5.7 Comparison of Results of Macroscopic and Microscopic Demand

The demand forecast results obtained by the macroscopic and microscopic methods for each Study area are summarized in Table 5.13 and Figure 5.5 (1/6-6/6) are shown the difference of results in the exchange base.

Generally, forecasted demand based on the microscopic method has a tendency to develop high demand compared with the demand obtained by the other method, and represents more regional features.

According to the observation of the results, the exchange areas could be separated into two groups by the difference of demand obtained by macro and micro methods in the year of 2011.

One group is BEATRICE, KEZI, CHATSWORTH and GUTU in which the difference is considerably small, and the other group is MURAMBINDA and NKAYI in which the difference is large, and it is considered this difference is caused due to the following reasons;

- The population of these two areas are higher than the other areas,
- On the macroscopic forecast, a population and GDP of the area are used as parameters, hence a demand may be obtained rather low, if the area has a large population and low GDP level.
- On the other hand, according to the results of microscopic demand forecast study, the population in MURAMBINDA and NKAYI engaged in businesses including government offices is not small compared with other areas. Refer to Table 5.1 and 5.2.

Thus, the demand forecasted based on the microscopic method is verified as a reasonable result of telephone demand for the Study areas.

Table 5.13 Comparison of Macroscopic and Microscopic Forecast

Exchange	Method	1991	1996	2001	2006	2011
BEATRICE	**Mic.**	**333**	**416**	**559**	**667**	**955**
	Mac.	311	426	556	741	962
KEZI	**Mic.**	**230**	**280**	**357**	**569**	**684**
	Mac.	149	206	275	399	518
MURAMBINDA	**Mic.**	**181**	**261**	**487**	**626**	**826**
	Mac.	143	200	263	342	444
CHATSWORTH	**Mic.**	**160**	**217**	**339**	**442**	**593**
	Mac.	152	206	281	370	481
GUTU	**Mic.**	**368**	**485**	**892**	**1,039**	**1,240**
	Mac.	400	555	702	969	1,258
NKAYI	**Mic.**	**161**	**223**	**396**	**456**	**550**
	Mac.	102	161	175	228	296
TOTAL	**Mic.**	**1,433**	**1,882**	**3,030**	**3,799**	**4,848**
	Mac.	1,257	1,754	2,252	3,049	3,959

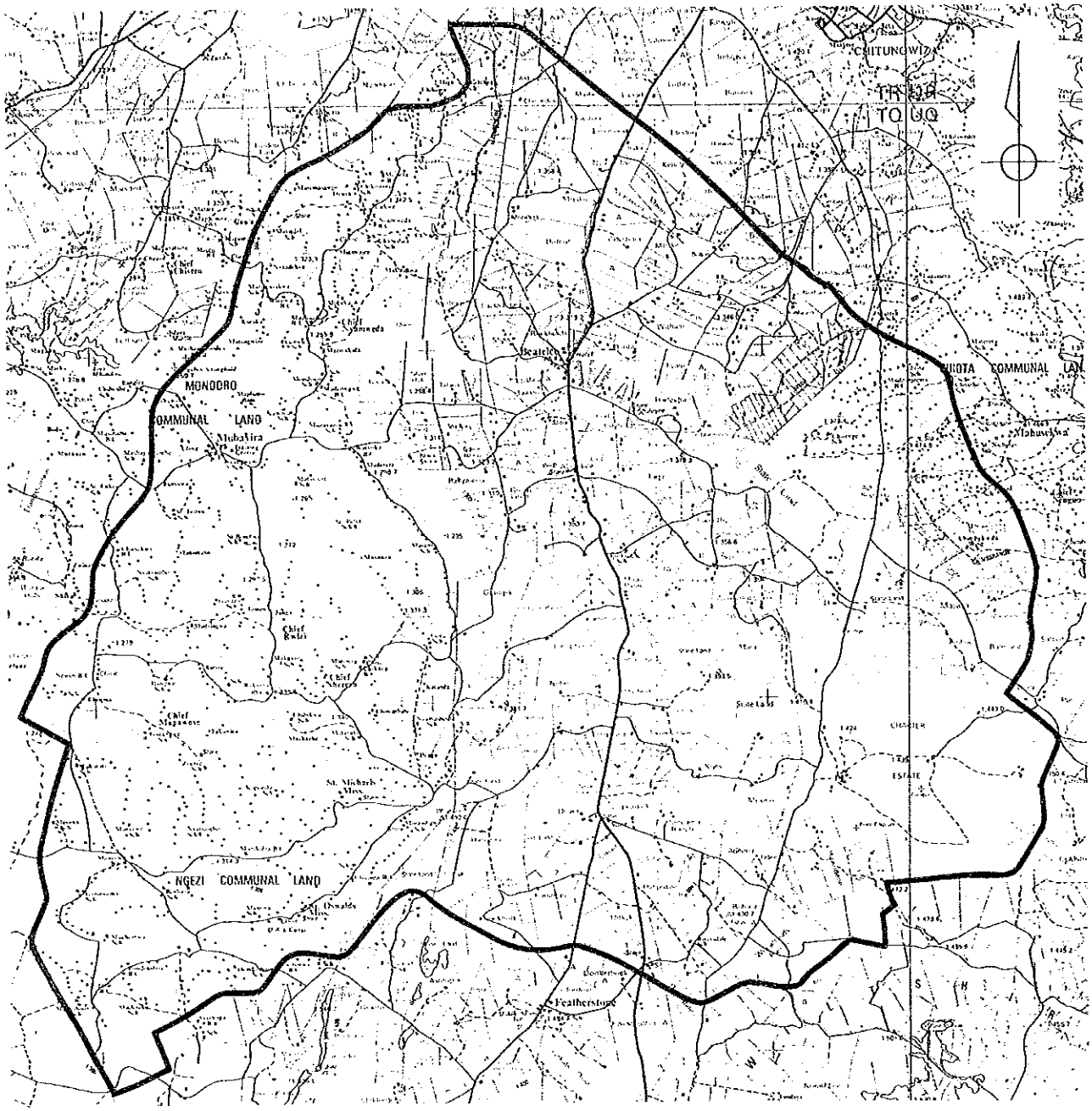


Figure 5.1 (1/6) Study Area (Beatrice)

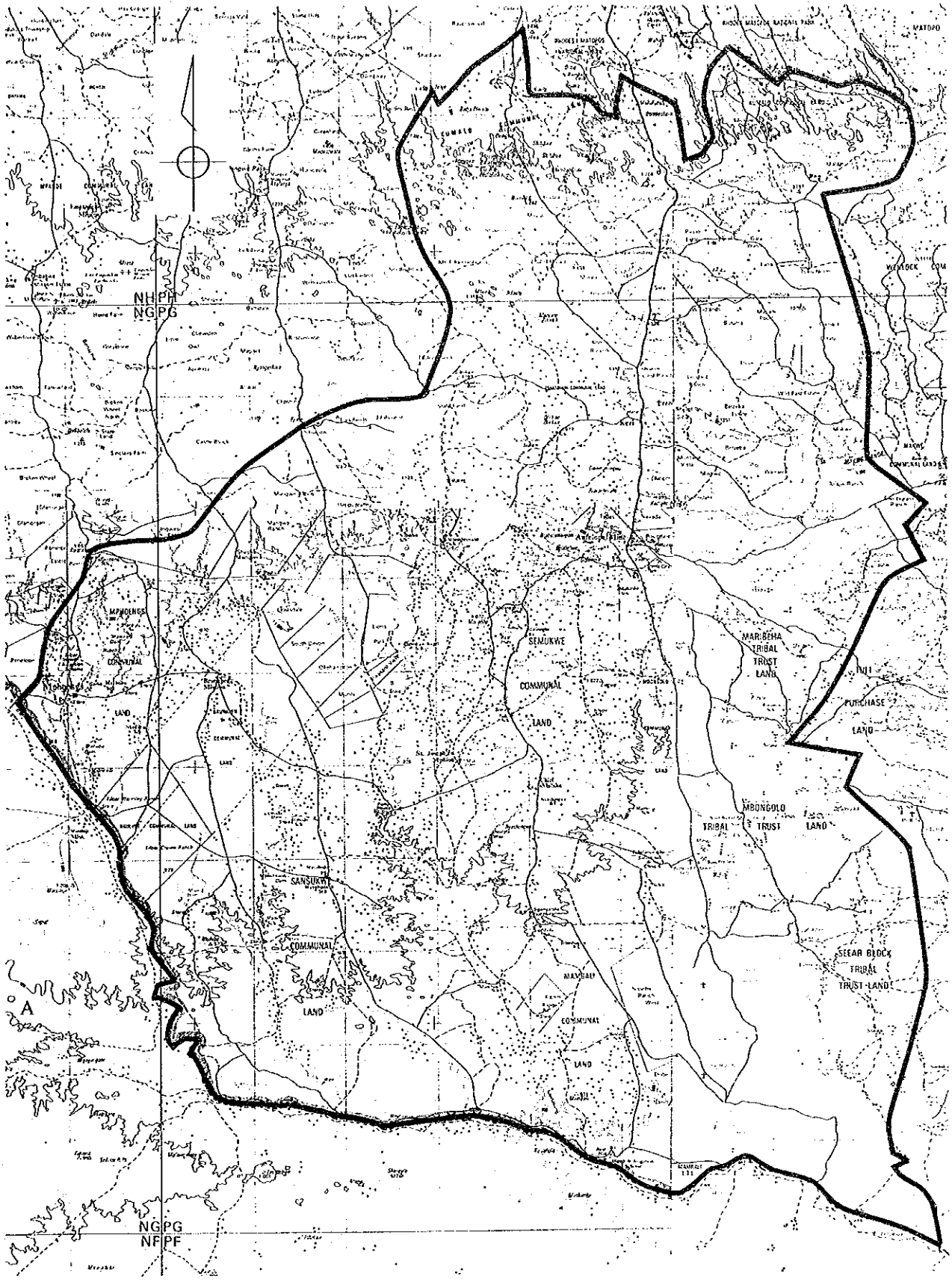


Figure 5.1 (2/6) Study Area (Kezi)

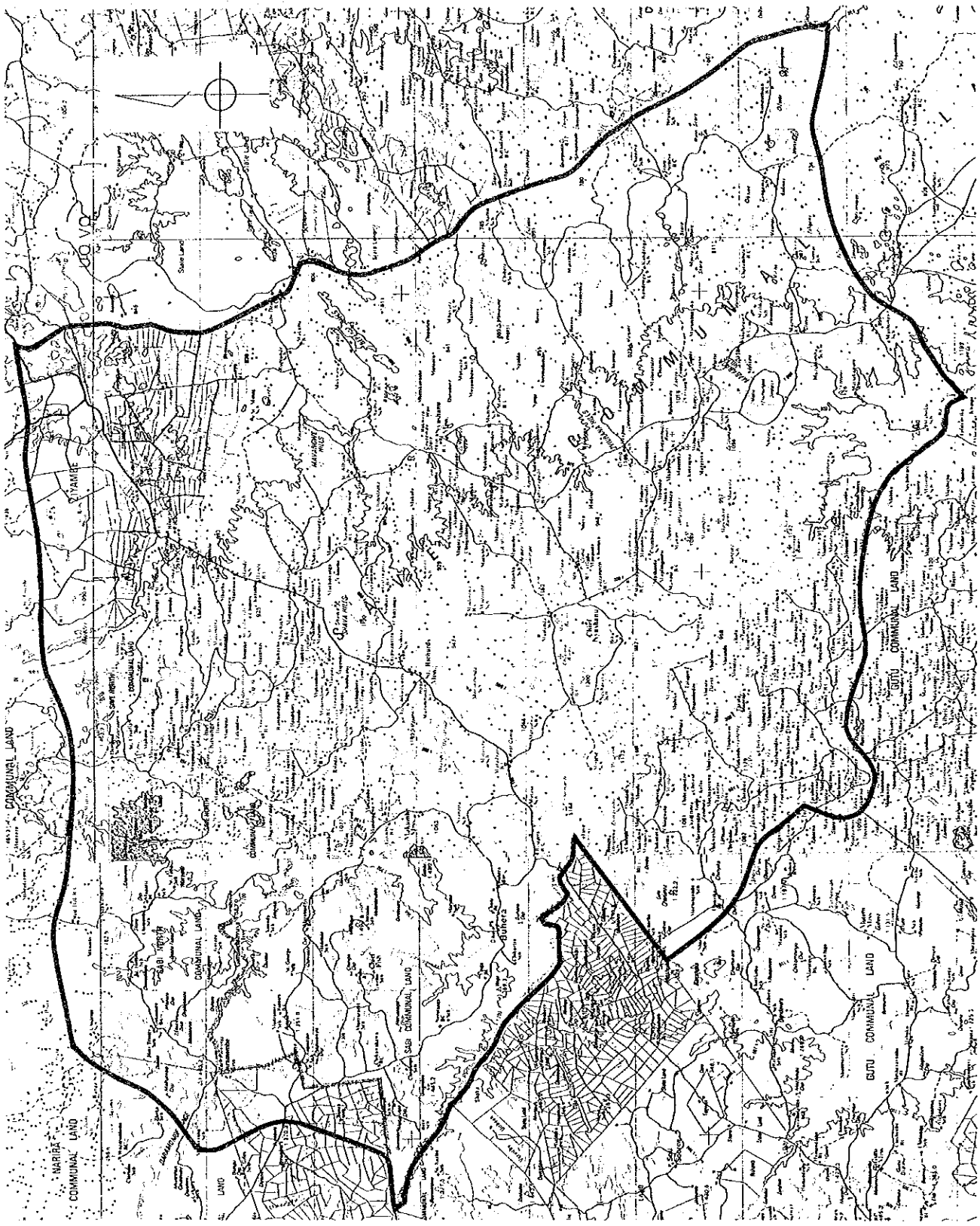


Figure 5.1 (3/6) Study Area (Murambinda)

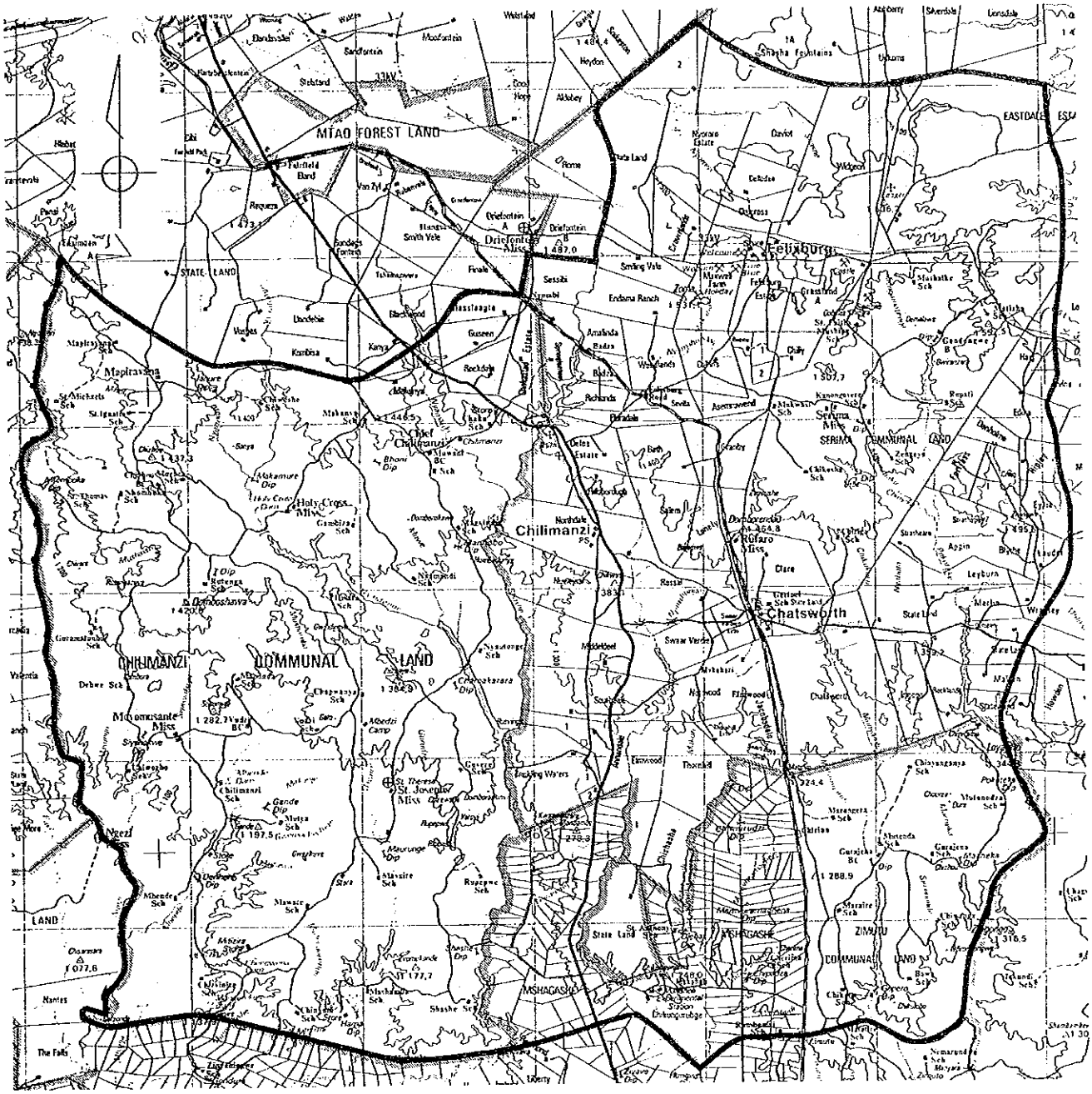


Figure 5.1 (4/6) Study Area (Chatsworth)

