REPUBLIC OF BOPHUTHATSWANA

DEPARTMENT OF WATER AFFAIRS

2.2 (525)

BULK WATER SUPPLY TO ITSOSENG AND SURROUNDING VILLAGES

APPRAISAL REPORT

DRAFT

MAY 1991

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EXECUTIVE SUMMARY

Eksteen, Van der Walt & Nissen were appointed to investigate and report on the bulk water supply to Itsoseng and surrounding villages, situated approximately 65 km south-east of Mmabatho.

A geohydrological investigation of the Polfontein and adjacent dolomitic compartments underlying Itsoseng was completed by consultants in collaboration with the Directorate of Geohydrology of the Department of Water Affairs of South Africa, and under the leadership of the Bophuthatswana Department of Water Affairs. This investigation was in response to the noted increase in abstraction from boreholes in the area.

In this investigation, borehole census data from the past nine years was used to analyse and forecast changes in the water level in the Polfontein Compartment (from which Itsoseng's water is abstracted at present), and adjacent dolomitic compartments. It was found that piezometric levels in the Polfontein Compartment are declining as a result of increased groundwater exploitation. The results of the investigation are documented in the report entitled "*Report on a Geohydrological Investigation of the Polfontein and Adjacent Dolomitic Compartments*".

Proposals for the practical implementation of the recommendations for groundwater management made in the abovementioned report were evaluated in this report. These included augmentation of supply to Itsoseng township from boreholes in the Verdwaal Compartment, and supply to Bodibe and the other villages west of Bodibe from boreholes in the Matlabes Compartment.

It was found that supply to the village of Verdwaal 2 is inadequate at present and the most economically effective means of upgrading supply will be via a pipeline linked to the existing 450 mm diameter main which supplies Itsoseng township. The proposed pipeline will supply a rudimentary reticulation in the village.

Various supply options to Bodibe and the villages located west of Bodibe were evaluated. It was found that in all cases, supply to these villages via a sub-regional supply scheme sourced from high yielding boreholes in the Matlabes Compartment was more economical over the long term than intensive *upgrading* of local boreholes in each village. However, it is not presently known whether the existing local borehole supplies and infrastructure in each village are adequate to meet long term demands in each case. The yields of boreholes supplying each village must be tested in order to establish their viability for supply over the long term. In the case of such existing boreholes proving to be inadequate, supply to the villages involved should be upgraded with supply from a sub-regional supply scheme as described above.

Since any villages which need to be supplied via such a sub-regional supply scheme will share the scheme with Bodibe, it is necessary that the requirements of these villages be established before the proposals of the bulk supply system to Bodibe can be finalised.

The most suitable point in the Matlabes Compartment for siting of a wellfield to supply the Bodibe zone as indicated by the gravity survey is located approximately 4 km from Bodibe. Further boreholes should be drilled in the Matlabes Compartment, but closer to Bodibe, and tested in order to minimise the length of pipeline required to supply Bodibe from the wellfield.

Capital cost implications of initial implementation were as follows :-

Augmentation of supply to Itsoseng from the Verdwaal Compartment is expected to amount to R 472 700-00.

Supply to Verdwaal 2 is expected to cost approximately R 111 000-00.

Supply to *Bodibe only* from a wellfield located at the point in the Matlabes Compartment indicated as being most suitable by the gravity map is expected to amount to some R 3.48 million.

BULK WATER SUPPLY TO ITSOSENG AND SURROUNDING VILLAGES

FEASIBILITY AND APPRAISAL REPORT

CONTENTS

1. INTRODUCTION

1.1 Background

Itsoseng, Bodibe and other surrounding villages are situated in the north eastern portion of the Ditsobotla District, approximately 40 km south east of Mmabatho. The location of the study area with respect to national, regional and local context is shown in figures 1.1, 1.2 and 1.3 attached.

Itsoseng fell under the jurisdiction of the South African Bantutrust up to 1982. According to drawings obtained from the BWSA, the consultants Fourie and Pretorius were appointed by the City Council of Lichtenburg (1969 - 1971) and by the Western Transvaal Bantu-Administration Board (1975 - 1982), on behalf of the SA Bantutrust, for design of extensions to the township as well as the applicable bulk supply.

Work on the bulk water supply to Itsoseng township was subsequently done by Messrs Groenewald and Partners, appointed by the Department of Water Affairs of South Africa, and by Messrs Salmon and McCormick Inc, appointed by the Department of Water Affairs of Bophuthatswana.

Itsoseng is situated close to the main aquifer in the Polfontein Compartment and already makes use of water drawn from a number of boreholes which tap this aquifer to supply all of its demands.

The village of Bodibe is a semi-rural settlement with a population more or less similar to Itsoseng, located approximately 4 km west of Itsoseng. The village is situated around a spring where the surplus water flow from the compartment is forced to the surface. Thus, although there is no piped reticulation in Bodibe, the residents live near enough to make use of surface water drawn from the spring and shallow boreholes situated around it.

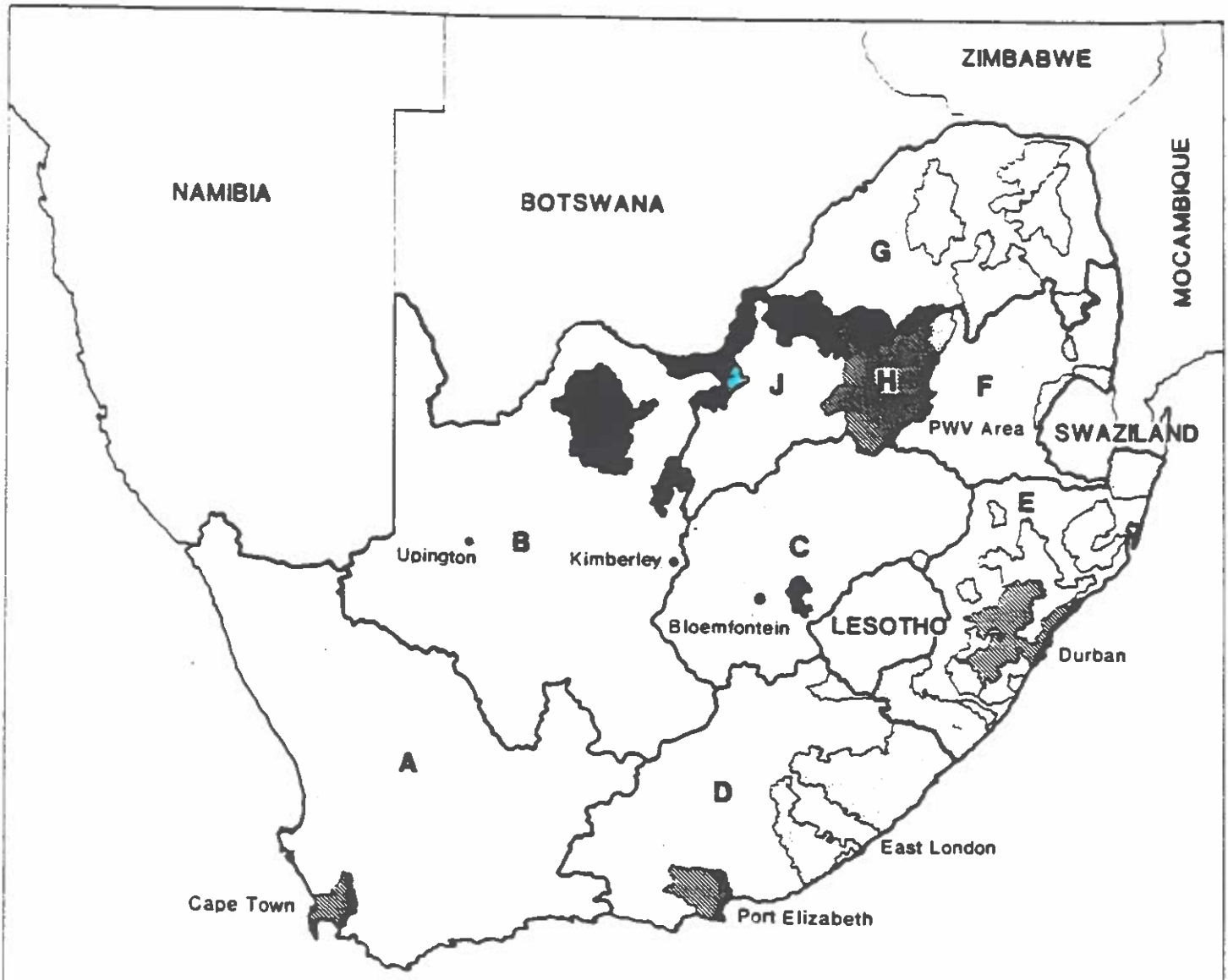
Shiela, Verdwaal 1 & 2, Springbokpan, Matile, Duikerbos, Welverdiend, Schoongezight and Bethel are mainly unconstructed rural settlements. Shiela is situated north east of Itsoseng, while the villages of Verdwaal 1 and 2 are located a few kilometres south and east of Itsoseng. The remaining villages are all located within 10 km south and west of Bodibe.

The locations of the villages are shown on the accompanying figures 1 and 2.

A geohydrological investigation of the Polfontein and adjacent dolomitic compartments underlying Itsoseng was completed by consultants to the Bophuthatswana Department of Water Affairs, in collaboration with the Directorate of Geohydrology of the Department of Water Affairs of South Africa.

The boundaries of the Polfontein Compartment were established with certainty during the investigation. It's area is some 75 km^2, and it is bounded to the north and south by the Matlabes and Verdwaal Compartments respectively. It was found that water movement across the various compartment boundaries is minimal. Using existing rather imprecise abstraction data, together with projections of future water demand from the Polfontein and Verdwaal Compartments both in South Africa and in Bophuthatswana, different scenarios based on variations in recharge, storativity and abstraction was modelled up to the year 2025. The model showed that the Polfontein spring would probably stop flowing by 1995 or sooner.

The flow of the Polfontein spring in recent months was found to be half substantially less than what was expected.



EASTERN DITSOBOTLA WITHIN THE CONTEXT OF DEVELOPMENT REGIONS OF SOUTH AFRICA

FIGURE 1.1

1.2 Terms of Reference

Eksteen, Van der Walt & Nissen were appointed by the Bophuthatswana Department of Water Affairs to investigate and report on the bulk water supply to Itsoseng and surrounding villages. Partridge, Maud and Associates (assisted by E Martinelli and Associates) in collaboration with the Directorate of Geohydrology (RSA), carried out a geohydrological investigation of the Polfontein and adjacent dolomitic compartments in order to assess the long term viability of supply from the Polfontein and surrounding dolomitic compartments.

1.3 Development Aims and Objectives

The broad objectives with which this feasibility study is concerned are those laid down by the Bophuthatswana Development Council. The specific objectives to be addressed are seen to be as follows :-

1.3.1 The provision of a well planned infrastructure as a prerequisite for the efficient economic development of the country.

1.3.2 The preferential allocation of water for domestic consumption and other uses which yield the highest return, in terms of raising the standard of living, for the smallest amount of investment in water supply.

In particular the major objective is to provide sufficient water to meet the needs of the population and thereby improve on both the quality of life and standards of health in general.

Other secondary objectives may be defined as follows :-

- To stimulate community involvement in the formulation and implementation of Development projects.
- To utilise appropriate technology.
- To create local employment during construction.
- To provide training for the operation and maintenance of the new scheme.
- To optimise utilisation of all the water resources in the area to meet the requirements of Itsoseng and surrounding villages.

2. PROJECT DESCRIPTION

The project sets out to provide investment in water infrastructure in accordance with the Development objectives.

2.1 Existing Supply Systems

* Itsoseng

  Supply to Itsoseng comes from a 20 Ml ground reservoir and a 350 kl elevated storage tank, situated approximately 3 km east of Itsoseng, and a 500 kl ground reservoir in the northern part of Itsoseng. The 20 Ml reservoir is fed from 3 boreholes located very close by (Polfontein Compartment), with a capacity of approximately 85 l/s. The elevated tank is fed from the 20 Ml reservoir by means of booster pumps.

  The 500 kl ground reservoir is fed from two boreholes. One of the boreholes is situated approximately 100 m from the reservoir and is commonly used as the Chief supply to feed the reservoir through a 100 mm diameter pumpmain. The second borehole is situated at Bodibe, near the Bodibe spring, approximately 4 km west of Itsoseng. It is not commonly used and it also feeds through a 100 mm dia pumpmain. Both boreholes yield approximately 10 l/s.

* Bodibe

  Bodibe is situated around a spring. There is no piped reticulation in Bodibe. The residents make use of surface water drawn from the spring and shallow boreholes situated around it. Due to the fact that there is no waterborne sewerage system in Bodibe, and the high local water table, it is expected that the groundwater could get contaminated in the near future.

* Shiela

  The village of Shiela is situated approximately 4.5 km north east of Itsoseng. It is at present served from one borehole located near the south western corner of the village.

  Water is drawn from the borehole by an engine-driven pump, from where it is pumped via a sub-surface pipeline to a series of four 4.5 kl elevated storage tanks located on the north western side of the village. The engine and pump at the borehole are located in a pumphouse.

  Approximately 90 % of the sites in the village have their own standpipes. These yard connections are all supplied from the above storage tanks and a rudimentary reticulation system. There are other boreholes on record as being located in and around the village, but can be assumed to be no longer in use.

* Verdwaal 1

Verdwaal 1 is located approximately 2 km east of Itsoseng and is served by the following three boreholes :-

- **V1** is located near the north eastern corner of the township and is owned and operated by the local tribe. It is equipped with an electric submersible pump and has a reliably measured yield of 15.8 l/s. A pipeline from this borehole supplies a series of six 10 kl elevated storage tanks located on the south eastern edge of the village.

  A pipeline has recently been laid up to this borehole with a view to possibly incorporating it into the Itsoseng supply scheme.

- **T17006** is located centrally in the village and is equipped with a windmill which supplies a standard 38 kl concrete ground reservoir. This borehole is on record as having a yield of 4.5, but the units in which this is measured are unknown, the record being very old and of unknown origin.

- **T17661** is located at the north western corner of the village and is equipped with a windmill which supplies a standard 38 kl concrete ground reservoir. This borehole is on record as having a yield of 2.7, but the units in which this is measured are unknown, the record being very old and of unknown origin.

Observation has indicated that approximately 80 % of stands in the village have their own standpipes, these being supplied from the elevated storage tanks mentioned above, via a rudimentary reticulation system.

The remaining 20 % of the village, located on the western side, is served by one communal standpipe.

* Verdwaal 2

The village of Verdwaal 2 is situated some 2 km south east of Itsoseng, south west of Verdwaal 1. The only supply to the village is from a single borehole, viz. number T17055. This borehole is equipped with a windmill which supplies a standard 38 kl concrete reservoir. This serves as a communal watering point, and is the only source of water in the village. Villagers have complained that in periods of windlessness, which can be long and occur frequently, water has to be imported from Itsoseng or Verdwaal 1.

T17055 is on record as having a yield of 1.8, but the units in which this is measured are unknown, the record being very old and of unknown origin.

* Springbokpan

Springbokpan is located approximately 8 km west and south of Itsoseng, and is served by the following five boreholes :-

- **T17080** is located centrally in the eastern portion of the village. It is equipped with a windmill and supplies a standard 38 kl ground reservoir, which serves as a communal watering point.

  The maximum yield of this borehole is not currently known.

- **10-77000** is located centrally in the western portion of the village. It is equipped with a windmill and supplies a 4.5 kl elevated storage tank, which serves as a communal watering point.

  This borehole is on record as having a yield of 1.7, but the units in which this is measured are unknown, the record being very old and of unknown origin.

- **T17609** is located on the northern side of the village and is equipped with a windmill which supplies a 10 kl elevated storage tank. The tank in turn supplies a standard 38 kl concrete ground reservoir which serves as a communal watering point.

  This borehole is on record as having a yield of 4.3, but the units in which this is measured are unknown, the record being very old and of unknown origin.

- **T17048** is located to the west of the village. It is equipped with a windmill and supplies a standard 38 kl ground reservoir, which serves as a communal watering point.

  This borehole is on record as having a yield of 2.4, but the units in which this is measured are unknown, the record being very old and of unknown origin.

- The fifth borehole has no official number and is located approximately 1 km west of the village. It is equipped with an engine-driven pump which supplies a 4.5 kl elevated storage tank. The tank in turn supplies a standard 38 kl concrete ground reservoir located in a schoolyard a short distance away.

