REPORT

ADELAIDE WATER SUPPLY : PROPOSED FOXWOOD DAM

FEBRUARY 1998

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DRAWINGS BOUND INTO REPORT:

Drawing No 5862 PE 200 : Schematic Layout Plan
Drawing No 5862 PE 201 : Proposed Foxwood Dam to meet domestic demand
Drawing No 5862 PE 202 : Proposed Foxwood Dam to meet domestic and irrigation demand.

BULK WATER SUPPLY TO ADELAIDE : PROPOSED FOXWOOD DAM

1. INTRODUCTION

The Foxwood Dam was identified in our report "Bulk Water Supply to Adelaide : Proposed Foxwood Dam" of April 1997 as a possible scheme which could satisfy the long term future domestic bulk water requirements of Adelaide.

In December 1997, the Department of Water affairs appointed Ninham Shand to investigate the possibility of enlarging the proposed Foxwood Dam given in our report of April 1997, to include for storage for both the domestic consumption and irrigation of 150 ha of municipal land.

This report therefore discusses the construction of a dam at the Foxwood site to satisfy the domestic and municipal irrigation demand of Adelaide.

2. ESTIMATED WATER DEMAND

2.1 ESTIMATED FUTURE POPULATION

2.1.1 The population in 1996, as determined from a survey by the Adelaide Municipality, is as follows :

Adelaide (Central)	1 149
Bezuidenhoutville	2 001
Lingelethu	13 209
Total	16 359

2.1.2 For projecting the future population figures, the following growth rates were assumed.

Adelaide (Central)

A growth rate of 0,6% p.a. to 2000 reducing over the following 20 years to 0,4% in 2020.

Bezuidenhoutville

A growth rate to 2000 of 1,7% p.a. reducing over the following 10 years to 1,2% p.a.

and remaining at 1,2% p.a. thereafter.

Lingelethu

A growth rate to 2000 of 3% reducing to 2% p.a. in 2020.

2.1.3 Based on the above, the estimated future population of Adelaide was calculated to be as shown in Table 1 below.

TABLE 1 : ESTIMATED FUTURE POPULATION

Year	Adelaide (Central		Bezuidenhoutville		Lingelethu		Total
	Population	Growth Rate %	Population	Growth Rate %	Population	Growth Rate %	Population
1996	1 149		2 001		13 209		16 259
1997	1 156	0,6	2 035	1,7	13 605	3,0	16 796
2000	1 177	0,6	2 141	1,7	14 867	3,0	18 185
2005	1 213	0,6	2 306	1,5	17 235	3,0	20 754
2010	1 250	0,6	2 447	1,2	19 980	3,0	23 677
2015	1 282	0,5	2 887	1,2	22 606	2,5	26 775
2020	1 308	0,4	3 064	1,2	24 959	2,0	29 331

2.2 ESTIMATED DOMESTIC WATER DEMAND

2.2.1 The following assumptions were used for estimating the future water demand.

i) The recorded monthly consumption figures for Adelaide (Central) from January 1997 to December 1997 as provided by the Municipality are given below.

January 1997	:	17 000 m³
February 1997	:	36 342 m³
March 1997	:	13 177 m³
April 1997	:	12 850 m³
May 1997	:	11 467 m³
June 1997	:	11 062 m³
July 1997	:	10 977 m³
August 1997	:	10 777 m³
September 1997	:	13 818 m³
October 1997	:	15 460 m³

November 1997 : 15 004 m³

December 1997 : 17 395 m³

Based on the estimated population of Adelaide (Central) in 1997 of 1156 and including for the consumption of schools, the hospital and industrial purposes, the per capita consumption during peak months was 485 ℓ/d.

Other similar Karoo towns with reliable water supplies however have white per capita consumption figures as high as 575 ℓ/d (including industrial demand). We therefore believe that with an improved water supply, the consumption will increase. We have therefore assumed that the per capita consumption will increase to 550 ℓ/d by 2000.

ii) The per capita consumption of the Lingelethu and the Bezuidenhoutville population was obtained from the figures as proposed in the framework plan for civil services in Adelaide.