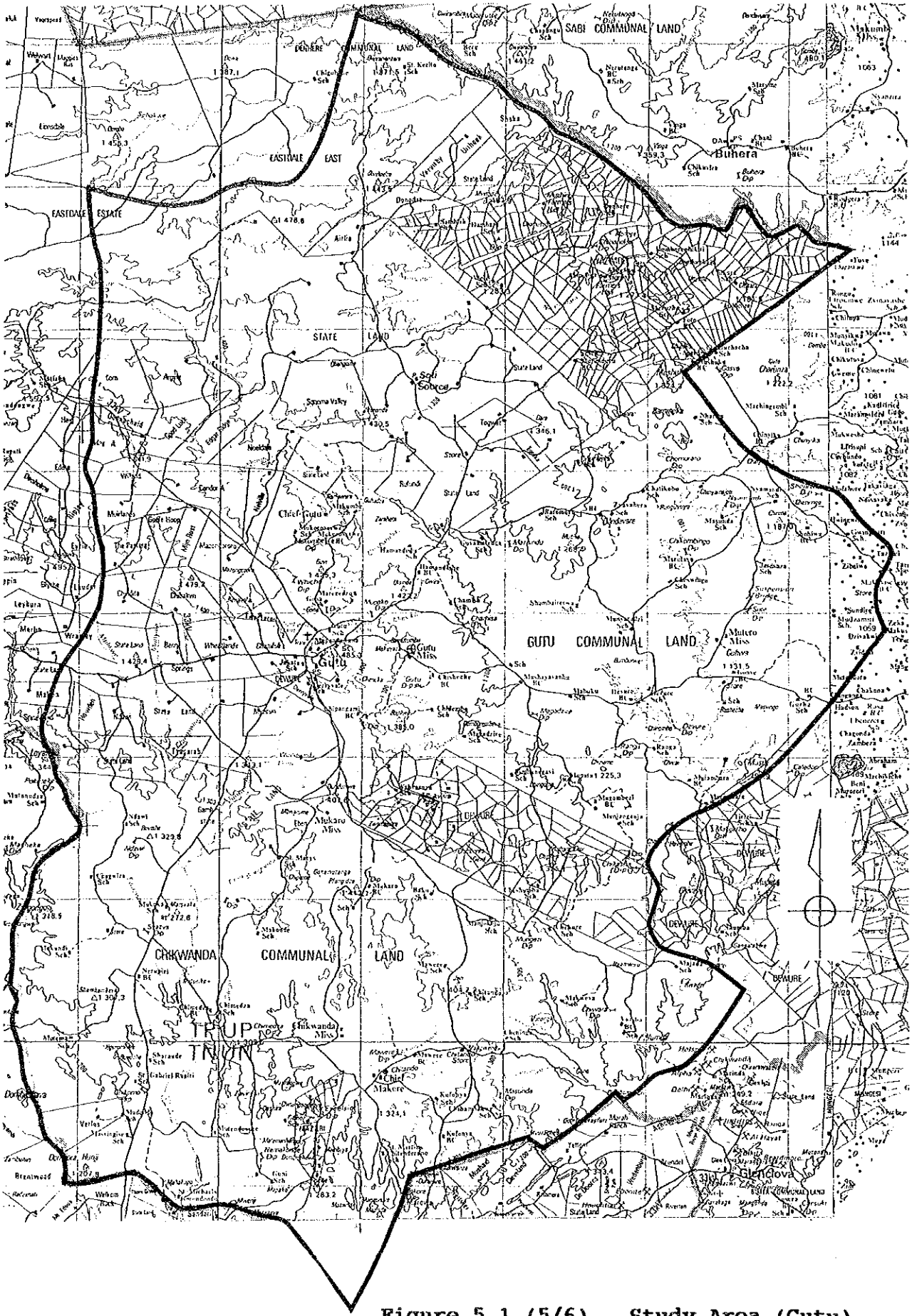


Figure 5.1 (5/6) Study Area (Gutu)

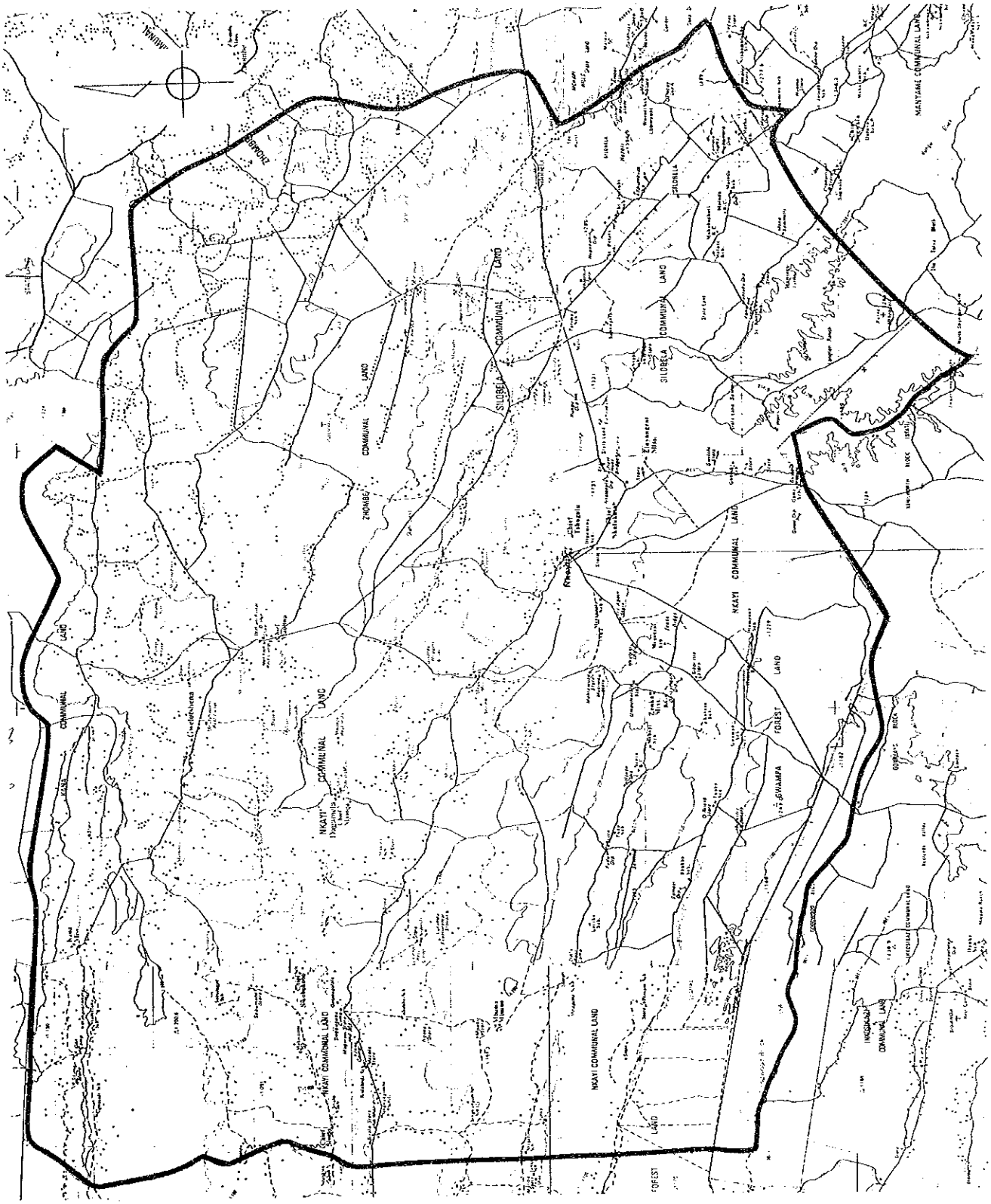


Figure 5.1 (6/6) Study Area (Nkayi)