* Matile

Matile is situated approximately 5 km north of Springbokpan and 10 km west of Itsoseng. The two Matile villages are served by the following :-

- **Borehole T17001** is located in the eastern portion of the village, next to the Springbokpan road. The borehole is equipped with a windmill and a standard 38 kl concrete ground reservoir which serves as a communal watering point.

  The reliable yield of this borehole is not known at the present time.

- The second borehole has no number and was identified as M1 for the purposes of this report. The borehole is located on the western side of the eastern portion of the village. The borehole is equipped with a windmill and a standard 38 kl concrete ground reservoir which serves as a communal watering point.

  The reliable yield of this borehole is not known at the present time.

- A well in which the water level is approximately 3 m below ground level is located in the western portion of the village and serves as a communal watering point.

  The reliable yield of this well is not known at the present time.

In the western part of the larger village a few residents have their own boreholes. There is evidence that the lower western part of the village was once served with standpipes in the streets, which are no longer operational.

* Welverdiend

Welverdiend is situated approximately 14 km west of Itsoseng and 3 km west of Bodibe (Driefontein). The village is served by the following boreholes :-

- **T17598** is located near the south western edge of the village and is equipped with a windmill. The windmill in turn supplies a standard 38 kl concrete ground level reservoir, which serves as a communal watering point.

  The reliable yield of the borehole is not known at this stage.

- A second borehole, the number of which is not known is located centrally in the village. The borehole is equipped with a handpump which serves as a communal watering point.

  The reliable yield of the borehole is not known at this stage.

Only two privately owned boreholes exist in the village.

* Matsephe (Duikerbos)

Matsephe is situated approximately 1 km north of Welverdiend. The village is served by the following boreholes :-

- **T8573** is centrally located in the village and is equipped with a windmill. The windmill in turn supplies a standard 38 kl concrete ground reservoir which serves as a communal watering point.

  The reliable yield of the borehole is not known at this stage.

- **0974158** is located in the grounds of a clinic on the western outskirts of the village. The borehole is served by a handpump.

  The reliable yield of the borehole is not known at this stage.

- A third borehole, the number of which is not known is located centrally in the village. The borehole is equipped with a handpump.

  The reliable yield of the borehole is not known at this stage.

There were also 14 privately owned handpumps noted in the village.

* Schoongezicht

The village of Schoongezicht is located approximately 6.5 km west of Bodibe. The village is currently served by the following boreholes :-

- **T17070** is located at the eastern edge of the village, close to the main Itsoseng road. A windmill which is located at the borehole is no longer operational and the borehole is at present only equipped with a handpump. A standard 38 kl concrete ground reservoir is located next to the windmill but is also no longer operational.

  The reliable yield of the borehole is not known at this stage.

- A second borehole, the number of which is not known is located centrally in the village, in the grounds of a school. The borehole is equipped with a handpump.

  The reliable yield of the borehole is not known at this stage.

- A third borehole is believed to be located in the village but neither its location, number or yield are known at this stage.

* Bethel

The village of Bethel is located approximately 11 km west of Bodibe. The village is currently served by the following boreholes :-

- **T17515** is located on the north western border of the village, next to the Makouspan road. The borehole is equipped with a windmill which in turn supplies a 4.5 kl elevated storage tank and a 38 kl standard concrete ground reservoir. The ground reservoir appears to serve as communal watering point.

  The reliable yield of the borehole is not known at this stage.

- **10-77011** is located in the south western portion of the village. The borehole is equipped with a handpump which serves as a communal watering point.

  The reliable yield of the borehole is not known at this stage.

- A third borehole is located on the south eastern boundary of the village, in the grounds of a clinic. The borehole is equipped with a diesel engine and pump, which in turn supplies a 4.5 kl elevated storage tank. The tank appears to be for supply to the clinic only.

  Neither the number nor the reliable yield of the borehole are known at this stage.

- A fourth borehole is located on the north eastern boundary of the village. The borehole is equipped with a hand pump which serves as a communal watering point.

  Neither the number nor the reliable yield of the borehole are known at this stage.

2.2 The Need to Upgrade the Existing Bulk Supply System

The need to upgrade the existing bulk supply system to Itsoseng and certain of the surrounding villages is apparent from the following observations :-

* The need for reticulated water supply to Bodibe, as perceived by residents, is illustrated in the report prepared by Messrs. Setplan entitled *"Bodibe, Development Status Report"*. The present bulk supply to the town is expected to become inadequate, since the geohydrological study shows that the Polfontein spring is likely to stop flowing within the next five years.

* It is possible that local groundwater resources for the remaining villages may become contaminated due to the extensive use of pit latrines in these areas. Observations would also appear to indicate that in certain areas borehole supply is inadequate in terms of either yield capacity or the ability of existing windmill driven pumps to keep pace with demand.

* Nett Present Worth analyses of borehole costs and costs of the various schemes proposed hereafter have indicated that in every case it is more economical over the long term to upgrade water supply to the villages by means of sub-regional supply schemes sourced by strong yielding boreholes in the dolomitic underground compartments east of Bodibe than to embark on a programme of intensive local ground water exploitation in each village.

3. DEMAND ESTIMATES

3.1 Present and Future Estimated Demand

No data of present consumption from pumping rates or other means is available. However, estimates can be made from data available on the population numbers obtained from a development study for the sub-region, including Itsoseng and Bodibe, by Town Planners Messrs Setplan. The baseline population numbers for these settlements were based on house and plot counts, together with occupancy rates commensurate with the socio-economic status of these settlements.

Population growth rates for Itsoseng, Bodibe and surrounding villages were established taking cognizance of growth-affecting socio-economic factors such as local and regional commercial and industrial activity, and availability of housing, schooling and medical facilities. Population growth and numbers for upper, lower and probable growth scenarios were estimated and are shown in detail in Annexure A attached. Probable growth scenario population figures are shown in Table 3.1 attached.

The levels of service as established from evaluation of existing infrastructure as well as the urban development status study completed by Messrs. Setplan are as per table 3.2 below.

PROJECTED POPULATION FIGURES

VILLAGE	POPULATION		
	1990	2000	2010
ITSOSENG	26287	32678	40226
BODIBE	24445	29798	35969
SHIELA	903	1090	1303
VERDWAAL 1	1598	1929	2306
VERDWAAL 2	822	963	1118
SPRINGBOKPAN	2171	2570	3012
MATILE	2385	2798	3254
WELVERDIEND	434	499	567
DUIKERBOS	1940	2274	2639
BETHEL	1146	1356	1590
SCHOONGEZICHT	486	558	635
TOTAL	62617	76513	92619

TABLE 3.1

TABLE 3.2 : LEVELS OF SERVICE

1990

VILLAGE	LEVEL OF SERVICE		
	% H.C.	% Y.C.	% S.P.
ITSOSENG	100	0	0
BODIBE	0	0	100
SHIELA	0	80	20
VERDWAAL 1	0	80	20
VERDWAAL 2	0	0	100
SPRINGBOKPAN	0	0	100
MATILE	0	0	100
WELVERDIEND	0	0	100
DUIKERBOS	0	0	100
BETHEL	0	0	100
SCHOONGEZICHT	0	0	100

2000

VILLAGE	LEVEL OF SERVICE		
	% H.C.	% Y.C.	% S.P.
ITSOSENG	100	0	0
BODIBE	0	2.5	97.5
SHIELA	0	87.5	12.5
VERDWAAL 1	0	87.5	12.5
VERDWAAL 2	0	2.5	97.5
SPRINGBOKPAN	0	2.5	97.5
MATILE	0	2.5	97.5
WELVERDIEND	0	2.5	97.5
DUIKERBOS	0	2.5	97.5
BETHEL	0	2.5	97.5
SCHOONGEZICHT	0	2.5	97.5

2010

VILLAGE	LEVEL OF SERVICE		
	% H.C.	% Y.C.	% S.P.
ITSOSENG	100	0	0
BODIBE	0	5	95
SHIELA	0	95	5
VERDWAAL 1	0	95	5
VERDWAAL 2	0	5	95
SPRINGBOKPAN	0	5	95
MATILE	0	5	95
WELVERDIEND	0	5	95
DUIKERBOS	0	5	95
BETHEL	0	5	95
SCHOONGEZICHT	0	5	95

Design standards, norms and levels of service have all been based on the Bophuthatswana Department of Water Affairs' "*Guidelines for the Selection of Design Criteria, March 1991.*", the relevant extracts of which are shown in Annexure B to this document. Gross Annual Average Daily Demand generated by the population numbers shown above, using these standards and levels of service, is shown for the various growth scenarios in Figure 3.1.

Detailed demands and related factors are shown in detail in Annexure B to this document.

BULK WATER SUPPLY TO ITSOSENG AND SURROUNDING VILLAGES

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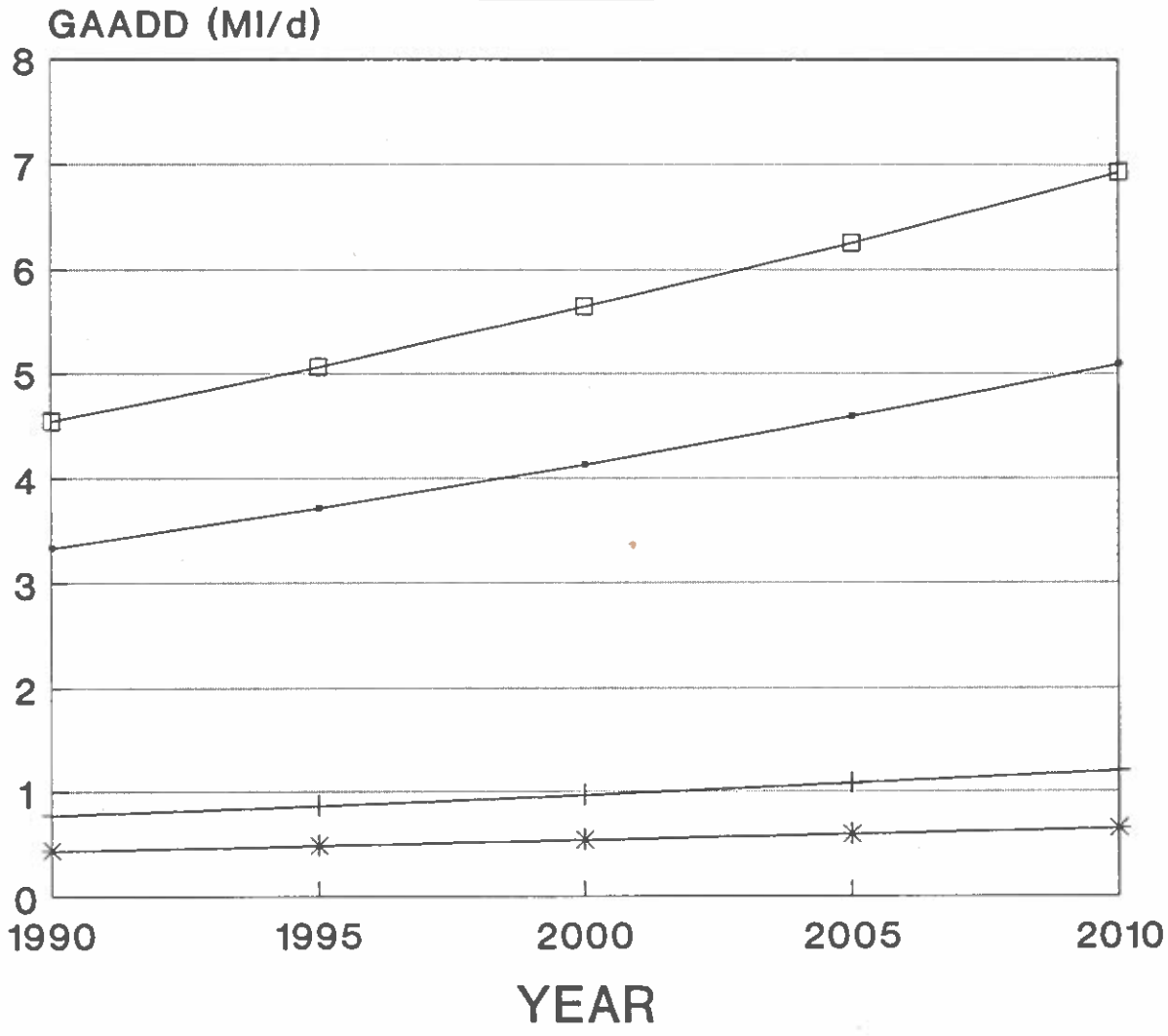


FIGURE 3.1

4. SOURCES OF SUPPLY

4.1 General Principles

The results of the geohydrological survey completed by Messrs. Partridge Maud & Associates in the area around Itsoseng are documented in the report prepared by them entitled "*Report on a Geohydrological Investigation of Polfontein and Adjacent Dolomitic Compartments*", which is available on request.

The following observations and conclusions arose out of the survey :-

i.) There are three underground dolomitic compartments with viable groundwater resources in the area. These are the Polfontein, Verdwaal and Matlabes Compartments. The layout of the compartments is shown on figure 4.1 attached.

ii.) Water is currently pumped out of a single wellfield in the Polfontein Compartment for consumption by Itsoseng. At the current rate of abstraction from the Polfontein compartment, the Polfontein spring, from whence the residents of Bodibe currently draw water, is likely to run dry within a few years.

iii.) Abstraction at a rate of more than 85 l/s from the existing Itsoseng wellfield is likely to lead to serious instability of the ground surface in the region of the existing Itsoseng reservoir and water tower.

iv.) The combined maximum viable yield for the Verdwaal and Polfontein compartments is 5.6 million m^3/yr of which farmers over the South African portion of the compartments use approximately 2.25 million m^3. This leaves a usable yield of some 3.35 million m^3/yr, or 9.172 Ml/d.

v.) The maximum viable yield of the Matlabes Compartment is approximately 1 million m^3/yr, or 2.738 Ml/d, which is largely unutilised at present.

The following recommendations with respect to groundwater management were made in the report :-

i.) Abstraction from the Polfontein compartment should be limited to that required for Itsoseng only.

ii.) A wellfield should be established in the Verdwaal compartment to be used to supplement supply to Itsoseng from the Polfontein compartment.

iii.) Where possible, abstraction points in the Polfontein compartment should be spread across the compartment to limit the high draw-of from one single abstraction point.

iv.) Bodibe should be supplied from a wellfield to be established in the Matlabes compartment in order to limit further loading of the resources of the Polfontein Compartment.

4.2 Alternative Supply Sources Considered

Bulk supply to the townships of Itsoseng and Bodibe will be supplied by the Polfontein / Verdwaal and Matlabes compartments respectively, as proposed by the geohydrological survey described above.

The remainder of the villages in the area were also appraised in terms of bulk water supply requirements and the following alternatives considered for supply thereto :-

a.) Rudimentary Supply from local boreholes.

b.) Supply via pipeline from the Matlabes and Itsoseng / Verdwaal wellfield.

5. SUPPLY AND ROUTING

5.1 Supply Zones

For the purposes of analysis in this report, the area was broken up into two separate supply zones. These were delineated by the compartments to be used for bulk supply.

The *Itsoseng* supply zone includes areas which will be supplied, if necessary from the Polfontein / Verdwaal compartments. The villages included in this supply zone include Itsoseng, Verdwaal 1 and Verdwaal 2.