Based on the above, the estimated future domestic demand of Adelaide was calculated to be as shown in Table 2 below.

TABLE 2 : ESTIMATED FUTURE DOMESTIC DEMAND OF ADELAIDE

Year	Adelaide (Central)			Bezuidenhoutville			Lingelethu			Total Consumption	
	Population	Ave. daily consumption		Popu-lation	Ave. daily consumption		Population	Ave. daily consumption		Daily	Annual
		ℓ/c	m³/d		ℓ/c	m³/d		ℓ/c	m³/d	m³/d	m³
1996	1149			2001			13209				
1997	1156	485	561	2035	80	163	13605	80	1088	1887	689 000
2000	1177	550	647	2141	80	171	14867	80	1189	2007	733 000
2005	1213	550	667	2306	90	207	17235	90	1551	2425	885 000
2010	1250	550	687	2447	100	245	19980	100	1998	2930	1069 000
2015	1282	550	705	2887	120	346	22606	100	2261	3312	1209 000
2020	1308	550	719	3064	150	460	24959	100	2496	3675	1341 000

2.3 MUNICIPAL IRRIGATION

It was originally the intension to develop approximately 150 ha of land available within the municipal boundaries as garden lots. These areas are shown on the enclosed drawing 5862 PE 200. At the request of the Adelaide Municipality, the Department of Agriculture in September 1992 investigated the suitability of these soils for irrigation purposes. In short, the Department found that these soils do not appear to be suitable for the production of crops. (A copy of the report giving the findings of this investigation is enclosed as Appendix 1).

Subsequent to this report of the Department of Agriculture, a privately owned piece of land on the right bank of the Koonap River just downstream of Adelaide was identified as being suitable for municipal irrigation. The locality of this land is shown as Area A on drawing 5862 PE 200. This land is being commercially farmed at present and it is therefore assumed that the soils are suitable for irrigation. It is understood that the owner of the land would be interested to sell the farm which comprises approximately 400 ha. However, there have been no negotiations at this stage between the farmer and the Adelaide Municipality regarding the purchase of the land for use as municipal irrigation plots.

It is therefore assumed, for the purpose of this report, that this land (area A) will be available for municipal development. It was furthermore assumed that the crops grown on the municipal irrigation plots would be mainly vegetables such as potatoes, corn, tomatoes, beans, onions, etc. It is further assumed that annual irrigation requirement for the aforementioned crops including 10% for losses, is 12 500 m^3/ha/annum. Based on the above, the annual irrigation demand is 1,88 x 10^6 m^3/annum.

2.4 ESTIMATED TOTAL WATER DEMAND

Based on the above, Adelaide's estimated total water demand is as follows:

	Annual demand (million m^3)
Domestic	1.34
Municipal Irrigation	1.88
Total	3.22

3. DESIGN PARAMETERS

The following design parameters were used in the sizing of the various components of the water supply scheme.

3.1 PLANNING HORIZON

The Department of Water Affairs and Forestry advised that the planning horizon for this scheme should be 20 years. Assuming that the scheme is completed by the year 2000 it follows that the scheme should be designed to meet the estimated future demand of Adelaide until the year 2020.

3.2 ASSURANCE OF SUPPLY

The alternative dams were sized to provide water for domestic consumption at 98% and irrigation water at 90% surety respectively.

3.3 PIPELINES

Pipelines were sized to accommodate the annual average daily flow at the end of the design period.

3.4 PUMPS

Full standby capacity was allowed for.

4. PROPOSED DAM AT FOXWOOD SITE

4.1 DAM SITE

The proposed Foxwood site is situated on the Koonap River approximately 3,5 km north-west of Adelaide at 32°-41'S, 26°-16'E as shown on drawing 5862 PE 200.