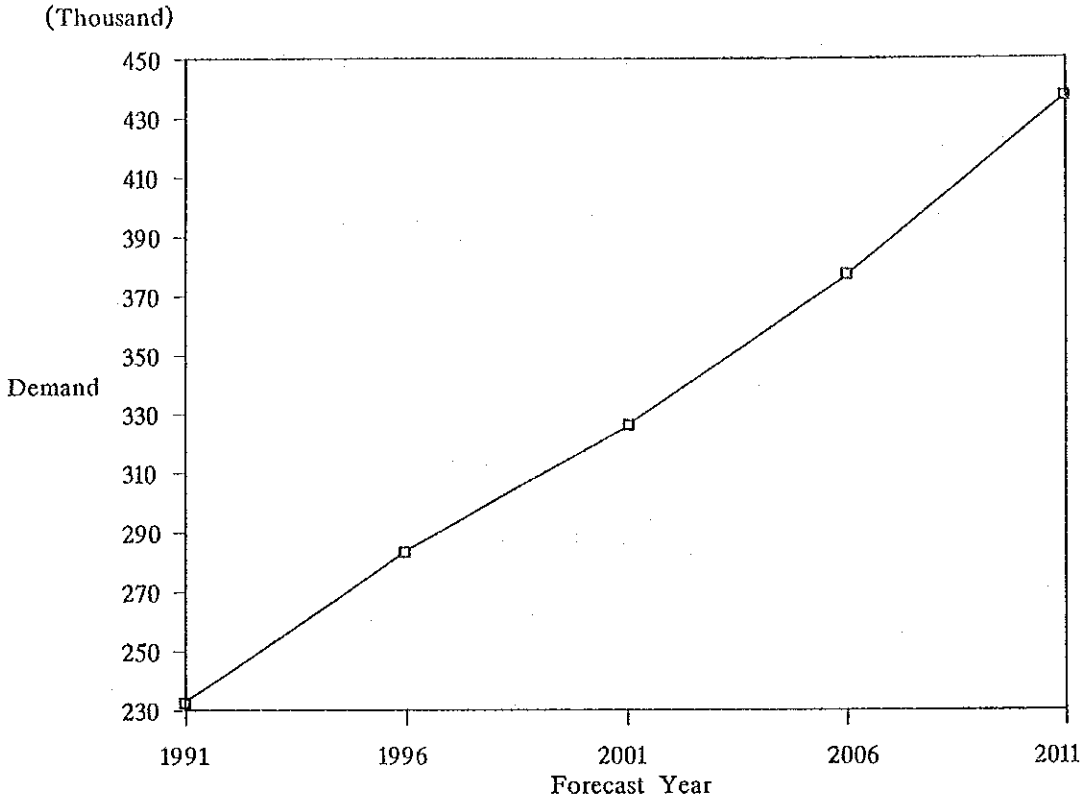


Figure 5.2 (1/3) Density & GDP/Capita

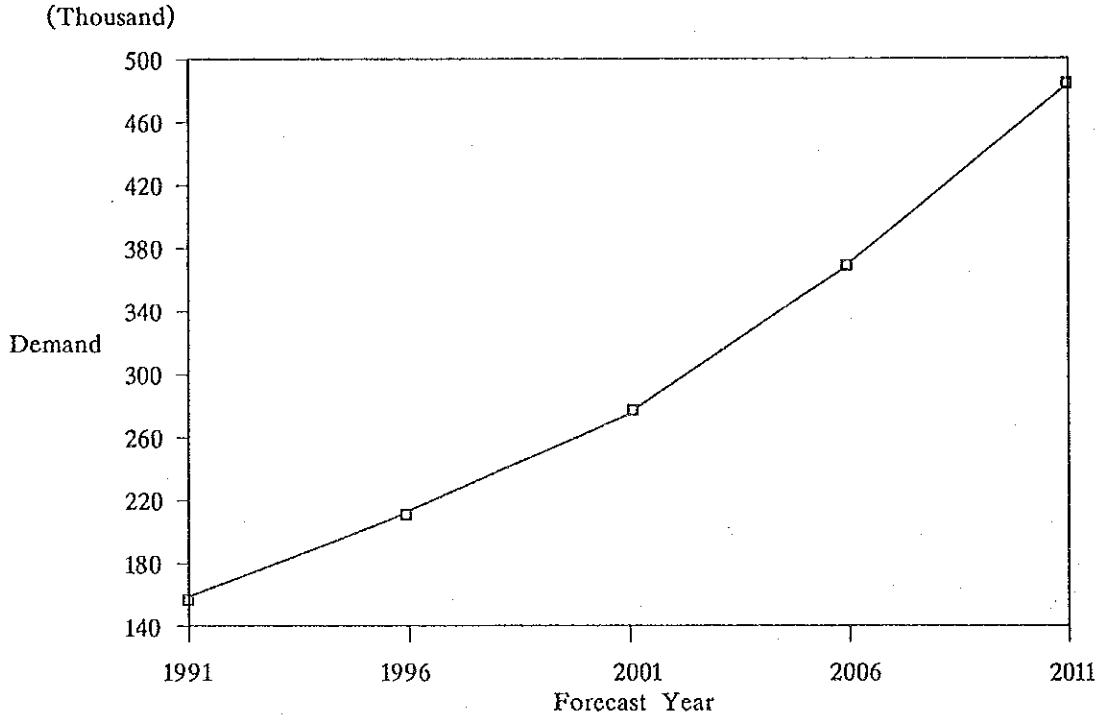


Figure 5.2 (2/3) Logistic Curve Model

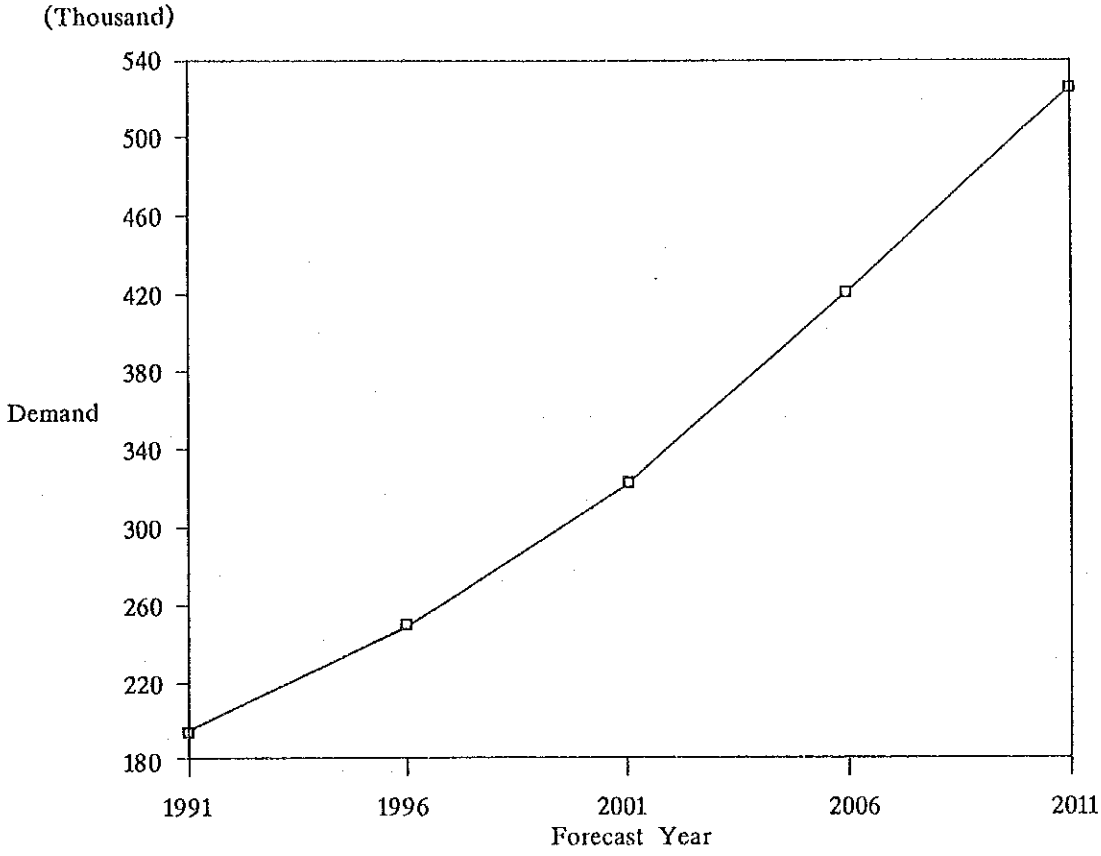


Figure 5.2 (3/3) General Econometric

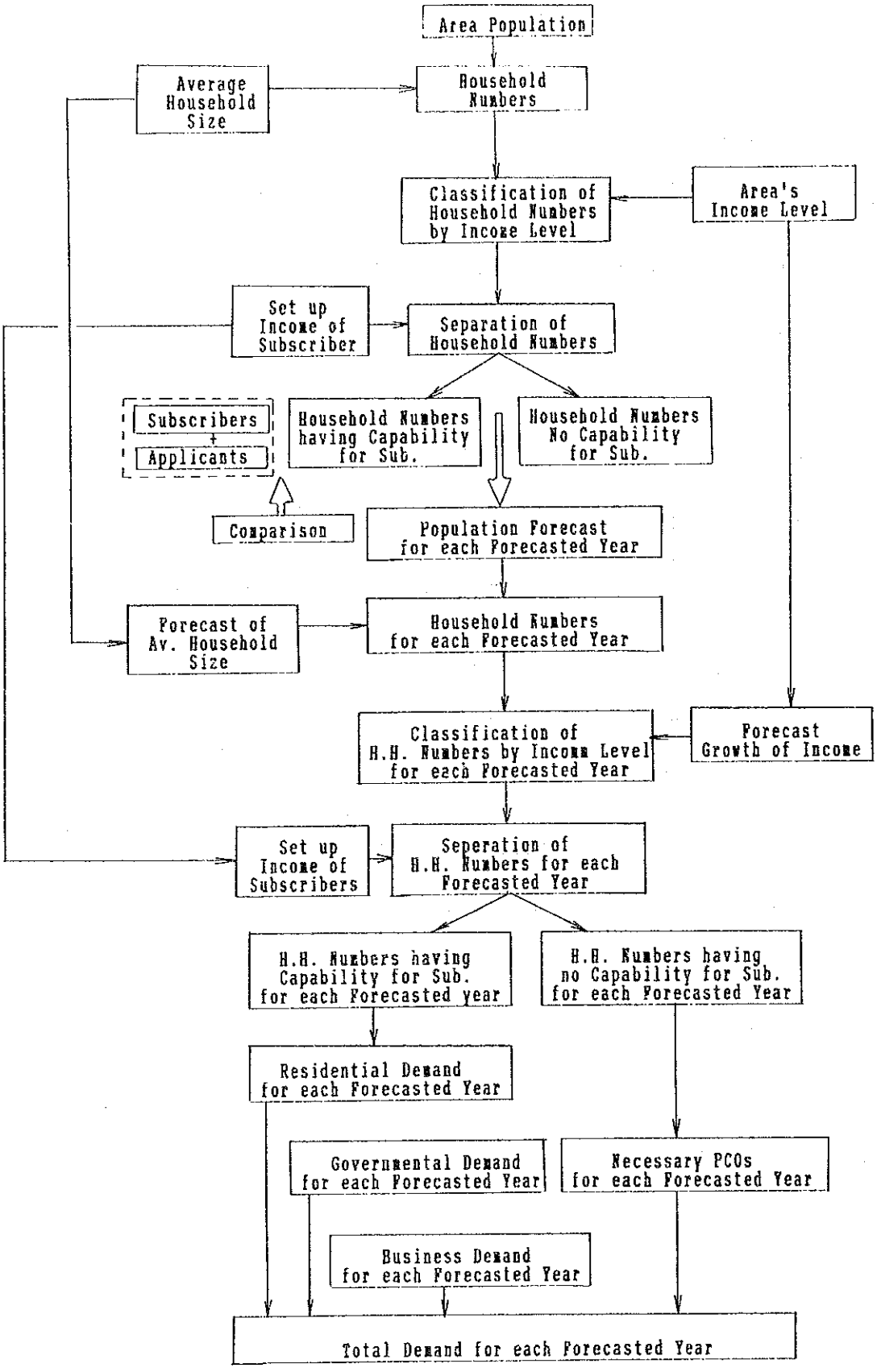


Figure 5.3 Flow Chart for Microscopic Demand Forecast

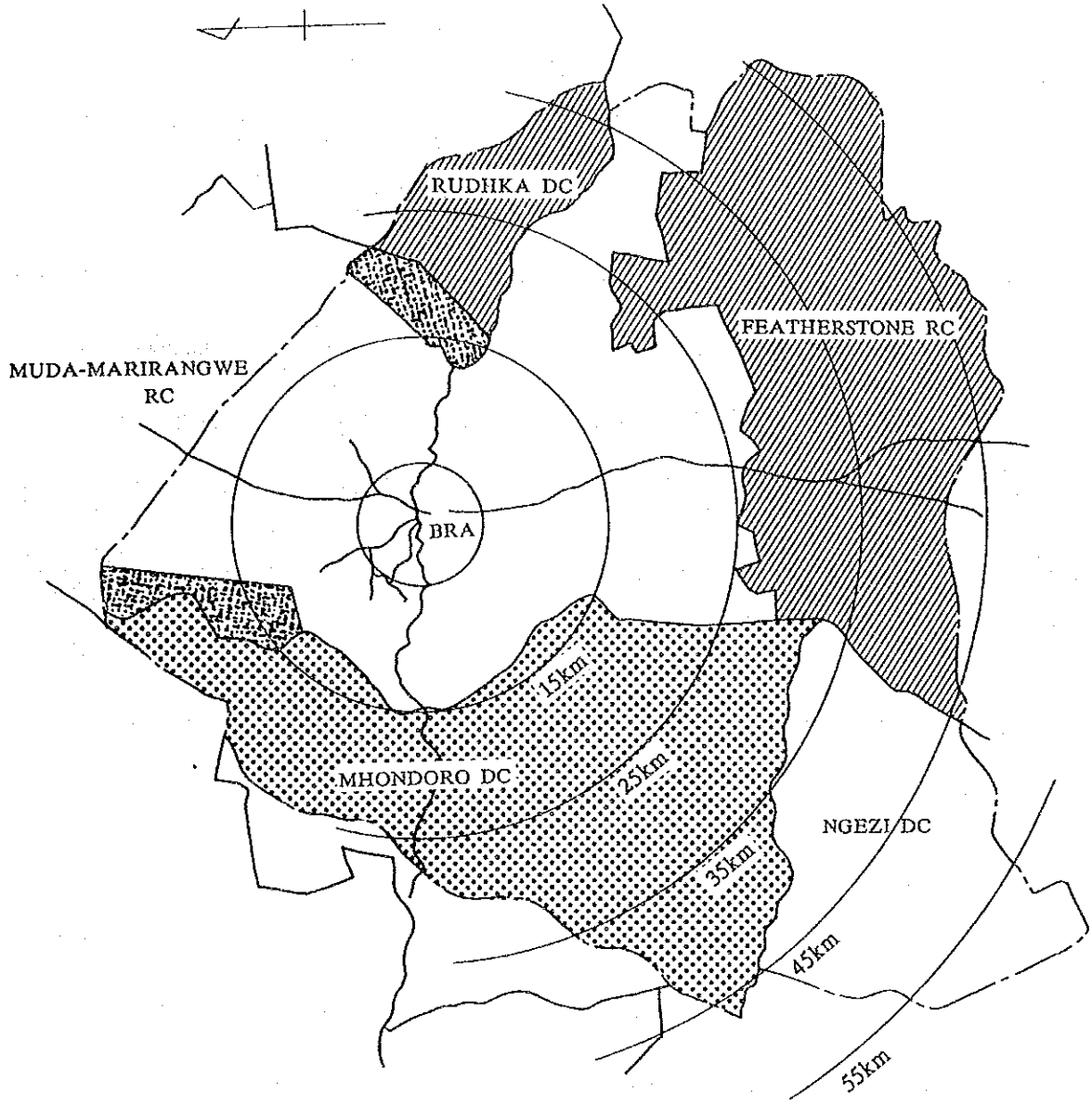


Figure 5.4 (1/6) Administrations in the Study Area
BEATRICE EXCHANGE

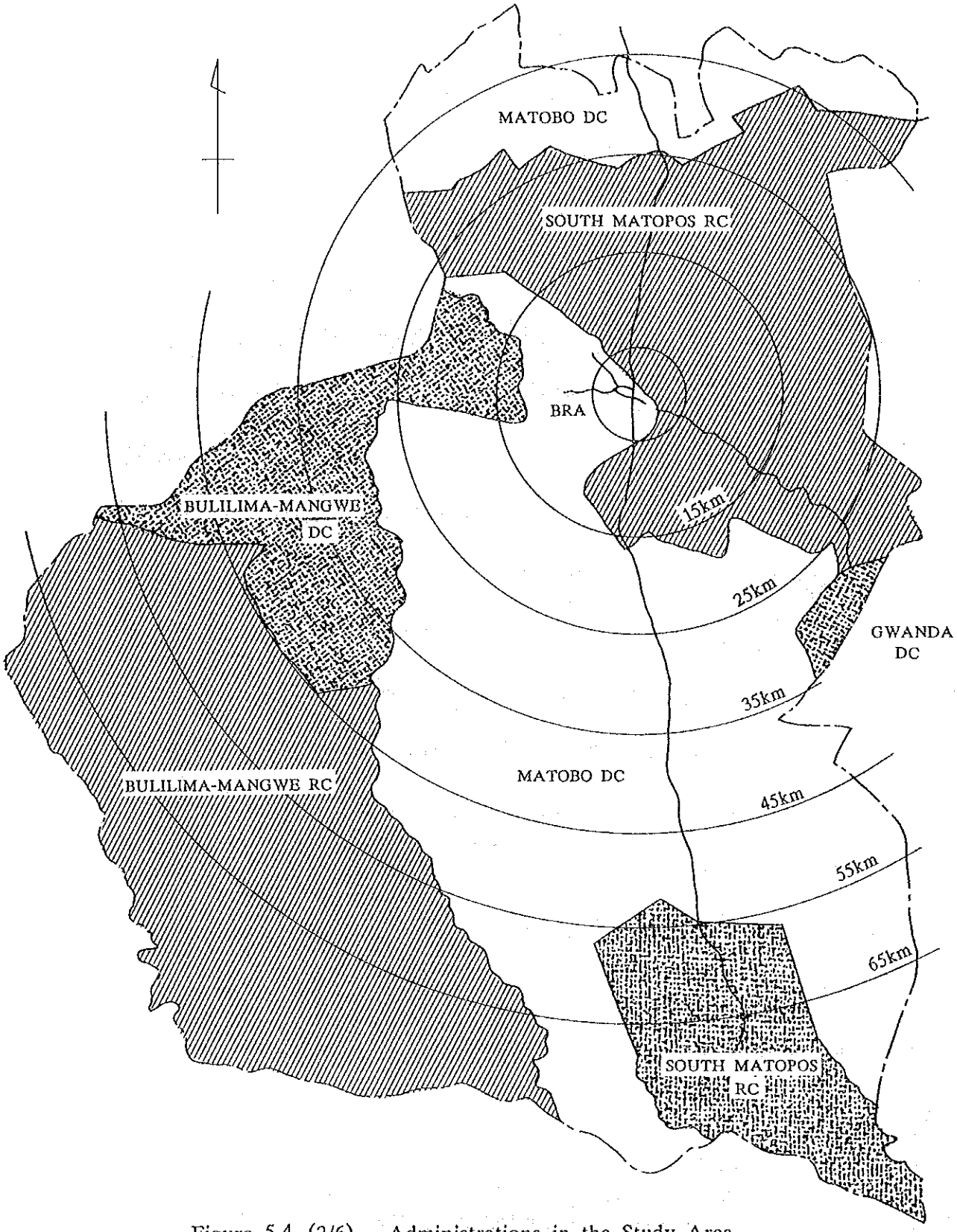


Figure 5.4 (2/6) Administrations in the Study Area
KEZI EXCHANGE

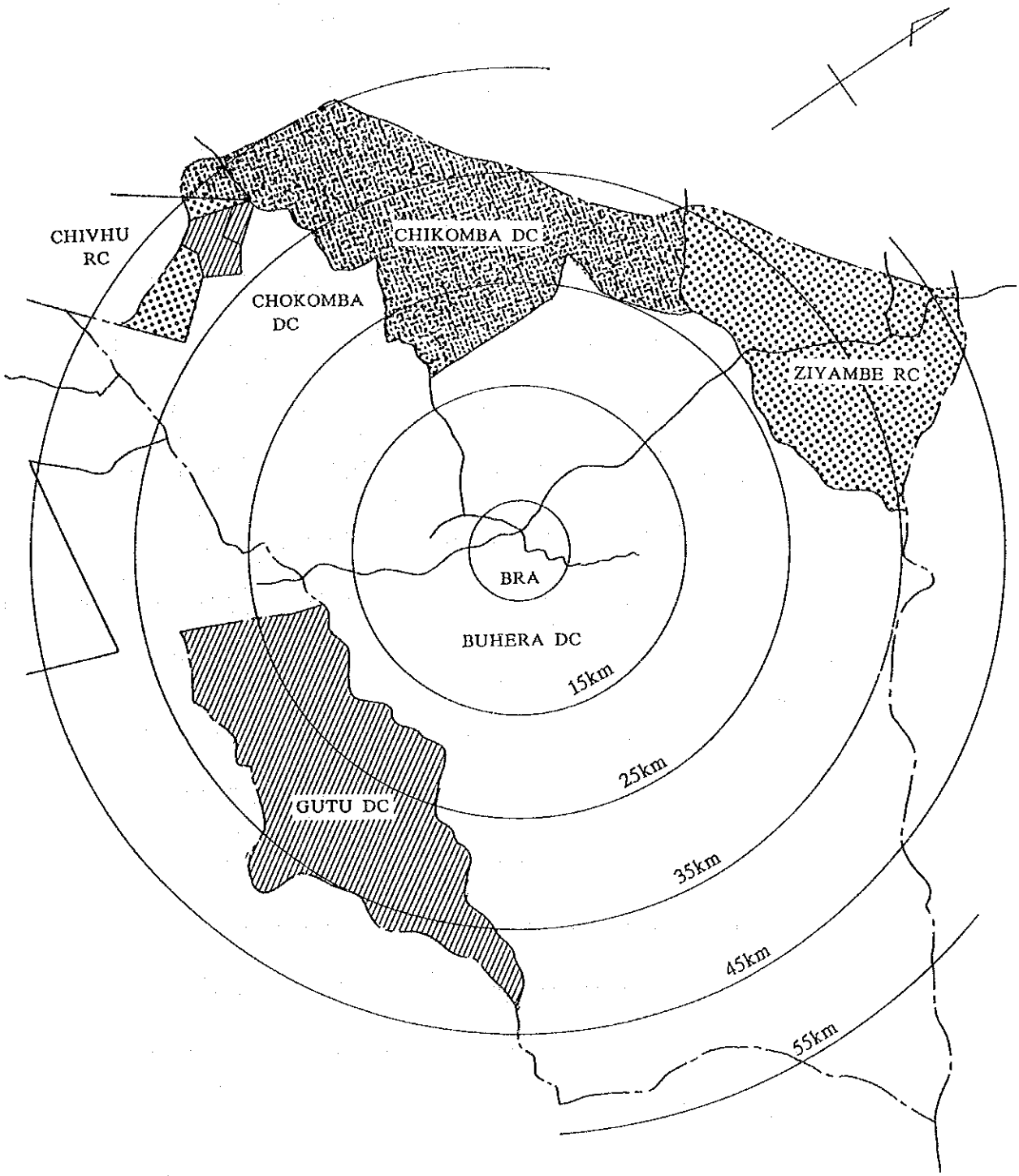


Figure 5.4 (3/6) Administrations in the Study Area
MURAMBINDA EXCHANGE

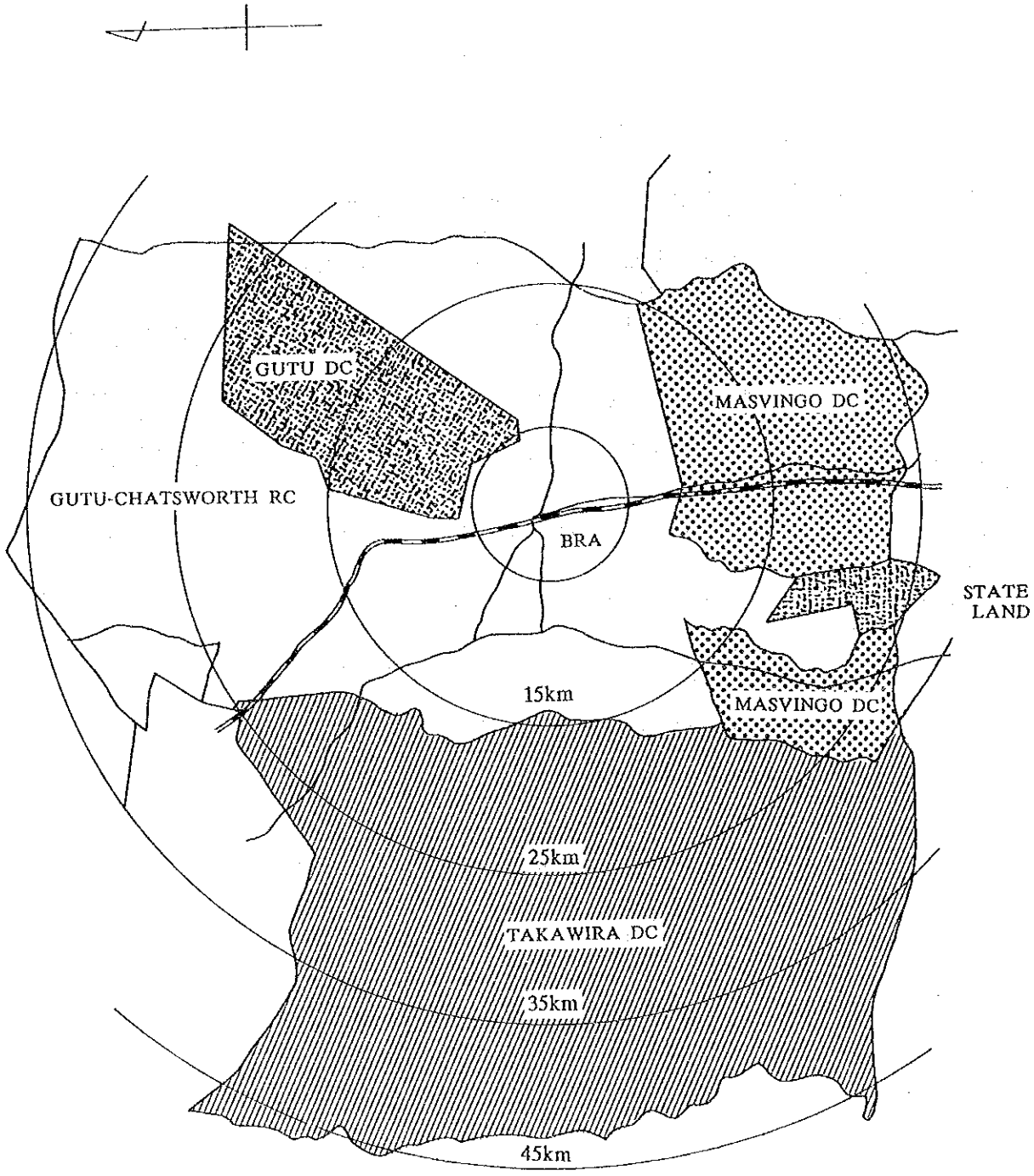


Figure 5.4 (4/6) Administrations in the Study Area
CHATSWORTH EXCHANGE

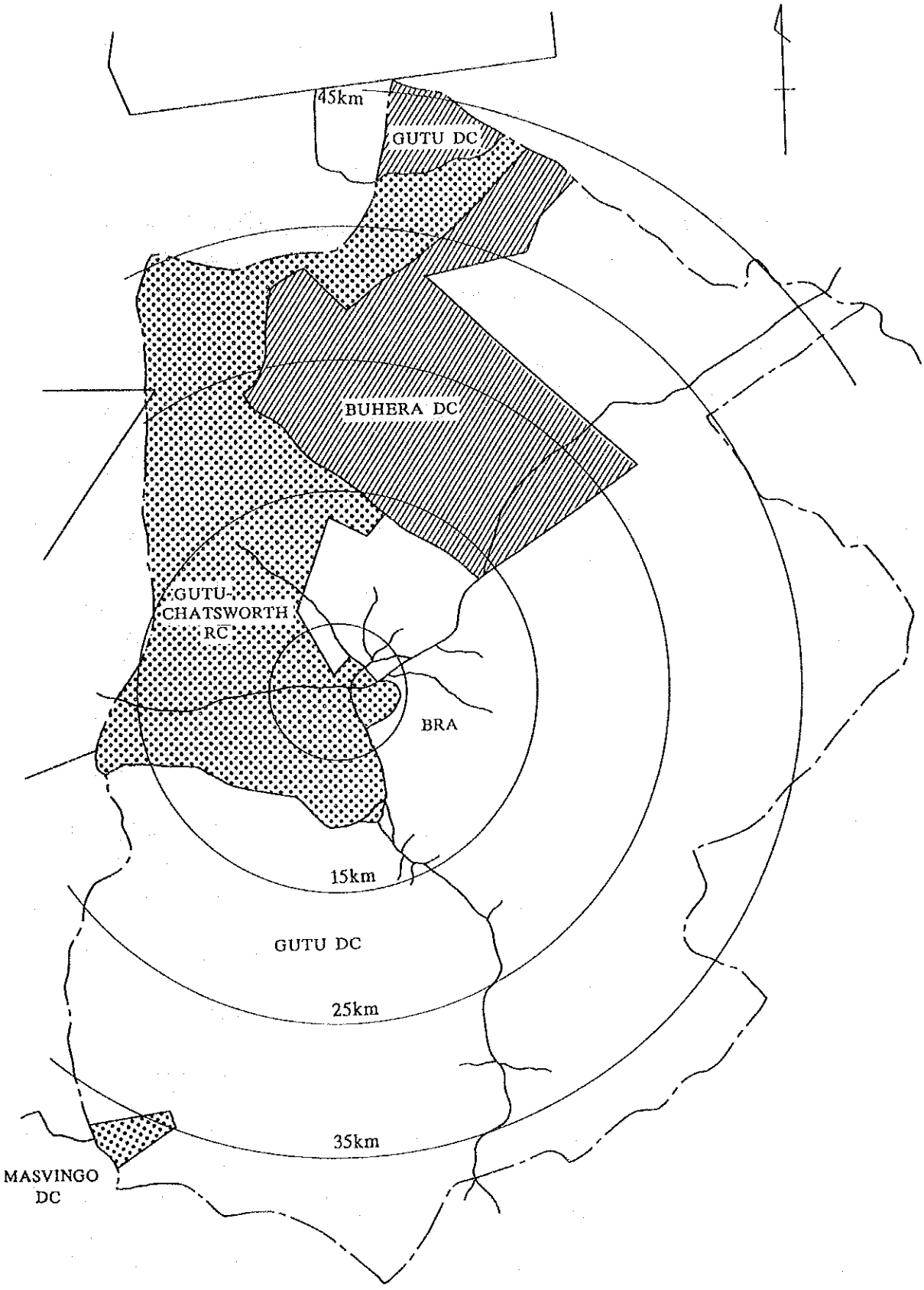


Figure 5.4 (5/6) Administrations in the Study Area
GUTU EXCHANGE

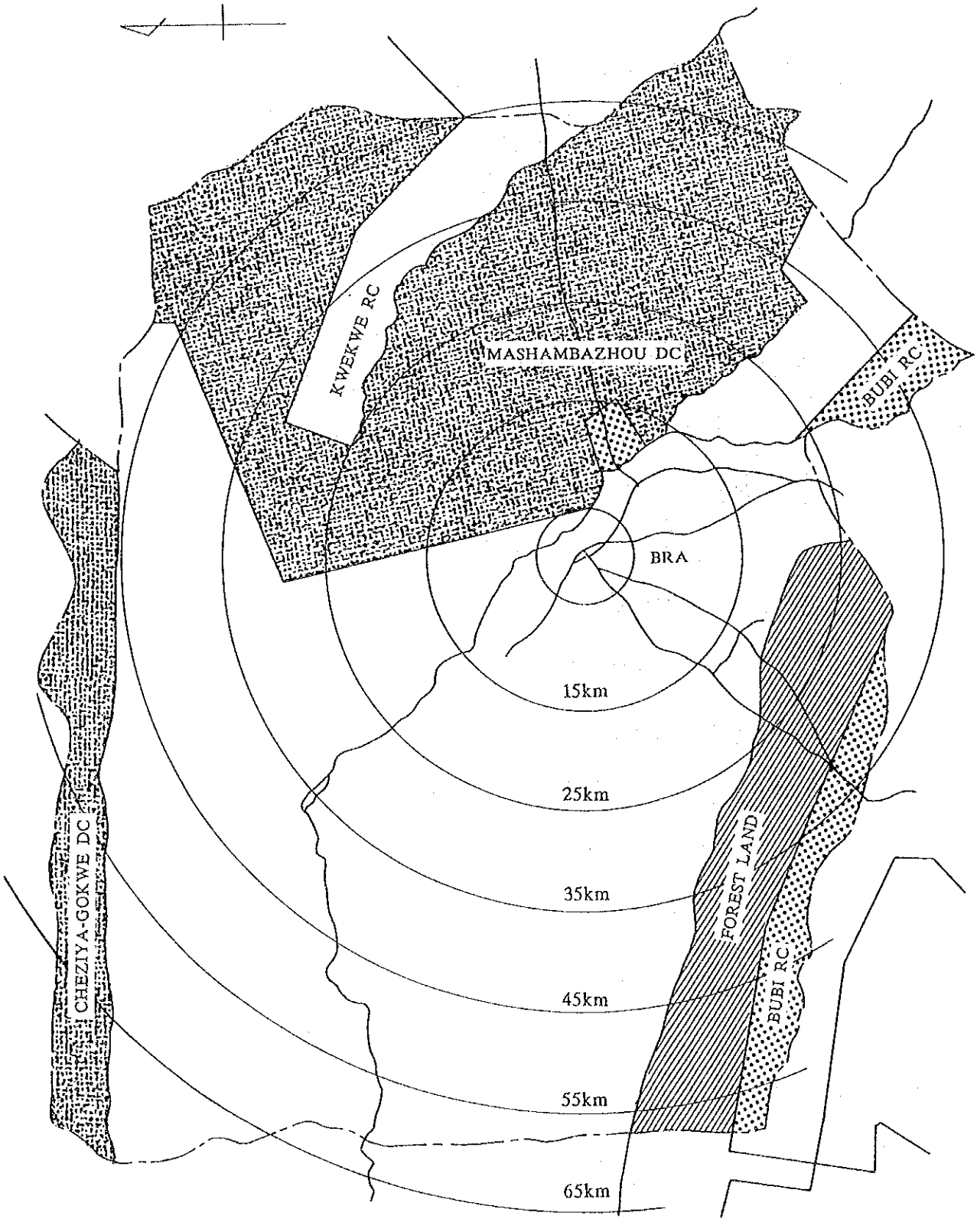


Figure 5.4 (6/6) Administrations in the Study Area
