Adelaide Municipality

Water Supply: Proposed Foxwood Dam

Report No. 1966/5862

September 1992

NINHAM SHAND
CONSULTING ENGINEERS

PORT ELIZABETH

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NINHAM SHAND
CONSULTING ENGINEERS
PORT ELIZABETH

DATE 30 September 1992 YOUR REF

OUR REF 5862/17
SPB/dmd

The Town Clerk
Adelaide Municipality
Private Bag X350
ADELAIDE
5760

Dear Sir,

REPORT NO. 1966/5862 : WATER SUPPLY : PROPOSED FOXWOOD DAM

It is with pleasure that we submit herewith our report in the above regard.

A brief summary of our findings is as follows :

- Adelaide's existing water supply, even under normal conditions, has for some time been inadequate to meet even the domestic demand.
- Previous investigations into the water supply options in the area showed that the only possible source to satisfy the future demand would be to construct a dam on the Koonap River. The only suitable site in the immediate vicinity of Adelaide is the so-called Foxwood site.
- Farmers downstream of the proposed dam have indicated their interest in obtaining irrigation water from a dam.
- A dam at the Foxwood site with a capacity of 17 million m^3 would, together with the existing Municipal dam, provide sufficient water to meet Adelaide's domestic and irrigation demand until 2020. Water would also be available for 790 ha of farm irrigation.
- The estimated capital cost of a dam at the Foxwood site is given in Section 7 on page 27. Alternative costs of R24 000 000 and R20 000 000 are given, depending on the spillway types.
- It is shown in Section 8 on page 29 that the scheme is economically beneficial.

The procedures to be followed for the implementation of the scheme are set out in Section 9 on page 37, and a complete summary of the report is given in Section 10 on page 39.

We trust this report meets with your requirements and we look forward to discussing the report with your Council and the other parties involved.

Yours faithfully,
NINHAM SHAND

J KRITZINGER PrEng

ADELAIDE MUNICIPALITY

WATER SUPPLY :

PROPOSED FOXWOOD DAM

NINHAM SHAND INC
P O BOX 505
PORT ELIZABETH
6000

SEPTEMBER 1992

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REPORT REFERENCES

1. Augmentation of Raw Water and Treated Water Supplies.
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4. Koonap Rivier : Wenslikheid van Besproeiingsontwikkeling
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5. Die Potensiele Rol en Impak van die Koonap Rivier ontwikkelingsprojek op Streeksontwikkeling in Adelaide en Omliggende Gebiede.
   Instituut vir Beplanningsnavorsing : Universiteit van Port Elizabeth
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6. Municipality of Adelaide
   Cost comparison of Alternative Water Supplies to Adelaide
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8. Assessment of Groundwater Potential - Adelaide
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1. INTRODUCTION

Adelaide is an established Karoo town situated on the banks of the Koonap River, approximately 200 km. north-east from Port Elizabeth. The locality of Adelaide and the Koonap River are shown on drawing 5862 PE100, bound into this report.

The Koonap River, which is a tributary of the Great Fish River, has a total catchment area of 3360 km² and is approximately 220 km long. The Koonap River is the only major undeveloped river in the area. The abstraction of water at present is by means of either canals or pumping.

Although a relatively small town, Adelaide is the business centre of the Koonap River Irrigation area. It is the largest municipal development in the area and the only town situated on the banks of the Koonap River.

Since the early 1980's Adelaide has experienced regular water shortages. Since 1980 only three years, i.e. 82, 85 and 86 have been without restrictions. This situation is partly the result of the extended drought in this region, but can also be attributed to the increase in the black population and the upgrading of services presently being undertaken. It will be shown in this report that Adelaide's existing water supply, even under normal conditions, has been inadequate for some time. At present the water situation in Adelaide is critical. Water is being transported in railway tankers from Cookhouse at a cost of R48 000 per month. Severe rationing has been introduced and houses are allowed a maximum of 7000 litres of water per month. This report deals with the long term water supply to Adelaide and does not cover the critical situation being experienced at present.

Based on previous investigations into the water supply options in the area, it was apparent that the only possible source able to satisfy the future water demand would be a dam on the Koonap River.

In September 1991 the Adelaide Town Council appointed Ninham Shand to investigate the feasibility of a dam at the so-called De Beersdrift site.

A dam at this site was investigated, but it soon became obvious that due to the topographical limitations of the area, it would not be possible to build a dam large enough to meet the water demand.

It was therefore necessary to find another site in the vicinity of Adelaide. Following consultation with the Council it was decided to investigate the feasibility of building a dam at the Foxwood site. At this time farmers downstream of this site indicated their interest in obtaining irrigation water from a possible dam at this site.

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

2. MUNICIPALITY'S ECONOMIC DEVELOPMENT PLAN

The need, from a socio-economic point of view, to stimulate development in Adelaide is clearly identified in the report "Die Potensiele Rol en Impak van die Koonap Rivierontwikkelingsprojek op Streekontwikkeling in Adelaide en Omliggende Gebiede" - Institute for Planning Research, University of Port Elizabeth (April 1989)[5].

As a result of the water shortages experienced since the early 1980's development in Adelaide has reached a standstill and is in fact declining. The present situation is as follows :

- The white population as determined by the 1991 census is the same as that in 1951.
- The coloured and particularly the black population has shown a steady growth.
- There is no demand for new white housing.
- No demand exists for industrial sites which are readily available.
- The lack of development combined with growing coloured and black populations has led to increasing unemployment.

The Municipality recognised the urgent need to stimulate development in the area and in 1990/91 proposed the following development plan.

- Approximately 200 ha irrigable commonage be divided into garden lots to create jobs for the poorer population groups. The Municipality plans to develop up to 50 ha immediately a water supply is available and thereafter to make the garden lots available as required, to be used for the upliftment of the coloured and black population.
- To develop tourism of the area by promoting the natural beauty of the Adelaide region together with the recreational facilities which would be created by the construction of a dam on the Koonap River.
- To supply affordable irrigation water to farms in the vicinity of Adelaide which would provide a strong stimulus to the economy of Adelaide.

The division of irrigable commonage into 50 m x 25 m garden lots could provide food for a family. The scheme would initially be aimed at subsistence. As the ability of the "gardeners" improves, the size of the plots could be increased to allow the occupier to make a proper livelihood.

50 ha utilized in this way could therefore immediately provide food for up to 400 families.

The increased income generated as a result of farm irrigation would also lead to increased job opportunities and growth in the economy of the region.

The cost of creating sufficient jobs in industry to support a similar number of people in Adelaide would be prohibitively expensive.

The consequences of not providing job opportunities for the growing coloured and black populations would lead to a migration of people to the larger centres, e.g. Port Elizabeth and Uitenhage. Housing and jobs would therefore need to be provided in these areas at an even greater cost.

In view of the above it is therefore evident that the Municipality's development plan is the most economical way of providing employment opportunities for the poorer population groups in Adelaide.

This, when considering the alternative of providing housing and jobs in the Port Elizabeth/Uitenhage area, would represent a significant saving to the country as a whole.

It will be shown in Section 3 of this report that Adelaide's water supply even under normal rainfall conditions is at present insufficient. This, together with the above development plans means that a reliable water source urgently needs to be developed.

3. EXISTING WATER SUPPLY SYSTEM

3.1 DESCRIPTION

At present the Municipality of Adelaide obtains its water from a diversion weir in the Koonap River, situated approximately 12 km upstream of the town. The water is transported via a concrete lined canal, two inverted syphons and a tunnel, to an off-channel storage dam situated near Adelaide. The capacity of the dam is approximately 700 000 m^3. The canal is in extremely poor condition and is subject to severe siltation. The layout of the existing water supply scheme is shown on Drawing 5607 PE100.

The flow in the canal has in the past been supplemented by means of pumping directly from the Koonap River into the canal feeding the storage dam.

Limited additional water supplies are drawn from an existing Municipal borehole situated at the north-west side of Adelaide on the east bank of the Koonap River.

3.2 CAPACITY OF EXISTING SYSTEM

3.2.1 Capacity of Canal

Based on the longitudinal sections of the canal obtained from the Department of Water Affairs, the canal fall varies from a maximum of 1 : 1820 to a minimum of 1 : 3500.

Based on our observations on site as to the condition of the canal and the gradient, we calculate the capacity of the canal to be approximately 100 l/sec. Recordings taken during rains in 1991 agree with our estimated capacity. We estimate the capacity of the two inverted syphons to be approximately 350 l/s.

3.2.2 Pumping from Koonap River

The existing pumping equipment is situated on the river bank and is removed to safety when any significant flow in the river occurs. When pumping does take place, the capacity of the canal is exceeded and significant spillage occurs.

REPUBLIEK VAN SUID-AFRIKA
DEPARTEMENT VAN WATERWESE

AANSOEK OM 'N PERMIT INGEVOLGE ARTIKEL 9B(1) VAN DIE WATERWET, 1956 (WET 54 VAN 1956) VIR DIE OPRIGTING, VERANDERING OF VERGROTING VAN 'N WATERWERK VIR DIE UITNEEM, OPGARING OF OPDAMMING VAN OPENBARE WATER BUITE 'N STAATSWATERBEHEERGEBIED

1. Volle naam van applikant (geregistreerde eienaar): ______________________

2. Posadres: ______________________

3. Telefoonnommer en sentrale: ______________________

4. Beskrywing van eiendom volgens transportakte(s), waarop -

(a) die waterwerk opgerig, verander of vergroot gaan word, naamlik:

(i) Gedeelte, naam en nommer van plaas: ______________________

(ii) Distrik/afdeling: ______________________

(iii) Provinsie: ______________________

(iv) Grootte (ha): ______________________

(v) Nommer en datum van transportakte: ______________________

(vi) Volle naam van geregistreerde eienaar: ______________________

(vii) Identiteitsnommer: ______________________

(b) Die water aangewend gaan word, naamlik:

(i) Gedeelte, naam en nommer van plaas: ______________________

(ii) Distrik/afdeling: ______________________

(iii) Provinsie: ______________________

(iv) Grootte (ha): ______________________

(v) Nommer en datum van transportakte: ______________________

(vi) Volle naam van geregistreerde eienaar: ______________________

5. Besonderhede van bestaande waterwerke vir die uitneem, opgaring of opdamming van openbare water:

(a) Naam van rivier/stroom: ______________________

(b) Beskrywing van waterwerke: ______________________

(c) Lewerings- of opgaarvermoë van waterwerke: ______________________

(d) Tempo waarteen water uitgeneem word: ______________________

6. Totale oppervlakte tans onder besproeiing deur middel van die bestaande waterwerke hierbo beskryf (ha): ______________________

7. Besonderhede van landbougewasse besproei en beraamde gemiddelde jaarlikse watertoediening op sodanige gewasse toegepas (kubieke meter per hektaar per jaar of diepte in millimeter per jaar): ______________________________

____

____

8. Beraamde totale jaarlikse hoeveelheid openbare water onttrek deur middel van die bestaande waterwerke (kubieke meter per jaar): ______________________________

9. Besonderhede van voorgestelde waterwerke ten opsigte waarvan 'n permit verlang word:

(a) Naam van rivier/stroom: ______________________________

(b) Beskrywing van voorgestelde waterwerke: ______________________________

____

(c) Lewerings- of opgaarvermoë van voorgestelde waterwerke: ______________________________

____

(d) Tempo waarteen water uitgeneem sal word: ______________________________

10. Totale oppervlakte (of addisionele oppervlakte) besproei te word met die voorgestelde waterwerke (ha): ______________________________

11. Besonderhede van landbougewasse wat verbou gaan word en beraamde gemiddelde jaarlikse waterbehoefte van sodanige gewasse (kubieke meter per ha per jaar of toediening in millimeter per jaar): ______________________________

____

____

12. Beraamde totale jaarlikse onttrekking met die voorgestelde waterwerke (kubieke meter per jaar): ______________________________

13. Totale besproeibare (bewerkbare) oppervlakte op die betrokke eiendom(me) beskikbaar (ha): ______________________________

14. Besonderhede van bestaande waterregte soos Waterhoftoekennings, verdelings en geregistreerde waterregte, indien van toepassing: ______________________________

____

____

15. In die geval van 'n gemeenskaplike skema moet alle aandeelhouers se name asook volle besonderhede van hulle betrokke eiendomme verstrek word en moet 'n ooreenkoms voorgelê word wat aantoon in watter verhouding elke aandeelhouer tot die skema sal bydra en daarin sal deel.

16. Ter verduideliking en ondersteuning van my/ons aansoek word die volgende dokumente aangeheg:
(a) 1:50 000 liggingsplan
(b) Detail planne van die voorgestelde waterwerke
(c) 'n Volledige verslag met planne en spesifikasies ten opsigte van die voorgestelde waterwerk soos opgestel deur: ______________________________

____
HANDTEKENING VAN APPLIKANT(E)

____
DATUM

L.W. (i) Die aansoekvorm moet na voltooiing tesame met die bylae(s) aan die betrokke Streekdirekteur van die Departement besorg word vir nasiening en deursending.

(ii) Indien die spasies op die vorm onvoldoende is, kan besonderhede by wyse van 'n bylae verstrek word.

According to previous reports[1], pumping can take place at a rate to provide approximately 90 000 m³/annum.

3.2.3 Boreholes

The existing borehole can, under normal rainfall conditions, deliver approximately 79 000 m³/a.

3.3 INSUFFICIENCY OF EXISTING SYSTEM

An examination of the records of flow in the Koonap River shows the flow to be extremely irregular and characterised by relatively large flows of short duration.

The sufficiency of the existing supply system is therefore determined by the capacity of the canal and the frequency and duration of flows in the river. The pumping arrangement therefore need not be considered separately.