The site is the only suitable dam site in the immediate vicinity of Adelaide. The valley is the narrowest at the site chosen and the storage volume : fill volume ratio is favourable.

The preferred location for the dam was chosen at a point where both abutments are readily accessible for the excavation of the core trench. The right hand side and middle section of the river valley consists of a thick silt deposit underlain by mudstone. The main river channel is situated on the left hand side of the river valley and consists of approximately 300 mm diameter boulders underlain by mudstone. The left flank rises near vertical for the first 8 to 10 m and consists of red clayey silt underlain by highly weathered, fractured mudstone.

4.2 SEDIMENT

Based on Rooseboom's sediment yield map of South Africa (1978), the catchments upstream of Adelaide are in a zone of high sediment yield with a maximum expected yield of 1 000 t/km²/a.

This sediment yield map provides a rough guide for the maximum expected sediment yields from a particular catchment. The values determined from the map can, and in fact should, be adjusted based on local catchment information and experience.

In view of the high cost of providing storage for siltation, Prof Rooseboom was requested to evaluate the conditions in the Koonap catchment upstream of Adelaide which he visited in January 1992. Based on his on-site evaluation and new statistical analyses of data and information in the area, Prof Rooseboom is of he opinion that the catchment can be categorised as having a medium sediment yield potential and

recommended that the sediment yield of the catchment be taken as 185 t/km²/a.

The volume of sediment accumulation is also dependent on the trap efficiency which is in turn dependent on the ratio of the storage capacity versus inflow (MAR). The trap efficiency will therefore increase with an increase in the storage capacity of the dam. The Brune curve in the WRC '90 Report No 298/1/94 was used to determine the trap efficiencies. It was found that the dam to supply domestic water only and the dam to supply water for domestic and irrigation purposes will have trap efficiencies of 76% and 87% respectively.

Based on the above, the sediment accumulation in the dam to supply water for domestic purposes only over a period of 30 years was calculated as being approximately 3,4 million m³ and that in the combined dam 4,26 million m³.

4.3 STORAGE REQUIREMENTS

The Department of Water Affairs and Forestry streamflow gauge Q9M02 measures flow in the Koonap River at Adelaide. Flow records exist from 1926. The HRU have analysed records from Q9MO2 for the period 1926 to 1979.

These records show a large monthly and annual variation in flow in the Koonap. Records of daily flows in the Koonap obtained from the Department of Water Affairs and Forestry show that the flow is extremely irregular and is characterised by relatively large flows of short duration.

The storage necessary to provide a yield of 1,34 million m³/annum with a 98% surety of yield for domestic purposes and a yield of 1,88 million m³/annum with a 90% surety of yield for domestic and irrigation purposes, was determined by simulating the operation of the dam using the flow records at Q9MO2 adjusted according to the catchment area of the dam.

The operation of the system was simulated using the "Water Resources Yield Model" computer programme with the following flow records:

ii) Records from 1926 to 1979 was analysed by the HRU

iii) Records from 1926 to 1979 as above, with additional flow records from 1979 to 1990 obtained from Department of Water Affairs and Forestry, added.

The assumptions used in the analysis are briefly given below.

i) The existing Municipal dam's storage capacity of 750 000 m³ was included in the analysis.

ii) Dead storage of 3,4 and 4,26 million m³ was allowed for siltation over a 30 year period for a dam to supply water for domestic purposes and for a dam for domestic and-irrigation purposes respectively.

Based on the above, a dam with a gross capacity of 4 million m³ will be required for domestic purposes only and a dam with a gross capacity of 5,5 million m³ will be required for domestic and irrigation purposes.

4.4 FLOOD PEAKS

The proposed dam must be capable of safely passing a design flood peak as determined in terms of the Dam Safety Regulations.

The guidelines used for the selection and determination of suitable design floods are contained in the SANCOLD publication "Guidelines on Safety in Relation to Floods".