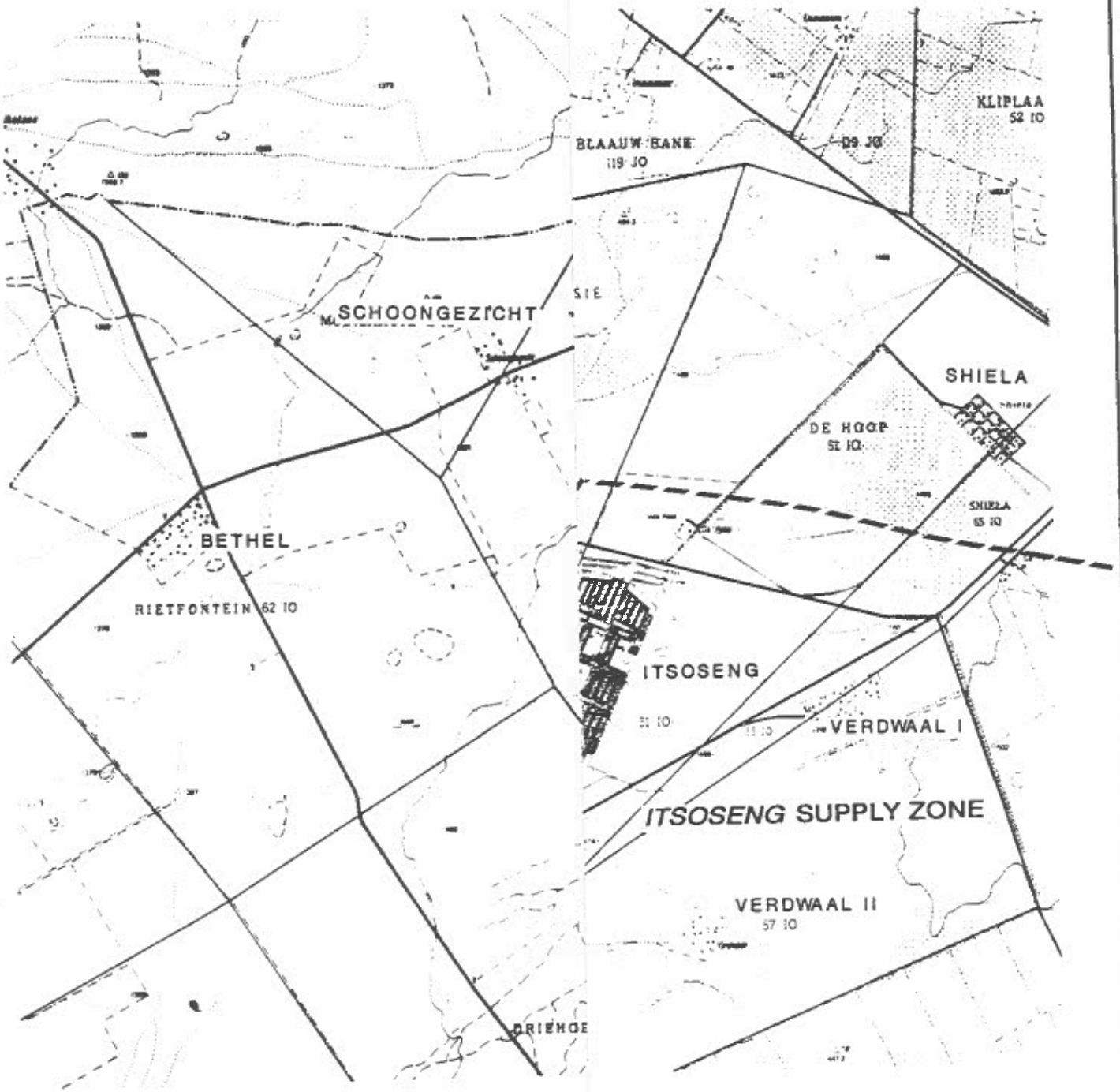
Although it is necessary to limit draw-off from the Verdwaal / Polfontein compartments to a minimum, the villages of Verdwaal 1 and 2 where considered for supply from the Verdwaal compartment because of their close proximity to boreholes in the compartment and their relatively minor demands.

Total demand from the Itsoseng supply zone will amount to 5.154 Ml/d, or 1.883 million m^3 p.a. by 2010. This is well within the 3.35 million m^3 p.a. maximum usable yield of the Polfontein / Verdwaal compartments stipulated in the geohydrological survey report.

The remaining villages in the area were all considered to fall into the *Bodibe* supply zone. This is because the villages in this zone could all be served either from a header tank at Bodibe, supplied from a wellfield in the Matlabes compartment, or directly from the Matlabes wellfield, as in the case of Shiela.

Total demand from the Bodibe Supply Zone, if all villages included are indeed supplied from the Matlabes compartment via a sub-regional scheme, will amount to 2.057 Ml/d or 0.751 million m^3 p.a. by 2010. This is well within the 1.0 million m^3 p.a. maximum usable yield of the Matlabes compartment stipulated in the geohydrological survey report.

The supply zones determined are shown in figure 5.1 attached.



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5.2 Supply and Routing Options

The following alternatives were evaluated and considered for supply and routing to the various villages.

A. ITSOSENG SUPPLY ZONE

a.1) Supplementary Supply to Itsoseng From Verdwaal Compartment

This system is as directly recommended from the geohydrological survey report. A borehole was drilled for the purposes of testing, located at (1) as shown on the accompanying drawing 8838/100/1. The borehole was found to have a usable yield of 15.8 l/s. It was recommended that this would be the most suitable borehole to be utilised for supplementation of the supply to Itsoseng.

Another borehole, which was used for testing purposes, is located near the north east corner of Verdwaal 1 village substantially closer to Itsoseng, shown as borehole (3) on the accompanying drawing 8838/100/1. The yield of this borehole was measured during the geohydrological investigation as 7.2 l/s.

It was decided to link boreholes (1) and (3) via a pipeline and through an existing road crossing to the existing 450 mm diameter pipeline which runs from the 20 Ml reservoir to the southern corner of Itsoseng. A 140 mm diameter uPVC pipeline 2600 m long will then be required to accomplish this aspect.

These boreholes will be retained as a standby supply to Itsoseng at present and be brought into permanent service at a later stage to limit draw-off from the Polfontein Compartment.

Detailed technical analysis for this pipeline is shown in Annexure B to this document, while detailed cost implications are shown in Annexure C.

a2.) Supply to the Verdwaal Villages from Verdwaal Compartment

The village of Verdwaal 1 already has supply from the tribal borehole V1 which has a yield of some 15 l/s, or 1.3 Ml/d. This is sufficient to supply Verdwaal 1, having a 20 year SDD of 206 kl/d, until well past the 20 year design horizon. Approximately 80 % of the village is also presently equipped with yard connections. It is obvious therefor that the village of Verdwaal 1 does not need attention at present.

Residents at Verdwaal 2 stated that their only form of supply is via a windmill from a single borehole. During periods of windlessness, which can be long and occur frequently, there is no water supply to the village.

A pipeline may be laid to Verdwaal 2, branching off from the existing 450 mm diameter pipeline running to southern corner of Itsoseng.

The detailed technical analysis of the system proposed is set out in Annexure B. The pipeline required would be 75 mm diameter uPVC, approximately 2300 m long.

A nett present worth analysis was done to appraise and compare the costs of equipping the existing borehole with a diesel engine and the costs of piped supply as described above. The cost analysis is set out in Annexure C to this document.

It was found that the total cost of the proposal of supplying piped water to the village of Verdwaal 2 is substantially more economical than that of re-equipping the borehole.

B. BODIBE SUPPLY ZONE

The borehole supply to Shiela appears to be adequate at present, there being no apparent deficiencies or inadequacies arising from the engine driven borehole pump. Approximately 80 % of the village is supplied with yard connections. Shiela does not therefor appear to require any further attention at this stage.

b1.) Supply to Bodibe From Matlabes Compartment

The site indicated in the geohydrological (gravity) survey as being most suitable for the siting of the borehole which will supply Bodibe is located approximately 4.5 km north east of Bodibe.

It is recommended that further holes be drilled and tested at the south western edge of the compartment to try and establish a viable yielding supply closer to Bodibe. However, for the purposes of this report, it was assumed that the borehole to be used would be sited as per the recommendation in the geohydrological report.

A rudimentary network will also have to be laid in Bodibe, the details of which are covered in further detail in the report prepared by Eksteen, Van der Walt & Nissen entitled "*Bodibe Water Supply, Draft Appraisal Report*".

A detailed analysis of the supply system considered is shown in Annexure B to this document, while detailed cost estimates are shown in Annexure C.

b2.) Supply to Bodibe, Welverdiend and Duikerbos From Matlabes Compartment

Under this alternative, supply would come from the wellfield located in the Matlabes compartment as proposed in (b1.) above. However, a pipeline running from the western side of Bodibe will be installed to supply the villages of Welverdiend and Duikerbos.

A detailed analysis of the supply system considered is shown in Annexure B to this document, while detailed cost estimates are shown in Annexure C.

b3.) Supply to Bodibe, Welverdiend, Duikerbos, Matile and Springbokpan From Matlabes Compartment

This option would be similar to that described in (b2.) above, but would include a branchmain to the villages of Matile and Springbokpan, located south west of Bodibe.

A detailed analysis of the supply system considered is shown in Annexure B to this document, while detailed cost estimates are shown in Annexure C.

b4.) Supply to Bodibe, Welverdiend, Duikerbos, Matile, Springbokpan, Schoongezight and Bethel From Matlabes Compartment

This option would be similar to that described in (b3.) above would include a branch main to the villages of Schoongezight and Bethel, located further west.

A detailed analysis of the supply system considered is shown in Annexure B to this document, while detailed cost estimates are shown in Annexure C.

5.3 Appraisal of Supply and Routing Proposals and Alternatives

Implementation of proposal (a1) described above has been identified in the Geohydrological survey report as being essential to limit draw-off from the Polfontein Compartment.

Proposal (a2) has been identified as necessary due to the noted inadequacy of the existing supply system to Verdwaal 2, as well as being the most economically suitable alternative under the circumstances.

Supply to Bodibe from the Matlabes Compartment has been identified by the geohydrological report as being essential for the following reasons :-

- The Polfontein eye is expected to run dry in a number of years, removing the existing supply from Bodibe.

- The draw-off from the Polfontein Compartment should be limited as much as possible.

However, investigation of sub-regional supply schemes to the other villages located west of Bodibe, also sourced from the Matlabes Compartment, have indicated that in all cases such supply schemes would be substantially more economical in the long term than intensive exploitation of the local groundwater resources in each village.

A programme of testing must be implemented to establish which of the villages listed below has existing ground water resources and infrastructure which is adequate for at least the 20 year design horizon. Those villages in which existing infrastructure and resources will have to be extensively upgraded in the near future should then be considered for supply under one of the schemes described in (b2) to (b4) above. The villages are as follows :-

Welverdiend
Duikerbos
Springbokpan
Matile
Schoongezight
Bethel

All of the alternatives listed in (b1) to (b4) above utilise a wellfield to be established in the Matlabes compartment, as well as a 250 mm diameter F/C pipeline approximately 4 km long, as well as ground reservoir and elevated storage tank to be erected at the eastern corner of Bodibe.

6 RECOMMENDATIONS

6.1 The borehole indicated as (1) on the accompanying drawing 8838/100/1 must be equipped with a pump having a capacity of 15.8 l/s. The borehole indicated as (3) must also be equipped with a pump having a capacity of 7.2 l/s. A 140 mm diameter uPVC pump main should be laid from borehole (1) to borehole (3) and from there to the existing road crossing at borehole V1 where it will join the existing 450 mm supply main running from the existing 20 Ml reservoir to the southern corner of Itsoseng.

6.2 Further boreholes should be drilled and tested in the south-western corner of the Matlabes Compartment in order to establish the viability of groundwater resources in the Matlabes Compartment, close to Bodibe.

6.3 The viability of existing groundwater resources and infrastructure in the villages of Welverdiend, Duikerbos, Springbokpan, Matile, Schoongezight and Bethel should be investigated and their viability to maintain adequate supply up to 2010 confirmed or rejected. Villages in which extensive exploitation of local groundwater resources appears to be necessary should rather be supplied via a sub-regional supply scheme sourced from the Matlabes Compartment than by extensive local groundwater exploitation.

6.4 A wellfield must be established in the Matlabes Compartment, as close as possible to Bodibe. The wellfield will supply a ground storage reservoir and elevated storage tank to be located at the eastern corner of Bodibe via 250 mm diameter F/C pipeline. The capacities of the borehole pumps, elevated storage tank and main supply line running through Bodibe will be dictated by the number of those villages listed above which will have to utilise water from the Matlabes Compartment as well, via the same scheme.

6.5 The village of Verdwaal 2 should be supplied with potable water and rudimentary reticulation system. The supply would be via a branchmain taken from the existing 450 mm main which runs from the 20 Ml reservoir to the southern corner of Itsoseng.

7 FINANCIAL IMPLICATIONS

The capital cost implications of those recommendations which may be implemented forthwith are as follows :-

Supplementary Supply to Itsoseng From Verdwaal Compartment

Total expected capital expenditure - R 472 700-00

Supply to Verdwaal 2 From Itsoseng Supply Main

Total expected capital expenditure - R 110 950-00

Supply to Bodibe From Matlabes Compartment

Total expected capital expenditure - R 3 479 690-00

Note that the cost estimate given above for Bodibe is for the case of supply to Bodibe only. Should ground water testing indicate that other villages further west of Bodibe require potable water supply, the cost of supply to Bodibe will be influenced accordingly.

REFERENCES

* Partridge, Maud & Associates ; *Report on a Geohydrological Investigation of the Polfontein and Adjacent Dolomitic Compartments* ; November 1990

* Setplan ; *Bodibe Development Status Report* ; April 1990

ANNEXURE A

ECONOMIC MODULE

ANNEXURE A

ECONOMIC MODULE

A1 DETAILED POPULATION ESTIMATES

BULK WATER SUPPLY TO ITSOSENG AND SURROUNDING VILLAGES

TABLE A1 : PULATION GROWTH PROJECTIONS

UPPER GROWTH SCENARIO

VILLAGE	POPULATION				
	1990	2000		2010	
ITSOSENG	26287	2.80%	34648	2.60%	44786
BODIBE	24445	2.60%	31598	2.40%	40056
SHIELA	903	2.60%	1167	2.40%	1480
VERDWAAL 1	1598	2.60%	2066	2.40%	2618
VERDWAAL 2	822	2.30%	1032	2.10%	1270
SPRINGBOKPAN	2171	2.50%	2779	2.30%	3489
MATILE	2385	2.36%	3012	2.19%	3742
WELVERDIEND	434	2.10%	534	1.91%	645
DUIKERBOS	1940	2.40%	2459	2.20%	3057
BETHEL	1146	2.50%	1467	2.30%	1842
SCHOONGEZICHT	486	2.10%	598	1.90%	722
TOTAL	62617	2.65%	81360	2.46%	103707

LOWER GROWTH SCENARIO

VILLAGE	POPULATION				
	1990	2000		2010	
ITSOSENG	26287	1.80%	31421	1.50%	36465
BODIBE	24445	1.60%	28650	1.40%	32924
SHIELA	903	1.60%	1058	1.40%	1216
VERDWAAL 1	1598	1.60%	1873	1.40%	2152
VERDWAAL 2	822	1.30%	935	1.10%	1043
SPRINGBOKPAN	2171	1.50%	2520	1.30%	2867
MATILE	2385	1.42%	2745	1.24%	3105
WELVERDIEND	434	1.20%	489	1.00%	540
DUIKERBOS	1940	1.40%	2229	1.20%	2512
BETHEL	1146	1.50%	1330	1.30%	1513

PROBABLE GROWTH SCENARIO

VILLAGE	POPULATION				
	1990	2000		2010	
ITSOSENG	26287	2.20%	32678	2.10%	40226
BODIBE	24445	2.00%	29798	1.90%	35969
SHIELA	903	1.90%	1090	1.80%	1303
VERDWAAL 1	1598	1.90%	1929	1.80%	2306
VERDWAAL 2	822	1.60%	963	1.50%	1118
SPRINGBOKPAN	2171	1.70%	2570	1.60%	3012
MATILE	2385	1.61%	2798	1.52%	3254
WELVERDIEND	434	1.41%	499	1.29%	567
DUIKERBOS	1940	1.60%	2274	1.50%	2639
BETHEL	1146	1.70%	1356	1.60%	1590
SCHOONGEZICHT	486	1.39%	558	1.30%	635
TOTAL	62617	2.02%	76513	1.93%	92619

ANNEXURE B

TECHNICAL MODULE

ANNEXURE B

TECHNICAL MODULE

B1 DETAILED ANALYSIS OF DEMANDS AND RELATED FACTORS

ITSOSENG & SURROUNDING VILLAGES
BULK WATER SUPPLY
TABLE B1 : DEMANDS AND RELATED FACTORS

1990

VILLAGE	POPULATION	GGADD (kl/d)	SDD (kl/d)	DPFR (l/s)
ITSOSENG	26287	3325.3	4534.5	143.76
BODIBE	24445	773.1	870.9	27.06
SHIELA	903	51.4	68.7	2.18
VERDWAAL 1	1598	91.0	121.6	3.85
VERDWAAL 2	822	26.0	29.3	0.91
SPRINGBOKPAN	2171	68.7	77.3	2.40
MATILE	2385	75.4	85.0	2.64
WELVERDIEND	434	13.7	15.5	0.48
DUIKERBOS	1940	61.4	69.1	2.15
BETHEL	1146	36.2	40.8	1.27
SCHOONGEZICHT	486	15.4	17.3	0.54
TOTAL	62617	4537.5	5930.1	187.22

2000

VILLAGE	POPULATION	GGADD (kl/d)	SDD (kl/d)	DPFR (l/s)
ITSOSENG	32678	4133.77	5636.96	178.71
BODIBE	29798	965.92	1187.08	35.21
SHIELA	1090	64.63	92.99	2.83
VERDWAAL 1	1929	114.38	164.57	5.00
VERDWAAL 2	963	31.22	38.36	1.14
SPRINGBOKPAN	2570	83.31	102.38	3.04
MATILE	2798	90.70	111.47	3.31
WELVERDIEND	499	16.18	19.88	0.59
DUIKERBOS	2274	73.71	90.59	2.69
BETHEL	1356	43.96	54.02	1.60
SCHOONGEZICHT	558	18.09	22.23	0.66
TOTAL	76513	5635.9	7520.5	234.76

B2 DEMAND CRITERIA, NORMS AND STANDARDS

2.1 General Philosophy

The planning and design of infrastructure for Hoekfontein are related to the standard norms and standards laid down in the Bophuthatswana Department of Water Affairs publication *"Guidelines for the Selection of Design Criteria"*, these having been designated by the above-mentioned committee.