To determine the sufficiency of the existing canal and off-channel storage system, we modelled the actual daily flow in the Koonap using computer methods. The model was based on the recorded daily flow from 1933 to 1990.

Based on a present estimated demand of 400 000 m³/a, the simulation of the operation of the system showed that the system had an assurance of less than 90%. The assurance which is normally accepted for a domestic supply is 98%.

The existing system is therefore inadequate to meet even the present domestic demand. Since 1980 only three years have been without restrictions.

4. WATER DEMAND

4.1 DOMESTIC

4.1.1 Population

The historical population figures for Adelaide, as provided by the Central Statistical Service (CSS) are given below.

TABLE 1 : Historical Population

Year	White		Coloured		Black		Total Popu-lation
	Popula-tion	Growth Rate %	Popula-tion	Growth Rate %	Popula-tion	Growth Rate %	
1951	1335		730		2404		4 469
1960	1329	- 0,05	877	2,06	3362	3,80	5 568
1970	1174	- 1.23	1395	4,75	4658	3,31	7 227
1980	1216	0,35	1498	0,72	4927	0,56	7 641
1985	1495	4,22	2008	6,04	9133	13,14	12 636
1991	1311	- 2,17	1897	- 0,94	9866	1,30	13 074
Average							
1951-1991		- 0,05		2,42		3,59	
1970-1991		0,53		1,48		3,64	

The 1985 census figures have been adjusted by the CSS. It was generally accepted that the original 1985 figures for the coloured and black population groups were unreliable due to political unrest at the time. The 1991 census figures are provisional. Once again, due to political factors, the response by the coloured and black population groups to the 1991 census was extremely poor, and the census figures for these population groups should be regarded as unreliable.

The Adelaide Municipality have advised us that there is a growth in the coloured housing being provided and a negative growth rate as reflected by the 1991 census figures is therefore unrealistic. In their opinion the growth rate in coloured population since 1985 has been at least 1,5% per annum which gives a coloured population in 1991 of 2195.

The Lingelethu Town Council estimated the black population in 1991 to be approximately 13 680.

In view of the unreliability of the 1991 census figures for the coloured and black population groups, the above populations, i.e. 2195 for the coloureds and 13 680 for the blacks, as determined by the Municipality and the Lingelethu Town Council respectively, will be used in the estimation of the future population.

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

Whites : 1% p.a. Although the above table shows a negative growth rate of -0,05% from 1951 to 1991 and a growth rate of 0,53% from 1970 to 1991, we have assumed that the introduction of a reliable water supply will stimulate development of the area, resulting in a steady positive growth rate.

Coloureds : The House of Representatives have advised us that they are at present using a growth rate to 1995 of 2% p.a. reducing over the following 10 years to 1,5%, and thereafter to 1,2%. This agrees reasonably well with the average growth rates shown in the above table and will therefore be used for the projection of the future coloured population.

Blacks : The CPA : Office for Community Services advised us to use the growth rates as shown in the table below.

TABLE 2 : Estimated Future Population

Year	White		Coloured		Black		Total Population
	Population	Growth Rate %	Population	Growth Rate %	Population	Growth Rate %	
1995	1364	1%	2375	2,0	14 865	2,1	18 604
2000	1434	1%	2584	1,7	16 252	1,8	20 270
2005	1507	1%	2783	1,5	17 681	1,7	21 971
2010	1584	1%	2954	1,2	19 047	1,5	23 585
2015	1665	1%	3135	1,2	20 519	1,5	25 319
2020	1750	1%	3328	1,2	22 105	1,5	27 183

4.1.2 Water Consumption

The historical water consumption figures as provided by the Municipality are given below.

Year	Consumption (Ml)
1977	261
1978	298
1979	277
1980	313
1981	253 *
1982	326
1983	245 *
1984	** *
1985	323
1986	342
1987	309 *
1988	293 *
1989	192 *
1990	** *
1991	180 *

* Water Restrictions
** Consumption not available.

The above consumption figures are obtained from meters at the storage reservoirs and therefore include for industrial, school, and hospital consumption.

The Municipality have estimated that the present consumption can be divided as follows :

Household	76,0%
School	16,0%
Hospital	2,6%
Industry	0,4%
Municipal irrigation	5,0%
	100%

The estimated future domestic water demand of Adelaide is shown in Table 3 on page 11.

The following assumptions were used for the calculation of the figures in Table 3.

i) 1986 was the last recorded consumption without restrictions. The consumption of water by the whites in 1986 was, according to the Municipality, 261 Ml.

Based on a white population in 1986 of 1463, and including School, hospital, industrial and municipal irrigation demand, the per capita consumption was 499 l/d.

This appears realistic at present. Other Karoo towns with established reliable water supplies do 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 by 1995 the per capita consumption will increase to 525 l/d and by 2000 to 550 l/d.

ii) The per capita consumption of the coloureds was provided by the House of Representatives.

iii) The per capita consumption of the blacks was provided by the CPA : Office for Community Services.

TABLE 3 : Estimated future water demand

Year	White			Coloured			Black			Total Consumption	
	Population	Ave daily cons		Population	Ave. daily cons.		Population	Ave. daily cons.		Daily	Annual
		l/c	m³/d		l/c	m³		l/c	m³/d	m³/d	Ml
1991	1311			2195			13680				130*
1995	1364	525	716	2375	70	166	14865	80	1189	2071	756
2000	1434	550	789	2584	80	207	16252	90	1463	2459	898
2005	1507	550	829	2793	90	250	17681	100	1768	2847	1039
2010	1584	550	871	2954	100	295	19047	110	2095	3261	1190
2015	1665	550	916	3135	150	470	20519	120	2462	3848	1405
2020	1750	550	963	3328	150	499	22105	120	2653	4115	1502

* Recorded consumption

4.2 MUNICIPAL IRRIGATION

The Municipality at present has 200 ha of irrigable land which can be developed. In view of the water shortage the land is at present largely unused. As stated previously the Municipality intends to develop 50 ha as soon as a reliable water supply is developed, with plans to develop the remaining area in the future.

The annual irrigation requirement for lucerne in Adelaide is 1115 mm[2]. This includes 10% for losses (refer 4.3 below).

We however propose that, for the purpose of this report, a demand of 10 000 m^3/ha/a be used, i.e. 1000 mm/a.

4.3 FARMING

The farming pattern and irrigation requirements along the Koonap River, both upstream and downstream of Adelaide, were investigated and reported on in detail in the report by De Wet Shand Inc et al[2]. Although at present the crop most widely grown is lucerne, the climate of the region is similar to that along the Kat River where Citrus farming is highly successful.

Citrus farming has been carried out along the Koonap River for many years but, due to the absence of a reliable source of water, development has ceased, with the result that the tremendous citrus potential of the area is not being realised.

The following pertinent information is extracted from the above report :

i) The crop most widely grown at present is lucerne.

ii) The annual irrigation requirement for lucerne is 1200 mm. The annual rainfall for Adelaide and downstream farm areas is 463 mm which was assumed to be 40% effective. Irrigation required, allowing 10% for losses, was therefore assumed to be 1115 mm per annum.

iii) The total potential irrigable land downstream of Adelaide is approximately 3330 ha.

iv) A water cost of up to R946/ha (June 1988) was shown to be economically viable.

A summary of the irrigable areas downstream of Adelaide is given in Appendix A. The information in Appendix A was extracted from the report by De Wet Shand et al[2].

Although previous feasibility studies have shown that a water cost of up to R950/ha in 1988 was economically viable, discussions with the farmers at that time showed that they would not have been prepared to pay that much.

R950/ha at today's prices would amount to R1660/ha. This annual cost per hectare in comparison with other schemes with which we are involved is very high and we believe it can be ruled out that irrigators would be prepared to commit themselves to this cost.

The inclusion of irrigators in the scheme is beneficial and in view of the above, and the fact that the irrigation water would be made available at the dam, i.e. farmers would have to distribute water at their own cost, it was felt that in order to incorporate farmers in the scheme, water would have to be made available at a more attractive price.

The Council therefore proposed that a cost of R700/ha (1992 price) be proposed to the farmers to determine their interest in the scheme.

To determine the farmers' interest in obtaining water from a dam at the Foxwood site, the Municipality sent out questionnaires to selected farmers downstream of Adelaide in April 1992. A copy of the questionnaire is enclosed as Appendix B.

The total areas for which the farmers who received questionnaires were interested in obtaining water, amounted to 1227 ha. Based on an annual irrigation requirement of 1115 mm, this amounts to 13,7 million m³/a.

4.4 TOTAL WATER DEMAND

During our preliminary investigations into the construction of a dam at the Foxwood site, we inter-alia looked at the affordability of various dam sizes, taking into account the Municipal demand and varying irrigation demands.

The primary purpose of the dam is to provide Adelaide with a reliable water supply. It is however evident that there is more than sufficient demand from the farmers downstream of Adelaide to substantiate the Municipality's proposal to construct a dam to provide water for both Municipal and some farm irrigation requirements.

During the preliminary investigation, we determined the approximate storage required to meet varying demands. An irrigation demand of 10 000 m³/ha/a was assumed (i.e. 1000 mm/a). Adelaide's domestic demand was, for comparison purposes, converted into an equivalent irrigable area.

The results of our analysis are given in the table below :

TABLE 4 : Cost of various dam sizes

Area Irrigated (ha)	Demand million m³/a	Storage Capacity required million m³	Annual Cost per ha (R)
350 *	3,5	9	5 300
1 140	11,4	17	1 850
1 640	16,4	27	1 750
2 140	21,4	39	1 550

* Municipal demand only, i.e. domestic 1,5 million m³/a plus 200 ha irrigation.

In calculating the annual costs the following was assumed :

i) A $33.^{1}/_{3}$% subsidy on the capital cost.

ii) Finance at the following rates : 75% at 11,25%
25% at 16,5%

ii) Contingencies, escalation and Professional fees have been included.

The above costs show that when irrigation demand over and above Adelaide's demand is included, the annual cost initially reduces drastically, i.e. R5300/ha to R1850/ha.

In reply to the questionnaires sent out by the Municipality, the farmers who received the questionnaire have indicated that they would be interested in scheduling 1227 ha at a cost of R700/ha/a. Water would be released from the dam at a rate of 10 000 m³/ha/a.

It is not possible at this stage to finalise the demand for farm irrigation. In view of the financial implications to the Municipality, it is important to adopt a conservative approach, taking the following into consideration.

i) Farmers who indicated their interest in the questionnaire may "back out" when asked to commit themselves to the scheme.

ii) Although 3330 ha of potential irrigable land exists downstream of the dam, extensive losses will occur in the river making it uneconomical for farmers lower down the river to participate in the scheme.

Table 4 above shows clearly that a dam for Adelaide's Municipal demand only is uneconomical and the only feasible option is to construct a dam for both Municipal and farm irrigation requirements.

Based on the foregoing it is reasonable to assume that a demand of 11,4 million m³/a would be obtainable. This would ultimate provide sufficient water to irrigate approximately 790 ha in addition to Adelaide's domestic and irrigation demand.

We therefore propose that at this stage the total demand be taken as follows :

TABLE 5 : Assumed Water Demand

	Annual Demand million m³
Domestic	1,5
Municipal Irrigation (200 ha)	2,0
Farm Irrigation (790 ha)	7,9
Total Annual Demand	11,4

We reiterate that it is not possible at this stage to finalise the demand (and hence the dam size). Although the above assumptions with regard to future irrigation requirements may be conservative, i.e. more area may be scheduled for irrigation than has been assumed, we believe that the assumptions are realistic. In our opinion the actual demand will not vary substantially from the above and will be finalised during the detailed design stage.

5. ALTERNATIVE WATER SUPPLY OPTIONS

5.1 GENERAL

A number of alternative options to provide a reliable long term water supply to Adelaide have previously been investigated. Brief details of the options are summarised below together with our comments as to the sufficiency of each option. The locality of the various options are shown on drawing no. 5862 PE100.

5.2 DE BEERSDRIFT DAM

We investigated the construction of a dam on the Koonap River at the de Beersdrift site, in September 1991. A dam with a maximum capacity of approximately 3,5 million m^3 could be constructed at the site. Siltation is however a problem, with silt accumulation over the life of the dam estimated as being approximately 2,8 million m^3. The net available storage of 700 000 m^3 is insufficient to meet even Adelaide's domestic demand.

5.3 OFF-CHANNEL STORAGE

To provide Adelaide with a domestic supply only in the year 2020 (domestic demand 1,5 million m^3) off-channel storage capacity of approximately 2 million m^3 would be required. The supply to the dam (either pumping or canal) would require a capacity of approximately 1000 l/s. This however would not be sufficient to supply any irrigation water to Adelaide.

Although the existing Municipal dam and canal is an off-channel storage system, the dam wall has already been raised and we were advised that previous investigations had indicated that the foundation conditions are unsuitable for raising the wall any further. Our observations on site show that the ground on the east side of the dam falls away rapidly and the site is therefore not suited for obtaining additional storage.

Based on the 1 : 50 000 topographical maps and our investigations on site, there appear to be no sites which are suited for off-channel storage sufficient to provide water to meet Adelaide's demand of 1,5 million m^3 in the year 2020.

5.4 WATERKLOOF DAM

The development of this option to supplement the water supply to Adelaide would entail the Municipality purchasing the existing Waterkloof dam from a private owner (present purchase price R1,35 m) and constructing a pipeline to Adelaide.

The Waterkloof dam has a catchment area of approximately 90 km². The dam, which was constructed in 1960, initially had a full supply capacity of 1,79 million m^3. The spillway crest has subsequently been raised to give a full supply level capacity of 1,96 million m^3. The capacity of the dam has over its 30 year life been reduced by siltation to at most 1,5 million m^3.