According to the Guidelines, the spillway system must be designed to accommodate design, as well as extreme flood conditions. The design flood forms the basis of the design of the dam and spillway system. No damage should be caused by this flood. The spillway system must also be able to pass the extreme flood with possibly substantial damage to the dam and spillway but without catastrophic failure.

Our preliminary calculation of the Recommended Design Flood (RDF) and the extreme flood termed the Safety Evaluation Flood (SEF) are 700 m³/sec and 5 500 m³/sec respectively.

4.5 DAM HEIGHT

No definitive information is available regarding the depth of rock below riverbed. The height of the dam wall using an earth embankment wall with concrete spillway or mass concrete wall was determined assuming suitable rock for founding of the dam is situated 4 m below the river bed and below natural ground level on either flank.

4.6 DAM AND SPILLWAY TYPE

The large magnitude of the floods associated with this catchment makes the spillway structure relatively expensive. In view of this, cost comparisons were carried out between a mass concrete (rollcrete) wall and an earth embankment dam with a mass concrete spillway.

For an earth embankment dam with a mass concrete spillway and 5m freeboard, the spillway width required to pass the SEF is 134 m. Details of the proposed mass concrete (rollcrete) wall and an earth embankment dam with a mass concrete spillway are shown on Drawing's No 5862 PE 201 and 202 respectively.

4.7 INUNDATION OF LAND UPSTREAM OF DAM SITE

The land on the left bank of the Koonap River upstream of the Foxwood Dam belongs to the Municipality. The land on the right bank is however privately owned. Approximately 20 ha of irrigable land and 20 ha of grazing land will be circulated by the dam.

Based on discussions with a member of the Koonap Irrigation Board, it appears that the owner of the land would be willing to sell his land in the event that the Foxwood Dam goes ahead. There has however been no negotiations between the Municipality and the owner of the land regarding the purchasing of the land.

Based on available information, it appears that the gravel road and bridge over the Koonap River along the main route to Tarkastad situated approximately 1,5 km upstream of the Foxwood site would not be effected.

5. PROPOSED DISTRIBUTION OF WATER

5.1 DOMESTIC DEMAND

It is proposed that water be pumped from the Foxwood Dam to the existing Municipal dam at a rate to satisfy the annual average demand in 2020. This demand is 3 671 m^3/day which means that a pumping rate of 46 ℓ/s is required when pumping for 22 h/day. A 1 400 m long, 200 mm diameter pipeline will be required.

The pumpstation will be situated on the left flank, just downstream of the dam. It is proposed that 2 pumps, one duty and one standby, be provided. The pumps will require 40 kW motors. It is proposed that the pumps be controlled by means of time switches and that no-flow protection be provided.

There is no power supply at the Foxwood site. Based on the 1 : 50 000 topographical maps, there is an existing power line approximately 800 m west of the Foxwood site. We therefore propose that a 800 m long, 3,3 kV power line together with a 80 kVA transformer be installed from the existing power line to the dam site to provide power for the pumpstation.

The various components of the scheme are shown on Drawing 5862 PE 200.

5.2 MUNICIPAL IRRIGATION

The irrigable land identified above is situated below the low water level in the dam and can therefore be supplied under gravity.

It is proposed that the water be conveyed, firstly via an approximately 3 000 m long canal and then by means of a 4 500 m long 250 mm diameter pipeline on the right bank of the river. The pipeline will cross the Adelaide - Bedford road and will discharge into an unlined storage dam.

It is proposed that the capacity of the storage dam be equal to one day's average irrigation demand, i.e. 7 200 m^3 (assuming that irrigation will take place 5 days per week).

Available information indicate that it will be possible to place the dam at an elevation which will enable irrigation to take place under gravity, albeit at relatively low pressures.

It is assumed that the garden lots will be 1 ha each. The following minimal infrastructure is allowed for in this report:

- a pipe network to distribute the water to the boundaries of the lots.
- a very rudimentary gravel road network between the lots.
  (No provision is made for other infrastructure on the lots themselves).

