prices	-	-	-	-	-	-
10	Intake at dam		-	-	-	-	-	-
10,1	Loose excavation, incl. for ramp	4	-	-	-	-	-	-
10,2	Rock excavation	12	-	-	-	-	-	-
10,3	Shaft excavation	220	-	-	-	-	-	-
10,4	Rock bolts, 3 m dia 25	45	-	-	-	-	-	-
10,5	Rock bolts spilling, 6 m dia 25	120	-	-	-	-	-	-
10,6	Fiber Reinforced Shotcrete	380	-	-	-	-	-	-
10,7	Formwork	90	-	-	-	-	-	-
10,8	Concrete	220	-	-	-	-	-	-
10,9	Reinforcement	1300	-	-	-	-	-	-
10,10	Intake gates		-	-	-	-	-	-
			-	-	-	-	-	-
			-	-	-	-	-	-
			-	-	-	-	-	-
10,11	Maintenance, sliding gates		-	-	-	-	-	-
10,12	Trash racks		-	-	-	-	-	-
10,13	Miscellaneous Items		-	-	-	-	-	-
	Total Power Intake		-	-	-	-	-	-

12 Surge shaft								
								
Blue, water related cost								
Red, hydro cost								
12,1	Surface excavation loose rock	4	12 000	12 000	12 000	-	24 000	24 000
12,2	Galleries	100	1 080 000	1 080 000	1 080 000	-	600 000	600 000
12,3	Shaft excavation	280	6 220 678	7 285 475	7 960 091	-	49 001 920	55 735
12,4	Rock bolts, 2.4 m, dia 25	70	447 469	392 376	392 376	-	392 376	399 728
12,5	Fiber Reinforced Shotcrete	480	226 959	226 959	226 959	-	9 778 480	162 681
	Concrete lining	450	2 127 739	2 342 278	2 468 882	-	4 538 380	316 090
	Reinforcement	1450	411 363	-	-	-	-	-
12,6	Miscellaneous Items		2 105 241	2 267 818	2 428 062	-	12 867 031	311 647
	Total Surge Shaft and galleries		12 631 448	13 606 906	14 568 370	-	77 202 187	1 869 882
13 Pressure tunnel/penstock, civil and steel								
Water related cost in blue								
Upper tunnel valve/gate chamber or vertical shaft								
								
	Steel lined shaft and lower valve chamber	4						
13,2	Excavation, rock	200	-	-	-	-	-	-
13,3	Concrete embedment	350	329 867	329 867	329 867	-	275 356	91 839
13,4	Formwork	90	-	-	-	-	67 500	67 500
13,5	Reinforcement	1350	-	-	-	-	63 725	21 254
13,6	Steel for penstock	4350	1 748 687	1 952 523	2 304 773	-	4 427 590	772 454
13,7	Miscellaneous Items		519 639	570 598	658 660	-	1 208 543	238 262
	Total, Steel liner, civil		2 598 193	2 852 988	3 293 300	-	6 042 714	1 191 309
14 Powerhouse								
14,1	Loose excavation, road and platform	4	-	-	-	-	-	-
14,2	Rock excavation, road and platform	7	-	-	-	-	-	-
14,3	Tailrace, loose excavation	6	-	-	-	-	-	-
14,4	Tailrace excavation	8,4	-	-	-	-	-	-
14,5	Underground excavation, including access tunnel	80	812 000	1 218 000	1 624 000	-	1 218 000	7 793 840
14,7	Rock bolts, 3 m dia 25 mm	60	162 400	243 600	324 800	-	243 600	1 558 768
14,8	Rock bolts spiling, 6 m, dia 35 mm	130	40 600	60 900	81 200	-	60 900	389 692
14,9	Fiber Reinforced Shotcrete	380	254 304	381 457	508 609	-	381 457	287 280
14,10	Substructure Concrete	176	785 220	1 177 831	1 570 441	-	1 177 831	887 040
14,11	Structural concrete	240	374 764	562 146	749 529	-	562 146	289 200
14,12	Formwork	80	910 142	1 365 213	1 820 284	-	1 365 213	1 028 160
14,13	Reinforcement	1300	432 094	648 142	864 189	-	648 142	437 255
14,14	Miscellaneous Items, superstructure, metallic	0,25	942 881	1 414 322	1 885 763	-	1 414 322	3 167 809
	Total, Powerhouse		4 714 407	7 071 610	9 428 814	-	7 071 610	15 839 044