The spillway is in poor condition and requires extensive work[a]. No information as to the condition of the embankment is readily available.

Allowing for a similar siltation rate over the next say 25 years, would reduce the dams capacity to approximately 1,1 million m^3. Our preliminary analysis shows that the dam could provide approximately 700 000 m^3/annum with a surety of 94%.

This together with the existing Municipal scheme could provide approximately 1,1 million m^3/a, which is insufficient to meet the Municipal demand in the year 2020.

5.5 GROUND WATER

Ground water as a potential source was reported on by C.V. Joubert in November 1985[7] and A. Stone in October 1988[8]. Although the reports recommended the drilling of boreholes, no significant ground water source was identified.

Based on the information contained in the above reports the Municipality has over the years drilled numerous additional boreholes without success.

There are a number of existing low yielding private boreholes in the town.

The only borehole which has been used successfully by the Municipality is situated at the north-west edge of town on the east bank of the Koonap River. This hole has in the past yielded up to 79 000 m^3/a at a rate of approximately 18 m^3/h.

The yield of this hole is however decreasing rapidly and at present is only pumped for approximately 4 hours per day.

As an emergency measure the Municipality has started using a borehole situated at the school. The hole was previously used to water the school sportsfields and is presently being pumped at a rate of 23 m^3/hour.

As a further emergency measure a borehole situated approximately 3 km from Adelaide is likely to be used to replace the water being transported in railway tankers from Cookhouse.

In view of the above, in our opinion there is insufficient ground water to provide a reliable long term water supply to Adelaide.

5.6 FOXWOOD DAM

A dam on the Koonap River at the Foxwood site was first investigated by the Department of Water Affairs in 1962, with the most recent investigation being carried out for the Koonap Irrigation Board by De Wet Shand in November 1989[3].

The Foxwood site is ideally suited for construction of a large dam, and would utilise the runoff from both the Koonap and Mankazana rivers. The site is suitable for construction of a dam of up to 87 million m^3.

5.7 CONCLUSIONS

Based on the foregoing investigations it is clear that the only option with sufficient potential to meet the long term water demand of Adelaide is the construction of a dam on the Koonap River at the Foxwood Site.

6. PROPOSED DAM AT FOXWOOD SITE

6.1 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.

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.

6.2 EXISTING INFORMATION

In 1962 the Department of Water Affairs carried out a foundation investigation at the Foxwood site. Seven boreholes were drilled. On both flanks, fine grained mudstone is overlain by medium grained sandstone. The site is suitable for an earth embankment dam and it is anticipated that excavation of the cut off trench into the underlying mudstone will provide a suitable seal with a minimal amount of grouting.

During our investigation of a dam at the De Beersdrift site, trial holes were excavated to determine the availability of material for the embankment. The reddish brown clayey silt found appears to be typical for the Adelaide area and would be suitable for the core of an earth embankment dam. The general fill of an embankment could be constructed from silt deposits within the river valley. It is assumed that rock excavation from the spillway would be suitable for rip-rap.

During the investigation of the area by De Wet Shand in 1988[2], a contour survey of the dam basin was produced at a 1 in 5000 scale from aerial photographs of the area.

This survey was used to determine the capacity curve of the dam basin. The capacity curve is enclosed as Appendix C.

Wherever possible all other available information was used in the preparation of this report. A list of report references is given at the front of this report.

6.3 DETERMINATION OF MEAN ANNUAL RUNOFF

The catchment area of the proposed dam is 1090 km^2.

A Department of Water Affairs streamflow gauge Q9MO2 measures flow in the Koonap at Adelaide and is situated approximately 7 km below the dam site. The catchment area of the gauge is 1250 km^2 and has been in operation since 1926. The recorded MAR at Q9MO2 over the 54 year record period is 50,7 million m^3.

Adjusting the MAR at Q9MO2 according to the catchment area of the dam gives an MAR at the dam site of 44,2 million m^3.

Based on the HRU quartenary subcatchment information the virgin MAR at the dam site is approximately 65 million m^3.

If the total potential irrigable land upstream of Adelaide is taken as 2980 ha^2 and irrigation requirement taken as 800 mm per ha/a^2, the net MAR at the dam site allowing for upstream irrigation is approximately 41 million m^3.

For the purposes of this report an average of the above net MAR's will be assumed, i.e. 42,6 million m^3.

6.4 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 1000 $t/km^2/a$.

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 dead storage, Prof Rooseboom was requested to evaluate the conditions in the Koonap catchment upstream of Adelaide.

In January 1992 Prof. Rooseboom inspected the catchment. Based on his evaluation and new statistical analyses of data and information in the area, Prof Rooseboom is of the 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.

Based on the above, and assuming a 95% trap efficiency, the sediment accumulation in the dam over a period of 30 years was calculated as being approximately 4,26 million m³.

6.5 STORAGE REQUIREMENTS

The Department of Water Affairs streamflow gauge Q9MO2 measures flow in the Koonap River at Adelaide. Flow records exist from 1926. The HRU have analyzed 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 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 11,4 million m³/annum with a 90% surety, which is the normally accepted surety for an irrigation scheme, 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 following flow records :

i) Records from 1926 to 1979 as analyzed by the HRU
ii) Records from 1926 to 1979 as above with additional flow records from 1979 to 1990 obtained from Department of Water Affairs added.

The assumptions used in the analysis are given briefly below.

i) The storage in the existing Municipal dam was taken as 700 000 m³ and was included in the analysis.
ii) Dead storage of 4,26 million m³ was allowed for siltation over a 30 year period.

iii) At this stage it is proposed that the dam provide a yield with a 90% surety. It is proposed however that storage for 6 months domestic consumption, including an allowance for evaporation, be reserved in the dam. The assured yield which is normally accepted for a domestic supply is 98%.

At the detailed design stage an analysis will be carried out to determine the reserve storage requirements as well as the economic effect of reducing the surety of yield for irrigation water.

Based on the above, a dam with a gross capacity of 17 million m^3 yielded 11,4 million m^3/annum with the following sureties.

Flow records	Surety
1926 to 1979	94%
1926 to 1990	90%

6.6 FLOODS AND DAM SAFETY

6.6.1 Dam Safety Legislation

In terms of Section 9C of the Water Act, construction of a dam with a "safety risk" requires a permit from the Minister of Water Affairs. A dam with a safety risk is generally a dam of height over 5 metres and impounding more than 50 000 m^3.

The regulations classify dams according to their maximum wall height, i.e. size, as well as their hazard ratings which are combined to produce a safety risk category. The safety risk category prescribes the degree of attention as regards design, construction, commissioning, operation and maintenance of a dam.

Based on a dam with a maximum wall height of less than 30 metres (medium size) with a high hazard rating, we have assumed that the dam will be classified by the Department of Water Affairs as a Category III dam.

6.6.2 Guidelines

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" Report No. 4 (Sancold Dec. 1991).

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.

The design flood is termed the Recommended Design Flood (RDF) and the extreme flood the Safety Evaluation Flood (SEF).

6.6.3 Flood peak calculations

6.6.3.1 Recommended Design Flood (RDF)

Table 5.4 of the Guidelines recommends an RDF equal to the 1 in 200 year flood for a dam of medium size with a high hazard rating.

Based on the HRU Unitgraph method we calculated the 1 in 200 year flood to be 700 m^3/sec.

6.6.3.2 Safety Evaluation Flood (SEF)

According to the guidelines, the SEF for this particular dam size and hazard rating must be determined by routing the Probable Maximum Flood (PMF) through the reservoir.

The PMF hydrograph was calculated using the HRU Unitgraph method and using probable maximum precipitation values given in Fig C4 of HRU Report No. 1/72.

The unrouted PMF was calculated to be 5500 m^3/sec. The PMF was routed through the reservoir to obtain an outflow peak of 5280 m^3/sec.

6.7 DAM AND SPILLWAY TYPE

6.7.1 Spillway capacity equal to SEF

A comparison between the cost of a mass concrete (rollcrete) wall and earth embankment showed the earth embankment to be much more economical. Based on existing information (refer Section 6.2) there appears to be sufficient suitable material to construct an earth embankment. A more detailed investigation will however be required at detailed design stage.

The large magnitude of the floods associated with this size catchment make the spillway structure relatively expensive. In view of this a number of different types of spillways were investigated to determine the most economical spillway arrangement.

Cost comparisons between the following spillways were carried out :

i) Side channel (on left flank)

ii) Open channel with ogee crest (on right flank)

iii) Combined mass concrete overflow and open channel with ogee crest

Option iii) was found to be the most economical. The overall spillway width is 138 metres. The embankment has a 7 metre freeboard to allow a maximum flow depth at the spillway crest of 7 metres. Details of the proposed earth embankment dam with combined mass concrete overflow and open channel spillway are shown on drawing no. 5862 PE102.

The above spillways are all capable of passing the SEF and were therefore compared on an equal basis.

6.7.2 Reduced Spillway Capacity

As stated previously, the size of the floods in this instance make the spillway structure very expensive. It follows therefore that any reduction in spillway capacity could lead to substantial initial cost savings on the overall cost of the dam.

The larger the spillway capacity, the lower the risk of substantial damage or failure of the dam.

It is not possible to provide absolute safety against all floods. The objective is therefore to balance the benefits of the dam against the cost of reducing the risk of failure. This in turn must be balanced against the cost of damage, both to the dam and downstream of it, should a flood release from the dam due to either a dam breach or partial breach occur.

In order to reduce the cost of the spillway structure we therefore propose that a spillway containing a "fuse plug" also be considered as an alternative to option iii) in 6.7.1 above.

The concept of this spillway is to design a service spillway capable of safely passing a flood somewhere between the RDF and the SEF. The size of the flood would ultimately be determined by comparing the cost of the spillway to the cost of possible damage to the dam and downstream of it. This risk based analysis can only be finalised during detailed design.

We propose therefore at this stage that the 50 m wide ogee portion of the spillway be used as a service spillway. The capacity of the service spillway would therefore be approximately 935 m^3/sec which is 235 m^3/sec more than the RDF. A section of the embankment is then designed to fail progressively to ultimately obtain a spillway capable of passing the SEF. This "erodible fuse plug" would require replacing should the PMF flood occur..

If the risks associated with this option are found to be acceptable by the Municipality, we recommend that the proposal be submitted to the Department of Water Affairs for approval.

Details of a combined service and fuse plug spillway are shown on drawing 5862 PE103.

6.8 MUNICIPAL WATER SUPPLY

6.8.1 Domestic

To provide water for domestic consumption, we propose that water be pumped from the Foxwood dam into the existing Municipal dam. The Municipal dam will act as a balancing reservoir and pumping can therefore take place at the average demand rate over say 22 hours per day.

The demand in 2020 of 4115 m^3/day could therefore be met by pumping at a rate of approximately 52 l/sec.

For the purposes of this report, we will therefore assume that domestic water will be supplied from the Foxwood dam by pumping to the existing Municipal dam at a rate of 52 l/sec via a 200 mm diameter pipeline approximately 1500 metres long.

6.8.2 Municipal Irrigation

Most of the Municipality's irrigable land is situated below the low water level in the Foxwood dam and we will therefore assume that irrigation from the dam will take place under gravity via an earth canal.

7. COST ESTIMATES

7.1 GENERAL

The cost estimates below are based on preliminary quantities, available geotechnical information and current rates (September 1992) for similar types of work. In view of the poor economy and the low level of work in the Civil Engineering industry at present, extremely competitive rates can be expected until, in our opinion, at least the middle of 1993. It is however expected that rates will show a rapid and sharp increase when the economy improves.

A 12 month construction period has been assumed with construction commencing in July 1993. 10 month's escalation at 1,25% per month has been assumed before construction and an average of 6 months at 1,25% per month during construction.

7.2 EARTH EMBANKMENT AND COMBINATION MASS CONCRETE OVERFLOW AND OPEN CHANNEL WITH OGEE CREST

7.2.1 Capital Cost

Embankment : 570 000 m³ @ R12	6 840 000
Spillway excavation : 107 200 m³ @ R20	2 144 000
Core excavation	1 000 000
Mass concrete in wall : 13 000 m³ @ R350	4 550 000
Concrete in wing walls and spillway apron : 510 m³ @ R500 600 m³ @ R350	465 000
Purchase of farm land below TWL, relocation of roads, power and telephone lines	1 000 000
Municipal supply : Pumps, pipeline and canal	330 000
	16 329 000
10% Contingencies	1 632 900
	17 961 900
Escalation - 16 months @ 1,25% (20%)	3 592 400
	21 554 300
Professional Fees - say 10%	2 155 400
	23 709 700
Geotechnical Investigation	200 000
	23 909 700
Say	R 24 000 000

7.3 EARTH EMBANKMENT AND COMBINATION MASS CONCRETE, FUSE PLUG AND OPEN CHANNEL

7.3.1 Capital Cost

Embankment : 598 000 m^3 @ R12	7 176 000
Spillway excavation : 107 200 m^3 @ R20	2 144 000
Fuse plug : 25 000 m^3 @ R15	375 000
Core excavation	1 000 000
Mass concrete in wall : 1400 m^3 @ R400	560 000
Concrete in wing walls and spillway apron : 1400 m^3 @ R500	700 000
Purchase of farm land below TWL. Relocation of roads, power and telephone lines	1 000 000
Municipal water supply : Pumps, pipeline and canal	330 000
	13 285 000
10% Contingencies	1 328 500
	14 613 500
Escalation - 16 months @ 1,25% (20%)	2 922 700
	17 536 200
Professional Fees - say 10%	1 753 600
	19 289 800
Geotechnical Investigation	200 000
	19 489 800
Say	R 20 000 000

8. FINANCIAL ASPECTS

8.1 DIVISION OF WATER DEMAND

The proposed dam will supply water to the following parties.