The most relevant extracts from this document are listed below :-

a) Definitions

Throughout this section the following definitions and abbreviations apply :-

* **Standpipe supply**

  Supply where water is distributed to manually operated taps located in public open spaces and street reserves.

* **Yard Connection**

  Supply where each yard (erf) is provided with a (metered) single tap and which is not expected to be upgraded during the design horizon.

* **House Connection**

  Supply where the building on each erf (plot) is fitted with a (metered) multiple tap installation and sanitary fittings.

* **Building Connection**

  Metered multi-tap and sanitary fittings installation for buildings intended for other uses than domestic.

* **AADD - Average Annual Daily Demand (Ml/d)**

  The AADD is the total volume of water required by a demand centre divided by the number of days in the year.

* **GAADD - Gross Average Annual Daily Demand (Ml/d)**

  The GAADD is the AADD plus system losses allowed.

* **SDD - Summer Daily Demand (Ml/d)**

  The SDD is the maximum demand (including losses) required over a single day during the year and can be expressed as the AADD multiplied by a Summer Peak Factor (SPF)

* **SPF - Summer Peak Factor (factor)**

  The Summer Peak Factor is a factor (not less than 1,0) by which the AADD should be multiplied to obtain the SDD. This SPF is a function of use of the water (e.g. gardening, lawns, washing of cars, household, industrial) as well as the climatic conditions of the Demand Centre.

* **DPFR - Design Peak Flow Rate (l/s)**

The DPFR is the flow capacity required in a pipeline to cater for the instantaneous peak consumption of a demand centre. This DPFR is determined by multiplying the SDD by a Design Peak Factor (DPF).

* **DPF - Design Peak Factor (factor)**

The daily peak factor is a value by which the SDD should be multiplied to obtain the DPFR. This DPF is derived in accordance with the following concepts for:

i) Stand-Pipe supply

The DPF for stand-pipe supply is derived from that portion of the day during which consumers generally obtain their requirements. In most cases of stand-pipe supply, no street lights are available and hence the draw-off period is normally limited to daylight hours. If the assumption is made that all stand-pipes supplied are open permanently during daylight hours and that consumers are constantly obtaining water from such stand-pipes, the minimum value of the DPF for summer (10 hours of daylight) is therefore 2,4 and for winter 3,0 (8 hours daylight).

This situation is however considered unlikely in practice due to the occupation of people fetching the water and a minimum DPF for standpipe supply is therefor recommended as 3.0

ii) Yard, House and Building connections

The DPF describes the requirement that at certain peak periods of the day a large portion of the consumers require water at the same time (e.g. morning, evening). This factor can vary in accordance with the number of consumers being serviced and can be equated to the "Peak Factor" defined in "Guidelines for the provision of Engineering Services in Residential Townships - RSA Department of Community Development" (A.K.A. The Blue Book) as given in figure F3 of that publication, divided by the SPF.

* **Gross Floor Area**

Total enclosed floor area of a building.

* **Design Horizon**

That length of time for which the physical components of the system are to be sized.

* **Planning Horizon**

That length of time for which the system is planned to cater for projected demands.

b.) Demand Criteria

The following design criteria are to be adopted for the end of the design horizon :-

*	**Water Demand (AADD)**	**Range**
	Standpipe supply	20 - 50 l/c/d
	Yard Connections	50 - 100 l/c/d
	House Connections	100 - 150 l/c/d

Note :
The values at the lower end of the ranges are to be used in general and higher values used only when motivation exists for the use thereof.

*	**Peak Factors**	**SPF**	**DPF**
	Standpipe supply	1.2	3.0
	Yard Connections	1.5	3.0
	House Connections	1.5	3.0

Note :
Means of reducing these values, e.g. by the use of on-site storage tanks may be considered providing these measures are economically justified.

* **Target maximum walking distance to standpipe :**

500 m

* **Maximum number of people per tap**

(Multiple taps per standpipe are acceptable)

50 to 75 with 75 as the norm and
motivation required for a lower number.

* **Storage**

(Fire requirements are additional to these values)
The extent of storage to be provided shall be based on rational design including a site specific risk analysis, e.g. consequences of supply interruption. The following values serve to indicate the maximum which could be provided.

Surface -

Pump supply	: 48 hours of GAADD
Gravity supply	: 24 hours of GAADD

Elevated (Pump supply) : 4 hours at DPFR

Capacity of distribution
from reservoirs : DPFR plus fire flow

Capacity of bulk supply mains
to reservoirs : Optimise with reservoir capacity

* **Residual Pressures**

Minimum * -

Standpipes	: 5 m
Yard Connections	: 5 m
House Connections	: 12 m at highest point on erf

Maximum (under static conditions) -

All cases	: 90 m

* Where applicable, pressure required for fire supply purposes should be provided.

* **Losses**

The design of the reticulation is to be based on the nett requirements using the appropriate peak factors. The gross system demand is to include for losses of 10 % of the AADD as a norm. Provision for losses in excess of 10 % must be motivated.

* **Design Life of Components**

(For economic analysis)

Bulk supply lines	: 20 years
Treatment Works	: 20 years
Reservoirs	: 20 years
Reticulation mains	: 20 years
Electrical equipment	: 15 years
Mechanical Equipment	: 10 years
Buildings	: 20 years

* **Development Horizons**

	Planning	**Design**
Bulk supply lines	: 20 years	10 years
Treatment Works	: 10 years	5 years
Reservoirs	: 10 years	5 years
Reticulation mains	: 10 years	5 years

Notes :
Final selection of planning and design horizons should be based on a socio-economic evaluation of the conditions pertaining to the project.

In situations of high uncertainty shorter horizons than those given above should be considered.

Treatment works capacities and reservoir sizes should take practical sizes of modules into account.

B3 ROUTING ALTERNATIVES : DETAILED ANALYSES

3.1 Alternative (a1) : Supplementary Supply to Itsoseng From Verdwaal Compartment

The pipeline route proposed is shown in figure B1 attached.

The computer pipeflow network analysis is shown in Annexure D to this document.

Under this proposal, supply to Itsoseng will come from the following two sources :-

* Main Itsoseng Wellfield (At existing 20 Ml reservoir) (Polfontein Compartment)

  - Average of 38.0 l/s
  - 3.283 Ml/d

* Existing boreholes in Itsoseng (Supply to proposed booster pumps - Polfontein Compartment)

  - 40 l/s, only at peak times ie. 6 hours / day
  - 864 kl/d

3.2 Alternative (a2) : Supply to Verdwaal 2 from Itsoseng / Verdwaal Wellfields

The route proposed is as per figure B1 attached.

The computer pipeflow network analysis is shown in Annexure D to this document.

Note that the pipeline proposed is adequate to supply DPFR to the township and therefor no further ground or elevated storage is required.

3.4 Alternative (b2) : Supply to Bodibe, Welverdiend and Duikerbos From Proposed Matlabes Wellfield

The routes of the proposed bulk supply mains are as per figure B3 attached.

A Wellfield will have to be developed and be equipped with a pumping capacity of 20.0 l/s, which will have to be upgraded to 24.9 l/s at the end of the 10 year design horizon.

The wellfield will supply a ground storage reservoir with a capacity of 2.2 Ml located at the eastern corner of Bodibe. Supply to the reservoir will be via a 160 mm diameter uPVC pipeline approximately 4500 m long. The ground reservoir capacity will have to be upgraded to 2.6 Ml by 2001.

A booster pump with a capacity of 39 l/s will supply an elevated storage tank with a capacity of 550 kl, located next to the ground reservoir, via a 200 mm diameter pipeline. The capacity of the elevated tank will have to be upgraded to 690 kl, and that of the booster pump to 48 l/s at the end of the 10 year design horizon.

Additional pipelines required will be as follows :-

Bulk Supply Mains :-

75 mm dia.	-	2750 m
90 mm dia.	-	3250 m
110 mm dia.	-	1000 m
150 mm dia.	-	2800 m
200 mm dia.	-	3450 m
250 mm dia.	-	500 m

Reticulation :-

Bodibe

75 mm dia.	-	4550 m
90 mm dia.	-	10300 m
110 mm dia.	-	1250 m
150 mm dia.	-	1700 m

Welverdiend

75 mm dia.	-	1200 m

Duikerbos

75 mm dia.	-	3000 m

3.5 Alternative (b3) : Supply to Bodibe, Welverdiend, Duikerbos, Matile and Springbokpan From Proposed Matlabes Wellfield

The routes of the proposed bulk supply mains are as per figure B3 attached.

A Wellfield will have to be developed and be equipped with a pumping capacity of 23.3 l/s, which will have to be upgraded to 28.9 l/s at the end of the 10 year design horizon.

The wellfield will supply a ground storage reservoir with a capacity of 2.5 Ml located at the eastern corner of Bodibe. Supply to the reservoir will be via a 200 mm diameter F/C pipeline approximately 4500 m long. The ground reservoir capacity will have to be upgraded to 3.0 Ml by 2001.

A booster pump with a capacity of 45 l/s will supply an elevated storage tank with a capacity of 650 kl, located next to the ground reservoir, via a 200 mm diameter pipeline. The capacity of the elevated tank will have to be upgraded to 800 kl, and that of the booster pump to 56 l/s at the end of the 10 year design horizon.

Additional pipelines required will be as follows :-

Bulk Supply Mains :-

75 mm dia.	-	2750 m
90 mm dia.	-	3250 m
110 mm dia.	-	5250 m
140 mm dia.	-	4500 m
150 mm dia.	-	1000 m
200 mm dia.	-	3800 m
250 mm dia.	-	2450 m
300 mm dia.	-	500 m

Reticulation :-

Bodibe

75 mm dia.	-	4550 m
90 mm dia.	-	10300 m
110 mm dia.	-	1250 m
150 mm dia.	-	1700 m

Welverdiend

75 mm dia.	-	1200 m

Duikerbos

75 mm dia.	-	3000 m

Matile

75 mm dia.	-	2500 m

Springbokpan

75 mm dia.	-	3000 m

3.6 Alternative (b4) : Supply to Bodibe, Welverdiend, Duikerbos, Matile, Springbokpan, Schoongezight and Bethel From Proposed Matlabes Wellfield

The routes of the proposed bulk supply mains are as per figure B3 attached.

A Wellfield will have to be developed and be equipped with a pumping capacity of 24.5 l/s, which will have to be upgraded to 30.3 l/s at the end of the 10 year design horizon.

The wellfield will supply a ground storage reservoir with a capacity of 2.6 Ml located at the eastern corner of Bodibe. Supply to the reservoir will be via a 200 mm diameter F/C pipeline approximately 4500 m long. The ground reservoir capacity will have to be upgraded to 3.2 Ml by 2001.

A booster pump with a capacity of 47 l/s will supply an elevated storage tank with a capacity of 680 kl, located next to the ground reservoir, via a 250 mm diameter pipeline. The capacity of the elevated tank will have to be upgraded to 840 kl, and that of the booster pump to 58 l/s at the end of the 10 year design horizon.

Additional pipelines required will be as follows :-

Bulk Supply Mains :-

75 mm dia.	-	6850 m
90 mm dia.	-	4350 m
110 mm dia.	-	5250 m
140 mm dia.	-	4500 m
160 mm dia.	-	3250 m
200 mm dia.	-	1750 m
250 mm dia.	-	5500 m
300 mm dia.	-	500 m

Reticulation :-

Bodibe

75 mm dia.	-	4550 m
90 mm dia.	-	10300 m
110 mm dia.	-	1250 m
150 mm dia.	-	1700 m

Welverdiend

75 mm dia.	-	1200 m

Duikerbos

75 mm dia.	-	3000 m

Matile

75 mm dia.	-	2500 m

Springbokpan

75 mm dia.	-	3000 m

Schoongezight

75 mm dia.	-	1800 m

Bethel

75 mm dia.	-	3000 m

ANNEXURE C

FINANCIAL MODULE

ANNEXURE C : FINANCIAL MODULE

C1 TYPICAL RUDIMENTARY SUPPLY COSTS

1.1 Supply Unit Costs

It was necessary to establish a typical unit supply cost for rudimentary local borehole supply. This was in order to compare the viability of sub-regional supply schemes against that of rudimentary local borehole supply.

Components of the unit costs of a typical rudimentary supply scheme, with costs where available taken from the above-mentioned report on Bophuthatswana rural water supply, are listed below.

For the purposes of comparison, a typical borehole with a yield of 3500 l/hr, pumping 12 hours/day was considered.

Drilling cost — **R 5 091-77**

Testing cost — **R 2 425-31**

Equipping (approximately 50 % mechanical) — **R 27 027-79**

The mechanical components will have to be replaced after 10 years — **R 13 500-00**

Fuel :-

Pumping requirements are typically 0.972 l/s against a head of 80 m, requiring a power input of 1.526 kW, or 18.312 kWhrs / day.
Fuel consumption at this rate = 6.74 l/d
Fuel Cost = R 8-42 c/day

or **R 3 075-41 / yr**

Maintenance. A maintenance team will visit the installation on average 6 times per year, at a cost of R 800-00 per time
Total maintenance cost per year is thus — **R 4 800-00 / yr**

Total costs are thus expected to be as shown below :-

TABLE C1.1 : RUDIMENTARY BOREHOLE SUPPLY LONG TERM COST CONSIDERATIONS

COST COMPONENT	PRESENT VALUE	ESCALATED VALUE	NETT PRESENT WORTH
Drilling	R5 091.77	R5 091.77	R5 091.77
Testing	R2 425.31	R2 425.31	R2 425.31
Equipping	R27 027.79	R27 027.79	R27 027.79
Replace Mech. Items after 10 years.	R13 500.00	R47 057.94	R31 790.65
Fuel Cost over 20 years.	R61 508.20	R257 839.91	R156 323.31
Maintenance cost over 20 years.	R96 000.00	R402 428.15	R243 984.34
TOTALS	R205 552.07	R741 870.86	R466 643.17

The total volume of water supplied by such a typical borehole will then be :-

3500 l/hr
= 42.0 kl/d
= 15340.5 kl/yr
= 306810 kl over 20 years

Unit costs are than as follows :-

Present value :-	R 0-670 c/kl
Escalated value :-	R 2-418 c/kl
Nett Present worth :-	R 1-521 c/kl

For the purpose of evaluation of the cost of supply to villages from such rudimentary supply, it was decided to use the *present value* unit cost calculated above, and then apply escalation and nett present worth evaluation to the demand required for each year.

Furthermore, it was decided to break this present unit cost up into an 3 components. These are as follows :-

- That which will be spent immediately ie. drilling, testing and equipping. This portion amounts to 11.26 c/kl.

- That which will be spent after 10 years ie. replacement and upgrading of pumping equipment. This portion amounts to 4.4 c/kl.

- That which will be spent uniformly throughout the life of the scheme ie. fuel and maintenance. This portion will amount to 51.34 c/kl.

The three components listed above will then total the R 0-67 c present value calculated above.

1.2 Population Unit Costs

Unit costs in this respect encountered to date in Bophuthatswana are summarised in the report entitled "*Bophuthatswana Rural Water Supply Programme, Project Co-ordination Meeting No. 1, April 1991*". The general figure established for unit costs to date in this application is R 172-20 c/capita.

It must be noted, however, that this figure of R 172-00 / capita is only representative of initial implementation costs and does not take running and maintenance costs into account.

In order to obtain a realistic unit cost, representative of running and maintenance costs, the values estimated in paragraph 1.1 above should be included. A borehole supplying 42 kl/d should be able to supply an average of 1344 people, assuming the level of service of supply is for 25 % yard connections and 75 % standpipes.