Rights-of-way will have to be obtained from the relevant property owners for the aforementioned infrastructure.

The necessary management structures for the control and organisational aspects of the municipal garden lots will need to be established before the implementation of the irrigation scheme. These matters have not been addressed in this report.

6. COST ESTIMATES

The cost estimates below are based on preliminary quantities and available geotechnical information. The estimated capital costs allow for 15 % preliminary and general costs, 10 % contingencies and professional fees and are based on current construction rates. No provision has been made for escalation. Cost estimates are provided for the following alternatives.

Option A: : A dam for domestic purposes only using a mass concrete wall.

Option B : A dam for domestic purposes only using an earth embankment wall with a mass concrete spillway.

Option C : A dam for domestic and irrigation purposes using a mass concrete wall

Option D : A dam for domestic and irrigation purposes using an earth embankment wall with a mass concrete spillway.

The estimated capital cost of each option is given in the Table below.

Option	A	B	C	D
R million	17,37	13,62	29,50	26,43

Details of the estimated capital costs of the four options are given in Appendices 1, 2, 3 and 4 respectively.

7. SUMMARY

7.1 A dam at the Foxwood site with a capacity of 4 million m^3 will, together with the existing Municipal dam, provide sufficient water to meet Adelaide's domestic demand until 2020. The estimated capital cost of this dam is R 17,5 million for a mass concrete dam and R 13,5 million for an earth embankment dam with a concrete spillway.

7.2 A dam at the Foxwood site with a capacity of 5,5 million m^3 will, together with the existing Municipal dam provide sufficient water to meet Adelaide's domestic and irrigation demand until 2020. Water will be available for 150 ha of irrigation. The estimated capital cost of this dam is R29,5 million for a mass concrete dam and R26,5 million for an earth embankment dam with a concrete spillway.

8. RECOMMENDATIONS

It is recommended that :

8.1 This report be submitted to the Adelaide Municipality and the Department of Agriculture and Land Affairs.

8.2 A decision be taken on whether to develop a municipal irrigation scheme.

8.3 Steps be taken to obtain funding for the project.

NINHAM SHAND
PORT ELIZABETH

FEBRUARY 1998

Appendix 2

ESTIMATED CAPITAL COST OF COMPONENTS OF OPTION A

Item	Component	Cost R x 10^6
1.	Mass gravity concrete dam Capacity 4 million m^3 Volume of wall = 17 900 m^3 @ R600/m^3	10,74
2.	Geotechnical investigation	0,25
3.	Rising main from Foxwood dam to existing municipal dam. Capacity : 46 ℓ/s 1400 m 200 mm FC @ R250/m	0,35
4.	Pumpstation at dam (TWL ± 595) delivering 46ℓ/s to existing municipal dam (TWL ± 610) Capacity : 40 kW	0,15
5.	Power supply to pumpstation Capacity 40 kW	0,15
6.	Provision for purchase of land and relocation of roads	0,30
	Sub-Total 15% Preliminary and General costs	11,94 1,79
	10% Contingencies	13,73 1,37
	Professional fees and other indirect cost.	15,10 2,27
	TOTAL ESTIMATED CAPITAL COST	R17,37 million

ESTIMATED CAPITAL COST OF COMPONENTS OF OPTION B

Item	Component	Cost R x 10^6
1.	Earth embankment dam with concrete spillway Capacity 4 million m^3	
1.1	Volume of earth embankment = 120 000 m^3 @ R15/m^3	1,80
1.2	Volume of concrete in spillway = 10 600 m^3 @ R600/m^3	6,36
2.	Geotechnical investigation	0,25
3.	Rising main from Foxwood dam to existing municipal dam. Capacity : 46 ℓ/s 1400 m 200 mm FC @ R250/m	0,35
4.	Pumpstation at dam (TWL ± 595) delivering 46 ℓ/s to existing municipal dam (TWL ± 610) Capacity : 40 kW	0,15
5.	Power supply to pumpstation Capacity 40 kW	0,15
6.	Provision for purchase of land and relocation of roads	0,30
	Sub-Total	9,36
	15% Preliminary and General	1,40
		10,76
	10% Contingencies	1,08
		11,84
	Professional fees and other indirect costs.	1,78
	TOTAL ESTIMATED CAPITAL COST	R 13,62 million