NKAYI EXCHANGE

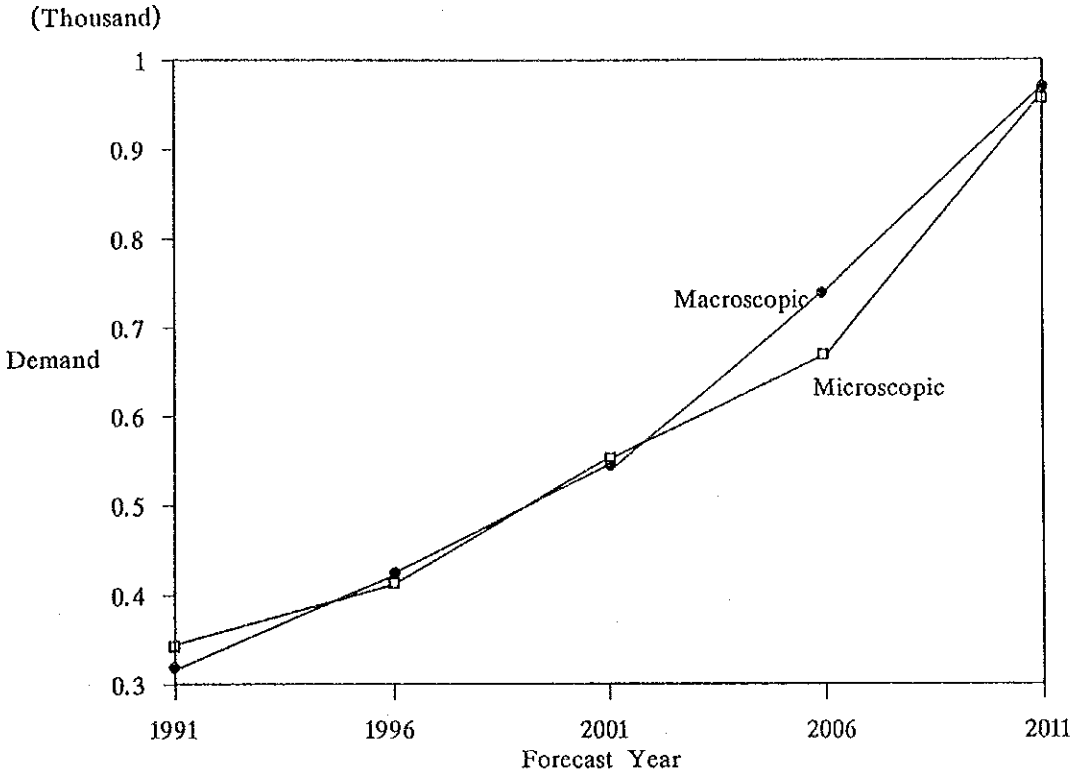


Figure 5.5 (1/6) BEATRICE EXCHANGE

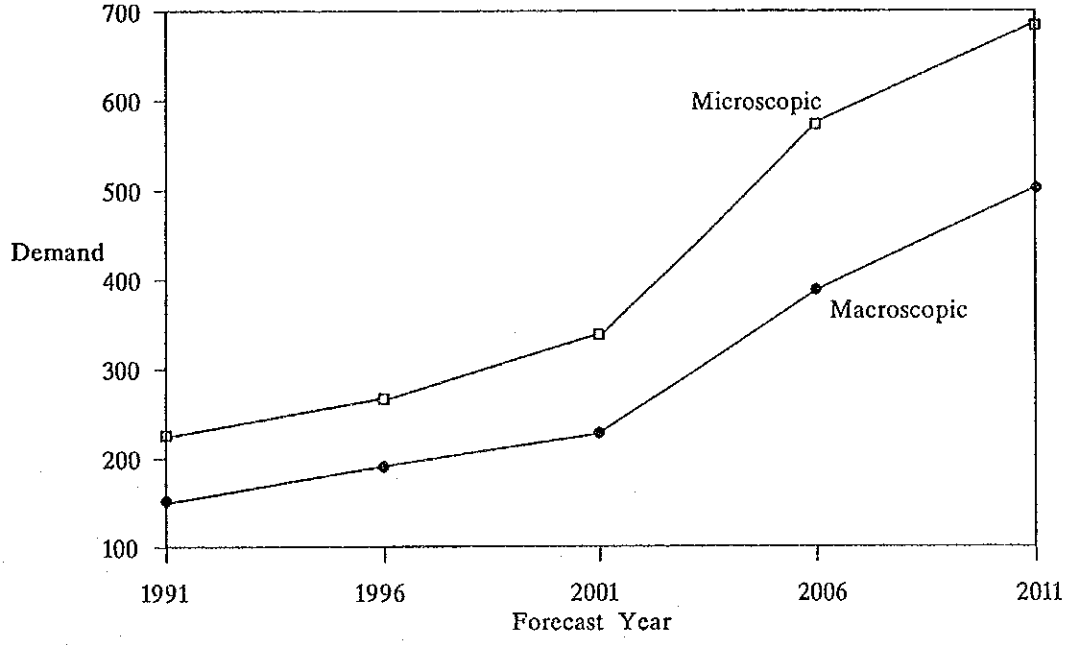


Figure 5.5 (2/6) KEZI EXCHANGE

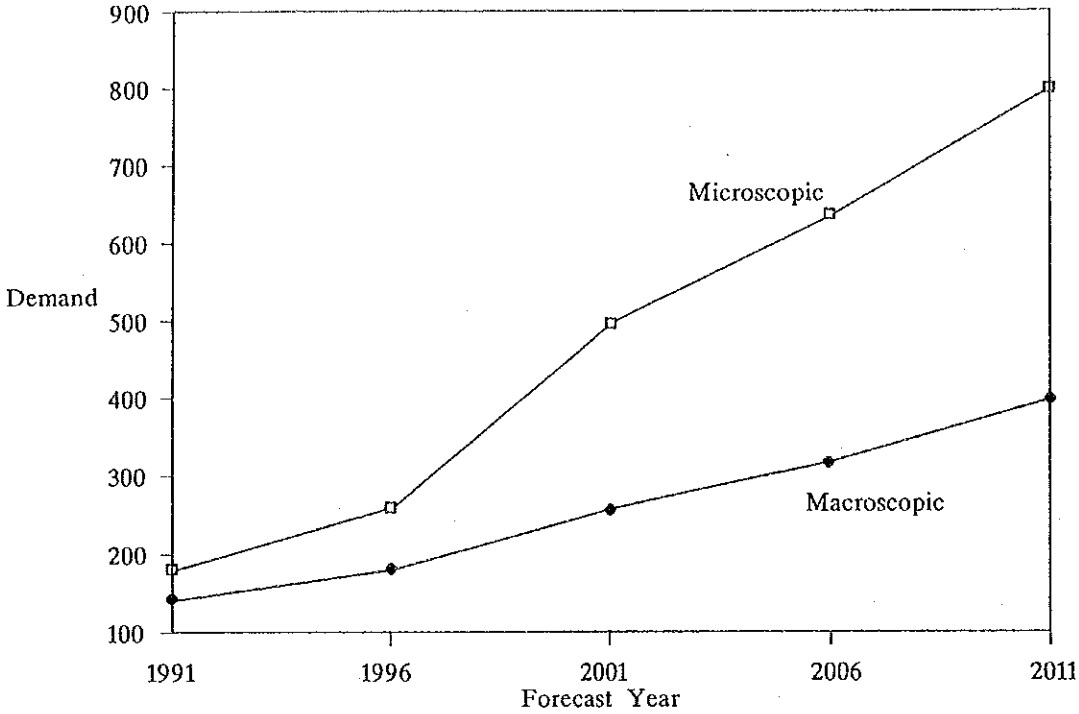


Figure 5.5 (3/6) MURAMBINDA EXCHANGE

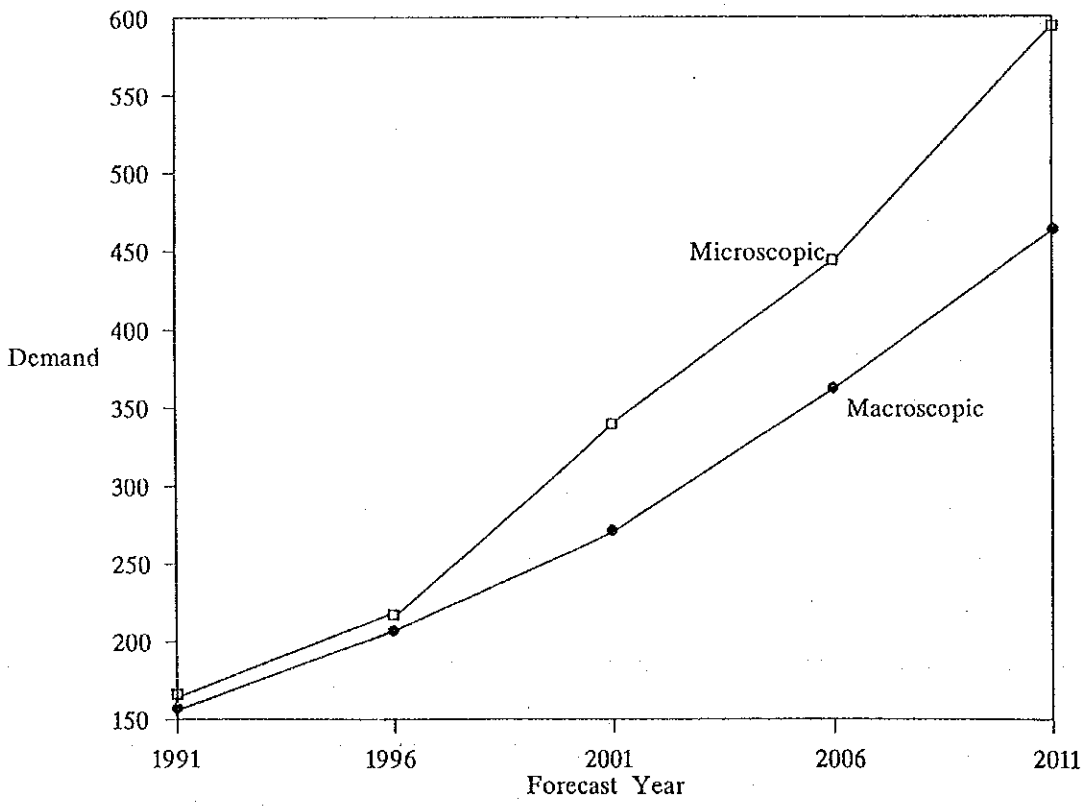


Figure 5.5 (4/6) CHATSWORTH EXCHANGE

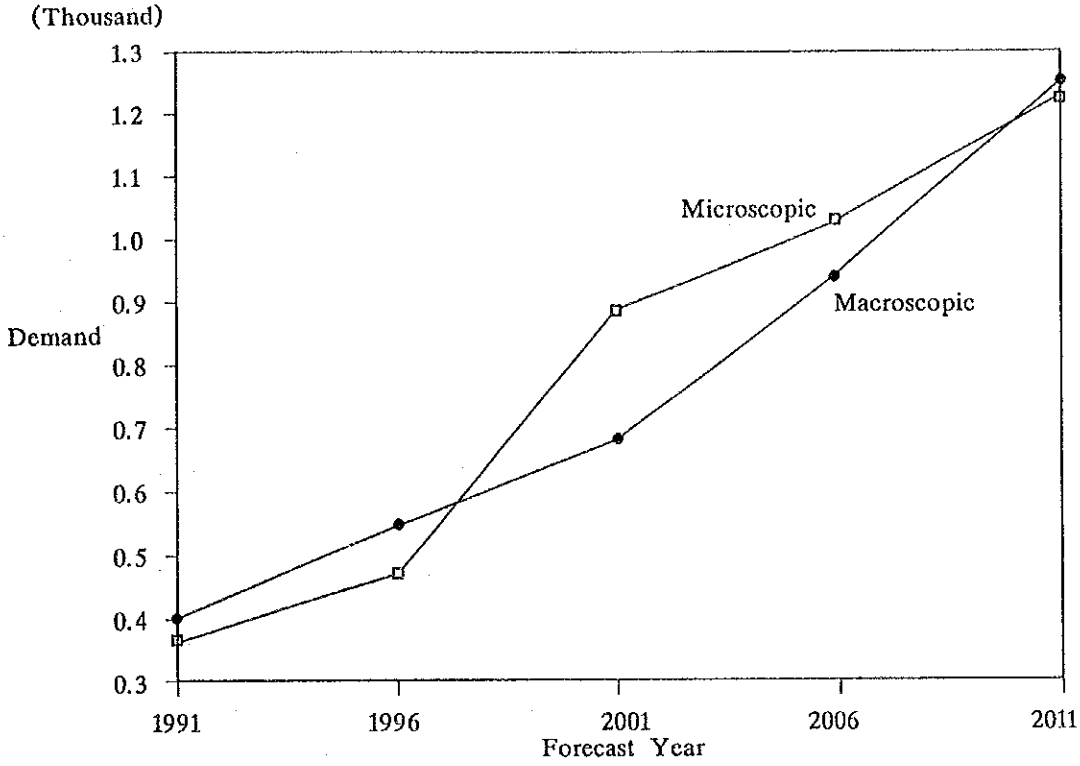


Figure 5.5 (5/6) GUTU EXCHANGE

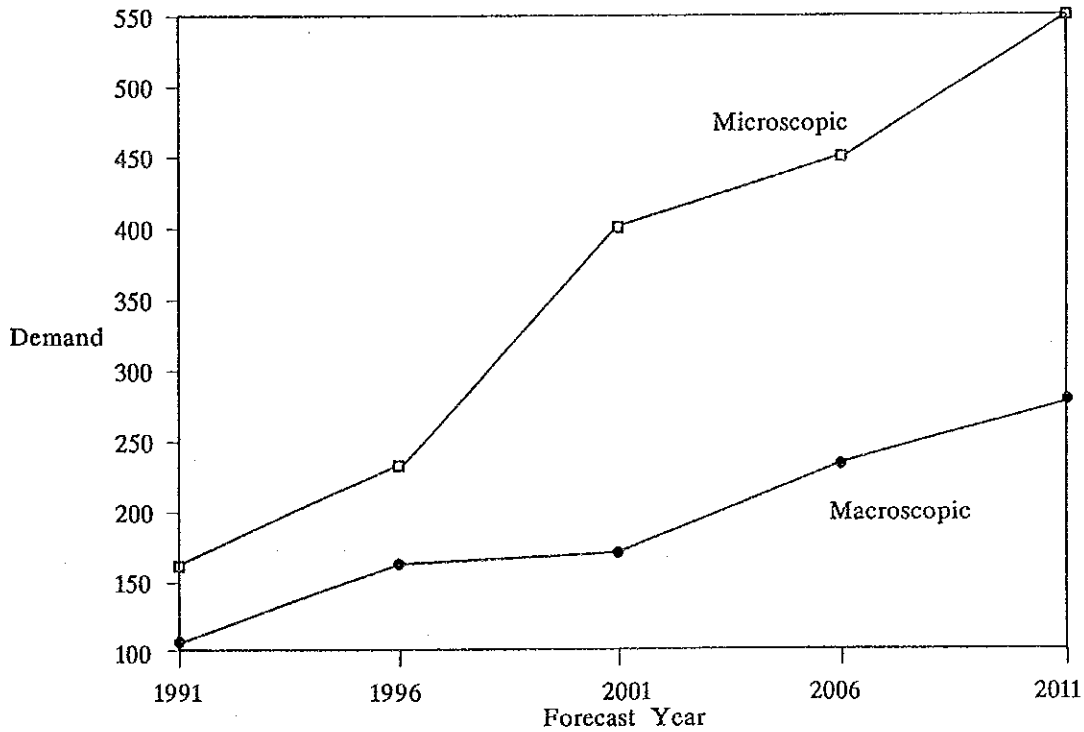


Figure 5.5 (6/6) NKAYI EXCHANGE

SECTION 6 TRAFFIC FORECAST AND CIRCUITS REQUIREMENTS

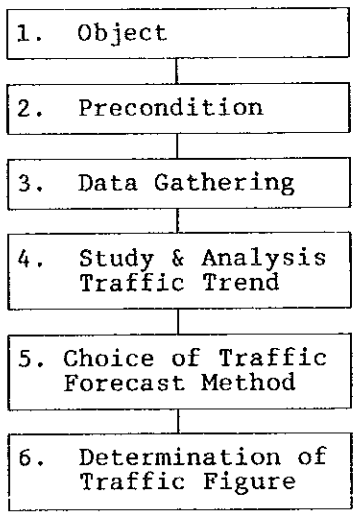
SECTION 6 TRAFFIC FORECAST AND CIRCUITS REQUIREMENTS

Generally, traffic forecast is made in consideration of many elements such as demand increase, economic situation, social structure, charging system and all sorts of services to be provided. However gathering the necessary data for traffic forecast in a rural area is sometimes difficult and accuracy of the gathered data may not be good enough.