Population unit costs will therefor be as follows :-

Present value	-	R 152-94 c/capita
Escalated value	-	R 551-99 c/capita
Nett Present Worth	-	R 347-20 c/capita

2. TYPICAL ENERGY COSTS - SUB-REGIONAL SCHEMES

Certain schemes proposed will make use of electrically powered boreholes for bulk supply. It was necessary to calculate the unit electricity cost for the purposes of comparison of the schemes against each other and against rudimentary borehole supply.

The electricity tariffs which will be paid for these boreholes will be for large scale consumers and will be as follows :-

- Service charge of R 60-10 c / month
- Energy charge of R 0-0501 c / kWhr
- Demand charge of R 24-49 c / kW / month

Unit electrical cost was calculated on the basis of the following assumptions :-

- Average borehole depth will be 60 m
- Average pumping time will be 18 hours/day.
- Average pump efficiency will be 50 %

Unit electrical costs are therefor as follows :-

1 l/s borehole pump	-	R 0-0517 c/kl
10 l/s borehole pump	-	R 0-0453 c/kl
20 l/s borehole pump	-	R 0-0438 c/kl

3. DETAILED COST ESTIMATES AND COMPARISONS OF PROPOSED SCHEMES

3.1 Proposal (a1) : Supplementary Supply From Verdwaal Compartment to Itsoseng

Equip Borehole (1)	R 95 000-00
Equip Borehole (3)	R 60 000-00
140 mm dia uPVC pipeline 2600 m long @ R 65-00 / m	R 169 000-00
Total cost of works	R 324 000-00
Preliminary & General	R 48 600-00
Contingencies	R 37 300-00
Escalation	R 13 600-00
Professional Fees	R 49 200-00
TOTAL	**R 472 700-00**

SUPPLY TO ITSOSENG FROM VERDWAAL COMPARTMENT
Nett Present Worth Analysis

ITEM	PRESENT VALUE 1990	PRESENT VALUE 2000	ESCALATED VALUE @ 13.3 % p.a.	NETT PRESEN WORTH @ 4 % p.a.
SCHEME C - SUB-REGIONAL SCHEME				
Equip Boreholes	R226 140.00	R226 140.00	R1 014 412.70	R758 668.79
Pipelines	R246 560.00		R246 560.00	R246 560.00
Pipeline Maintenance (0.4% p.a. Over 20 years)	R19 724.80		R82 685.57	R50 130.65
M & E Maintenance (1.0% p.a. Over 20 years)	R45 228.00		R189 593.96	R114 947.12
TOTALS	R537 652.80	R226 140.00	R1 533 252.23	R1 170 306.56

TABLE C3.1

3.2 **Alternative (b1) : Verdwaal 2**

Costs for implementation of piped supply are as follows :-

2300 m of 75 mm uPVC pipeline @ 30-40 / m	R 69 920-00
Preliminary & General	R 10 500-00
Contingencies	R 8 130-00
Professional Fees	R 12 400-00
Escalation	R 10 000-00
TOTAL	**R 110 950-00**

Nett Worth Analyses are as shown below :-

VERDWAAL 2 SUPPLY SCHEME - COST / PRESENT WORTH ANALYSIS

Nett Present Worth Analysis

ITEM	PRESENT VALUE 1990	PRESENT VALUE 2000	ESCALATED VALUE @ 13.3 % p.a.	NETT PRESENT WORTH @ 4 % p.a.
SCHEME C - SUB-REGIONAL SCHEME				
Pipelines	R100 950.00		R100 950.00	R100 950.00
Pipeline Maintenance (0.4% p.a. Over 20 years)	R8 076.00		R33 854.27	R20 525.18
Electric Power Cost @ 4.35 c/kl Over 20 years	R9 996.98		R44 856.83	R26 693.58
TOTALS	**R119 022.98**	**R0.00**	**R179 661.09**	**R148 168.76**
RUDIMENTARY BOREHOLE SUPPLY EQUIVALENT				
Installation & Upgrading	R25 877.00	R10 112.00	R61 125.14	R49 689.38
Energy & Maintenance	R117 987.33	R0.00	R529 413.67	R315 045.61
TOTAL - B/H SUPPLY	**R143 864.33**	**R10 112.00**	**R590 538.81**	**R364 734.99**

TABLE C3.2

As shown above, the cost of piping water to Verdwaal 2 is substantially cheaper in terms of nett worth value than the cost of equipping, running and maintaining a diesel engine on the existing borehole.

3.2 Alternative (b1) : Supply to Bodibe

Detailed cost estimates, including P & G and contingencies, are as follows :-

Drill & Test 4 Boreholes @ R 7500-00 each	R 30 000-00
Equip Boreholes	R 110 000-00
Re-Equip & Upgrade after 10 years	R 137 000-00
2 Ml Ground Storage Reservoir	R 600 000-00
Upgraded to 2.4 Ml by 2001	R 150 000-00
35 l/s Booster pump to Elevated Tank	R 157 000-00
Upgraded to 44 l/s by 2001	R 198 000-00
510 kl Elevated Storage Tank	R 250 000-00
Upgraded to 635 kl after 10 years	R 70 000-00
Pipelines :-	
7850 m x 75 mm dia. @ R 38-50 / m	R 302 225-00
8250 m x 90 mm dia. @ R 44-24 / m	R 364 980-00
2700 m x 110 mm dia. @ R 57-05 / m	R 154 035-00
2800 m x 150 mm dia. @ R 70-13 / m	R 196 364-00
4500 m x 160 mm dia. @ R 85-00 / m	R 382 500-00
3450 m x 200 mm dia. @ R 92-48 / m	R 319 056-00
500 m x 250 mm dia. @ R 117-06 / m	R 58 530-00
Professional Fees	R 418 000-00
Escalation	R 244 000-00
Total	**R 4 141 690-00**

Nett Worth Analyses are as shown below :-

SCHEME (b1)

NETT PRESENT WORTH AND CAPITAL COST ANALYSIS

ITEM	FOR IMPLEMENTATION			ESCALATED COST	NETT PRESENT WORTH
	1991	2000	Annually, over 20 years		
Boreholes	R30 000.00	R0.00		R30 000.00	R30 000.00
Pumps	R267 000.00	R335 000.00		R1 434 733.95	R1 055 879.21
Pipelines	R1 777 690.00	R336 526.00		R2 950 743.24	R2 570 162.73
Reservoirs	R850 000.00	R220 000.00		R1 616 870.05	R1 368 069.93
Telemetry	R60 000.00				
Maintenance :					
Pipework (0.4%)			R157 022.30	R687 999.11	R412 377.50
Reservoirs (0.5%)			R97 100.00	R431 364.93	R257 652.33
M & E (1.0 %)			R102 250.00	R502 710.48	R292 979.94
Energy Costs			R314 010.95	R1 429 770.28	R847 469.64
TOTAL	R2 984 690.00	R891 526.00	R670 383.25	R9 084 192.03	R6 834 591.28
Rudimentary Bore-Hole Costs					
- Initial	R803 582.58			R803 582.58	R803 582.58
- Upgrading		R314 010.95		R1 094 570.90	R739 452.88
- Annual			R3 663 936.90	R16 682 819.63	R9 888 429.87
TOTAL	R803 582.58	R314 010.95	R3 663 936.90	R18 580 973.11	R11 431 465.32

TABLE C3.3

The total cost of works which may be implemented forthwith is as follows :-

Works	R 2 924 690-00
Fees	R 350 000-00
Escalation	R 205 000-00
Total	**R 3 479 690-00**

3.3 Alternative (b2) : Supply to Bodibe, Welverdiend, Duikerbos

Detailed cost estimates, including P & G and contingencies, are as follows :-

Drill & Test 4 Boreholes @ R 7500-00 each	R 30 000-00
Equip Boreholes	R 120 000-00
Re-Equip & Upgrade after 10 years	R 149 000-00
2.2 Ml Ground Storage Reservoir	R 650 000-00
Upgraded to 2.4 Ml by 2001	R 150 000-00
39 l/s Booster pump to Elevated Tank	R 176 000-00
Upgraded to 48 l/s by 2001	R 216 000-00
555 kl Elevated Storage Tank	R 270 000-00
Upgraded to 690 kl after 10 years	R 75 000-00
Pipelines :-	
11500 m x 75 mm dia. @ R 38-50 / m	R 442 750-00
13550 m x 90 mm dia. @ R 44-24 / m	R 599 452-00
1250 m x 110 mm dia. @ R 57-05 / m	R 71 312-50
3450 m x 150 mm dia. @ R 70-13 / m	R 241 948-50
4500 m x 160 mm dia. @ R 85-00 / m	R 382 500-00
4800 m x 200 mm dia. @ R 92-48 / m	R 443 904-00
700 m x 250 mm dia. @ R 117-06 / m	R 81 942-00
500 m x 300 mm dia. @ R 141-29 / m	R 70 645-00
Professional Fees	R 500 000-00
Total	**R 4 670 454-00**

Nett Worth Analyses are as shown below :-

SCHEME (b2)

NETT PRESENT WORTH AND CAPITAL COST ANALYSIS

ITEM	FOR IMPLEMENTATION			ESCALATED COST	NETT PRESENT WORTH
	1991	2000	Annually, over 20 years		
Boreholes	R30 000.00	R0.00		R30 000.00	R30 000.00
Pumps	R296 000.00	R365 000.00		R1 568 307.14	R1 155 525.11
Pipelines	R2 334 454.00	R407 674.00		R3 755 513.01	R3 294 470.55
Reservoirs	R920 000.00	R225 000.00		R1 704 298.92	R1 449 844.25
Telemetry	R60 000.00				
Maintenance :					
Pipework (0.4%)			R204 694.10	R894 131.08	R536 348.52
Reservoirs (0.5%)			R104 375.00	R462 414.29	R276 388.86
M & E (1.0%)			R111 350.00	R547 491.57	R319 072.80
Energy Costs			R343 102.89	R1 560 083.25	R925 054.14
TOTAL	R3 640 454.00	R997 674.00	R763 521.99	R10 522 239.26	R7 986 704.23
Rudimentary Bore-Hole Costs					
- Initial	R878 031.48			R878 031.48	R878 031.48
- Upgrading		R343 102.89		R1 195 978.78	R807 960.41
- Annual			R4 003 386.88	R18 203 335.02	R10 793 699.89
TOTAL	R878 031.48	R343 102.89	R4 003 386.88	R20 277 345.28	R12 479 691.78

TABLE C3.4

3.4 Alternative (b3) : Supply to Bodibe, Welverdiend, Duikerbos, Matile, Springbokpan

Detailed cost estimates, including P & G and contingencies, are as follows :-

Drill & Test 4 Boreholes @ R 7500-00 each	R 30 000-00
Equip Boreholes	R 140 000-00
Re-Equip & Upgrade after 10 years	R 173 000-00
2.5Ml Ground Storage Reservoir	R 680 000-00
Upgraded to 3.0 Ml by 2001	R 170 000-00
45 l/s Booster pump to Elevated Tank	R 203 000-00
Upgraded to 56 l/s by 2001	R 252 000-00
650 kl Elevated Storage Tank	R 350 000-00
Upgraded to 800 kl after 10 years	R 100 000-00
Pipelines :-	
17000 m x 75 mm dia. @ R 38-50 / m	R 654 500-00
13550 m x 90 mm dia. @ R 44-24 / m	R 599 452-00
6500 m x 110 mm dia. @ R 57-05 / m	R 370 825-00
4500 m x 140 mm dia. @ R 65-50 / m	R 294 750-00
2700 m x 150 mm dia. @ R 70-13 / m	R 189 351-00
8300 m x 200 mm dia. @ R 92-48 / m	R 767 584-00
2450 m x 250 mm dia. @ R 117-06 / m	R 286 797-00
500 m x 300 mm dia. @ R 141-29 / m	R 70 645-00
Professional Fees	R 640 000-00
Total	**R 5 971 904-00**

Nett Worth Analyses are as shown below :-

SCHEME (b3)

NETT PRESENT WORTH AND CAPITAL COST ANALYSIS

ITEM	FOR IMPLEMENTATION			ESCALATED COST	NETT PRESENT WORTH
	1991	2000	Annually, over 20 years		
Boreholes	R30 000.00	R0.00		R30 000.00	R30 000.00
Pumps	R343 000.00	R425 000.00		R1 824 453.51	R1 343 816.91
Pipelines	R3 233 904.00	R500 844.00		R4 979 732.48	R4 413 323.17
Reservoirs	R1 030 000.00	R270 000.00		R1 971 158.70	R1 665 813.10
Telemetry	R60 000.00				
Maintenance :					
Pipework (0.4%)			R280 749.58	R1 221 194.12	R733 327.33
Reservoirs (0.5%)			R117 850.00	R523 876.64	R312 859.51
M & E (1.0%)			R127 350.00	R627 831.45	R365 667.22
Energy Costs			R399 505.25	R1 813 734.26	R1 075 904.92
TOTAL	R4 696 904.00	R1 195 844.00	R925 454.83	R12 991 981.18	R9 940 712.16
Rudimentary Bore-Hole Costs					
- Initial	R1 022 370.26			R1 022 370.26	R1 022 370.26
- Upgrading		R399 505.25		R1 392 584.62	R940 780.27
-Annual			R4 661 499.94	R21 162 981.13	R12 553 854.25
TOTAL	R1 022 370.26	R399 505.25	R4 661 499.94	R23 577 936.01	R14 517 004.78

TABLE C3.5

3.5 **Alternative (b4) : Supply to Bodibe, Welverdiend, Duikerbos, Matile, Springbokpan, Schoongezight, Bethel**

Detailed cost estimates, including P & G and contingencies, are as follows :-

Drill & Test 4 Boreholes @ R 7500-00 each	R 30 000-00
Equip Boreholes	R 147 000-00
Re-Equip & Upgrade after 10 years	R 182 000-00
2.5Ml Ground Storage Reservoir	R 720 000-00
Upgraded to 3.0 Ml by 2001	R 170 000-00
47 l/s Booster pump to Elevated Tank	R 212 000-00
Upgraded to 58 l/s by 2001	R 261 000-00
680 kl Elevated Storage Tank	R 370 000-00
Upgraded to 840 kl after 10 years	R 120 000-00
Pipelines :-	
25900 m x 75 mm dia. @ R 38-50 / m	R 997 150-00
14650 m x 90 mm dia. @ R 44-24 / m	R 648 116-00
6500 m x 110 mm dia. @ R 57-05 / m	R 370 825-00
4500 m x 140 mm dia. @ R 65-50 / m	R 294 750-00
1700 m x 150 mm dia. @ R 70-13 / m	R 119 221-00
3250 m x 160 mm dia. @ R 74-50 / m	R 242 125-00
6250 m x 200 mm dia. @ R 92-48 / m	R 578 000-00
5500 m x 250 mm dia. @ R 117-06 / m	R 643 830-00
500 m x 300 mm dia. @ R 141-29 / m	R 70 645-00
Professional Fees	R 740 000-00
Total	**R 6 916 662-00**

Nett Worth Analyses are as shown below :-

SCHEME (b4)

NETT PRESENT WORTH AND CAPITAL COST ANALYSIS

ITEM	FOR IMPLEMENTATION			ESCALATED COST	NETT PRES-ENT WORTH
	1991	2000	Annually, over 20 years		
Boreholes	R30 000.00	R0.00		R30 000.00	R30 000.00
Pumps	R359 000.00	R443 000.00		R1 903 197.43	R1 402 204.45
Pipelines	R3 964 662.00	R582 156.00		R5 993 925.65	R5 335 559.81
Reservoirs	R1 090 000.00	R290 000.00		R2 100 874.16	R1 772 910.36
Telemetry	R60 000.00				
Maintenance :					
Pipework (0.4%)			342787.82	1488448.359	894212.3890
Reservoirs (0.5%)			124950	555850.9798	331892.5775
M & E (1.0%)			132530	653526.3615	380611.3182
Energy Costs			R419 615.73	R1 904 018.27	R1 129 624.29
TOTAL	R5 503 662.00	R1 315 156.00	R1 019 883.55	R14 629 841.21	R11 277 015.20
Rudimentary Bore-Hole Costs					
- Initial	R1 073 834.79			R1 073 834.79	R1 073 834.79
- Upgrading		R419 615.73		R1 462 685.16	R988 137.68
- Annual			R4 896 152.59	R22 216 431.30	R13 180 661.58
TOTAL	R1 073 834.79	R419 615.73	R4 896 152.59	R24 752 951.26	R15 242 634.05