TABLE 6 : Division of Water Demand

	Annual Demand in 2020 million m³	Share of Demand	
Adelaide Domestic			
Whites	351,5	3,1%	
Coloureds	182.1	1,6%	30,7%
Blacks	968,4	8,5%	
Adelaide Irrigation	2000	17,5%	
Farm Irrigation	7900	69,3%	69,3%
	11 402,0	100%	

8.2 FINANCING OF SCHEME

8.2.1 There are a number of financial scenarios which can be examined. The normal way of financing a combined water supply scheme such as this would be to divide the capital cost of the scheme based on the water demand. Table 6 shows that the cost of the scheme would firstly be divided between the Municipality (30,7%) and farmers (69,3%).

This would entail the formation of a new Irrigation Board for those farmers participating in the scheme. Because of separate sources of funding, the Municipality's share would again be divided between the whites, coloureds and blacks.

A subsidy on the cost of a water scheme such as this would normally be available from the Department of Water Affairs for both the Municipality and Irrigation Board.

TABLE 7 : Division of Costs

Party	Share of Capital Cost before subsidy		Subsidy	Average Interest Rate	Interest and Redemption of Capital 30 years	
	R24 mill.	R20 mill			R24	R20
Whites	0,744	0,620	33¹/₃	16,5	82 683	68 902
Coloureds	0,384	0,320	33¹/₃	11,25	30 029	25 024
Blacks	2,040	1,700	33¹/₃	11,25	159 528	132 940
Municipal irrigation	4,200	3,500	33¹/₃	16,5	466 760	388 966
Farm Irrigation	16,632	13,860	33¹/₃	16,5	1 848 370	1 540 308
Total annual interest and redemption					2 587 370	2 156 140

8.2.2 The present domestic water price is approximately 68c/m³.

8.2.3 Based on the annual domestic consumption of 624 000 m³ and an irrigation area of 990 ha on completion of the scheme in say 1994, a domestic water price of say R1-91/m³ and a price per ha of R1840 would be required in the first year in order to meet the payment of capital redemption and interest given in Table 7 above.

Although it can be shown that the scheme is economically advantageous in the long term, the above unit prices would be unaffordable to both the domestic consumer and the irrigators. This means that the consumers will initially not be able to cover the cost of the scheme. However, it is proposed that it be accepted that a certain deficit be accumulated over the first number of years (say 5 - 10 years) and that this deficit, together with the initial capital cost of the scheme, be paid off over the remainder of the life of the scheme.

8.2.4 In view of the above we propose the following :

(i) Initially the unit price for both domestic and irrigation water be limited to the maximum affordable price. We propose that this maximum price be R1-53/m³ for domestic water (an increase of R0-85/m³) and R750/ha for irrigation water.

(ii) The price per hectare for irrigation water be kept constant for the first five years after completion of the scheme, to enable the farmers to establish their crops

(iii) The domestic price initially increases at the rate of inflation (Assumed to be 15% per annum).

(iv) The proposed price structure in (ii) and (iii) above would mean that the price of the irrigation water would decrease rapidly in real terms over the first five years (refer tables 8 to 11). In order to ensure that the irrigators pay a reasonable share of the cost of the scheme over its lifetime, it is proposed that the price of irrigation water be increased after 5 years at more than the rate of inflation so as to reach a price of approximately R600/ha in real terms in say 2008. (This is still well below the R700/ha they have declared themselves prepared to pay in 1992).

(v) We propose further that the cost of domestic water be kept constant in Rand terms after 2008.

8.2.5 Tables 8 and 9 show typical cash flow scenarios based on the above assumptions for annual costs of R2,58 million (R24 million) and R 2,15 million (R20 million).

The above tables show that in both cases, a substantial cumulative deficit (including interest compounded at 16% p.a.) occurs. Table 8 shows a maximum deficit of R10,38 million in 2002 and Table 9 R4,53 million in 2000. The deficit is as a result of the shortfall, during the first number of years, in income required to repay the annual interest and redemption of capital on the loan to construct the scheme.

8.2.6 The only means of keeping both the water price affordable and to limit the deficit in either amount or time period, would be to reduce the annual amount payable on the loan. This could be done in either of the following ways.

i) Obtain an increased subsidy or grant to reduce the loan required by the participants in the scheme.

ii) Obtain a loan at substantially reduced interest rates

iii) A combination of the above.

8.2.7 To illustrate the above, Table 10 shows that in order to limit the cumulative deficit to say R3 million, an additional capital subsidy or grant of R3,7 million would be required to afford a R24 million scheme.

8.2.8 Table 11 shows that to repay the deficit in say 5 years, an additional capital subsidy or grant of R5,7 million would be required to afford a R24 million scheme.

8.2.9 The cash flows shown in Tables 8 to 11 show that a relatively small difference in capital cost results in a large difference in the cumulative deficit. For example, considering Tables 8 and 9 -

Table	Capital Cost	Annual Cost	Maximum deficit
8	R 24 million	R2,58 m	R10,38 m
9	R 20 million	R2,15 m	R 4,53 m

This means that a relatively small amount of additional assistance makes a big difference in the affordability of the scheme.

8.2.10 The same method of financing could of course be applied to a scheme supplying domestic water only. However, as shown below, such a scheme would be prohibitively expensive.

Table 4 on page 14 shows that a dam with a capacity of approximately 9 million m^3 would be required to supply water for the Municipal demand only. The annual cost of the water would be approximately R1,86 million.

Based on the Municipality's domestic and irrigation demand of 1 164 000 m^3 in 1994, a domestic water price of approximately R3-34/m^3 would be required (assuming R1840/ha for irrigation).

This is obviously unaffordable and a combined scheme is therefore the only feasible option to provide affordable water to meet Adelaide's Municipal and irrigation demand.

8.3 CONCLUSIONS

It is evident from the above that there are many ways of financing the scheme. It is clear however that a combined scheme is beneficial to all parties in the long term.

When negotiating the financing of the scheme, the overall long term benefits for the area should be considered. Although the domestic consumers for example subsidise the farmers to a certain extent, a Municipal scheme on its own is not affordable. and it is therefore in the Municipality's interest to attract participation in a scheme which will ultimately lead to increased income generation, increased job opportunities and the overall growth in the economy of the region.

TABLE 8 : CASH FLOW : CAPITAL COST R24 MILLION

YEAR	ANNUAL COST R X 10^6	DOMESTIC WATER DEMAND m^3	UNIT COST @ 15 % R/m^3	INCOME - SALES DOMESTIC WATER R/annum X 10^6	IRRIGATION DEMAND ha	UNIT COST @ 22 % R/ha	INCOME - IRRIGATION R X 10^6	TOTAL INCOME R X 10^6	SURPLUS / DEFICIT R X 10^6	CUMULATIV SURPLUS / DEFICIT R X 10^6	CUM SURPLUS/ DEFICIT + INTEREST @ 16 % R X 10^6	PRESENT DAY CUM SURPLUS/ DEFICIT +INT @ 15 % R X 10^6	PRESENT DAY DOMESTIC COSTS @ 15 % R/m^3	PRESENT DAY IRRIGATION COSTS @ 15 % R/ha
1994	2.58	664000	0.85	0.56	990	750.00	0.74	1.31	-1.27	-1.27	-1.48	-1.12	0.64	567.11
1995	2.58	756000	0.98	0.74	990	750.00	0.74	1.48	-1.10	-2.37	-2.81	-1.85	0.64	493.14
1996	2.58	782000	1.12	0.88	990	750.00	0.74	1.62	-0.96	-3.33	-4.22	-2.41	0.64	428.81
1997	2.58	810000	1.29	1.05	990	750.00	0.74	1.79	-0.79	-4.12	-5.69	-2.83	0.64	372.88
1998	2.58	830000	1.49	1.25	990	750.00	0.74	1.99	-0.59	-4.71	-7.19	-3.11	0.64	324.25
1999	2.58	867000	1.71	1.48	990	915.00	0.91	2.39	-0.19	-4.90	-8.53	-3.21	0.64	340.90
2000	2.58	890000	1.97	1.77	990	1116.30	1.11	2.87	0.29	-4.61	-9.60	-3.14	0.64	364.92
2001	2.58	925000	2.26	2.09	990	1361.89	1.35	3.44	0.86	-3.75	-10.28	-2.92	0.64	387.13
2002	2.58	952000	2.60	2.48	990	1661.50	1.64	4.12	1.54	-2.21	-10.38	-2.57	0.64	410.70
2003	2.58	980000	2.99	2.93	990	2027.03	2.01	4.94	2.36	0.14	-9.69	-2.08	0.64	435.70
2004	2.58	1009000	3.44	3.47	990	2472.98	2.45	5.92	3.34	3.48	-7.98	-1.48	0.64	462.22
2005	2.58	1039000	3.95	4.11	990	3017.03	2.99	7.10	4.52	8.00	-4.65	-0.76	0.64	490.35
2006	2.58	1068000	4.55	4.86	990	3680.78	3.64	8.50	5.92	13.92	0.53	0.07	0.64	520.20
2007	2.58	1097000	5.23	5.74	990	4490.55	4.45	10.18	7.60	21.52	8.22	1.01	0.64	551.86
2008	2.58	1127000	6.01	6.78	990	5478.47	5.42	12.20	9.62	31.14	19.15	2.05	0.64	585.46
2009	2.58	1158000	6.92	8.01	990	5478.00	5.42	13.44	10.86	42.00	33.07	3.07	0.64	509.05
2010	2.58	1190000	6.92	8.23	990	5478.00	5.42	13.66	11.08	53.08	49.44	4.08	0.56	442.65
2011	2.58	1230000	6.92	8.51	990	5478.00	5.42	13.93	11.35	64.43	68.71	5.55	0.49	384.91
2012	2.58	1272000	6.92	8.80	990	5478.00	5.42	14.23	11.65	76.08	91.35	7.38	0.42	334.71
2013	2.58	1315000	6.92	9.10	990	5478.00	5.42	14.52	11.94	88.02	117.91	9.53	0.37	291.05
2014	2.58	1359000	6.92	9.40	990	5478.00	5.42	14.83	12.25	100.27	149.02	12.04	0.32	253.09
2015	2.58	1405000	6.92	9.72	990	5478.00	5.42	15.15	12.57	112.83	185.43	14.98	0.28	220.08
2016	2.58	1424000	6.92	9.85	990	5478.00	5.42	15.28	12.70	125.53	227.88	18.41	0.24	191.37
2017	2.58	1443000	6.92	9.99	990	5478.00	5.42	15.41	12.83	138.36	277.07	22.39	0.21	166.41
2018	2.58	1462000	6.92	10.12	990	5478.00	5.42	15.54	12.96	151.32	334.36	27.02	0.18	144.70
2019	2.58	1482000	6.92	10.26	990	5478.00	5.42	15.68	13.10	164.42	400.96	32.40	0.16	125.83
2020	2.58	1502000	6.92	10.39	990	5478.00	5.42	15.82	13.24	177.66	478.35	38.65	0.14	109.42
TOTALS		30054000		152.57	26730		94.75	247.32	177.66					