When a traffic forecast is made in the conditions such as those mentioned above, traffic is assumed by using the data from similar type of exchange areas and refer to available report and data to supplement to the gathered data.

In forecasting traffic for the Study areas, gathered data during the field survey and the supplied information and data from PTC are referred to.

A traffic forecast for the Study areas is made with the following procedures:



6.1 Object

(1) There are some sort of telecommunication services, such as Telephone services, Telex, Data Transmission, Videotex.
However, the major service demanded is obviously Telephone service, because of low penetration ratio of telephone, in particular in the rural areas, the penetration ratio is only 0.3 per 100 inhabitants,

therefore, to raise penetration ratio this must be the highest priority.

Also in the rural areas, just a few Telex terminals and Data transmission circuits are seen, and total number of telex terminals in the Study areas were only five (5) at the time of the field survey.
However, all the Telex circuits are switched by the Telex exchange at Harare with a concentrator at Bulawayo, and Data transmission circuits are provided on leased point-to-point circuit without switching by a Telephone exchange. Therefore, it is not necessary to consider Telex and Data transmission traffic on Telephone exchange.
However, the number of transmission circuits to be provided for Telex and Data transmission should be considered at the Network Planning stage.
Hence, the object of traffic forecast is Telephone service.

(2) Traffic to be forecasted are:

a. All traffic to be originated in the Study areas.
b. Traffic from/to other exchange areas.

(3) Period of forecast

The feasibility Study was started in 1991 and the field survey and gathering most of data for the Study were carried out in the same year.

It is also assumed that commissioning of service with the telecommunication networks to be introduced into the Study areas will be performed in 1996, in consideration of the period of study, preparations and installation.

Therefore, it has been decided that the forecasts cover a fifteen-year period with effect from 1996.

6.2 Precondition

The existing switching network hierarchy of PTC is of a Star structure. Although, PTC intends to introduce a meshed configuration, a changing of technical conditions of the terminal exchanges in the rural areas is not expected very much. And usually, the number of subscribers and traffic

volume of a rural exchange are not so high as that of an urban exchange and the constitution is simple.

Therefore, in case of the terminal exchange in the rural areas, it is not necessary to equip with an alternative trunk route to any primary or secondary exchange.

Generally, capability of a switching equipment to be installed in an urban area is designed in consideration of its traffic volume which is different depending upon residential area, business area because of high traffic and large number of subscribers accommodated in an exchange.

In rural areas, however, traffic volume is very low whether residential or business. According to the Specification No. ZWE/PTC/301 issued by PTC, typical average value for calling or called traffic rates in residential and business areas in the rural areas are the same. Besides, the number of subscribers to be accommodated in an exchange is small.

In principle, the exchange system to be introduced into each Study area is an independent digital exchange as stated in Section 8.1, however, a RLC (Remote Line Concentrator) which belongs to Gutu host exchange is to be employed for Chatsworth exchange area in consideration of low increasing demand shown in Table 5.12 (5/7).
RLC is deemed to be a part of a host exchange and extended Subscriber Line Circuit. The concept is shown in Figure 6.1.

In Zimbabwe, there is a particular type of subscriber party line system where a number of subscribers share one physical line, however in this study, it is assumed that this party line system will remain until the year 2006.

Hence, in principle, the conditions of exchanges to be introduced into the Study areas are as follows:

a. To provide one trunk route with a primary or a secondary exchange.
b. No function for transit calls.
c. No traffic distinction between residential and business areas.
d. The exchange to be employed for Chatsworth exchange area is

RLC (Remote Line Concentrator) with Gutu host exchange.

e. In 2006 and after that, party line system is deemed non existent as those party line subscribers will be transferred to DEL by 2006.

6.3 Data Gathering

The data used for traffic forecast was gathered by the Study Team during the field survey and was supplied by PTC. The data gathered are:

a. Status of the existing exchanges in the Study areas, supplied by PTC
b. Master plan (Telecommunication Development Plan 1986-2005) published by ITU, supplied by PTC
c. Traffic count reports of the existing exchanges in the Study areas (Beatrice, Kezi, Murambinda and Gutu), supplied by PTC
d. Traffic count reports of the existing exchanges other than the Study areas
(Mberengwa, Centenary, Mvuma, and Chimanimani), supplied by PTC
e. Data from demand forecast, obtained by the Study Team
f. Other reference data

6.4 Study and Analysis of Traffic Trend

Telecommunication networks are operational in the five of the six Study areas, and the status are as shown in Table 4.1.

In Nkayi exchange area, switching equipment has already been installed without outside plant and transmission system, and at the present moment it's not working.
Therefore, no actual data of the Nkayi exchange is available.

The following exchanges in the Study areas went into service respectively:

YEAR	NAME OF EXCHANGE
1985	Beatrice
1987	Kezi, Murambinda, Gutu, and Chatsworth

Most of the exchanges in the rural areas are equipped with Strowger Switching systems having commissioned their service after 1984 and no historical traffic data for those exchanges is available. Available traffic data of the existing exchanges in the Study areas are of Beatrice, Kezi, Murambinda and Gutu, and are shown in Figure 6.2 (1/4 - 4/4) which details each type of traffic flow.

In addition to the above, traffic data of Mberengwa, Centenary, Mvuma, and Chimanimani exchanges are available as references which are shown in Table 6.1.

Table 6.1 Traffic Distribution of Reference Exchanges

Items	Mberengwa	Centenary	Mvuma	Chimanimani
Originating Call	3.84	4.93	10.73	3.51
Trunk (OG)	2.72	3.67	9.77	8.68
Trunk (IC)	0.55	1.41	4.08	3.60
Terminating Call	1.51	2.53	5.04	8.43
Lost Call	0.16	0.12		
DEL's (line)	48	126	198	100
P/L's (line)	10	16	7	23
PCO's (line)		3	2	3

(1) Traffic Distribution

Traffic ratio of local call and trunk call basically depends on the number of subscribers to be accommodated in an exchange according to the Master Plan formulated by ITU.

In the case of the number of subscribers being less than 251, percentage of trunk calls is over 50% and this increases more as the number of subscribers decreases, and if the number of subscribers is more than 500, the opposite is true as shown below:

Local and Trunk Traffic Distribution (Master Plan)

No. of Subscribers	Traffic (%)	
	Local	Trunk
21 - 50	20	80
51 - 100	30	70
101 - 250	40	60
251 - 500	50	50
501 - 1000	60	40
1001 - 2000	70	30

However, considering the characteristics of the rural areas in Zimbabwe such as stock raising, farming, and the extreme low density population, it may be difficult to apply the traffic distribution pattern as shown above.

Generally, a big percentage of the calls handled in the rural areas are trunk calls. According to the report prepared by the PTC Rural Exchange Section, dated 17 September 1990, the percentage of STD traffic has risen to 60-70% throughout Zimbabwe. Some exchanges like Beatrice, which is one of the Study areas of this project and Mvuma STD traffic is over 80%.

The exchanges which originate high ratio of trunk calls seem to have a direct trunk route with a big major city such as Beatrice - Harare and Kezi - Bulawayo.
For provision of telephone service to the Study areas, 50 - 80% of total originated traffic of an exchange is assigned for the trunk calls.

(2) Calling and Called Rates

According to the PTC Specification No. ZWE/PTC/301, the national average for the both way traffic per DEL (Direct Exchange Line) is 0.12 Erl.

Therefore, a half figure 0.06 of the both way traffic 0.12 Erl. can be deemed to be a figure of calling or called rate, although the current actual calling rate is slightly higher than the called rate due to the existing congestion conditions.

On the other hand, according to a PTC's answer to the questionnaire by the JICA preliminary study team, the overall originating traffic figure is 0.07 Erl. per line in the Rural areas.

Besides, after telecommunication networks have been digitalized, grade of service will be improved and consequently, it may make slight increase traffic in the Study areas. So it has been suggested that the realistic figure 0.07 Erl. should be applied for Calling rate and 0.06 Erl. for Called rate.
The figures mentioned above are from the data measured in the busy hours.

(3) Traffic Trend

No historical data which indicates a trend of traffic in the Study areas are available as stated in Section 6.3. In the Master Plan formulated by ITU, the trunk traffic forecasts from 1986 to 2005 are stated and the traffic figures of the Study areas concerned are shown below.

Forecast of Total Trunk Traffic in Erlangs (Master Plan)

Ex. Area	1986	1988	1990	1992	1995	2000	2005
Beatrice	22.8	25.1	27.5	30.2	36.5	50.0	68.6
Kezi	13.8	14.8	15.7	16.8	20.5	28.8	40.3
Murambinda	-	14.0	15.0	16.1	19.2	25.7	34.5
Nkayi	-	8.7	10.9	13.8	16.1	30.0	34.5
Gutu	29.6	32.4	35.6	39.2	47.4	65.2	80.0
Chatsworth	13.8	14.8	15.7	16.8	26.6	27.5	37.4

In comparison of the above figures with the figures of the existing exchanges in the Study areas as shown in Figure 6.1, no correlation is seen, the data of the existing exchanges show that, actual traffic figures are much less than the expected figures in the Master plan, therefore, it may be difficult to use the data of the Master Plan as reference.

(4) Demand Forecast

The forecasted figures of demand in the Study areas by the JICA Study Team are shown in Table 5.12, and those are applied for the traffic forecast.

The forecasted Data shows that high demand increase up to the year 2011 is not expected except Gutu and Beatrice, and even in both exchanges, the maximum figures of demand are quite less than the Master Plan's figure and the forecast data by PTC which is in the Network Planning Information Circular No. 010 issued in September 1991.

As stated in Section 6.2, it is assumed that the party line systems will exist until 2006, therefore, in order to calculate the total traffic, the assumed number of party line subscribers are added to the forecasted demand shown in Table 5.12.

The assumed number of party line subscribers and physical party lines are shown in Table 6.2 below.

Table 6.2 Number of Party Lines

Ex. Area	No. of P/L	1996	2001	2006
BEATRICE	Party Line Subscriber	33 198	16 99	0 0
KEZI	Party Line Subscriber	9 50	4 22	0 0
GUTU	Party Line Subscriber	12 72	6 36	0 0
CHATSWORTH	Party Line Subscriber	8 48	4 24	0 0

Note: Murambinda exchange does not accommodate any P/L subscribers and Nkayi exchange is not in service.

The value for the calling or called rate per physical party-line is set as 0.25 Erl. as described in the PTC standard No. ZWE/PTC/301.

6.5 Choice of Traffic Forecast Method

There are some methods for traffic forecasting standardized by CCITT which are usually applicable to urban exchanges and for reasonably large areas.

However, any applicable proper method for a traffic forecasting in scattered rural areas, has not been established yet. Besides, the forecasted demand in the Study areas in 2011 are low as stated in item (4), Section 6.4.

Hence, the forecast method is shown as follows and Figure 6.2.

a) Originating Traffic

Originating Traffic by subscriber lines is:

$$Ci = Ni \times Pi$$

Ni: Number of subscribers

Pi: Calling Rate as stated in item (2), Section 6.4 and the figure is:

Calling Rate (DEL)	:	0.07 Erl./line
Calling Rate (P/L)	:	0.25 Erl./line

b) Outgoing Traffic

Outgoing Traffic, Gi to a Primary/Secondary centre is:

$$Gi = Ci \times \alpha/100$$

α: The following figures are applied in consideration of the conditions of the Rural exchange areas as stated in item (1), Section 6.4.

No. of Subscribers	Traffic (%)	
	Local	Trunk
Less than 400	20	80
400 - 699	30	70
700 - 1199	40	60
1200 - 1999	50	50

c) Incoming Traffic

Incoming Traffic, Ei from a Primary/Secondary centre is:

$$Ei = (Ni \times Qi) - Di$$

Qi: Called rate as stated in item (2), Section 6.4 and the figure is:

Called Rate 0.06 Erl./line

d) Intra-Office Traffic

Intra-Office Traffic, Di between subscribers within an exchange is:

$$Di = Ci - Gi$$

e) Terminating Traffic

Terminating Traffic, Li is:

$$Li = Di + Ei$$

Therefore, the Total Traffic of an exchange, Ti is:

$$Ti = Ci + Ei$$

6.6 Determination of Traffic Figure

Determined Traffic in Erlangs of each exchange in the Study areas are shown in Table 6.3 below:

Table 6.3 Traffic Figure in the Study Areas

Exchange	1996	2001	*a 2006	*a 2011
BEATRICE				
Originating	37.4	43.1	46.7	66.9
Outgoing	24.3	30.2	32.7	40.1
Incoming	20.1	24.6	26.0	30.5
Intra-Office	13.1	12.9	14.0	26.8
Total	57.5	67.7	72.7	97.4
KEZI				
Originating	21.9	26.0	39.8	47.9
Outgoing	17.6	20.8	27.9	33.5
Incoming	14.8	17.2	22.2	26.6
Intra-Office	4.3	5.2	11.9	14.4
Total	36.7	43.2	62.0	74.5
MURAMBINDA				
Originating	18.3	34.1	43.8	57.8
Outgoing	14.5	23.9	30.7	34.7
Incoming	11.9	19.0	24.5	26.5
Intra-Office	3.8	10.2	13.1	23.1
Total	30.2	53.1	68.3	84.3
NKAYI				
Originating	15.6	27.7	31.9	38.5
Outgoing	12.5	22.2	22.3	27.0
Incoming	10.3	18.3	17.8	21.5
Intra-Office	3.1	5.5	9.6	11.5
Total	25.9	46.0	49.7	60.0
GUTU				
Originating	37.0	63.9	72.7	86.8
Outgoing	37.9	53.2	62.2	64.2
Incoming	30.8	41.0	47.5	45.9
*b Intra-Office	16.3	35.4	41.4	64.1
Total	67.8	104.9	120.2	132.7
CHATSWORTH				
Originating	17.2	24.7	30.9	41.5
Terminating	15.0	21.3	26.5	35.6
Total	32.2	46.0	57.4	77.1

*a : Party-line will no longer exist in 2006 and 2011.
*b : Calls to be originated at Chatsworth are included.

6.7 Number of Subscriber Lines

The number of subscriber line circuits of each exchange is to be determined on the basis of the forecasted demand, and the number of subscriber lines to be provided should be equal to or greater than the number of subscribers including party-line subscribers at the intermediate stage of the project.

The total number of subscriber lines of each exchange including the party line subscribers is shown in Table 6.4 below:

Table 6.4 Number of Subscriber Lines

Exchange	1996	2001	2006	2011
BEATRICE	614	658	667	955
KEZI	330	379	569	684
MURAMBINDA	261	487	626	826
NKAYI	223	396	456	550
GUTU	557	928	1,039	1,240
CHATSWORTH	265	363	442	593

6.8 Number of Trunk Circuits

The number of trunk circuits is determined from the forecasted traffic in Section 6.6 with Erlang-B loss table.
The number of trunk circuits to be provided to each exchange is as shown in Table 6.5.

Table 6.5 Number of Trunk Circuits

Trunk Circuit	1996	2001	2006	2011
BEATRICE - HARARE	35	42	45	53
HARARE - BEATRICE	30	35	37	42
KEZI - BULAWAYO	27	31	39	46
BULAWAYO - KEZI	24	27	33	38
MURAMBINDA - MUTARE	23	35	42	47
MUTARE - MURAMBINDA	20	29	35	38
NKAYI - KWEKWE	21	33	33	38
KWEKWE - NKAYI	18	28	28	32
GUTU - MASVINGO	50	67	77	79
MASVINGO - GUTU	42	53	58	59
* GUTU - CHATSWORTH	2M	4M	4M	4M
* CHATSWORTH - GUTU	2M	4M	4M	4M

*: Digital interface of 2M/4Mbps stream between the host exchange and its RLC.