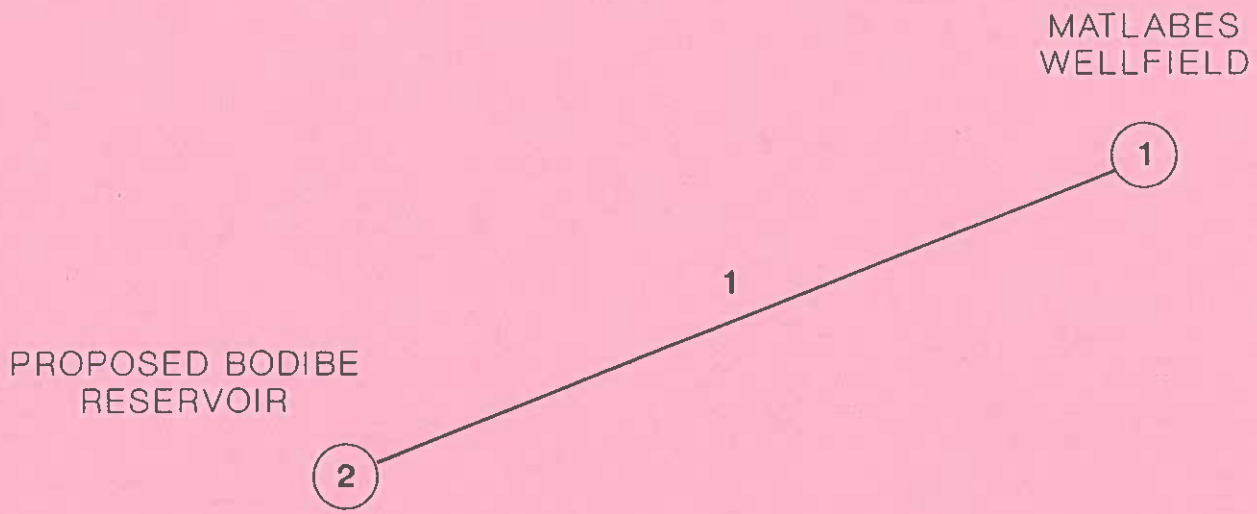
TABLE C3.6

ANNEXURE D

COMPUTER NETWORK ANALYSES

ANNEXURE D1

BODIBE BULK SUPPLY LINE



BILK WATER SUPPLY TO ITSOSENG AND SURROUNDING VILLAGES

BILK SUPPLY LINE - NODAL DIAGRAM

n Title Information :
==========
Bodibe Water Supply
Bulk Supply Line From Matlabes Wellfield
0 Year SDD Flows.
Scheme (b1) - Supply to Bodibe only.

Node Number	Ground Elevation [m]	Inflow/ Outflow [l/s]	Pressure at Node [kPa]	Hydraulic Grade Line [m]	Residual Head [m]
1	1490.000	22.852	0.000	1490.000	0.000
2	1497.000	-22.852	-124.673	1484.291	-12.709

Link No.	Strt Node	End Node	Link Type	Link Diamtr	Secondary Head_Loss [m]	Head_Loss Over_Link [m]	Rate_of Head_Loss [100m]	Rate of Flow [l/s]	Velocity of Flow [m/s]
1	1	2	F H P	160.0	0.000	5.709	0.143	22.852	1.137

Analysis Summary
==========

Total Inflow : 22.852
Total Outflow : 22.852
Nett Inflow : 0.000

Specified Tolerance = 0.00500

Number of Iterations = 6

m Title Information :
==========
Supply for Bodibe, Welverdiend, Duikerbos Water Supply
Bulk Supply Line From Matlabes Wellfield
0 Year SDD Flows.

Node Number	Ground Elevation [m]	Inflow/ Outflow [l/s]	Pressure at Node [kPa]	Hydraulic Grade Line [m]	Residual Head [m]
1	1490.000	24.897	0.000	1490.000	0.000
2	1497.000	-24.897	-135.876	1483.149	-13.851

Link No.	Strt Node	End Node	Link Type	Link Diamtr	Secondary Head_Loss [m]	Head_Loss Over_Link [m]	Rate_of Head_Loss [100m]	Rate of Flow [l/s]	Velocity of Flow [m/s]
1	1	2	F H P	160.0	0.000	6.851	0.171	24.897	1.238

Analysis Summary
==========

Total Inflow : 24.897
Total Outflow : 24.897
Nett Inflow : 0.000

Specified Tolerance = 0.00500

Number of Iterations = 6

Title Information :
==========
upply for Welverdiend. Duikerbos. Matile.
pringbokpan.
lk Supply Line From Matlabes Wellfield
Year SDD Flows.

Node Number	Ground Elevation [m]	Inflow/ Outflow [l/s]	Pressure at Node [kPa]	Hydraulic Grade Line [m]	Residual Head [m]
1	1490.000	28.901	0.000	1490.000	0.000
2	1497.000	-28.901	190.284	1516.397	19.397

k No.	Strt Node	End Node	Link Type	Link Diamtr	Secondary Head_Loss [m]	Head_Loss Over_Link [m]	Rate_of Head_Loss [100m]	Rate of Flow [l/s]	Velocity of Flow [m/s]
1	1	2	F H P	200.0	0.000	-26.397	-0.660	28.901	0.920

Analysis Summary
==========

Total Inflow : 28.901
Total Outflow : 28.901

Nett Inflow : 0.000

Specified Tolerance = 0.00500

Number of Iterations = 6

n Title Information :
==========
Supply for Bodibe, Weverdiend, Duikerbos, Matile,
Springbokpan, Schoongezicht, Bethel
alk Supply Line From Matlabes Wellfield
0 Year SDD Flows.

Node Number	Ground Elevation [m]	Inflow/ Outflow [l/s]	Pressure at Node [kPa]	Hydraulic Grade Line [m]	Residual Head [m]
1	1490.000	30.302	0.000	1490.000	0.000
2	1497.000	-30.302	222.623	1519.693	22.693

nk No.	Strt Node	End Node	Link Type	Link Diamtr	Secondary Head_Loss [m]	Head_Loss Over_Link [m]	Rate_of Head_Loss [100m]	Rate of Flow [l/s]	Velocity of Flow [m/s]
1	1	2	F H P	200.0	0.000	-29.693	-0.742	30.302	0.965

Analysis Summary
==========

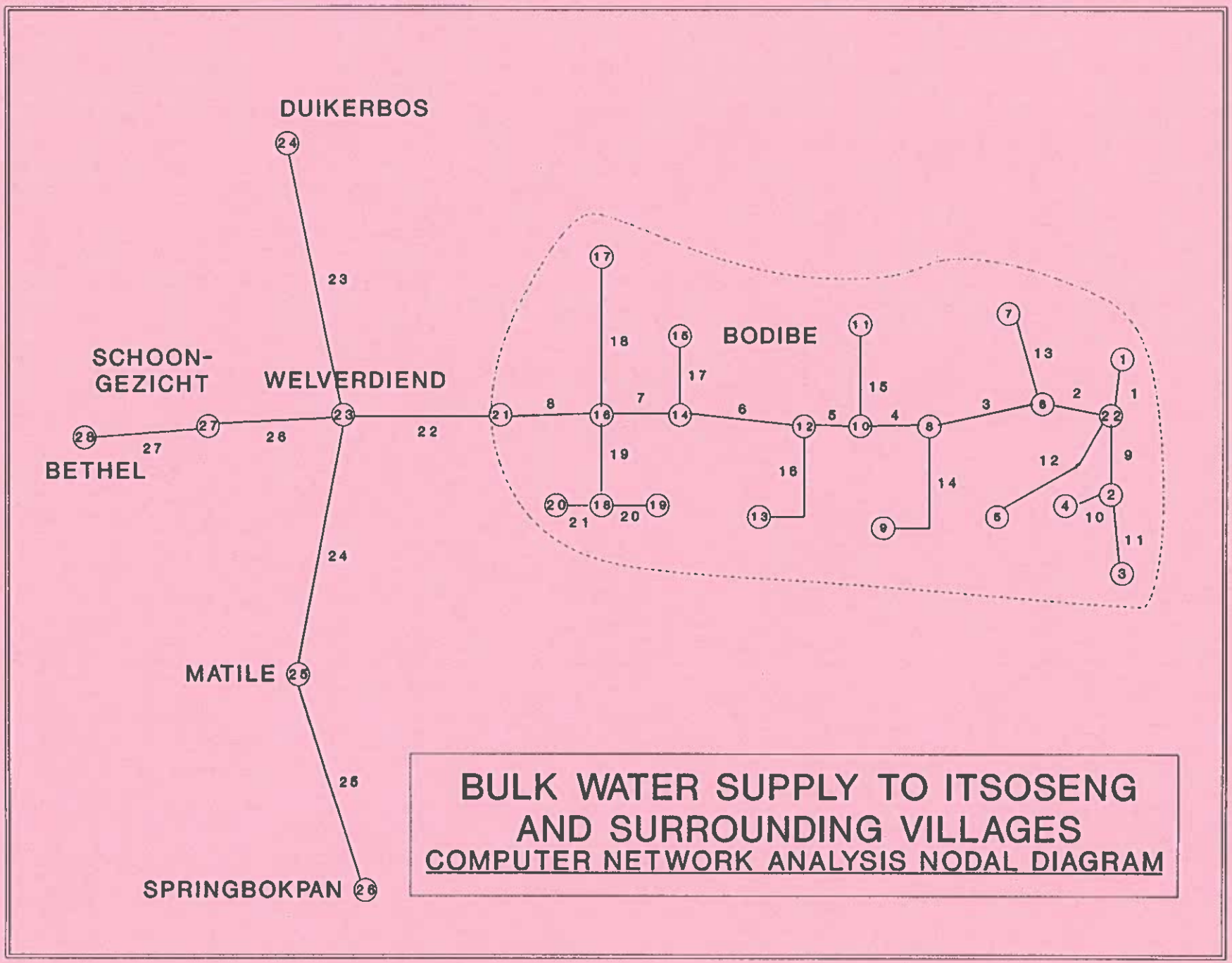
Total Inflow : 30.302
Total Outflow : 30.302
Nett Inflow : 0.000

Specified Tolerance = 0.00500

Number of Iterations = 6

ANNEXURE D2

SUPPLY TO BODIBE AND WESTERN VILLAGES


DUIKERBOS
SCHOON-
GEZICHT
WELVERDIEND
BODIBE
BETHEL
MATILE
SPRINGBOKPAN
BULK WATER SUPPLY TO ITSOSENG
AND SURROUNDING VILLAGES
COMPUTER NETWORK ANALYSIS NODAL DIAGRAM

Run Title Information :
==========
Lodibe Water Supply
Reticulation System
50 Year Flows

Node Number	Ground Elevation [m]	Inflow/ Outflow [l/s]	Pressure at Node [kPa]	Hydraulic Grade Line [m]	Residual Head [m]
1	1475.000	50.591	215.820	1497.000	22.000
2	1471.000	-1.486	215.535	1492.971	21.971
3	1470.000	-2.445	174.767	1487.815	17.815
4	1467.500	-2.199	226.917	1490.631	23.131
5	1462.500	-2.598	257.569	1488.756	26.256
6	1470.000	-4.014	193.087	1489.683	19.683
7	1462.500	-3.057	167.562	1479.581	17.081
8	1463.000	-1.719	196.667	1483.048	20.048
9	1460.000	-2.445	183.564	1478.712	18.712
10	1460.000	-1.460	211.506	1481.560	21.560
11	1460.000	-2.038	171.629	1477.495	17.495
12	1455.000	-3.211	232.766	1478.727	23.727
13	1452.000	-3.396	144.132	1466.692	14.692
14	1442.500	-1.516	235.532	1466.509	24.009
15	1443.000	-1.367	220.159	1465.442	22.442
16	1440.000	-3.566	230.097	1463.455	23.455
17	1429.000	-1.892	322.278	1461.852	32.852
18	1437.500	-1.851	222.998	1460.232	22.732
19	1439.000	-1.070	201.028	1459.492	20.492
20	1430.000	-1.443	280.794	1458.623	28.623
21	1420.000	-2.802	415.161	1462.320	42.320
22	1480.000	-5.017	145.064	1494.787	14.787

Link No.	Strt Node	End Node	Link Type	Link Diamtr	Secondary Head_Loss [m]	Head_Loss Over_Link [m]	Rate_of Head_Loss [100m]	Rate of Flow [l/s]	Velocity of Flow [m/s]
1	1	22	Pipe	250.0	0.000	2.213	0.443	50.591	1.031
2	22	6	Pipe	200.0	0.000	5.105	0.729	36.846	1.173
3	6	8	Pipe	200.0	0.000	6.635	0.491	29.775	0.948
4	8	10	Pipe	200.0	0.000	1.487	0.372	25.612	0.815
5	10	12	Pipe	200.0	0.000	2.833	0.283	22.113	0.704
6	12	14	Pipe	150.0	0.000	12.218	0.596	15.507	0.878
7	14	16	Pipe	150.0	0.000	3.054	0.407	12.624	0.714
8	16	21	Pipe	110.0	0.000	1.135	0.114	2.802	0.295
9	22	2	Pipe	150.0	0.000	1.816	0.107	6.130	0.347
10	2	4	Pipe	75.0	0.000	2.340	0.468	2.199	0.498
11	2	3	Pipe	90.0	0.000	5.156	0.234	2.445	0.384
12	22	5	Pipe	90.0	0.000	6.032	0.262	2.598	0.408
13	6	7	Pipe	90.0	0.000	10.102	0.354	3.057	0.481
14	8	9	Pipe	90.0	0.000	4.336	0.234	2.445	0.384
15	10	11	Pipe	75.0	0.000	4.065	0.406	2.038	0.461
16	12	13	Pipe	75.0	0.000	12.035	1.047	3.396	0.769
17	14	15	Pipe	75.0	0.000	1.067	0.194	1.367	0.309
18	16	17	Pipe	90.0	0.000	1.603	0.146	1.892	0.297
19	16	18	Pipe	110.0	0.000	3.224	0.258	4.364	0.459
20	18	19	Pipe	75.0	0.000	0.740	0.123	1.070	0.242
21	18	20	Pipe	75.0	0.000	1.609	0.214	1.443	0.327

Analysis Summary

Total Inflow	:	50.591
Total Outflow	:	50.591
Nett Inflow	:	0.000

Specified Tolerance = 0.00100

Number of Iterations = 7

n Title Information :
==========
odibe, Welverdiend, Duikerbos Water Supply
ilk Supply Lines
Year Flows

Node Number	Ground Elevation [m]	Inflow/ Outflow [l/s]	Pressure at Node [kPa]	Hydraulic Grade Line [m]	Residual Head [m]
1	1475.000	54.511	215.820	1497.000	22.000
2	1471.000	-1.486	226.985	1494.138	23.138
3	1470.000	-2.445	186.215	1488.982	18.982
4	1467.500	-2.199	238.366	1491.798	24.298
5	1462.500	-2.598	269.019	1489.923	27.423
6	1470.000	-4.013	234.243	1493.878	23.878
7	1462.500	-3.057	208.718	1483.776	21.276
8	1463.000	-1.719	221.068	1485.535	22.535
9	1460.000	-2.445	207.965	1481.199	21.199
10	1460.000	-1.460	231.504	1483.599	23.599
11	1460.000	-2.038	191.627	1479.534	19.534
12	1455.000	-3.210	242.956	1479.766	24.766
13	1452.000	-3.396	154.320	1467.731	15.731
14	1442.500	-1.516	320.760	1475.197	32.697
15	1443.000	-1.367	305.386	1474.130	31.130
16	1440.000	-3.566	295.849	1470.158	30.158
17	1429.000	-1.892	388.029	1468.554	39.554
18	1437.500	-1.851	288.750	1466.934	29.434
19	1439.000	-1.070	266.780	1466.195	27.195
20	1430.000	-1.443	346.545	1465.326	35.326
21	1420.000	-2.802	479.615	1468.890	48.890
22	1480.000	-5.018	156.514	1495.955	15.955
[illegible]	[illegible]	[illegible]	[illegible]329	1450.633	42.633
	24	1393.000	-3.230	308.072	1424.404