15	Switchyard - civil							
15,1		4,5						
15,2	Concrete structure	180						
15,3	Formwork	80						
15,4	Reinforcement	1300						
15,5	Miscellaneous Items							
	Total Switchyard		229 142	293 858	358 574	293 858	335 998	319 529
16	Tailrace tunnel outlet works							
	Outlet sizing							
16,1	Portal rock excavation	7						
16,2	Rock support	0,00%						
16,4	Concrete	240						
16,5	Formwork	80						
16,6	Draft tube gate	1	314 768	314 768	314 768			
16,7	Crane	1	112 500	112 500	112 500		272 631	272 631
16,8	Miscellaneous Items		85 454	85 454	85 454		112 500	112 500
	Total, Tailrace tunnels (2) and outlet works		512 722	512 722	512 722		462 158	462 158
17	Mechanical equipment and turbines							
17,1	Turbine with governors		5 972 765	7 848 567	10 203 663			
17,2	Valves		2 642 816	3 472 817	4 514 895		9 070 073	5 214 489
17,3	EOT cranes		858 915	1 128 666	1 467 341		4 013 307	2 307 296
17,4	Cooling system		237 853	312 554	406 341		1 304 325	749 871
17,5	Compressed air system		211 425	277 825	361 192		361 198	207 657
17,6	Oil treatment and transfer system		171 783	225 733	293 468		321 065	184 584
17,7	Heat, vent, A/C		660 704	868 204	1 128 724		260 865	149 974
17,8	Fire protection		211 425	277 825	361 192		1 003 327	576 824
17,9	Domestic water and sewage		118 927	156 277	203 170		321 065	184 584
17,10	Cooling system		462 493	607 743	790 107		180 599	103 828
17,11	Dewatering and drainage system		264 282	347 282	451 490		702 329	403 777
17,12	Workshop equipment		184 997	243 097	316 043		401 331	230 730
17,13	Tailrace gate and related equipment		1 215 695	1 597 496	2 076 852		280 931	161 511
17,13			2 757 356	4 136 034	5 514 712		1 846 121	1 061 356
	Total mechanical equipment and turbines		15 971 437	21 500 120	28 089 187	2 500 000	20 066 534	11 536 480
	Spherical valves							
18	Electrical Equipment							
	Generator and excitation		80%, use existing system					
	Generator terminal equipment		12 504 487	15 781 281	18 614 745		17 664 821	16 947 272
	High voltage power cables		1 667 265	2 104 171	2 481 966		2 355 309	2 259 636
	400 V MDC		166 726	210 417	248 197		235 531	225 964
	110 V DC system		729 428	920 575	1 085 860		1 030 448	988 591
	Diesel generator		333 453	420 834	496 393		471 062	451 927
	Control and protection system		145 886	184 115	217 172		206 090	197 718
	Power transformers		1 875 673	2 367 192	2 792 212		2 649 723	2 542 091
	Switchgear		2 292 489	2 893 235	3 412 703		3 238 551	3 107 000
	Cabling and general work		333 453	420 834	496 393		471 062	451 927
	Miscellaneous switchyard and other cost		791 951	999 481	1 178 934		1 118 772	1 073 327
	Total Electrical system		840 329	1 120 445	1 412 383	1 541 279	1 309 513	1 235 129
	Check, el mech		21 681 140	26 302 135	31 024 575	2 500 000	29 441 368	28 245 453
	Additional Substation cost, el mech				31 024 575			
19	Transmission lines							
19,1	275 kV double circuit transmission > 200 MW	171 875						
19,2	132 kV single circuit to terminal, < 100 MW	115 000						
	Total transmission lines							920 000
								920 000