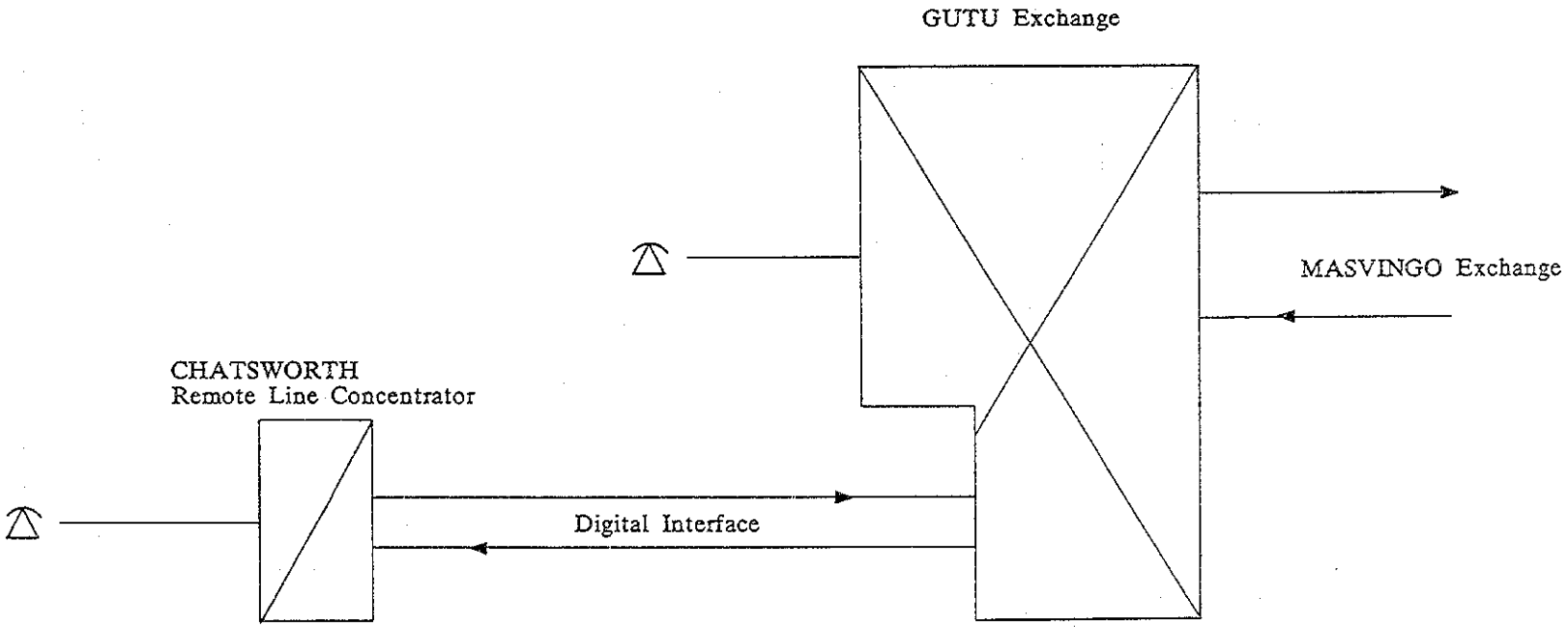
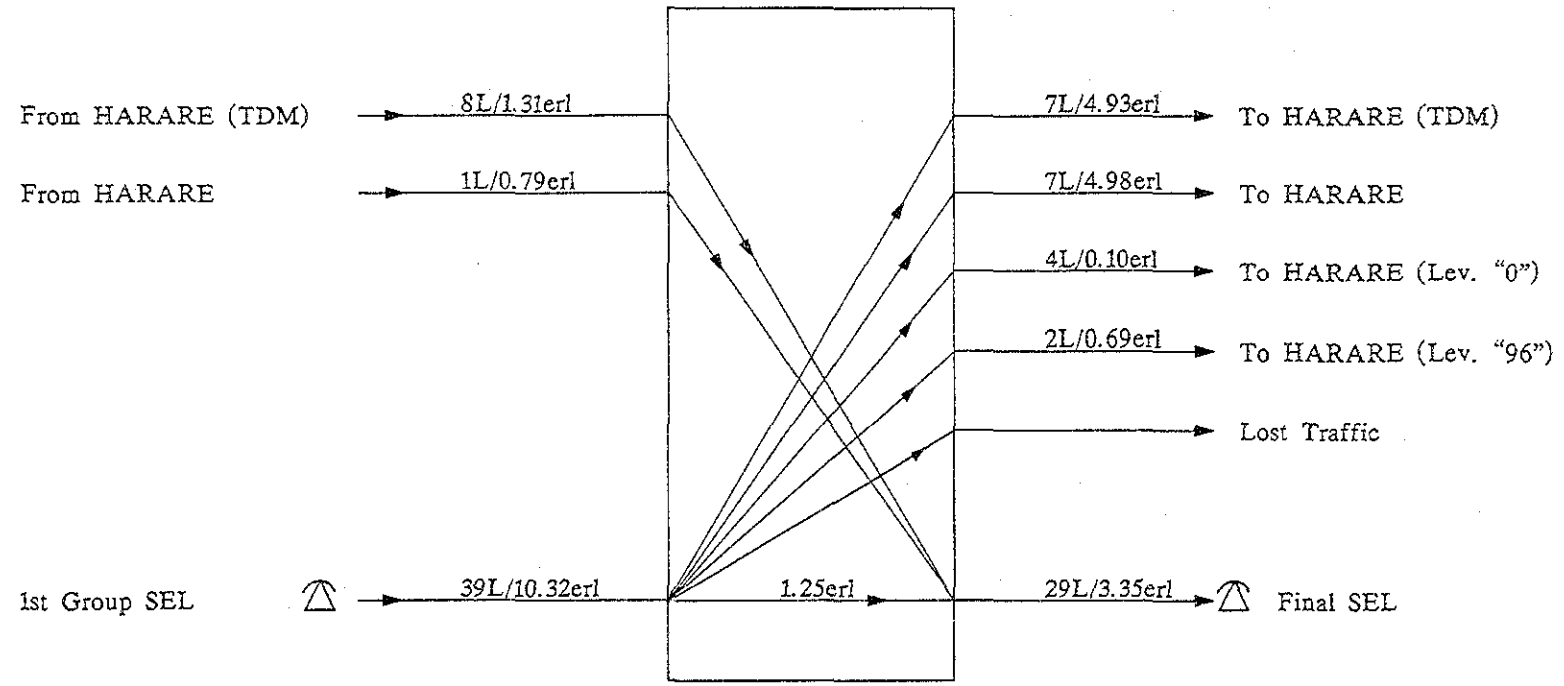


Figure 6.1 Configuration of Host Exchange and RLC

From the Data measured on the 7 Mar. 1990



(OG) Calling Rate (DEL's + EPL's +PCO's)

10.32erl/120L = 0.09erl/L

(IC) Called Rate (DEL's + EPL's)

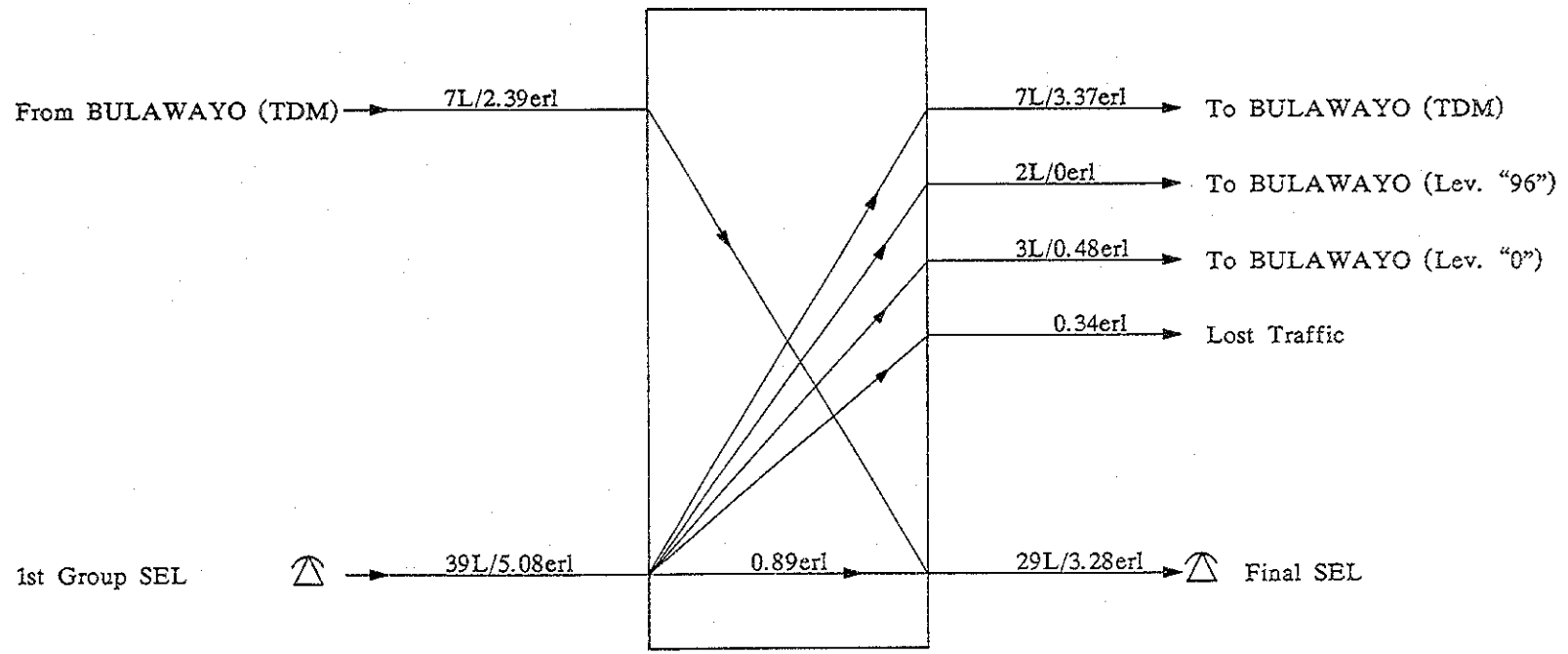
3.35erl/118L =0.03erl/L

Exchange Data

Working DELs	=	86 lines
Working EPLs	=	32 line (210 subs)
Working PCOs	=	2 lines
Spare	=	80 lines
Waiting DELs	=	44 lines
Total Capacity	=	200 lines

Figure 6.2 (1/4) BEATRICE EXCHANGE TRAFFIC FLOW DIAGRAM

From the Data measured on the 25 Jun. 1991



(OG) Calling Rate (DEL's + PCO's)

5.08erl/76L = 0.06erl/L

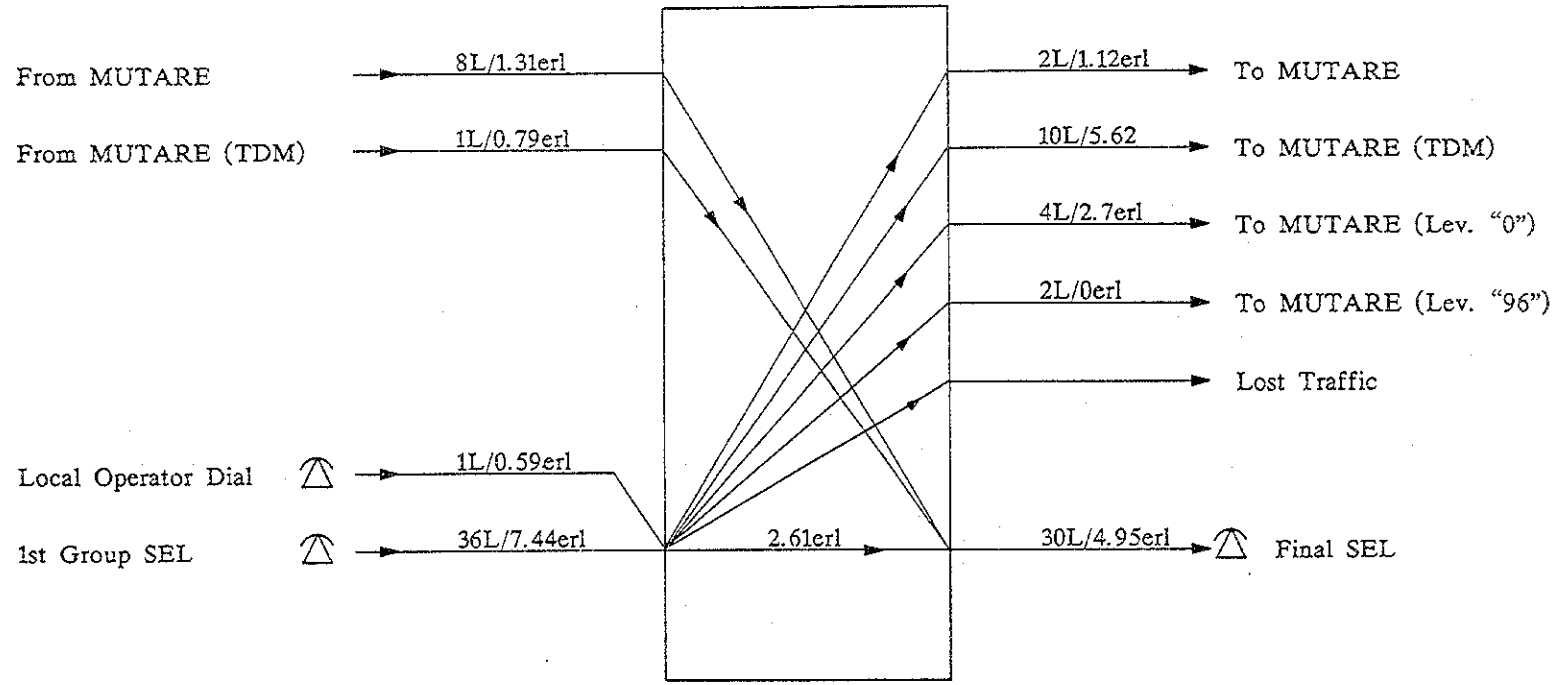
(IC) Called Rate (excluding PCO's)

3.28erl/74L =0.04erl/L

Exchange Data

Working DELs	=	74 lines
Working P/L	=	9 lines (Manual)
Working PCOs	=	2 lines
Spare DELs	=	115 lines
Waiting	=	24 lines
Total Capacity	=	200 lines

Figure 6.2 (2/4) KEZI EXCHANGE TRAFFIC FLOW DIAGRAM



(OG) Calling Rate (DEL's + +PCO's)

7.44erl/68L = 0.11erl/L

(IC) Called Rate (excluding PCO's)

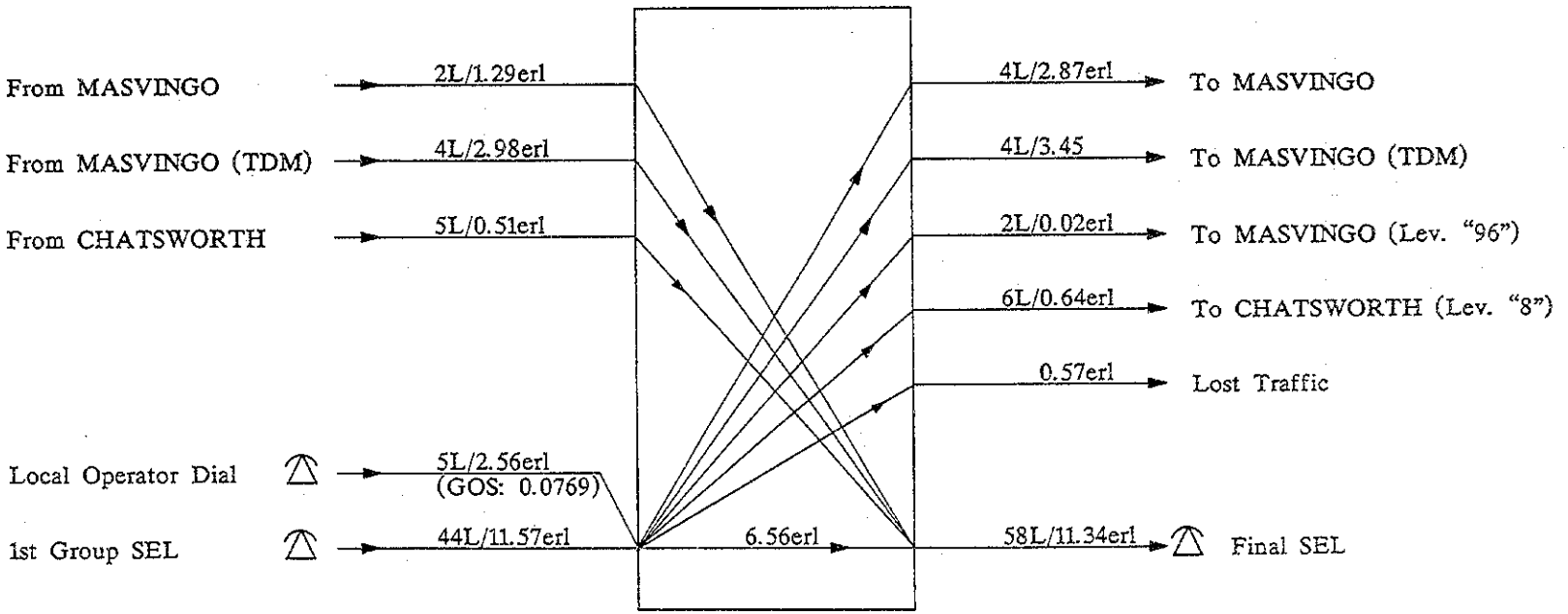
4.95erl/65L =0.08erl/L

Exchange Data

Working DELs	=	65 lines
Working PCOs	=	3 lines
Spare	=	110 lines
Waiting	=	153 lines
Total Capacity	=	200 lines

Figure 6.2 (3/4) MURAMBINDA EXCHANGE TRAFFIC FLOW DIAGRAM

From the Data measured on the 17 Jul. 1991



(OG) Calling Rate (including PCO's)

14.13erl/276L = 0.05erl/L

(IC) Called Rate (excluding PCO's)

11.34erl/274L =0.04erl/L

Exchange Data

Working DELs	=	260 lines
Working P/L	=	12 lines (128 subs)
Working PCOs	=	2 lines
Spare DELs	=	124 lines
Waiting	=	0
Total Capacity	=	400 lines

Figure 6.2 (4/4) GUTU EXCHANGE TRAFFIC FLOW DIAGRAM

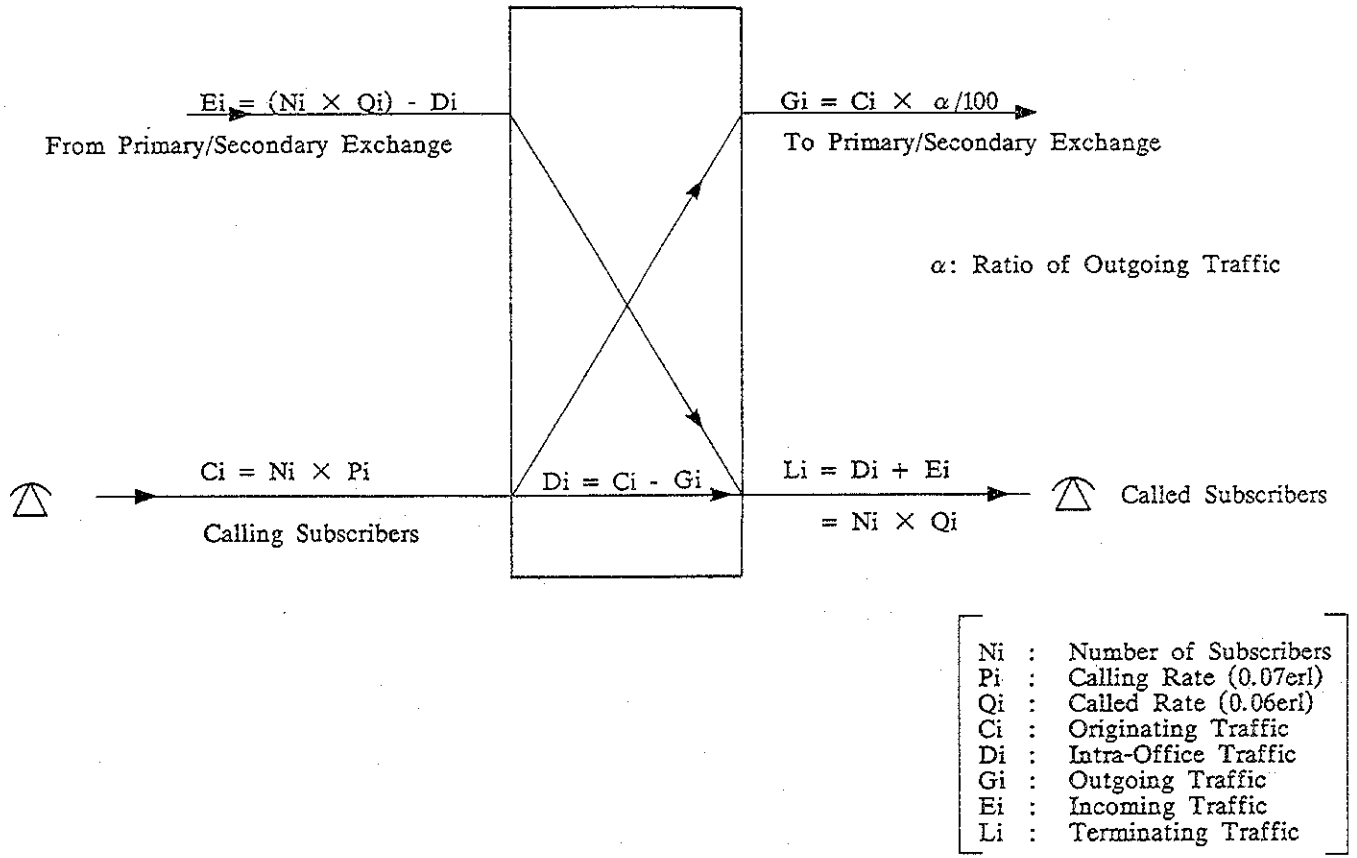


Figure 6.3 TRAFFIC FLOW OF EXCHANGE

SECTION 7

RURAL TELECOMMUNICATIONS NETWORK DEVELOPMENT PLAN

SECTION 7 RURAL TELECOMMUNICATIONS NETWORK DEVELOPMENT PLAN

7.1 Demand Fulfillment Plan

Telephone service in the rural areas is still insufficient in terms of both quantity and quality.
Telephone penetration in the rural areas concerned is in the range of 0.03 - 0.27 per 100 inhabitants which is very low compared with 13.2 per 100 inhabitants in major cities.