Link No.	Strt Node	End Node	Link Type	Link Diamtr	Secondary Head_Loss [m]	Head_Loss Over_Link [m]	Rate_of Head_Loss [100m]	Rate of Flow [l/s]
1	1	22	Pipe	300.0	0.000	1.045	0.209	54.511
2	22	6	Pipe	250.0	0.000	2.077	0.297	40.765
3	6	8	Pipe	200.0	0.000	8.343	0.618	33.695
4	8	10	Pipe	200.0	0.000	1.936	0.484	29.531
5	10	12	Pipe	200.0	0.000	3.833	0.383	26.033
6	12	14	Pipe	200.0	0.000	4.569	0.223	19.427
7	14	16	Pipe	150.0	0.000	5.039	0.672	16.544
8	16	21	Pipe	150.0	0.000	1.267	0.127	6.722
9	22	2	Pipe	150.0	0.000	1.816	0.107	6.130
10	2	4	Pipe	75.0	0.000	2.340	0.468	2.199
11	2	3	Pipe	90.0	0.000	5.156	0.234	2.445
12	22	5	Pipe	90.0	0.000	6.032	0.262	2.598
13	6	7	Pipe	90.0	0.000	10.102	0.354	3.057
14	8	9	Pipe	90.0	0.000	4.336	0.234	2.445
15	10	11	Pipe	75.0	0.000	4.065	0.406	2.038

21	18	20	Pipe	75.0	0.000	1.609	0.214	1.44
22	21	23	Pipe	90.0	0.000	18.258	0.562	3.92
23	23	24	Pipe	75.0	0.000	26.229	0.954	3.23

Analysis Summary

Total Inflow	:	54.511
Total Outflow	:	54.511
Nett Inflow	:	0.000

Specified Tolerance = 0.00100

Number of Iterations = 9

Run Title Information :
==========

Bodibe, Welverdiend, Duikerbos, Matile, Springbokpan Water Supply
Bilk Supply Lines
20 Year Flows

Node Number	Ground Elevation [m]	Inflow/ Outflow [l/s]	Pressure at Node [kPa]	Hydraulic Grade Line [m]
1	1475.000	62.167	215.820	1497.000
2	1471.000	-1.486	224.157	1493.850
3	1470.000	-2.445	183.388	1488.694
4	1467.500	-2.199	235.539	1491.510
5	1462.500	-2.598	266.191	1489.635
6	1470.000	-4.013	223.764	1492.810
7	1462.500	-3.057	198.239	1482.708
8	1463.000	-1.719	252.088	1488.697
9	1460.000	-2.445	238.985	1484.361
10	1460.000	-1.461	271.697	1487.696
11	1460.000	-2.038	231.820	1483.631
12	1455.000	-3.210	260.127	1481.517
13	1452.000	-3.396	171.493	1469.481
14	1442.500	-1.516	299.799	1473.061
15	1443.000	-1.367	284.425	1471.993
16	1440.000	-3.566	299.684	1470.549
17	1429.000	-1.892	391.865	1468.945
18	1437.500	-1.651	292.585	1467.325
19	1439.000	-1.070	270.615	1466.586
20	1430.000	-1.443	350.381	1465.717
21	1420.000	-2.802	445.028	1465.365
22	1480.000	-5.013	153.686	1495.666
23	1408.000	-0.690	383.642	1447.107
24	1393.000	-3.230	273.487	1420.878
25	1420.000	-3.980	345.308	1455.200
26	1430.000	-3.680	150.346	1445.326

Link No.	Strt Node	End Node	Link Type	Link Diamtr	Secondary Head_Loss [m]	Head_Loss Over_Link [m]	Rate_of Head_Loss [100m]	Rate of Flow [l/s]
1	1	22	Pipe	300.0	0.000	1.334	0.267	62.167
2	22	6	Pipe	250.0	0.000	2.857	0.408	48.42
3	6	8	Pipe	250.0	0.000	4.113	0.305	41.35
4	8	10	Pipe	250.0	0.000	1.001	0.250	37.19
5	10	12	Pipe	200.0	0.000	6.179	0.618	33.69
6	12	14	Pipe	200.0	0.000	8.456	0.412	27.08
7	14	16	Pipe	200.0	0.000	2.512	0.335	24.20
8	16	21	Pipe	150.0	0.000	5.184	0.518	14.38
9	22	2	Pipe	150.0	0.000	1.816	0.107	6.13
10	2	4	Pipe	75.0	0.000	2.340	0.468	2.19
11	2	3	Pipe	90.0	0.000	5.156	0.234	2.44
12	22	5	Pipe	90.0	0.000	6.032	0.262	2.59
13	6	7	Pipe	90.0	0.000	10.102	0.354	3.05

19	16	18	Pipe	110.0	0.000	3.224	0.256	4.36
20	18	19	Pipe	75.0	0.000	0.740	0.123	1.07
21	18	20	Pipe	75.0	0.000	1.609	0.214	1.44
22	21	23	Pipe	90.0	0.000	18.258	0.562	3.92
23	23	24	Pipe	75.0	0.000	26.229	0.954	3.23
24	21	25	Pipe	140.0	0.000	10.165	0.226	7.66
25	25	26	Pipe	110.0	0.000	9.874	0.188	3.68

Analysis Summary

Total Inflow	:	62.167
Total Outflow	:	62.167
Nett Inflow	:	0.000

Specified Tolerance = 0.01000

Number of Iterations = 7

Run Title Information :
==========
Bodibe, Welverdiend, Duikerbos, Matile,
Springbokpan, Schoongezicht, Bethel Water Supply
Bilk Supply Lines
20 Year Flows

Node Number	Ground Elevation [m]	Inflow/ Outflow [l/s]	Pressure at Node [kPa]	Hydraulic Grade Line [m]
1	1475.000	64.888	215.820	1497.000
2	1471.000	-1.486	223.077	1493.740
3	1470.000	-2.445	182.308	1488.584
4	1467.500	-2.199	234.459	1491.400
5	1462.500	-2.598	265.111	1489.525
6	1470.000	-4.014	219.699	1492.395
7	1462.500	-3.057	194.174	1482.294
8	1463.000	-1.719	242.972	1487.768
9	1460.000	-2.445	229.869	1483.432
10	1460.000	-1.460	261.209	1486.627
11	1460.000	-2.038	221.332	1482.562
12	1455.000	-3.210	286.648	1484.220
13	1452.000	-3.396	198.014	1472.185
14	1442.500	-1.517	375.865	1480.815
15	1443.000	-1.367	360.492	1479.747
16	1440.000	-3.566	370.379	1477.755
17	1429.000	-1.892	462.560	1476.152
18	1437.500	-1.851	363.280	1474.532
19	1439.000	-1.070	341.310	1473.792
20	1430.000	-1.443	421.075	1472.923
21	1420.000	-2.802	549.312	1475.995
22	1480.000	-5.014	152.606	1495.556
23	1408.000	-0.690	638.185	1473.055
24	1393.000	-3.230	528.030	1446.826
25	1420.000	-3.980	449.592	1465.830
26	1430.000	-3.680	254.630	1455.956
27	1392.000	-0.780	673.310	1460.635
28	1375.000	-1.940	690.846	1445.423

Link No.	Strt Node	End Node	Link Type	Link Diamtr	Secondary Head_Loss [m]	Head_Loss Over_Link [m]	Rate_of Head_Loss [100m]	Rate of Flow [l/s]
1	1	22	Pipe	300.0	0.000	1.444	0.289	64.888
2	22	6	Pipe	250.0	0.000	3.161	0.452	51.146
3	6	8	Pipe	250.0	0.000	4.628	0.343	44.075
4	8	10	Pipe	250.0	0.000	1.141	0.285	39.914
5	10	12	Pipe	250.0	0.000	2.407	0.241	36.414
6	12	14	Pipe	250.0	0.000	3.405	0.166	29.808
7	14	16	Pipe	200.0	0.000	3.059	0.408	26.924
8	16	21	Pipe	200.0	0.000	1.760	0.176	17.102
9	22	2	Pipe	150.0	0.000	1.816	0.107	6.130
10	2	4	Pipe	75.0	0.000	2.340	0.468	2.199
11	2	3	Pipe	90.0	0.000	5.156	0.234	2.445
12	22	5	Pipe	90.0	0.000	6.032	0.262	2.598
13	6	7	Pipe	90.0	0.000	10.102	0.354	3.057
14	8	9	Pipe	90.0	0.000	4.336	0.234	2.445

16	12	13	Pipe	75.0	0.000	12.035	1.047	3.39
17	14	15	Pipe	75.0	0.000	1.067	0.194	1.36
18	16	17	Pipe	90.0	0.000	1.603	0.146	1.89
19	16	18	Pipe	110.0	0.000	3.224	0.258	4.36
20	18	19	Pipe	75.0	0.000	0.740	0.123	1.07
21	18	20	Pipe	75.0	0.000	1.609	0.214	1.44
22	21	23	Pipe	160.0	0.000	2.941	0.090	6.64
23	23	24	Pipe	75.0	0.000	26.229	0.954	3.23
24	21	25	Pipe	140.0	0.000	10.165	0.226	7.66
25	25	26	Pipe	110.0	0.000	9.874	0.188	3.68
26	23	27	Pipe	90.0	0.000	12.420	0.286	2.72
27	27	28	Pipe	75.0	0.000	15.212	0.371	1.94

Analysis Summary

Total Inflow	:	64.888
Total Outflow	:	64.888
Nett Inflow	:	0.000

Specified Tolerance = 0.01000

Number of Iterations = 7

ANNEXURE D3

SUPPLY TO VERDWAAL 2 FROM EXISTING 450 MM ITSOSENG SPPLY MAIN

-:>- HYDRAULIC NETWORK ANALYSIS : INPUT DATA FILE -<:-
++

JOB NAME :- SUPPLY TO VERDWAAL 2 FROM 450 DIA. ITSOSENG SUPPLY LINE.

Max. permissible flow discrepancy :- .001 l/s

NODAL DATA

Node Number	Elevation (m)	Fixed Flow (l/s)	Fixed Head (m)
1	1497.80	0.00	1504.00
2	1482.00	-119.60	0.00
3	1485.00	-1.37	0.00

LINK DATA

Link Number	Type	Strt Node	End Node	Length (m)	Diameter (mm)	Rough-ness	Pump Head (m)
1	1	1	2	3900.0	450	130	0.0
2	1	2	3	2150.0	75	140	0.0

)(HYDRAULIC NETWORK ANALYSIS)(
++++++++++++++++++++++++++

-*- OUTPUT DATA -*-
==========

JOB NAME :- SUPPLY TO VERDWAAL 2 FROM 450 DIA. ITSOSENG SUPPLY LINE.

Maximum Permissible Out of Balalnce Flow :- .001 l/s

NODAL DATA

Node Number	Elevation (m)	Inflow (l/s)	Residual Head (m)	Hydraulic Grade Line (m)	Actual Pressure (kpa)
1	1497.80	120.97	6.20	1504.00	61.70
2	1482.00	-119.60	17.04	1499.04	170.27
3	1485.00	-1.37	10.39	1495.39	103.84

-*- PIPE DATA -*-

Link Number	Type	Strt Node	End Node	Head-Loss Over-Link (m)	Head-Loss per-100 m (m)	Flow Rate (l/s)	Flow Velocity (m/s)
1	Pipe	1	2	4.956	0.127	120.97	0.76
2	Pipe	2	3	3.652	0.170	1.37	0.31

2010

VILLAGE	POPULATION	GGADD (kl/d)	SDD (kl/d)	DPFR (l/s)
ITSOSENG	40226	5088.59	6938.99	219.99
BODIBE	35969	1194.40	1481.02	43.99
SHIELA	1303	80.35	116.39	3.54
VERDWAAL 1	2306	142.21	205.98	6.27
VERDWAAL 2	1118	37.12	46.03	1.37
SPRINGBOKPAN	3012	100.02	124.02	3.68
MATILE	3254	108.05	133.98	3.98
WELVERDIEND	567	18.83	23.35	0.69
DUIKERBOS	2639	87.63	108.66	3.23
BETHEL	1590	52.80	65.47	1.94
SCHOONGEZICHT	635	21.09	26.15	0.78
TOTAL	92619	6931.1	9270.0	289.46

3.3 Alternative (b1) : Supply to Bodibe From Proposed Matlabes Wellfield

The routes of the proposed bulk supply mains are as per figure B3 attached.

A Wellfield will have to be developed and be equipped with a pumping capacity of 18.3 l/s, which will have to be upgraded to 22.9 l/s at the end of the 10 year design horizon.

The wellfield will supply a ground storage reservoir with a capacity of 2.0 Ml located at the eastern corner of Bodibe. Supply to the reservoir will be via a 160 mm diameter uPVC pipeline approximately 4500 m long. The ground reservoir capacity will have to be upgraded to 2.4 Ml by 2001.

A booster pump with a capacity of 35 l/s will supply an elevated storage tank with a capacity of 510 kl, located next to the ground reservoir, via a 200 mm diameter pipeline. The capacity of the elevated tank will have to be upgraded to 635 kl, and that of the booster pump to 44 l/s at the end of the 10 year design horizon.

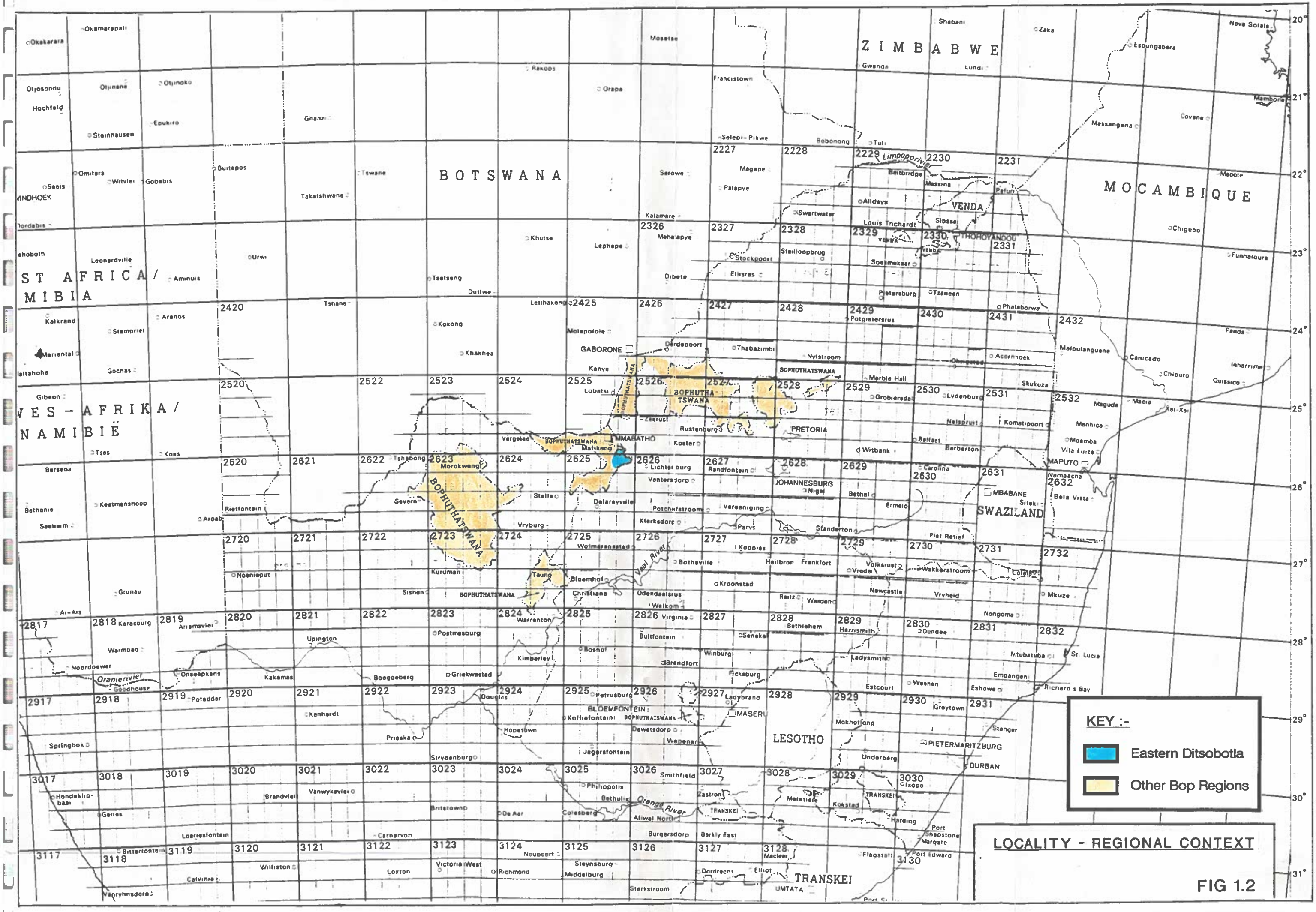
Additional pipelines required will be as follows :-