ESTIMATED CAPITAL COST OF COMPONENTS OF OPTION C

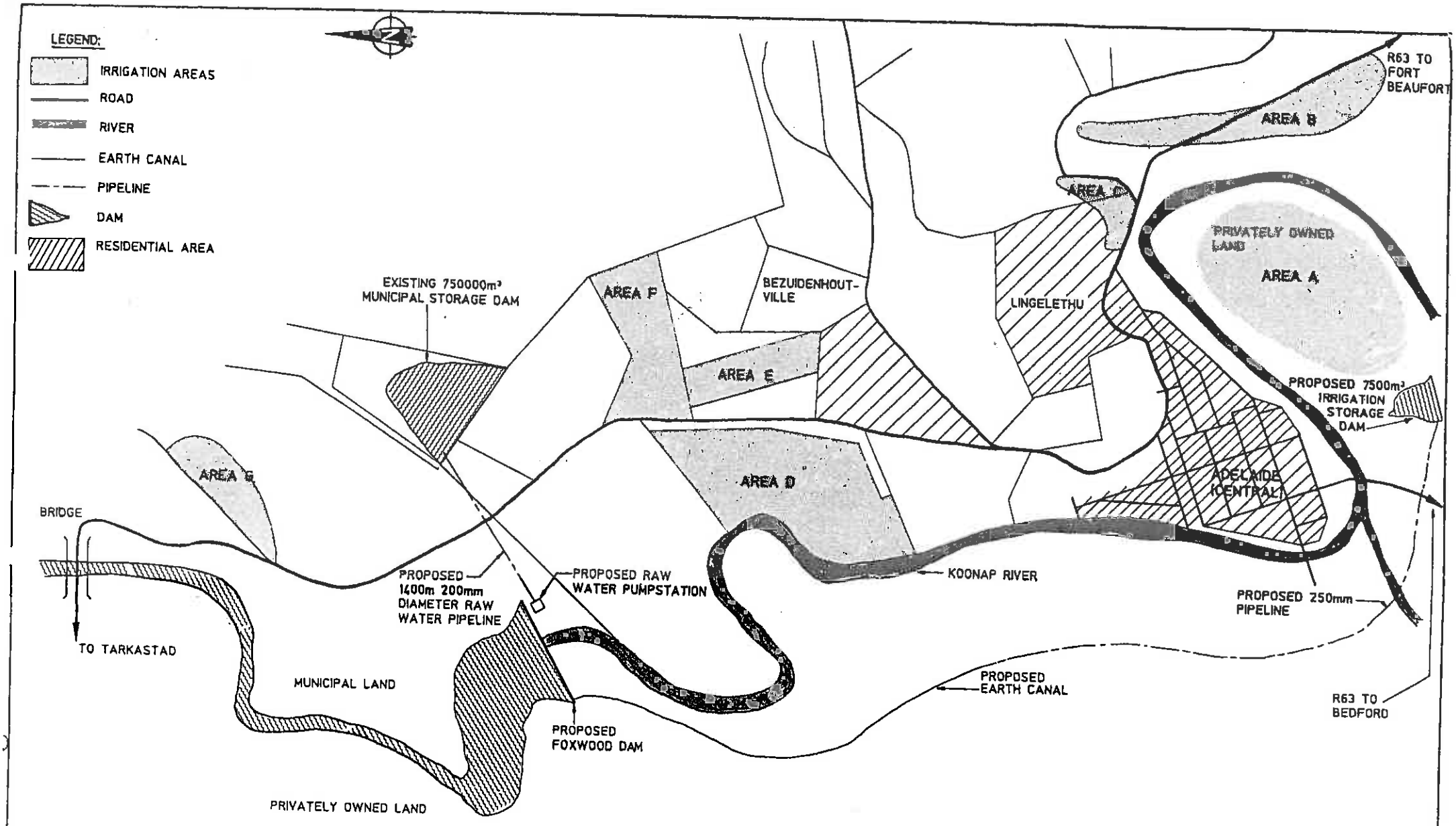
Item	Component	Cost R x 10^6
1.	Mass gravity concrete dam Capacity 5,5 million m^3	
1.1	Volume of wall = 23 350 m^3 @ R600/m^3	14,01
1.2	Outlet structure	0,25
2.	Geotechinical investigation	0,25
3.	Rising main from Foxwood dam to existing municipal dam Capacity : 46ℓ/s 1400m 200mm FC @ R 250/m	0,35
4.	Pumstation at Foxwood Dam (TWL ± 597,5) delivering 46ℓ/s to existing municipal dam (TWL± 610) Capacity : 40 kW	0,15
5.	Power supply to Foxwood Dam pumpstation Capacity 40 kW	0,15
6.	Irrigation canal: 3000 m @ R100/m	0,30
7.	Irrigation pipeline : 250 mm dia : 4 500 m @ R300/m	1,35
8.	Storage dam : 7500 m^3 @ R 200/m^3	1,50
9.	Distribution of irrigation water : 150 ha @ R 9000/ha	1,35
10.	Provision for purchase of land and relocation of roads	1,00
	Sub-Total 15% Preliminary and General	20,66 3,09
	10% Contingencies	23,95 2,39
	Professional fees and other indirect costs.	26,34 3,16
	TOTAL ESTIMATED CAPITAL COST	R29,50