TABLE 9 : CASH FLOW : CAPITAL COST R20 MILLION

YEAR	ANNUAL COST	DOMESTIC WATER DEMAND	UNIT COST @ 15 %	INCOME - SALES DOMESTIC WATER	IRRIGATION DEMAND	UNIT COST @ 22 %	INCOME - IRRIGATION	TOTAL INCOME	SURPLUS / DEFICIT	CUMULATIV SURPLUS / DEFICIT	CUM SURPLUS/ DEFICIT + INTEREST @ 16 %	PRESENT DAY CUM SURPLUS/ DEFICIT +INT @ 15 %	PRESENT DAY DOMESTIC COSTS @ 15 %	PRESENT DAY IRRIGATION COSTS @ 15 %
	R X 10^6	m^3	R/m^3	R/annum X 10^6	ha	R/ha	R X 10^6	R X 10^6	R X 10^6	R X 10^6	R X 10^6	R X 10^6	R/m^3	R/ha
1994	2.15	664000	0.85	0.56	990	750.00	0.74	1.31	-0.84	-0.84	-0.90	-0.74	0.64	567.11
1995	2.15	756000	0.98	0.74	990	750.00	0.74	1.48	-0.67	-1.51	-1.88	-1.19	0.64	493.14
1996	2.15	782000	1.12	0.88	990	750.00	0.74	1.62	-0.53	-2.04	-2.62	-1.50	0.64	420.81
1997	2.15	810000	1.29	1.05	990	750.00	0.74	1.79	-0.36	-2.40	-3.40	-1.69	0.64	372.08
1998	2.15	838000	1.49	1.25	990	750.00	0.74	1.99	-0.16	-2.56	-4.11	-1.77	0.64	324.25
1999	2.15	867000	1.71	1.48	990	915.00	0.91	2.39	0.24	-2.32	-4.52	-1.70	0.64	343.90
2000	2.15	898000	1.97	1.77	990	1116.30	1.11	2.87	0.72	-1.60	-4.53	-1.40	0.64	364.92
2001	2.15	925000	2.26	2.09	990	1361.09	1.35	3.44	1.29	-0.31	-3.96	-1.13	0.64	387.13
2002	2.15	952000	2.60	2.48	990	1661.50	1.64	4.12	1.97	1.66	-2.63	-0.65	0.64	410.70
2003	2.15	980000	2.99	2.93	990	2027.03	2.01	4.94	2.79	4.44	-0.26	-0.06	0.64	435.70
2004	2.15	1009000	3.44	3.47	990	2472.98	2.45	5.92	3.77	8.21	3.47	0.65	0.64	462.22
2005	2.15	1039000	3.95	4.11	990	3017.03	2.99	7.10	4.95	13.16	8.97	1.46	0.64	490.35
2006	2.15	1068000	4.55	4.86	990	3680.78	3.64	8.50	6.35	19.51	16.76	2.37	0.64	520.20
2007	2.15	1097000	5.23	5.74	990	4490.55	4.45	10.18	8.03	27.54	27.47	3.30	0.64	551.06
2008	2.15	1127000	6.01	6.78	990	5470.47	5.42	12.20	10.05	37.59	41.92	4.40	0.64	585.46
2009	2.15	1158000	6.92	8.01	990	5470.00	5.42	13.44	11.29	48.88	59.91	5.57	0.64	509.05
2010	2.15	1190000	6.92	8.23	990	5470.00	5.42	13.66	11.51	60.39	81.00	6.55	0.56	442.65
2011	2.15	1230000	6.92	8.51	990	5470.00	5.42	13.93	11.78	72.17	105.75	8.54	0.49	384.91
2012	2.15	1272000	6.92	8.80	990	5470.00	5.42	14.23	12.08	84.25	134.74	10.89	0.42	334.71
2013	2.15	1315000	6.92	9.10	990	5470.00	5.42	14.52	12.37	96.62	168.68	13.63	0.37	291.05
2014	2.15	1359000	6.92	9.40	990	5470.00	5.42	14.83	12.68	109.30	208.34	16.83	0.32	253.09
2015	2.15	1405000	6.92	9.72	990	5470.00	5.42	15.15	13.00	122.29	254.67	20.50	0.28	220.00
2016	2.15	1424000	6.92	9.85	990	5470.00	5.42	15.28	13.13	135.42	308.55	24.93	0.24	191.37
2017	2.15	1443000	6.92	9.99	990	5470.00	5.42	15.41	13.26	148.68	371.17	29.99	0.21	166.41
2018	2.15	1462000	6.92	10.12	990	5470.00	5.42	15.54	13.39	162.07	443.95	35.87	0.18	144.70
2019	2.15	1482000	6.92	10.26	990	5470.00	5.42	15.68	13.53	175.60	528.51	42.71	0.16	125.83
2020	2.15	1502000	6.92	10.39	990	5470.00	5.42	15.82	13.67	189.27	626.74	50.64	0.14	109.42
TOTALS		30054000		152.57	26730		94.75	247.32	189.27					

TABLE 10 : CASH FLOW : DEFICIT LIMITED TO R3,0 MILLION

YEAR	ANNUAL COST	DOMESTIC WATER DEMAND	UNIT COST @ 15 %	INCOME - SALES DOMESTIC WATER	IRRIGATION DEMAND	UNIT COST @ 22 %	INCOME - IRRIGATION	TOTAL INCOME	SURPLUS / DEFICIT	CUMULATIV SURPLUS / DEFICIT	CUM SURPLUS/ DEFICIT + INTEREST @ 16 %	PRESENT DAY CUM SURPLUS/ DEFICIT +INT @ 15 %	PRESENT DAY DOMESTIC COSTS @ 15 %	PRESENT DAY IRRIGATION COSTS @ 15 %
	R X 10^6	m^3	R/m^3	R/annum X 10^6	ha	R/ha	R X 10^6	R X 10^6	R X 10^6	R X 10^6	R X 10^6	R X 10^6	R/m^3	R/ha
1994	1.99	664000	0.05	0.56	990	750.00	0.74	1.31	-0.68	-0.68	-0.79	-0.68	0.64	567.11
1995	1.99	756000	0.98	0.74	990	750.00	0.74	1.48	-0.51	-1.19	-1.43	-0.94	0.64	493.14
1996	1.99	782000	1.12	0.08	990	750.00	0.74	1.62	-0.37	-1.56	-2.02	-1.16	0.64	428.81
1997	1.99	810000	1.29	1.05	990	750.00	0.74	1.79	-0.20	-1.76	-2.55	1.27	0.64	372.88
1998	1.99	830000	1.49	1.25	990	750.00	0.74	1.99	-0.00	-1.76	-2.96	-1.20	0.64	324.25
1999	1.99	867000	1.71	1.48	990	915.00	0.91	2.39	0.40	-1.36	-3.03	-1.14	0.64	343.98
2000	1.99	890000	1.97	1.77	990	1116.30	1.11	2.87	0.88	0.40	-2.64	-0.06	0.64	364.92
2001	1.99	925000	2.26	2.09	990	1361.09	1.35	3.44	1.45	0.97	-1.61	-0.46	0.64	387.13
2002	1.99	952000	2.60	2.48	990	1661.50	1.64	4.12	2.13	3.10	0.26	0.06	0.64	410.70
2003	1.99	980000	2.99	2.93	990	2027.03	2.01	4.94	2.95	6.04	3.25	0.70	0.64	435.70
2004	1.99	1009000	3.44	3.47	990	2472.98	2.45	5.92	3.93	9.97	7.70	1.44	0.64	462.22
2005	1.99	1039000	3.95	4.11	990	3017.03	2.99	7.10	5.11	15.08	14.04	2.20	0.64	490.35
2006	1.99	1068000	4.55	4.86	990	3680.78	3.64	8.50	6.51	21.59	22.79	3.22	0.64	520.20
2007	1.99	1097000	5.23	5.74	990	4490.55	4.45	10.10	8.19	29.78	34.63	4.26	0.64	551.86
2008	1.99	1127000	6.01	6.70	990	5478.47	5.42	12.20	10.21	39.99	50.39	5.30	0.64	585.46
2009	1.99	1158000	6.92	8.01	990	5478.00	5.42	13.44	11.45	51.44	69.09	6.50	0.64	509.05
2010	1.99	1190000	6.92	8.23	990	5478.00	5.42	13.66	11.67	63.11	92.75	7.49	0.56	442.65
2011	1.99	1230000	6.92	8.51	990	5478.00	5.42	13.93	11.94	75.05	119.53	9.06	0.49	384.91
2012	1.99	1272000	6.92	8.88	990	5478.00	5.42	14.23	12.24	87.29	150.09	12.19	0.42	334.71
2013	1.99	1315000	6.92	9.10	990	5478.00	5.42	14.52	12.53	99.82	187.57	15.16	0.37	291.05
2014	1.99	1359000	6.92	9.40	990	5478.00	5.42	14.83	12.84	112.66	230.41	18.62	0.32	253.09
2015	1.99	1405000	6.92	9.72	990	5478.00	5.42	15.15	13.16	125.81	280.44	22.66	0.28	220.08
2016	1.99	1424000	6.92	9.85	990	5478.00	5.42	15.28	13.29	139.10	338.59	27.36	0.24	191.37
2017	1.99	1443000	6.92	9.99	990	5478.00	5.42	15.41	13.42	152.52	406.19	32.02	0.21	166.41
2018	1.99	1462000	6.92	10.12	990	5478.00	5.42	15.54	13.55	166.07	484.73	39.17	0.18	144.70
2019	1.99	1482000	6.92	10.26	990	5478.00	5.42	15.68	13.69	179.76	575.97	46.54	0.16	125.83
2020	1.99	1502000	6.92	10.39	990	5478.00	5.42	15.82	13.83	193.59	681.95	55.11	0.14	109.42
TOTALS		30054000		152.57	26730		94.75	247.32	193.59					

TABLE 11 : CASH FLOW : DEFICIT REPAID IN 5 YEARS

YEAR	ANNUAL COST R X 10^6	DOMESTIC WATER DEMAND m^3	UNIT COST @ 15 % R/m^3	INCOME - SALES DOMESTIC WATER R/annum X 10^6	IRRIGATION DEMAND ha	UNIT COST @ 22 % R/ha	INCOME - IRRIGATION R X 10^6	TOTAL INCOME R X 10^6	SURPLUS / DEFICIT R X 10^6	CUMULATIV SURPLUS / DEFICIT R X 10^6	CUM SURPLUS/ DEFICIT + INTEREST @ 16 % R X 10^6	PRESENT DAY CUM SURPLUS/ DEFICIT +INT @ 15 % R X 10^6	PRESENT DAY DOMESTIC COSTS @ 15 % R/m^3	PRESENT DAY IRRIGATION COSTS @ 15 % R/ha
1994	1.66	664000	0.85	0.56	990	750.00	0.74	1.31	-0.35	-0.35	-0.41	-0.31	0.64	567.11
1995	1.66	756000	0.90	0.74	990	750.00	0.74	1.48	-0.18	-0.53	-0.65	-0.43	0.64	493.14
1996	1.66	782000	1.12	0.88	990	750.00	0.74	1.62	-0.04	-0.57	-0.80	-0.46	0.64	428.81
1997	1.66	810000	1.29	1.05	990	750.00	0.74	1.79	0.13	-0.44	-0.79	-0.40	0.64	372.88
1998	1.66	830000	1.49	1.25	990	750.00	0.74	1.99	0.33	-0.11	-0.59	-0.26	0.64	324.25
1999	1.66	867000	1.71	1.48	990	915.00	0.91	2.39	0.73	0.62	0.04	0.01	0.64	343.98
2000	1.66	898000	1.97	1.77	990	1116.30	1.11	2.87	1.21	1.83	1.26	0.41	0.64	364.92
2001	1.66	925000	2.26	2.09	990	1361.89	1.35	3.44	1.78	3.61	3.24	0.92	0.64	387.13
2002	1.66	952000	2.60	2.48	990	1661.50	1.64	4.12	2.46	6.07	6.22	1.54	0.64	410.70
2003	1.66	980000	2.99	2.93	990	2027.03	2.01	4.94	3.28	9.34	10.49	2.25	0.64	435.70
2004	1.66	1009000	3.44	3.47	990	2472.98	2.45	5.92	4.26	13.60	16.42	3.07	0.64	462.22
2005	1.66	1039000	3.95	4.11	990	3017.03	2.99	7.10	5.44	19.04	24.49	3.90	0.64	490.35
2006	1.66	1068000	4.55	4.86	990	3680.78	3.64	8.50	6.84	25.88	35.25	4.98	0.64	520.20
2007	1.66	1097000	5.23	5.74	990	4490.55	4.45	10.18	8.52	34.40	49.41	6.07	0.64	551.86
2008	1.66	1127000	6.01	6.78	990	5478.47	5.42	12.20	10.54	44.94	67.86	7.25	0.64	585.46
2009	1.66	1150000	6.92	8.01	990	5478.00	5.42	13.44	11.78	56.72	90.49	8.41	0.64	509.05
2010	1.66	1190000	6.92	8.23	990	5478.00	5.42	13.66	12.00	68.72	116.97	9.45	0.56	442.65
2011	1.66	1230000	6.92	8.51	990	5478.00	5.42	13.93	12.27	80.99	147.95	11.96	0.49	384.91
2012	1.66	1272000	6.92	8.80	990	5478.00	5.42	14.23	12.57	93.56	184.19	14.80	0.42	334.71
2013	1.66	1315000	6.92	9.10	990	5478.00	5.42	14.52	12.86	106.42	226.53	18.30	0.37	291.05
2014	1.66	1359000	6.92	9.40	990	5478.00	5.42	14.83	13.17	119.59	275.94	22.30	0.32	253.09
2015	1.66	1405000	6.92	9.72	990	5478.00	5.42	15.15	13.49	133.07	333.57	26.95	0.28	220.08
2016	1.66	1424000	6.92	9.85	990	5478.00	5.42	15.28	13.62	146.69	400.56	32.37	0.24	191.37
2017	1.66	1443000	6.92	9.99	990	5478.00	5.42	15.41	13.75	160.44	478.40	38.66	0.21	166.41
2018	1.66	1462000	6.92	10.12	990	5478.00	5.42	15.54	13.88	174.32	568.83	45.96	0.18	144.70
2019	1.66	1482000	6.92	10.26	990	5478.00	5.42	15.68	14.02	188.34	673.86	54.45	0.16	125.83
2020	1.66	1502000	6.92	10.39	990	5478.00	5.42	15.82	14.16	202.50	795.83	64.31	0.14	109.42
TOTALS		30054000		152.57	26730		94.75	247.32	202.50					

9. PROCEDURES FOR IMPLEMENTATION

Before the scheme can proceed the following aspects must be dealt with.

9.1 This report should be submitted to the CPA, House of Representatives, Lingelethu Town Council, Bezuidenhoutville Management Committee, Department of Water Affairs, Department of Agriculture, Midland Regional Services Council and the Koonap River Irrigation Board. The report should form the basis for further discussions between the above parties regarding participation in and financing of the scheme.

9.2 In order to expedite decision taking during the initial stages and to control the scheme on completion, it is proposed that a controlling body be formed on which the different consumers are represented.

9.3 A decision should be taken as to whether the reduced spillway capacity option is acceptable (lower capital cost) and if so this should be submitted to the Department of Water Affairs for approval.

9.4 Based on the discussions referred to in 9.1 above, preliminary agreements should be drawn up regarding the unit costs applicable to each party. In view of the influence of the irrigation demand on the size of the dam and consequently the cost, it is particularly important that an agreement be reached with the farmers regarding the cost of the water and the amount available.

9.5 An application for a subsidy for both the domestic and agricultural portions of the scheme should be made to the Department of Water Affairs and the Department of Agriculture and Water Supply.

9.6 A source of additional capital and/or low interest loans, should be sought.

9.7 The dam will be impounding more than 250 000 m^3 and an application must be made to the Minister of Water Affairs for the issue of a permit in terms of Section 9B of the Water Act. The processing of such application normally is time consuming and the application should therefore be made as soon as possible.