Currently, in providing subscribers' line, DEL connection is made mainly to the subscribers inside BRA, and P/L connection is being employed extensively for subscribers outside BRA to provide telephone services with less cost for the sparsely scattered subscribers in a vast area. There are many cases where nearly about 15 subscribers are connected on the same P/L served by manual switching, therefore such arrangement is causing heavy traffic congestion.

Telecommunication network development program is being implemented giving priority to urban or major cities. Consequently, the difference in telecommunication services would become wider between those major cities and rural areas.

In order to improve the above situation, the following basic concepts are to be applied for the development of the rural telecommunication network.

- To improve the services in both quantity and quality for supporting and enhancing the socio-economic activities and rural development program.

Targets for the rural telecommunication network development up to the year 2011 which is 15 years after the expected commissioning are set as follows:

a. To fully automatize telephone services,
b. To provide more DELs to government and other public offices,
c. To reduce subscribers on P/L and P/L itself,
d. To open more Public Call Offices inside BRA and outside BRA as well.

To realize the target mentioned above, the following strategies will be applied for telephone supply and network development.

7.1.1 Telephone Supply Strategy

- Supply of telephones other than public telephones is made taking into consideration the priority given to respective subscriber category groups as listed below:

Group	Priority Orders
Administrative group	Highest
Public group	:
Industrial/commercial group	:
Residential group	Lowest

- For the area within BRA, DELs are provided to all waiting applicants and more public telephones are provided,

- For the area outside BRA, DELs are provided at the initial stage only to waiting applicants of DEL and to existing P/L subscribers with high priority and those who play an important role in the community.

A large sum of investment might be required for installing subscriber lines to meet the telephone demand fully at once.
Therefore, for offices and applicants with lower priorities, DEL distribution is to be expanded gradually afterwards using alternative funding.

- In the initial stage, number of existing subscribers on the same P/L shall be reduced to a maximum of 6 by providing DEL to such subscribers with higher priority among those subscribers connected on the same P/L exceeding the maximum of 6.

Distribution of subscriber lines shall be made on a DEL connection basis for the new subscribers, and no more additional P/L with Electronic Party-Line (EPL) shall be considered for providing telephone lines.

Provision of DEL is made gradually for those party-line subscribers who do not get DEL at the initial stage and such provision would be

completed to all within 10 years, i.e., by the year 2006.

- In cases of subscribers terminated to the manual switch board, those subscribers shall be connected to an automatic exchange by providing new distribution lines. Currently, automatization of services is being considered by PTC for those subscribers by providing EPL, but with a maximum of 6 subscribers.

- Public Call Offices (PCOs) shall be provided at the initial stage in the premises of post office, hospital and clinic based on PTC's plan for opening public telephones. The plan was made taking into consideration accessibility to such telephones at any time and vandalism risk (mischief, thefts, etc).

After that additional PCOs shall be installed at newly established hospitals, clinics and/or business centres without PCO to increase availability of PCOs in rural areas, especially outside BRA.

7.1.2 Provisioning Period

- Capacity of respective systems to be introduced, such as exchange, cable/radio transmission system, power supply system, shall be decided considering not only the immediate requirements but also future requirements to economically establish the network in total.

- In principle, initial provision of telecommunications facilities shall be made to meet the 5 years ahead demand from the expected commissioning, i.e., the demand in 2001. Such an arrangement might be inevitable to expand the telecommunication services smoothly in the rural areas without heavy financial constraints.

Provisioning for further expansion would be appropriate if implemented every 5 years so as to avoid frequent expansion which may increase total costs for expansion work over the long period as labour costs may increase for completing such expansion.

7.2 Provision Strategies

To facilitate telecommunication facilities in economical manner as well as in a balanced manner with demand, sizing and expansion timing are dependent on the forecast of subscriber demand.

Provision of telecommunication facilities for each area is made 3 times in total for the project, i.e., in 1996, 2001 and 2006 based on the provisioning plan mentioned in the preceding paragraph.

Namely, the initial provision in 1996 is made based on the demand in 2001, and its expansion in 2001 and 2006 are made based on the demand in 2006 and 2011, respectively.

However, subscribers' line connection is provided gradually afterwards to meet with applications for telephone connection.

Introduction of new exchange system is planned to replace the existing exchange system. Therefore the new system should have capability of providing services not only for new subscribers but also for existing subscribers.

A surplus is to be included in the facility volume to cope with unexpected increasing demand as well as non-voice services requirements, like data service, facsimile service, as fairly long period is required for procurement of additional equipment and its installation.

The following are the expansion volume required in each 5-year period.

Exchange	Expansion Volume		
	1996-2001	2001-2006	2006-2011
BEATRICE	226(40*)/(559)	108/(667)	288/(955)
KEZI	127(40*)/(357)	212/(569)	115/(684)
MURAMBINDA	306(78*)/(487)	139/(626)	200/(826)
CHATSWORTH	179(41*)/(339)	103/(442)	151/(593)
GUTU	524(63*)/(892)	147/(1039)	201/(1240)
NKAYI	235(40*)/(396)	60/(456)	94/(550)
TOTAL	1597(302*)/(3030)	769/(3799)	1049/(4848)

It is anticipated that new subscriber line connections would be made by 1996 to some extent, but the volume would be small. Hence, increasing demand from the year 1991 to 2001 is considered as the expansion volume required in 1996.

Figure given in parentheses implies the total demand in 5 years ahead which includes existing subscribers.

Figure with * mark shows total number of subscribers connected on the same party line exceeding a limit of 6 (as of 1991) and subscribers served from adjacent exchange area(s) who will be converted to DEL subscribers in 1996.

7.3 Telecommunication Network Planning

7.3.1 Network Digitalization Plan

Digitalization of the telecommunications network in Zimbabwe is now in progress. Bulawayo, Masvingo and Gweru secondary exchanges have already been digitalized and are in operation.

In addition to the above, Mashonaland and Manicaland Digitalization Project, which includes Harare and Mutare secondary exchanges, is going on. New digital exchanges in Harare and Mutare are expected to be put in-service within 1992 and 1993, respectively.

The secondary exchanges mentioned above are to serve as parent exchanges of the respective terminal exchanges in the study areas, except Nkayi as listed below.

Terminal Exchange	Parent Exchange
Beatrice	Harare Secondary
Kezi	Bulawayo Secondary
Murambinda	Mutare Secondary
Gutu & Chatsworth	Masvingo Secondary
Nkayi	Kwekwe Primary

Kwekwe primary exchange being Nkayi's parent exchange is scheduled to be digitalized by 1994 in the PTC Plan.

The construction of trunk route between those terminal exchanges and their respective parent exchanges, except Kezi and Murambinda, are expected to be implemented either as part of national network digitalization program or to construct analogue links as an interim solution by PTC's own fund if no foreign fund is available, before the expected commissioning of the rural telecommunications network, i.e., by 1996.

7.3.2 Numbering Plan

The automatic terminal exchange in rural area, has a 3-digit local numbering plan in general, but party-line numbers work on an extended scheme.
According to descriptions in Chapter 5 of the Master Plan, telephone number should use a 7-digit scheme which consists of 2 digits for the office code and 5 digits for the subscriber number as shown below:

"**AB CXXXX**" where, "**AB**" : office code, "**CXXXX**" : subscriber number

The following numbering scheme will be used for subscribers in the study areas when exchanges are replaced by digital switching equipment.

Beatrice	:	65 CXXXX
Kezi	:	82 CXXXX
Murambinda	:	21 CXXXX
Gutu	:	30 CXXXX
Chatsworth	:	30 8XXXX
Nkayi	:	55 8XXXX

7.3.3 Routing Plan

In principle, one trunk route is sufficient for the section between a terminal exchange and its parent exchange as stated in Chapter 6 of the Master Plan, i.e., the establishment of an alternate trunk route is not required for exchanges in rural areas considering the number of subscribers and traffic volume.

As a result, the traffic routing plan is to be kept as it is for each exchange, as no necessity to change is foreseen in the present routing plan, even though changing of homing arrangement was suggested in the "Master Plan (1986-2005)" for Nkayi and Kezi in the future - for Nkayi the homing office is to be Bulawayo instead of Kwekwe, and for Kezi the homing office should be Figtree instead of Bulawayo.

A trunk route connecting to primary/secondary exchanges is not required for the Chatsworth exchange, because the introduction of Remote Line Concentrator (RLC), controlled by the host exchange at Gutu is recommended in consideration of small increasing demand in the future, numbering scheme, geographical conditions and socio-economic conditions, but a link connecting the RLC at Chatsworth and the host exchange at Gutu is required.

As a result of the demand forecast, a large demand increment is not expected in the Chatsworth exchange area within a 15 years period as shown in Table 5.12, and most subscribers are widely spread over the exchange area.

7.3.4 Grade of Service

In relation to the establishment of the rural telecommunications network, the following grades of services are to be applied for dimensioning the equipment as guidelines, which is considered as a standard by PTC for national network planning.

(1) Loss Probability

The internal point-to-point design blocking probability from any inlet to a selected free outlet is 0.002 for internal and 0.005 for both incoming and outgoing calls.

The grade of service on trunk circuits is to be better than 1 lost call in 100.

(2) Probability of Delay

Dial tone delay of less than 3 seconds for 97 % of the call attempts is prescribed under over loaded condition.

7.3.5 Transmission Plan

To ensure that subscribers in any part of the country are able to communicate with each other with adequate quality, the following design objectives which are specified in Network Planning Instructions, NP/005/X: "Transmission Plan - Loss Allocations", are applied for the study.

Overall Loudness Rating (OLR) for a national connection: 25 dB(Max)

SLR : 17 dB (Max) and 7.5 dB (Min), RLR : 8 dB (Max)

Transmission loss on Digital Loop	: 7 dB
Subscribers' line loss	: 8 dB(*)
Physical junctions loss	
for trunk or tandem junctions	: 5 dB
for direct junctions between local exchanges	: 10 dB

Loop resistance is to be less than 1000 Ohms for subscriber line.

(*): When a subscriber multiplexing system is introduced in the subscriber network, such as cable PCM, optical fiber cable system, radio transmission system, 5 dB loss at 800 Hz reference frequency can be allocated for 2-wire subscriber physical line connecting multiplex terminal equipment and subscriber, taking into account 3 dB of minimum transmission loss for 4-wire transmission section to eliminate the singing phenomenon.

The limits for the other impairments are to be in accordance with the Network Planning Instruction, NP/008/X; "Planning Performance of a Digital Transmission Network".

However, Bit Error Ratio (BER) performance objectives suggested in CCIR Rep. 380-3 are to be referred to as objectives in cases where digital Multi-Access Radio System (MARS) are introduced, to avoid excessive construction costs, namely the error performance for the local 64 kBit/s digital path with circuit lengths of less than 500 km shall not be

exceeded.

a) 1×10^{-3} for more than 0.05 % for any month (with integration time of 1 sec),
b) 1×10^{-6} for more than 1.5 % of any month (with integration time of 1 min),
c) 1×10^{-8} (residual bit error ratio).

7.3.6 Synchronization of Digital Network

Network synchronization is to be considered for rural network towards future ISDN, where digital exchanges and digital transmission lines are to be introduced, based on the standards in "The National Synchronization Plan for the Zimbabwe Network" which employs Master-Slave method, as the establishment of IDN at secondary and primary center levels of switching hierarchy is being implemented with a target year of 2000.

7.3.7 Introduction of Plan of New Services

Presently, telephone service is mainly provided through the public telephone network in the rural areas. While, telex and data services are also being provided for a limited number of subscribers in the areas. A data service is provided on leased point-to-point circuits.

Demand on non-voice services other than the above, e.g., facsimile service shall increase along with the growth of socio-economic activities in the future. Such non-voice services would be expected to be used by administrative and business sectors.

Currently, public facsimile services are being provided at Post Offices in major cities only, i.e., Harare, Bulawayo, Gweru, Kwekwe, Masvingo and Mutare, hence, the following telecommunications services will be considered in the rural telecommunication network in order to support socio-economic activities in the rural areas.

- Telephone service, Telex service, Data Communication service and Facsimile service

SECTION 8

PROPOSED RURAL TELECOMMUNICATIONS NETWORK DESIGN

SECTION 8 PROPOSED RURAL TELECOMMUNICATIONS NETWORK DESIGN

Proposed telecommunications network was formulated for each exchange area. Prior to formulating the network, an optimum system was selected for exchange system, transmission system and external plant taking various factors into consideration, such as geographical conditions, environment in the Study areas, procurement availability of equipment, trend of technologies concerned with telecommunications, etc.

8.1 Exchange System

8.1.1 Exchange Capacity

The exchanges where to introduce facilities and installation capacities in the period from the year 1996 to 2011 are as follows:

Number of Subscriber Line Units

Exchange	1996	2001	2006	2011
BEATRICE	650	700	700	1000
KEZI	350	400	600	700
MURAMBINDA	300	500	650	850
NKAYI	250	400	500	600
GUTU	600	950	1050	1250
CHATSWORTH	300	400	450	600

8.1.2 Type of Exchange System

Switching systems to be introduced for the exchanges except Chatsworth are of independent Digital type by the reason described in Section 8.1.6.

For Chatsworth exchange, a RLC (Remote Line Concentrator) with stand-alone function which belongs to Gutu host exchange is employed.

8.1.3 Basic Requirements for System

With regard to the basic requirements of switching systems, the top priority is to be compatible with the operational philosophy of digital telephone network. Beside, the switching systems are to be simple in construction and not to cost too much.

Basic requirements determined are as follows:

(1) Subscriber Circuit Accommodation

To accommodate not only ordinary subscriber circuits but also Public Call Office and PBX telephone circuits.

(2) Trunk Circuit Accommodation

To accommodate trunk circuits through digital interface with transmission bit rate of 2 MBit/s.

(3) Routing

To route to the parent exchange all the call except Intra-Office calls and part of special calls.

(4) Operation and Maintenance

To provide the undermentioned necessary minimum functions:

- Subscriber circuit and trunk circuit test
- Switching operation monitoring and test
- Switching systems fault alarm and fault information indication
- Traffic overload control
- Automatic measurement of traffic volume
- Switching service and charging observation
- Subscriber circuit and trunk circuit status modification
- Offering, circuit holding and re-ringing

8.1.4 Signalling

At the final stage of the digitalization of the telecommunications network in the country, CCITT No.7 signalling which is one of common channel signalling systems, will become common. However, before that, the transition of the signalling system from the conventional system to CCITT No.7 depends on the development of the telecommunication networks. The first No.7 signalling to be introduced for the backbone route will be between Harare and Bulawayo in accordance with the PTC plan and other

major routes will also employ CCITT No.7 in the future.

However, an optimum signalling system to be employed for the exchanges which will be installed in the Study areas, is R2 system which is a channel associated signalling system and by the reasons described below.

Completion of the telecommunication networks in the Study areas is expected in the late year 1996, however, CCITT No.7 will not become common at the terminal exchange level by that time. Features of the Common Channel Signalling Systems are:

- To transfer signals after establishing a speech path.
- To transfer signals in the reverse direction.
- To transfer signals which are not concerned with particular call and/or circuit.
- The high speed transfer of large volume signals.
- To transfer a variety of signals including not only usual signals for connection and observation but also other signals.

A large percentage is shared by a fixed portion of the cost of a common channel signalling system and the cost in proportion to the number of circuits is a small percentage of it, however, in the case of channel associated signalling systems, most of the cost is in proportion to the number of circuits, therefore, it is preferable to employ a R2 signalling system for the terminal exchanges in Rural areas, as it may not require a large number of trunk circuits and to transfer a large volume and variety of signals.

8.1.5 Charging Method

The most common current charging method in rural exchange areas is the metering system, however, as a result of introducing digitalized networks, more suitable and sophisticated systems can be employed.

Charging data recorded on a magnetic tape from each exchange is currently processed by the PTC's Computer Bureau. In consideration of unification of the charging method in the whole country, an optimum charging method to be introduced to the exchanges in the Study areas is

as follows:

- The charge determination and charge recording for all types of calls (Local, Trunk and International) are performed in each terminal exchanges.
- A bulk method is applied to charge local calls.
- A detailed charging method is applied to trunk and international calls.
- The magnetic tapes with recorded charging data at the exchanges are processed by the PTC's Computer Bureau.

8.1.6 Choice of Exchange System

There is a choice among exchange systems such as conventional Step-by-Step, Cross-bar, and sophisticated digital switching systems.
In order to select an optimum system, a comparative study of such systems has been carried out taking into consideration the following points.

(1) Procurement Availability

(Step-by-Step):
No longer manufactured but most parts are available secondhand from abroad and from existing exchanges in the country.

(Cross-bar):
Manufacturing in most of countries has already stopped, but secondhand equipment may be imported from abroad.

(Digital):
Easily available system world-wide.

(2) Cost

(Step-by-Step):
Much Strowger equipment will become idle as existing exchanges are digitalized in the country, and the salvage values of these equipments are low.

(Cross-bar):
Much higher than Step-by-Step but secondhand equipment costs are lower than Digital.

(Digital):
Higher than the other conventional systems.

(3) Quality

(Step-by-Step):
Occurrence rate of noise and some kind of problems caused by loose contact with a switch and/or a relay are higher than with digital systems, because this type of equipment consists of many mechanical parts.

(Cross-bar):
Almost the same as Step-by-Step.

(Digital):
Extremely good.

(4) Function

(Step-by-Step):
Basically dialling pulses are absorbed at each operation step and there is no function to transfer the calling subscriber number to the other exchanges, therefore the introduction of new services and functions is difficult.

(Cross-bar):
It is not very difficult to introduce and/or add new services and functions, however, in order to do that, additional hardware should be procured.

(Digital):
Availability of new services and functions is much higher than with other systems.

(5) Operation and Maintenance

(Step-by-Step):
It is not so easy to compare with digital systems, because, there are many mechanical parts.