ESTIMATED CAPITAL COST OF COMPONENTS OF OPTION D

Item	Component	Cost R x 10^6
1.	Earth embankment dam with concrete spillway Capacity 5,5 million m^3	
1.1	Volume of earth embankment = 160 000 m^3 @ R150/m^3	2,40
1.2	Volume of concrete in spillway = 160 000m^3 @ R600/m^3	9,60
1.3	Outlet Structure	0,25
2.	Geotechinical investigation	0,25
3.	Rising main from Foxwood dam to existing municipal dam Capacity : 46ℓ/s 1400m 200mm FC @ R 250/m	0,35
4.	Pumstation at Foxwood Dam (TWL ± 597,5) delivering 46ℓ/s to existing municipal dam (TWL± 610) Capacity : 40 kW	0,15
5.	Power supply to Foxwood Dam pumpstation Capacity 40 kW	0,15
6.	Irrigation canal: 3000 m @ R100/m	0,30
7.	Irrigation pipeline : 250 mm dia : 4 500 m @ R300/m	1,35
8.	Storage dam : 7500 m^3 @ R 200/m^3	1,50
9.	Distribution of irrigation water : 150 ha @ R 9 000/ha	1,35
10.	Provision for purchase of land and relocation of roads	1,00
	Sub-Total	18,65
	15% Preliminary and General	2,80
		21,45
	10% Contingencies	2,15
		23,60
	Professional fees and other indirect costs.	2,83
	TOTAL ESTIMATED CAPITAL COST	R26,43

DRAWING

ADELAIDE WATER SUPPLY : PROPOSED FOXWOOD DAM



NINHAM SHAND
CONSULTING ENGINEERS
RAADGEWENDE INGENIEURS

ADELAIDE WATER SUPPLY: PROPOSED FOXWOOD DAM

SCHEMATIC LAYOUT PLAN

SCALE SKAAL 1:10 000

DRG No: TKG Nr: 5862 PE 200