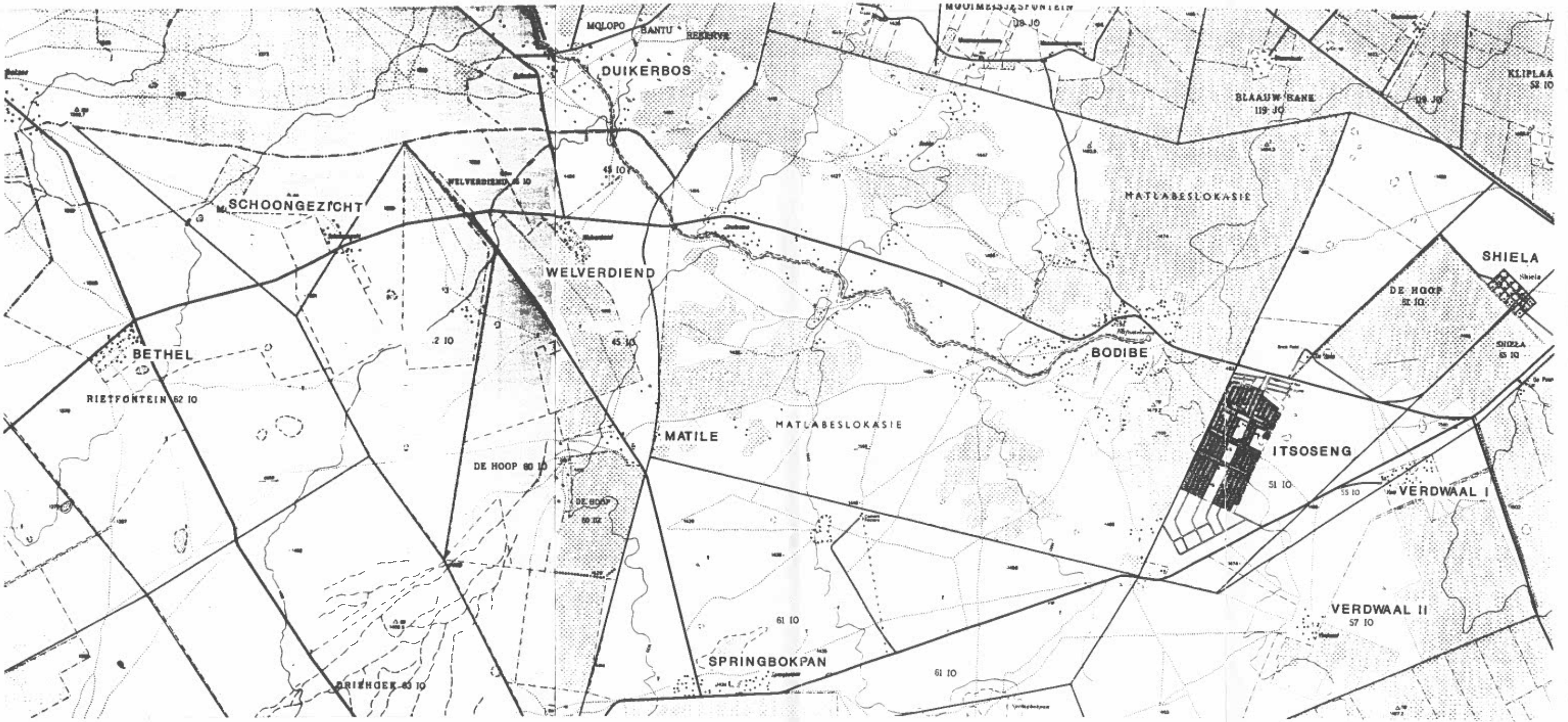
Bulk Supply Mains :-

110 mm dia.	-	1000 m
150 mm dia.	-	2800 m
200 mm dia.	-	3450 m
250 mm dia.	-	500 m

Reticulation :-

75 mm dia.	-	7850 m
90 mm dia.	-	8250 m
110 mm dia.	-	1700 m


BOTSWANA
ZIMBABWE
MOCAMBIQUE
SWAZILAND
LESOTHO
TRANSKEI
BOPHUTHATSWANA
VENDA
GABORONE
MMABATHO
Mafikeng
PRETORIA
JOHANNESBURG
BLOEMFONTEIN
MASERU
MBABANE
MAPUTO
Limpopo River
Vaal River
Orange River
KEY :-
Eastern Ditsobotla
Other Bop Regions
LOCALITY - REGIONAL CONTEXT
FIG 1.2



NO.	DAT.	WYSIGINGS / REVISIONS	GETEKEN DRAWN	TAKKANTOOR BRANCH OFFICE TEL NO

BULK WATER SUPPLY TO ITSOSENG AND SURROUNDING VILLAGES

LOCALITY - LOCAL CONTEXT

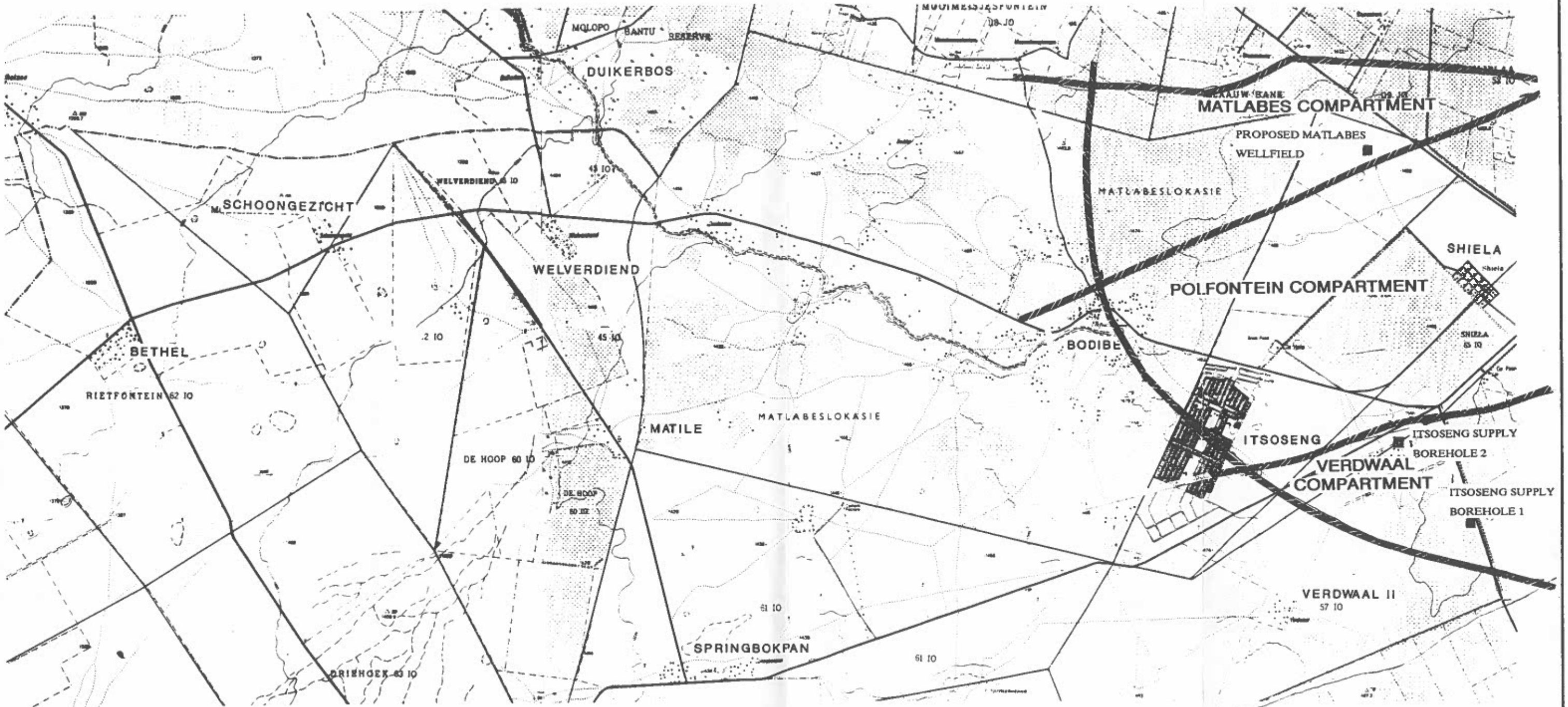
SA ACE (VRI)

EKSTEEN, VAN DER WALT & NISSEN
RAADGEWENDE INGENIEURS
CONSULTING ENGINEERS

VEL NR.
SHEET NO.

FIG 1.3

1270 ARCHNEER



KEY :-

Compartment Boundary

NO.	DAT.	WYSIGINGS / REVISIONS	GETEKEN DRAWN	TAKKANTOOR BRANCH OFFICE TEL NO	BULK WATER SUPPLY TO ITSOSENG AND SURROUNDING VILLAGES DOLOMITIC GROUNDWATER COMPARTMENTS	EKSTEEN, VAN DER WALT & NISSEN RAADGEWENDE INGENIEURS CONSULTING ENGINEERS	VEL NR. SHEET NO. FIG. 4.1

1270 ARCHNEER

2010

VILLAGE	POPULATION	GGADD (kl/d)	SDD (kl/d)	DPFR (l/s)
ITSOSENG	40226	5088.59	6938.99	219.99
BODIBE	35969	1194.40	1481.02	43.99
SHIELA	1303	80.35	116.39	3.54
VERDWAAL 1	2306	142.21	205.98	6.27
VERDWAAL 2	1118	37.12	46.03	1.37
SPRINGBOKPAN	3012	100.02	124.02	3.68
MATILE	3254	108.05	133.98	3.98
WELVERDIEND	567	18.83	23.35	0.69
DUIKERBOS	2639	87.63	108.66	3.23
BETHEL	1590	52.80	65.47	1.94
SCHOONGEZICHT	635	21.09	26.15	0.78
TOTAL	92619	6931.1	9270.0	289.46

MOLOPO BANTU RESERVE

DUIKERBOS

MOOIMEISJESFONTEIN 118 JO

KLIPLAA 52 IO

BLAAUW BANK 119 JO

119 JO

SCHOONGEZICHT

WELVERDIEND 65 IO

45 IO

MATLABESLOKASIE

WELVERDIEND

SHIELA

DE HOOP 51 IO

BETHEL

2 IO

45 IO

BODIBE

SHIELA 65 IO

RIETFONTEIN 62 IO

MATILE

MATLABESLOKASIE

ITSOSENG

DE HOOP 60 IO

DE HOOP 50 IO

51 IO

VERDWAAL I

VERDWAAL II 57 IO

51 IO

SPRINGBOKPAN

51 IO

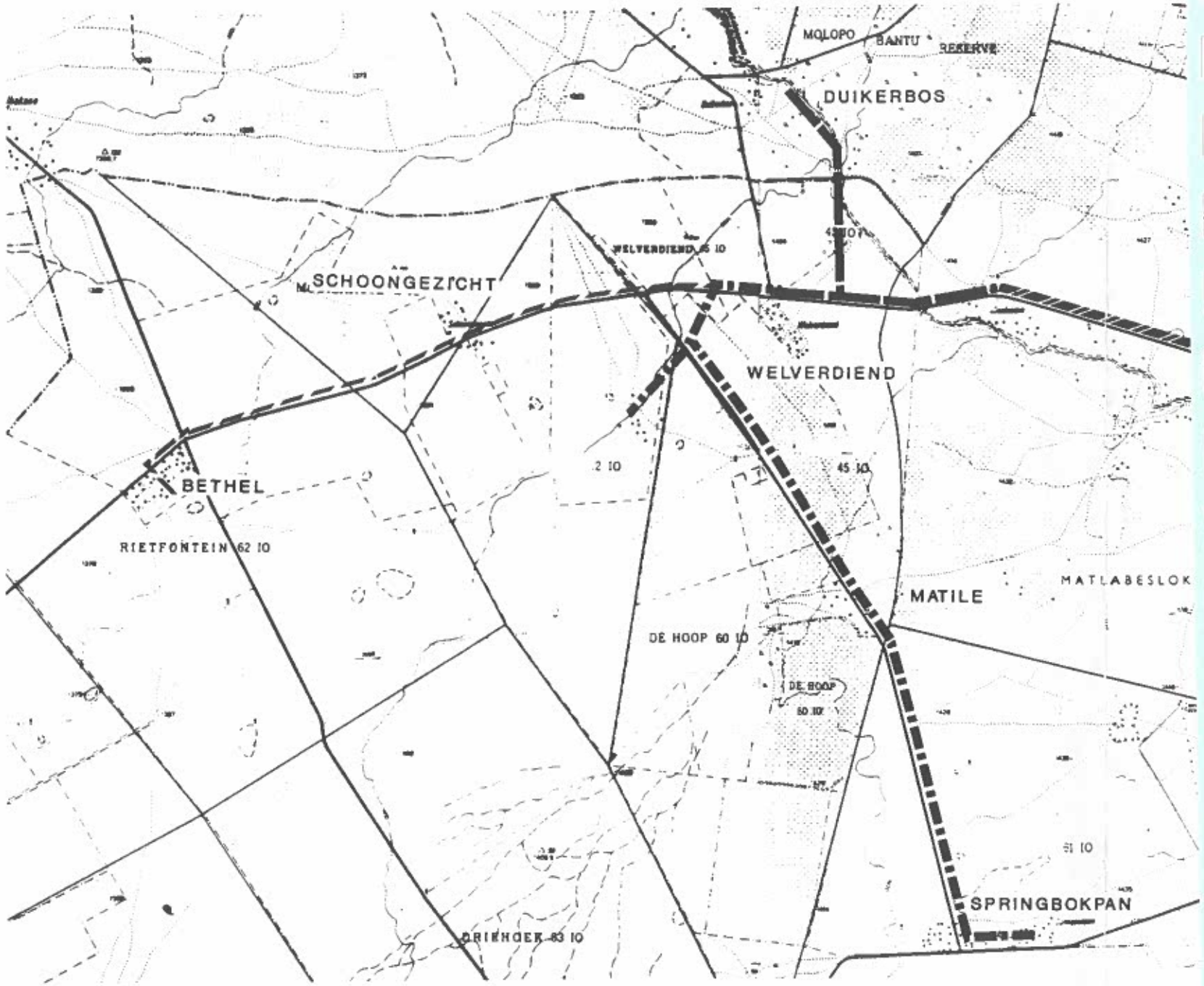
DRIEHOEK 63 IO

KEY :-

- Existing 450 dia. Line.
- Proposed 140 dia. Line to Verdwaal Boreholes.
- Proposed 75 dia. Line to Verdwaal II.

NO.	DAT.	WYSIGINGS / REVISIONS	GETEKEN DRAWN	TAKKANTOOR BRANCH OFFICE TEL NO	BULK WATER SUPPLY TO ITSOSENG AND SURROUNDING VILLAGES ITSOSENG / VERDWAAL PIPELINES	EKSTEEN, VAN DER WALT & NISSEN RAADGEWENDE INGENIEURS CONSULTING ENGINEERS	VEL NR. SHEET NO. FIG B1

1270 ARCHINEER



KEY :-

Scheme (b1) F pe
Scheme (b2) F pe
Scheme (b3) F
Scheme (b4) F pe

NO.	DAT.	WYSIGINGS / REVISIONS	GETEKEN DRAWN	TAKKANTOOR BRANCH OFFICE TEL NO	BULK WATER SUPP AND SURROUNDIN MATLABES / BO

3.3 Alternative (b1) : Supply to Bodibe From Proposed Matlabes Wellfield

The routes of the proposed bulk supply mains are as per figure B3 attached.

A Wellfield will have to be developed and be equipped with a pumping capacity of 18.3 l/s, which will have to be upgraded to 22.9 l/s at the end of the 10 year design horizon.

The wellfield will supply a ground storage reservoir with a capacity of 2.0 Ml located at the eastern corner of Bodibe. Supply to the reservoir will be via a 160 mm diameter uPVC pipeline approximately 4500 m long. The ground reservoir capacity will have to be upgraded to 2.4 Ml by 2001.

A booster pump with a capacity of 35 l/s will supply an elevated storage tank with a capacity of 510 kl, located next to the ground reservoir, via a 200 mm diameter pipeline. The capacity of the elevated tank will have to be upgraded to 635 kl, and that of the booster pump to 44 l/s at the end of the 10 year design horizon.

Additional pipelines required will be as follows :-

Bulk Supply Mains :-

110 mm dia.	-	1000 m
150 mm dia.	-	2800 m
200 mm dia.	-	3450 m
250 mm dia.	-	500 m

Reticulation :-

75 mm dia.	-	7850 m
90 mm dia.	-	8250 m
110 mm dia.	-	1700 m