9.8 The total wall height of the proposed dam will be greater than 5 m and an application must therefore also be made for the issue of a permit in terms of Section 9C of the Water Act (Permit to construct a dam). Application for this permit will be made during the detailed design stage.

9.9 Proposed Programme

To enable construction to commence in July 1993 we propose the following programme.

9.9.1	Submission of this report	October 1992
9.9.2	Application for 9B Permit	October 1992
9.9.3	Decision to proceed	end November 1992
9.9.4	Geotechnical investigation, Survey, etc.	January 1993
9.9.5	Design report for 9C Permit, dam design and preparation of tender documents	February to April 1993
9.9.6	Advertise tender	end April 1993
9.9.7	Report on Tenders and award of Contract	June 1993
9.9.8	Contractor on site	July/Aug 1993
9.9.9	Complete construction	August 1994

10. SUMMARY

The more important aspects of this report are briefly summarised below :

10.1 Adelaide has since the early 1980's experienced regular water shortages which has led to restrictions in the use of water.

10.2 As a result of the water shortages, development in Adelaide has reached a standstill. The coloured and black population groups have however shown a steady growth which has led to increasing unemployment. There is therefore an urgent need to stimulate development in Adelaide and the surrounding area. The Adelaide Municipality have a development plan which they are unable to implement until an adequate and reliable water source is developed.

10.3 Adelaide's existing water supply system is inadequate to meet even the present domestic demand. This, combined with the extended drought in the region, has given rise to a critical water shortage in the town at present.

10.4 Previous investigations into the water supply options in the area showed that the only possible source to satisfy the future demand would be to construct a dam on the Koonap River. The only suitable site in the immediate vicinity of Adelaide is the so-called Foxwood site.

10.5 Farmers downstream of the proposed dam have indicated their interest in obtaining irrigation water from a dam.

10.6 A dam at the Foxwood site with a capacity of 17 million m^3 would, together with the existing Municipal dam, provide sufficient water to meet an annual demand of 11,4 million m^3/a, which would cover Adelaide's domestic demand until 2020 as well as the irrigation demand of 200 ha. Water would also be available for 790 ha of farm irrigation.

10.7 The estimated capital cost of an earth embankment dam at the Foxwood site is given in Section 7. Alternative costs are given based on different spillway types, i.e.

- Earth embankment with combination mass concrete overflow and open channel spillway R 24 000 000
- Earth embankment and combination mass concrete, fuse plug and open channel R 20 000 000

10.8 It is shown in Section 8 that there are various ways of financing the scheme, and that the scheme is economically beneficial in the long term.

11. RECOMMENDATIONS

It is recommended that :

11.1 This report be submitted to the Koonap Irrigation Board, Lingelethu Town Council, Bezuidenhoutville Management Committee, CPA and House of Repressentatives, to form the basis for further discussions.

11.2 A controlling body be formed on which the different consumers are represented.

11.3 This report be submitted to the Department of Water Affairs, Department of Agriculture, and Midland Regional Services Council, in support of an application for assistance with the financing of the scheme.

11.4 A combined decision be taken as soon as possible to proceed with the construction of the Foxwood Dam.

S P BROPHY Pr Eng

NINHAM SHAND INC
PORT ELIZABETH

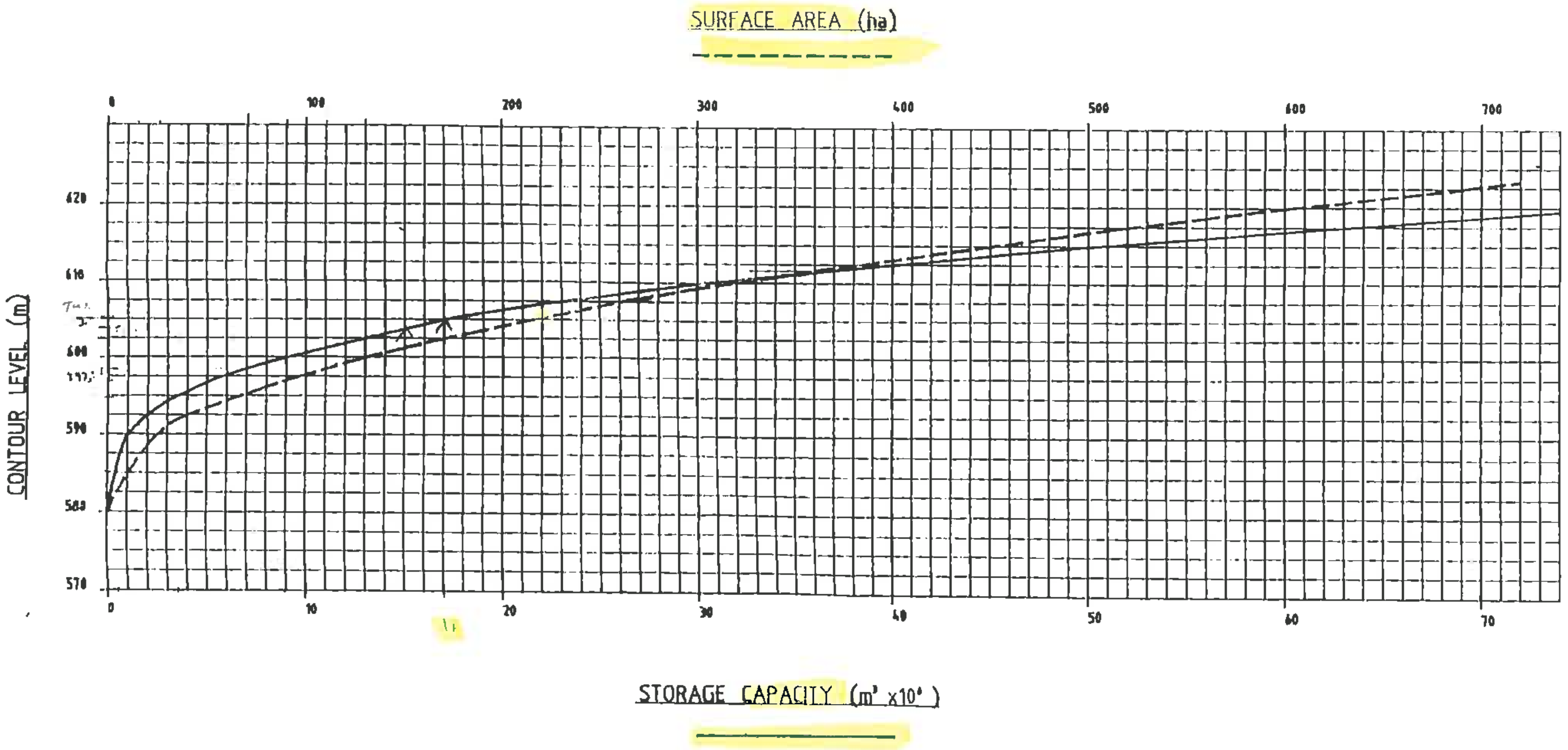
SEPTEMBER 1992

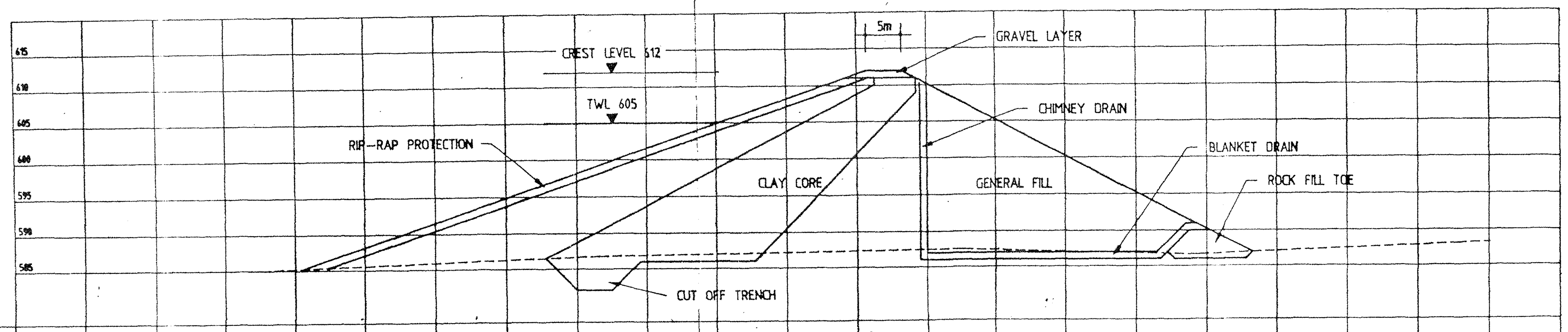
APPENDIX A

SUMMARY OF IRRIGABLE AREAS

Original Farm	Sub-divisions	Owner	Size	Present irrigation (ha)	Future possibilities
1 Kunap Post 196	Koonap Post Farm	John & Robert Spark	1651.3320	20	85
1A Koonap Reserve 197	Ged 2 & Ged Lifford	J C Potgieter	548.4884	18	15
2 Lifford Park 31	Restant	Sam Knott	1197.1462	62	18
3 Nelsrust 189	Ged 4	F J du Toit	146.2382	12	20
4 Bezuidenhoutskraal 29	Ged 4, 6, 7 & 8	F J du Toit	651.0691	20	20
5 Nelsrust 189	Ged 3 & 5 + Restant	W A Nel	293.5016	Nil	5
6 Grace Gift	Ged 4 & 6	W A Nel	269.6165	10	Nil
7 Aasvoëlkrans	Grace Gift & Preel	C P du Preez	1336.14	Nil	55
8 Grace Gift	Welgeluk	N J Els	Onbekend		
8A do	Goedgedagte	N J Els	Onbekend		
8B do	Vadersrus	N J Els	Onbekend	Nil	70
8C do	Vlakkloof	N J Els	Onbekend		
8D do	Landhoek	N J Els	Onbekend		
9 Ergernis	Vlaknek	Izak Malan	613.254	Nil	8.5
10 Driefontein	Edgehill	B Barnard	235	Nil	Nil
11 Driefontein	Ged 1 Sevenfontein	C P du Preez	546.4687	4	4
12 Renosterhoek	Ged van	A M van der Merwe	685.3765	15	20
13 Engelse Drift	Lot B Hoë Hoek G/E Drift	C P du Preez	492.7913	37	56
14 Vaderlands Wilgenboom	Soeterus	T F Dreyer	925.02	2	4
15 Engelse Drift	Inverleigh	T F Dreyer	1541.7	15.4	6
16 Hoë Hoek	HoëHoek & Riverside	J B du Preez	938.724	25	15
17 Klipplaat Drift	Otterburn	T F Dreyer	1156.275	11	2
18 Kordomos Mond	Ged Goodhope	E W D Keevy	91.6455	1.7	34.5
19 Klanghas Mond	Ged van	E W D Keevy	91.6455	20	20
20 Klanghas Mond	Ged Clifton & Loxley	H G Greeff	1541.7	30	100
21 Burgers Drift	Ged van	D J Malan	982	18	40
22 Vaalekrantz	Ged van	F H C van der Vyver	382	Nil	25
23 Burgersdrift	Ged Lauderdale	D J Malan	1027.8	NIL	70
24 Olifantsbeen	Geheel	F H C van der Vyver	1854	Nil	130
25 Grootte Drif	Geheel	H J Luttig & Seun	2355.375	125	127.5
26 Groenkloof	Geheel	S W Malan	1488.745	Nil	65
27 Paardefontein	Geheel	S W Malan	1341.2789	Nil	4
28 Smitshoek	Geheel	A L Grobbelaar	1594	25	175
29 Elandskop	Ged van	H J Luttig & Seun	685.2	Nil	55
30 Elandskop	Restant van	P du Preez	604.7116	Nil	4
31 Leuwis Drift	Ged 4 (Eureka)	P du Preez	822.9709	20	8
32 Leuwis Drift	Leeuwdrift	J H Dugmore	1510	11	25
33 Kliphoek	Kleinfontein	Prof M Eksteen	398	95	65
34 Gannanoek 215	Ged van	J F Bosch	1370	14	128.5
35 Kliphoek	Ged van	J H Engelbrecht	659.505	28.2	Nil
36 Kaka Mouth 195	Frieland & Kagtamond	C H Bosch	816.2445	21.4	42.8
37 Niewelings	Geheel	D R van der Meulen	1558.83	90	175
38 Blauwkrantz	Geheel	D R van der Meulen	839.37	1	5
39 Wagen Drift	Geheel	Whyte Bank Farm	1421.79	30	14
40 Kaffirs Hoek 192	Karee Vallei	F W Greeff	856.5	15	15
41 Kaffirs Hoek 192	Ged van	D R van der Meulen	445.38	40	80
42 Kaffirs Kloof	Roxlyn	J B du Preez	1627.35	17	3
43 Waterfall	Ged van	D R van der Meulen	256.95	25	Nil
44 Kunapo Porte	Ged van	L Pringle	557.5	30	22.5
45 Saxford Park	Geheel	L A D Danckwarts	770.85	130	145
46 Glen Lynden	Ged van	Kerk Gronde	Onbekend	Nil	67.5
47 Klipplaats Drift 130	Haddon	A Niehouse	2055.6	128.5	12.8
48 Klipplaats Drift 130	Hatsoe	L Pringle	46.0636	Nil	15
49 Norwood 127	Ged van	I P Pringle	90	30	Nil
50 Norwood 127	Ged van	W P Kroon	1500	29.9	25.7
Area of irrigable land downstream of Foxwood site				1227.1	2103.3
				3330.4	

FOXWOOD DAM

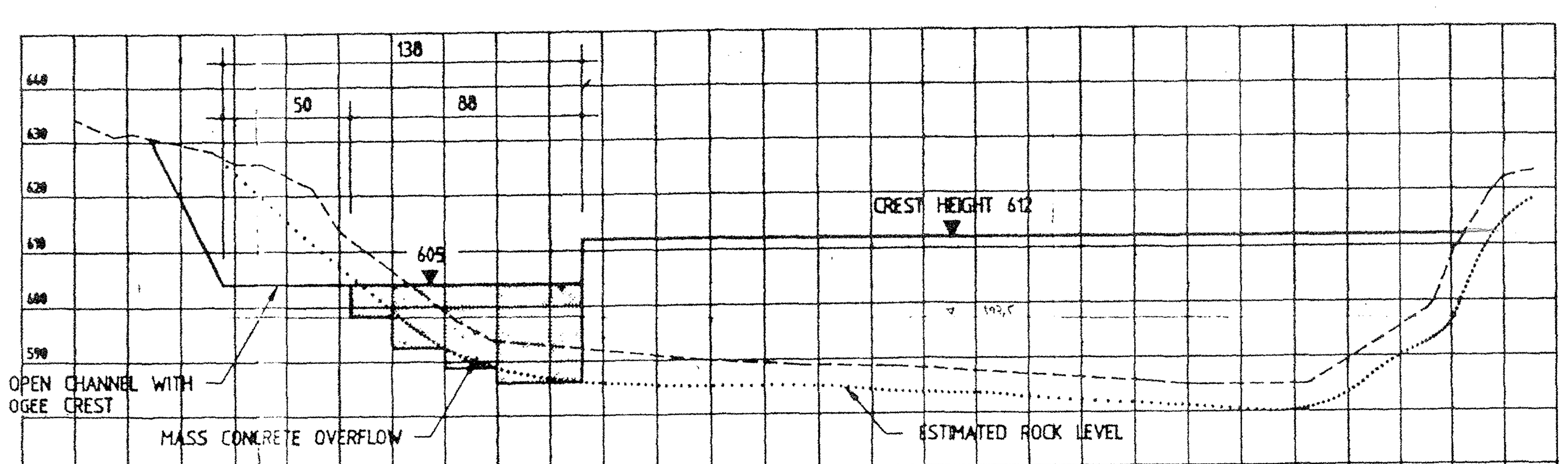

SURFACE AREA (ha)
0
100
200
300
400
500
600
700
CONTOUR LEVEL (m)
620
610
600
590
580
570
0
10
20
30
40
50
60
70
STORAGE CAPACITY (m^3 x10^6)



OFFSET DISTANCE	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
NATURAL GROUND LEVEL	585.000	585.000	585.000	585.176	585.541	585.905	586.270	586.635	586.853	587.005	587.157	587.309	587.460	587.413	587.155	586.897	586.714	587.097	587.479	587.862	588.250

SECTION B–B

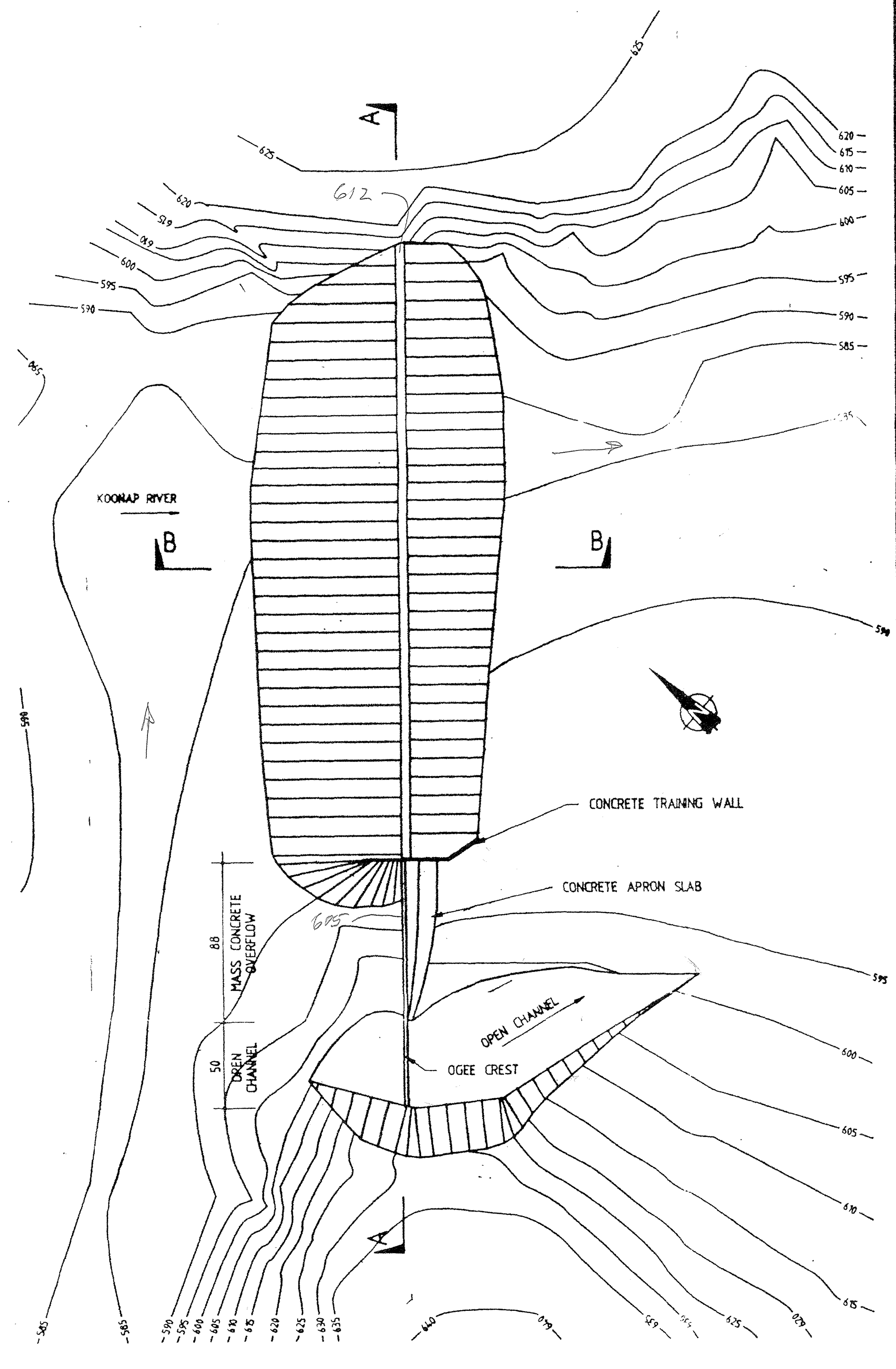
SCALE 1:500



OFFSET DISTANCE	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	500	520	540
NATURAL GROUND LEVEL	634.156	631.408	629.373	625.895	623.572	613.677	606.419	599.148	593.768	592.601	591.833	590.866	589.940	589.362	588.943	588.725	588.261	587.636	587.010	586.385	585.759	585.000	585.000	585.000	589.598	595.547	607.978	622.222

SECTION A–A

SCALE HOR. 1:2000
VERT. 1:1000



GENERAL LAYOUT

SCALE 1:2000

Inlet/outlet?
Canal to irrigation.

No	AMENDMENTS	APPR.	DATE

SURVEYED	FILE 5862\5862SITE
PLOTTED	SURVEY CHECKED
DRAWN d corrall	DRAWING CHECKED
DESIGNED	DESIGN CHECKED
	PLOT SCALE 1=2

Pr Eng
PROJECT ENGINEER
DATE Sept 92.

FOR Pr Eng
NINHAM SHAND Inc.
DATE

NINHAM SHAND
CONSULTING ENGINEERS

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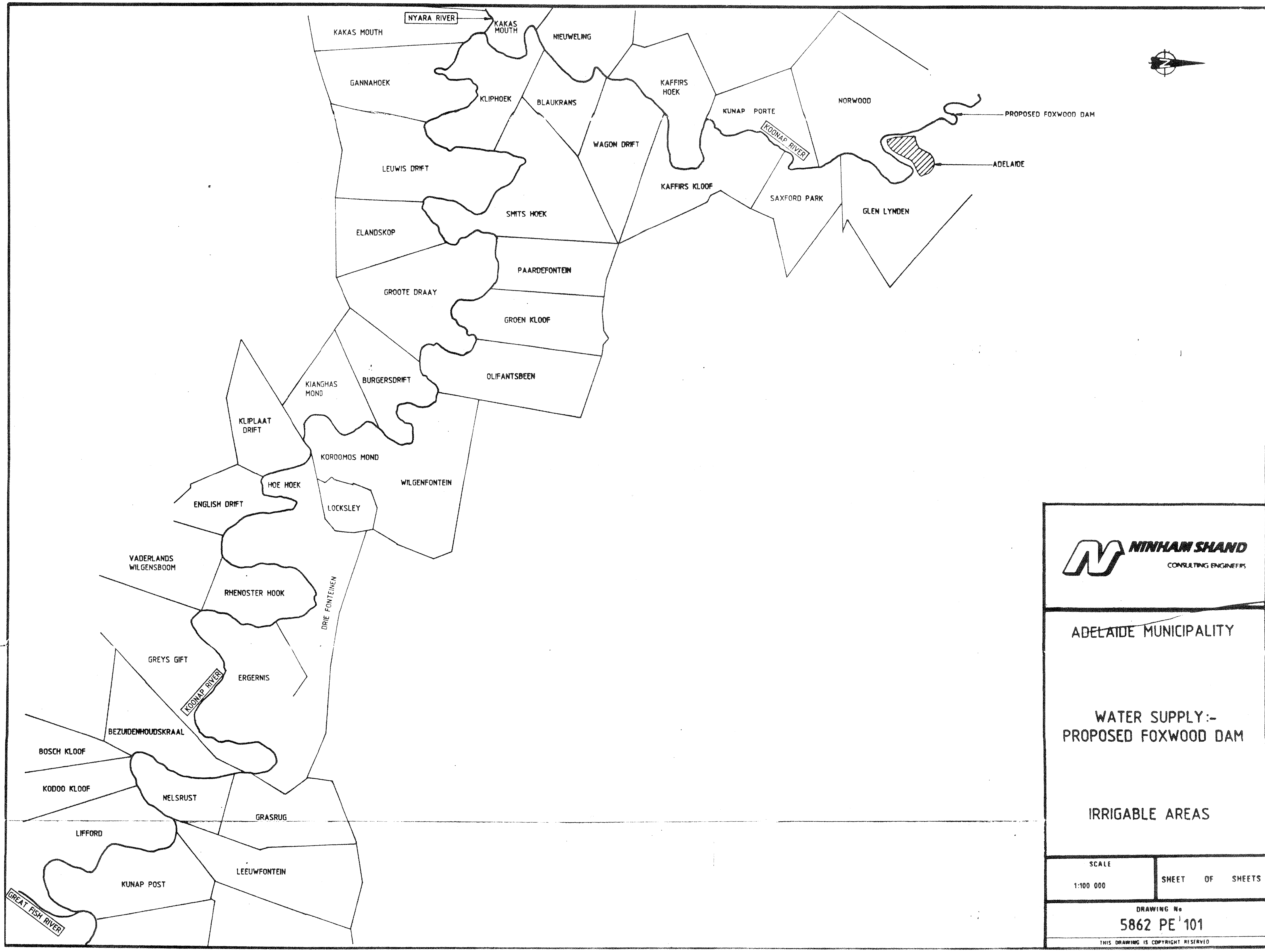
ADELAIDE MUNICIPALITY

WATER SUPPLY
PROPOSED FOXWOOD DAM

COMBINED CONCRETE
OVERFLOW AND
OPEN CHANNEL SPILLWAY

SCALE	SHEET OF SHEETS
AS SHOWN	

DRAWING No
5862 PE 102


NYARA RIVER
KAKAS MOUTH
KAKAS MOUTH
NIEUWELING
GANNAHOEK
KLIPHOEK
BLAUKRANS
KAFFIRS HOEK
NORWOOD
PROPOSED FOXWOOD DAM
KUNAP PORTE
KOONAP RIVER
WAGON DRIFT
ADELAIDE
LEUWIS DRIFT
KAFFIRS KLOOF
SAXFORD PARK
GLEN LYNDEN
SMITS HOEK
ELANDSKOP
PAARDEFONTEIN
GROOTE DRAAY
GROEN KLOOF
OLIFANTSBEEN
KIANGHAS MOND
BURGERSDRIFT
KLIPLAAT DRIFT
KOROOMOS MOND
WILGENFONTEIN
HOE HOEK
ENGLISH DRIFT
LOCKSLEY
VADERLANDS WILGENSBOOM
RHENOSTER HOOK
DRIE FONTEINEN
GREYS GIFT
ERGERNIS
KOONAP RIVER
BEZUIDENHOUDSKRAAL
BOSCH KLOOF
KODOO KLOOF
NELSRUST
GRASRUG
LIFFORD
LEEUWFONTEIN
KUNAP POST
GREAT FISH RIVER
NINHAM SHAND
CONSULTING ENGINEERS
ADELAIDE MUNICIPALITY
WATER SUPPLY:-
PROPOSED FOXWOOD DAM
IRRIGABLE AREAS
SCALE
1:100 000
SHEET OF SHEETS
DRAWING No
5862 PE 101
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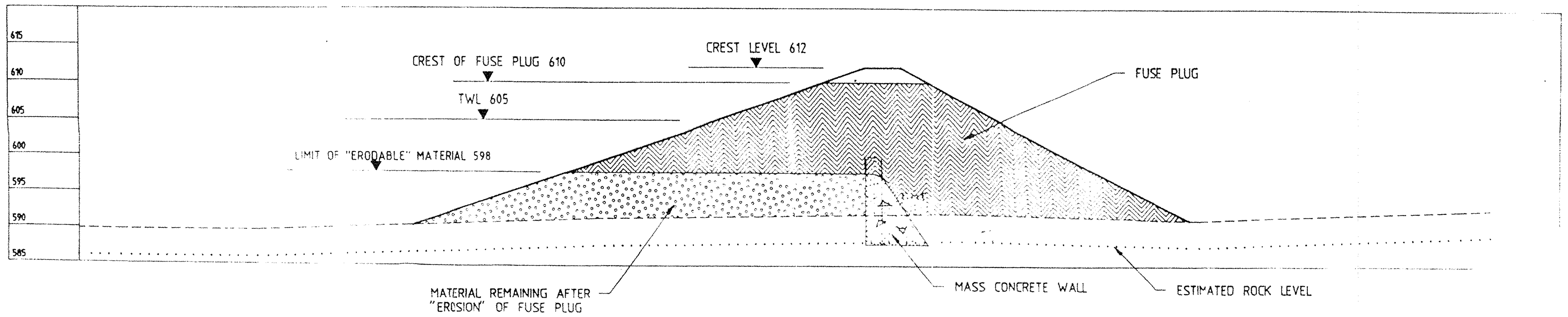
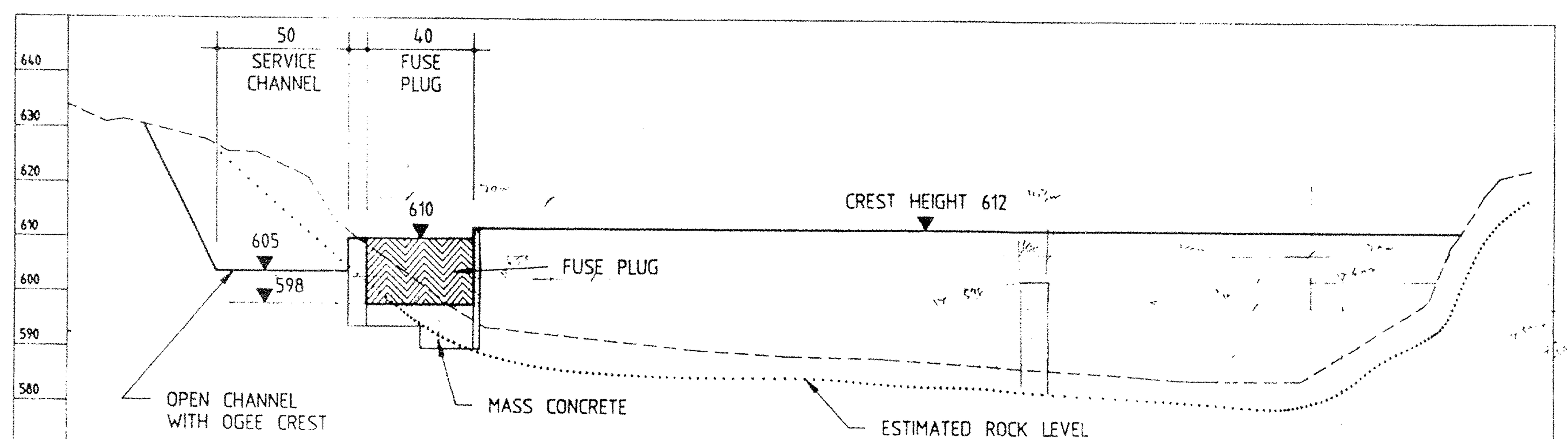


SECTION C-C

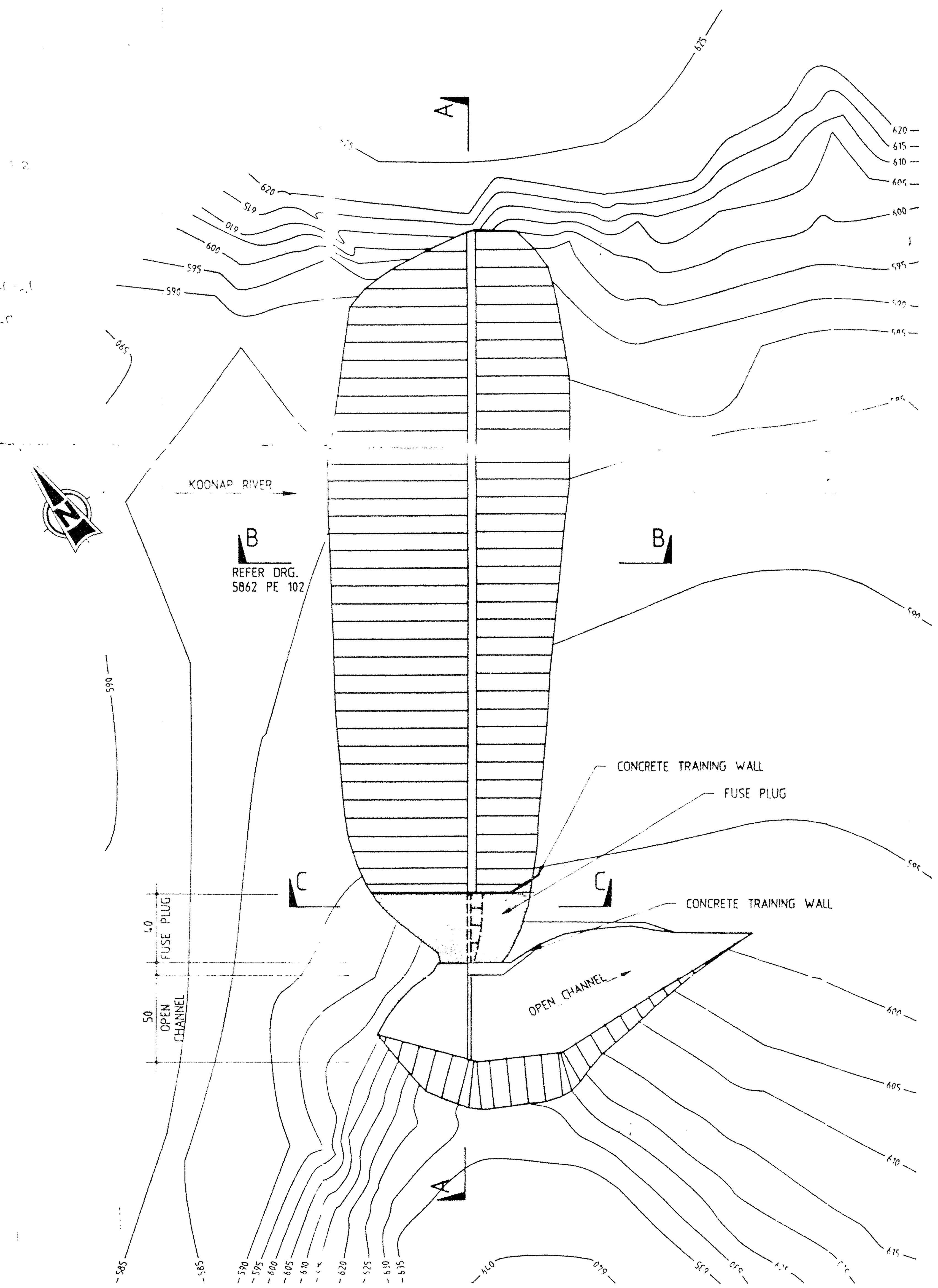
SCALE 1:500



OFFSET DISTANCE	NATURAL GROUND LEVEL
0	634.156
20	631.408
40	629.373
60	625.395
80	623.572
100	613.[illegible]
120	606.419
140	599.148
160	593.768
180	592.301
200	591.033
220	590.366
240	589.940
260	589.362
280	588.943
300	588.725
320	588.261
340	587.536
360	587.010
380	586.385
400	585.759
420	585.000
440	585.000
460	585.000
480	587.376
500	595.547
520	607.978
540	622.222

SECTION A—A

SCALE HOR. 1:2000
VERT. 1:1000



GENERAL LAYOUT

SCALE 1:2000

AMENDMENTS

PLOTTED	PLOT CHECKED
DRAWN d corrall	DRAWING CHECKED
DESIGNED	DESIGN CHECKED
	PLOT SCALE 1=2

PROJECT ENGINEER Pr Eng

DATE Sept 92

FOR NINHAM SHAND Inc. Pr Eng

DATE

NINHAM SHAND
CONSULTING ENGINEERS

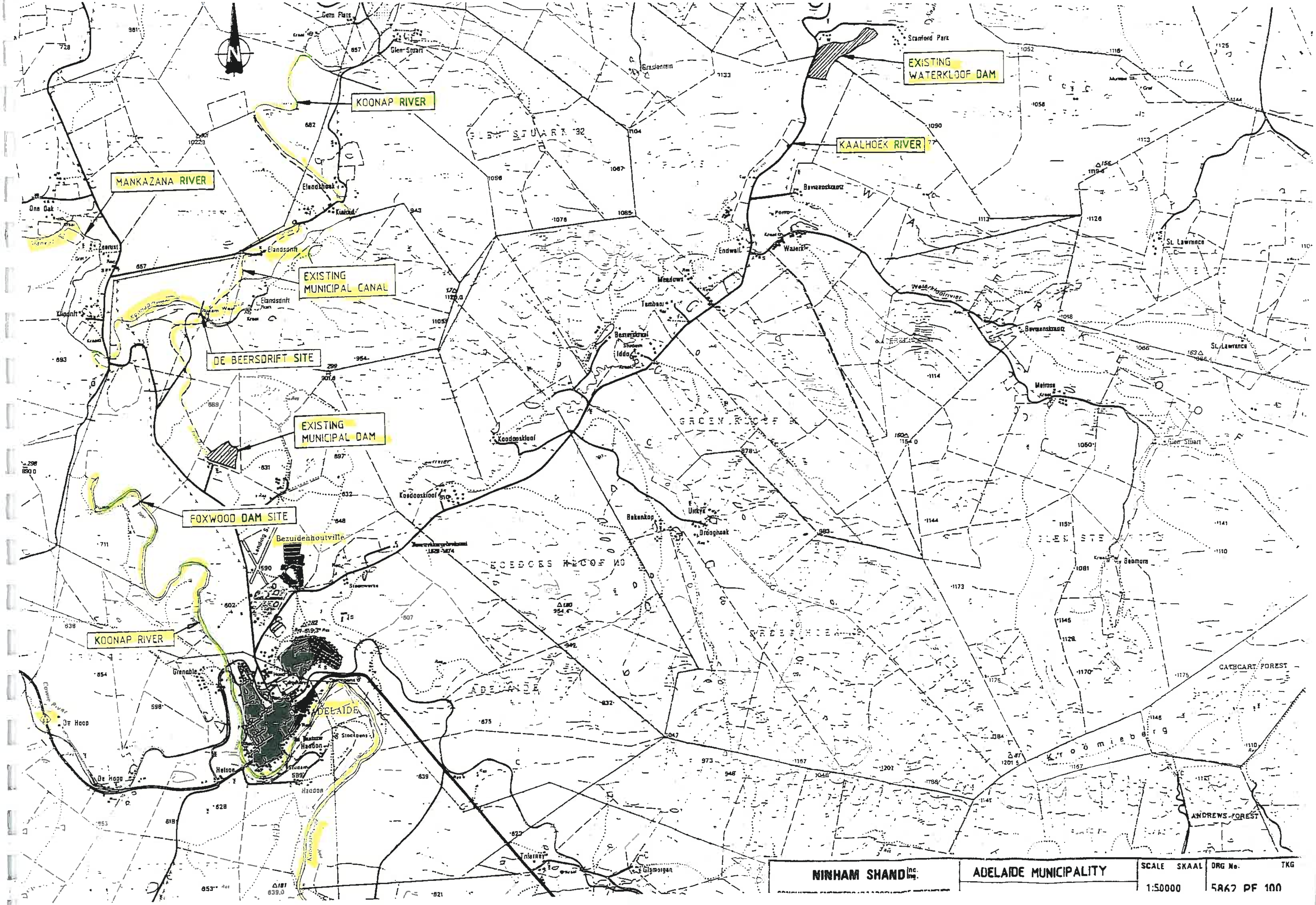
ADELAIDE MUNICIPALITY

WATER SUPPLY
PROPOSED FOXWOOD DAM

COMBINED SERVICE AND
FUSE PLUG SPILLWAY

SCALE	SHEET OF SHEETS
AS SHOWN	

DRAWING No
5862 PE 103


KOONAP RIVER
EXISTING WATERKLOOF DAM
KAALHOEK RIVER
MANKAZANA RIVER
EXISTING MUNICIPAL CANAL
DE BEERSDRIFT SITE
EXISTING MUNICIPAL DAM
FOXWOOD DAM SITE
KOONAP RIVER
Bezuidenhoutville
ADELAIDE
Glen Stuart
Stanford Park
Elandsdrift
Zeerust
One Oak
De Hoop
Grenoble
Helsoe
Haddon
Stockpens
Koodooskloof
Meadows
Tambani
Idddo
Bakenkop
Drooghoek
Endwell
Waterkloof
Bavaanskrantz
Melrose
St. Lawrence
Beamore
Kroomieberg
CATHCART FOREST
ANDREWS FOREST
Glamorgan
Tularney
NINHAM SHAND Inc.
ADELAIDE MUNICIPALITY
SCALE SKAAL 1:50000
DRG No. 5862 PF 100
TKG