(Cross-bar):
Almost the same as Step-by-Step.

(Digital):
The system has a self diagnostic function which always observes the operating conditions of the system. Operation and maintenance is much easier than with other systems.

(6) Floor Space for Equipment

(Step-by-Step):
Large floor space is required and in the PTC standard type of exchange building for rural exchanges, it is possible to accommodate a maximum of 800 subscriber lines.

(Cross-bar):
Large floor space is required, although it is less than that required for Step-by-Step.

(Digital):
Much less than Cross-bar and Step-by-Step.

(7) Network Development Trend

In order to improve telecommunication quality and to meet a variety of new service demands and ISDN in the future, digitalization of telecommunication networks is a common trend throughout the world, and conventional systems are being replaced by digital systems.
In ZIMBABWE, the digitalization program is in progress such as Mashonaland and Manicaland Digitalization Project and there are some plans to digitalize the existing telecommunication networks.

In consideration of the above, it has been decided that the optimum exchange system to be employed for the Study areas is the digital exchange system.

8.1.7 Exchange Building

In the Study areas, there are existing exchange buildings which have accommodated MDF, switching and transmission equipment, and each building still has some space for extra equipment. In the initial stage of facility provision from the year 1996 to 2001, a limited floor space only will be occupied by the equipment for several hundred of subscribers, therefore, in principle, no new accommodation is required to be built for the new exchanges, except at Maphisa where new exchange office is to be established. For the new exchange building, air-conditioner is to be facilitated in the exchange room.

8.1.8 Conditions of Exchange

The configuration and functions of equipment in an exchange are based on the result of the forecasted demand and traffic, CCITT's recommendations, PTC's standards and some other data.
The basic figures of demand and traffic to be used for a determination of an exchange system to be introduced are those for the year 2001, however, capabilities to be given to the exchanges should be decided in consideration of the forecasted demand and traffic in the year 2011.

In principle, the exchange system to be introduced into each Study area is an independent digital exchange. But for Chatsworth exchange area, RLC (Remote Line Concentrator with stand-alone function), controlled by Gutu host exchange would be appropriate in consideration of increasing future demand, the numbering scheme, the geographical conditions, and the economic conditions.
RLC is deemed to be a part of a host exchange and extended Subscriber Line Circuit. The concept is shown in Figure 6.1.

The required conditions of each exchange should be determined depending on the circumstances of the specific exchange area and network configuration.

8.2 Transmission System

For the planning of rural telecommunications network as well as trunk transmission system, selection of transmission system to be adopted and the transmission route selection are the two prerequisites. The following are the studies of these two prerequisites, and the transmission system planning, as well as the basic designing, based on such study findings.

8.2.1 Transmission System Selection

The transmission system to be used in the current plan is the one employing digital technique, i.e., subscriber multiplexing system on PCM cable for the cluster with a relatively large demand and Multi-Access Radio System for the area sparsely populated outside BRA in the rural telecommunication network, and a digital radio transmission system for trunk transmission route connecting terminal exchange and its parent exchange. Refer to the Figure 8.1, "Network Configuration Plan" and Figure 8.2, "Configuration of MARS Network".
The systems to be used are selected taking the following aspects into consideration.

(1) Subscribers' Line

Subscribers' lines in rural telecommunications network, commonly use the undermentioned;

- Pair cable and open-wire
- Cable PCM link
- Digital radio link
- Multi-access radio system (MARS)

In selecting an optimum transmission media for the rural telecommunications network, construction cost comparison was made for the 9 conceivable rural telecommunications networks, patterns given in Figure 8.3 (1/3), using distance from terminal exchange and number of subscribers as parameters. The results appear in Figure 8.3 (2/3-3/3), "System Selection Diagram for Rural Telecommunications Network" and "System Selection Diagram for Transmission Network".

The selection diagram presents standard scope of selection. In some parts, it is subject to change depending on location. Nevertheless, it was used as a guideline when basic plan was being established.

Subscriber multiplexing systems on cable PCM links and digital radio links are appropriate media for providing subscribers' lines to rural exchange areas. As shown in the diagram for Rural Telecommunications Network, subscriber multiplexing systems on a cable PCM system is a more economical media than the radio system when the distance between a telephone exchange and a cluster with a relatively large demand is 16 km or less.

In order to cater for wide-spread remote subscribers outside BRA, digital MARS is one of the adequate systems for use in rural telecommunications network, which has been introduced already to other rural exchange areas in the country, hence, these 2 systems, subscriber multiplexing system on cable PCM and MARS are selected as an optimum system to be applied for the rural telecommunications network.

Actual topographical conditions are to be considered in the selection of the system to be introduced, as construction costs vary widely depending on such topographical conditions along the cable route or at radio repeater sites.

(Possible Alternative Media):

While, adoption of a similar system to the Cellular System (namely, use of portable telephone set instead of ordinary telephone set, not requiring physical subscriber line and hand-off function) can be considered, introduction of this system was not considered in the current plan taking the following aspects into account.

- Difficulties may arise in covering the whole exchange area with the limited number of base stations owing to obstacles in the area, such as trees, mountains, hills, etc. Radio signals are attenuated greatly by these obstacles, especially in the area where trees are densely grown or just behind mountain or hill. Such area is so-called "blind area" and circuit performance may deteriorate in such area. To secure such blind areas, additional facilities, such as base repeater

station, booster station are to be required.

- Coverage area with one base station will not be as large as the one for the ordinary cellular system as transmitting output power of the portable telephone set is low compared with terminal set used for mobile telephone system, and besides that penetration loss to building is to be considered as such portable telephone is usually used inside building. This may necessitate increasing the number of base stations.

- Difficulty is also anticipated in maintaining batteries required for the portable telephone set since commercial power supply necessary for charging the battery is available only at limited locations in rural areas.

- Cell splitting becomes necessary in the future to cater for the increasing demand. Construction cost required at the initial stage would be kept at a relatively low level, however an additional cost becomes necessary for constructing such additional base stations required for cell splitting.

Besides the above, radio system (digital or analog) having single channel or a few channels is also available for providing subscriber lines to remote subscribers, which can be established at a relatively low cost. Adoption of this system was not considered in the current plan. However, introduction of the system is to be considered based on the findings in the course of detailed design.

(Outline of Digital MARS):

The following is an outline of digital MARS currently available on the market.

Radio frequency	:	1.5/2.4/2.6 GHz Band
Transmission capacity	:	2/4 MBit/s
Max. no. of subscribers	:	- 270 with 2 MBit/s transmission capacity. - 540 with 4 MBit/s transmission capacity. In the case of loss probability of 0.01 and an average traffic of 0.07 Erl./sub.

Access system : DAMA (Demand Assigned Multiple Access)

Digital MARS is composed of a radio subscriber terminal to accommodate subscribers, repeater stations which can facilitate the same function as the subscriber terminal and a base station to be set up in a terminal telephone exchange. Operating status of an entire MARS network can be monitored by the centralized supervisory system to be introduced at the base station.

According to the demand forecast result, one digital MARS with 2 MBit/s transmission capacity which is popular on the market is able to cater for the demand in 2006 in each area, however, addition of system becomes necessary afterwards in each area to cater for increasing demand.

Therefore, introduction of a system with 4 MBit/s capacity is considered in the study, as a big difference is not anticipated in the costs for 2 MBit/s and 4 MBit/s systems.

A radio frequency band of 1.5 GHz band is preferable, which is allocated for the existing digital MARS in the other rural exchange areas.

For local line distribution, pair cable is mainly used, however open-wire is also to be utilized alone or in combination with pair cable to cater for distant subscribers from such remote subscriber multiplex terminals and/or MARS terminals. It should be noted that subscriber line loop resistance is to be kept within the permissible limit of the system. The permissible limit of the MARS currently available on the market is 900 ohms maximum.

(2) Trunk Circuit:

The Provision of the trunk systems or an increase in the number of circuits on the (Murambinda-Mutare) and (Kezi-Bulawayo) sections is required in order to meet the increasing circuit requirements.

To cope with such a situation, it is preferable to establish digital trunk circuits for those routes in conformity with the PTC's network expansion policy and also to improve service quality.

Increasing the number of circuits on the existing open-wire carrier system was eliminated as difficulties are envisaged in obtaining spares on the market in the future. Transmission media fit for trunk line are cable PCM system including optical fiber cable systems and digital radio systems.

As seen in Figure 8.3 (3/3), a digital radio system is economically the most advantageous from among those 3 systems since the length of both trunk routes exceeds 100 km, therefore, digital radio system is selected as an optimum system to be applied for trunk route.

According to traffic study result, three 2 MBit/s PCM lines and four 2 MBit/s PCM lines are required in total for the telephone services on each trunk route to meet with circuit requirements in 2001 and 2011, respectively.

In addition to the above, another 2 MBit/s PCM line is required on each trunk route to cater for non-voice services, e.g., data communication and telex service assuming the permanent circuit assignment of 64 kBit path for those non-voice services, therefore, introduction of a system having 17 MBit/s or 34 MBit/s transmission capacity is required to meet the circuit requirements in 2011 for both sections.

Considering further expansion of telecommunications network to other areas with relatively low cost, introduction of radio system having 34 MBit/s capacity and operating in 2 GHz band is considered in the study.

However, radio frequency band for trunk transmission systems shall be reconsidered at the time of detailed system design taking into account PTC radio frequency assignment policies reflecting the resolutions made in WARC/92 (World Administrative Radio Conference held in 1992 at Malaga-Torremolinos), so as to avoid radio interference problem with future satellite communication system.

For such digital transmission system, remote supervisory and control system is to be provided to limit the number of maintenance personnel to a minimum.

The construction of digital transmission systems is expected for (Nkayi-Kwekwe), (Beatrice-Harare) and (Chatsworth-Gutu-Masvingo) sections to be implemented as a part of the national network digitalization program in time with the expected commissioning of the rural telecommunications network.

The transmission systems planned for those respective sections are able to provide enough number of 2 MBit/s lines for the rural telecommunication system as shown below.

Section	Transmission Capacity	2 MBit/s Lines Required		
		2001	2006	2011
Beatrice - Harare	Optical Fiber 140 MBit/s	(5)	(5)	(5)
Nkayi - Kwekwe	Digital Radio 34 MBit/s	(4)	(4)	(4)
Gutu - Masvingo	Digital Radio 34/140 MBit/s	(6)	(6)	(6)
Gutu - Chatsworth	Digital Radio 34 MBit/s	(5)	(5)	(5)

Note:
Figure in parentheses shows the number of 2 MBit/s lines required for telephone services and non-voice services for which one 2 MBit/s line is assigned.

The Harare-Gweru-Masvingo backbone trunk transmission system (140 MBit/s) can be utilized as the trunk circuits required for both (Harare-Beatrice) and (Masvingo-Gutu) sections.

Both spur routes to Gutu and Chatsworth branch from Chatsworth Repeater on the backbone trunk route mentioned above. The repeater is located in-between Gutu and Chatsworth.

Therefore, eleven (11) 2 MBit/s lines are required at a maximum for the section between the repeater and Gutu to cater for traffic to/from Chatsworth and Masvingo. It is planned to construct cable system for the section between the repeater and Chatsworth exchange.

8.2.2 Transmission Route Selection

(1) Transmission Route Selection

For the transmission route selection, the following basic items are to be considered:

a) The selected transmission system (the system selection is described in item 8.2.1) is to be compatible with the technical requirements, including the radio propagation requirement, on the transmission route.

b) The radio station sites are to be in the village environs and besides public road as much as possible and through repeaters required in the network are to be reduced to a necessary minimum.

c) The subscriber terminal sites are to be selected at the centers of populated area, in principle.

The transmission route plan selected in due consideration of the foregoing basic items appears in Figure 8.4 (1/6-6/6) for rural exchange areas and in Figure 8.5 (1/2-2/2) for trunk routes, respectively. And number of stations to be established in each exchange area is summarized in Table 8.1.

The profile map of each hop of the transmission route is given in the separate book, "DATA FILE". This transmission route plan is mainly formulated based on the desk work using maps of a scale of 1:50,000. Therefore, at the time of project implementation, the route plan must be modified where necessary, based on findings in more detailed investigation and studies including field survey.

Table 8.1 No. of Stations to be Constructed in Each Exchange Area

Type of Station	No. of Stations						
	NKI	GTU	CHT	KEZ	BTR	MRB	Total
(MARS)							
Base Station	1	1	1	1	1	1	6
Terminal Station	13	8	7	10	12	14	64
Repeater Station							
- with Sub. Unit	5	1	2	8	3	8	27
- without Sub. Unit	1	1	1	-	-	-	3
(Cable PCM)							
Sub. Terminal Station	1	5	2	-	5	-	13
(Trunk Transmission System)							
Terminal Station	-	-	-	1	-	1	2
Repeater Station	-	-	-	2	-	3	5

(Note) Sub. : Subscriber

Existing stations are not included in the above figures, where additional trunk transmission system is installed under the current plan, i.e., Syringa repeater in Kezi, Cecil Kop repeater and Mutare parent exchange in Murambinda. Trunk transmission system comprises of 3 radio hops for Maphisa-Syringa section and 5 hops for Murambinda-Mutare section, respectively as shown in Figure 8.5 (1/2-2/2). Channel accommodation plans for these to trunk transmission route are shown in Figure 8.6 (1/2-2/2).

8.3 Cable and External Plant

External plant for the local cable network expansion in the Study areas are planned based on the following concepts;

8.3.1 Objective Area

Objective area is a whole exchange area in the Study areas.
Refer to Figure 5.1, "Exchange Area".

8.3.2 Provisioning Period

In order to avoid repeated expansion work and heavy financial constraints, the initial provision of external plant facilities is made to meet the 10 years ahead demand after the expected commissioning year, i.e., the demand in 2006 which are listed below.

The Demand in 2006 for Study Area

Exchange	Total Demand	In BRA	Outside BRA
CHATSWORTH	442	136	306
GUTU	1,039	777	262
BEATRICE	667	226	441
KEZI	569	334	235
NKAYI	456	215	241
MURAMBINDA	626	259	367
Total	3,799	1,947	1,852

8.3.3 Structure of Cable Network

Cables to be used for local cable network in the Study areas are selected from among aerial cables including open-wire, direct buried cables, and ducts cables. These cables are used for local line distribution within BRA as well as outside BRA, i.e., from exchange to terminal blocks for the subscriber line distribution point within BRA, and the remote multiplex terminal which is connected to exchange through a cable PCM system or a multi-access radio system (MARS) and terminal blocks outside BRA.

A new local cable network is to be constructed, however, the existing open-wire network providing party-line services is to be maintained until all existing party-line subscribers are transferred to DEL which is planned to be completed within 10 years from the expected commissioning of the network, i.e., by 2006.
Refer to Figure 8.1, "Network Configuration Plan".

(1) Distribution System

Distribution system of the study areas should apply the direct wiring system considering the telephone demand size and existing system in both inside and outside BRA.

(2) Cable Route

A cable route should be selected carefully to avoid damage due to natural disaster, difficulty of accessibility for maintenance purposes, relocation of the route owing to regional development plans, such as expansion of road width, etc.

(3) Uni-Gauge System

The uni-gauge system is to be employed for local line distribution network as much as possible, in order to simplify cable procurement, installation, storage and maintenance of facilities.

In accordance with the transmission plan stated in item 2.1.5, permissible attenuation loss and loop resistance for external plant are 8 dB (at 800 Hz) and 1,000 ohm at maximum, however, those limitation are 5 dB (at 800 Hz) and 900 ohm respectively when MARS is applied.

The maximum cable length applied to uni-gauge system is as follows;

Gauge Size (mm)	BRA (km)	Outside BRA (km)
0.4	3.6	2.2
0.5	5.8	3.8
0.65	7.2	4.5
0.9	8.0	5.0
2.64 (open-wire)	46.5	41.6

(4) Cable Type

As per PTC's standard, conduit cables are polyethylene (PE) insulated and conductors of annealed copper arranged in unit twin form.
Direct buried cables are the steel armored type, while the rest have a polyethylene outer sheath.
The cable cores are either dry or jelly filled to prevent water ingression and pressurization is to be applied on all the dry cables.
The aerial cables are of the self-supporting type with a galvanized steel wire strand.

The number of cable pairs to be applied in this study is as follows;

Cable Type	Gauge : Number of Pairs
Conduit	0.4 /0.5 : 400, 500, 600, 700, 800, 1000, 1200
	0.65/0.9 :
Direct	0.4 /0.5 : 10, 20, 30, 40, 50, 70, 100, 200, 300
	0.65/0.9 : 400
Aerial	0.65/0.9 : 10, 20, 30, 40, 50

(5) In the BRA

Aerial cable installation methods are used in principle, however, duct/direct buried cable installations are also employed to install a cable with large number of pairs for which aerial cable is not applicable technically considering the cable size and environmental conditions of the area as well.

(6) In the Outside BRA

Aerial cable is used to connect between remote subscriber multiplexing terminals and subscribers, in principle.

Open-wire is used either in combination with aerial cables or without any cable for distant subscribers to keep line loss and loop resistance within the limits specified in the transmission plan.

(7) Cable to be used for Cable PCM System

Aerial cable, with polyethylene (PE) insulated and shielded by aluminum screen, is to be used for cable PCM systems (30 channel) for the section between the Terminal Exchange (TE) and the Remote subscriber multiplex terminal.

The number of cable pairs is determined by the following formula;

Number of systems >= (Expected demand in 2006 year)/30 (channel)

Number of cable pairs = (No. of systems) x 2 + (Spare pairs)

Spare pairs are utilized for providing alarm circuits, monitoring circuits, order wires, subscriber connections along the route and spare PCM systems.

8.3.4 Utilization of Existing Facilities

Existing facilities such as poles, open-wires are to be utilized as much as possible in order to minimize the construction costs.

8.3.5 Proposed External Plant in the Study Areas

Applying preceding concepts, work volume (Main items only) including respective supporting facilities of proposed external plant in each Study area is as follow. Refer to Figure 8.7 (1/6-6/6) Local Cable Distribution Plan in BRA.

(1) Termination of Cable to the Exchange

Total number of distribution cable pairs to be terminated on the MDF (Main Distribution Frame) to cater for inside BRA subscribers to meet the demand in 2006 is estimated based on the cables used for distribution of lines from the exchange. The figure is mentioned below,

Exchange	Demand in BRA	No. of Pairs
NKAYI	215	400
GUTU	777	1,200
CHATSWORTH	136	400
KEZI	334	600
BEATRICE	226	400
MURAMBINDA	259	400

(2) Conduit Cable and Duct System

Duct system is applied for the section between the cable entrance point at exchange building and the nearest point of main road.
And construction of four way ducts is recommended for these sections in order to accommodate the entrance cable mentioned in item a) above and the consideration of future expansion and maintenance.
For the study purposes, the length of duct section is estimated at about 30 m for each exchange.

Exchange	M/H	Duct Nos.	Length	Cable	Length
NKAYI	1	4 WAY	30 m	0.5- 400	50 m
GUTU	3	4 WAY	370 m	0.5-1200	400 m
CHATSWORTH	1	4 WAY	30 m	0.5- 400	50 m
KEZI	1	4 WAY	30 m	0.5- 600	50 m
BEATRICE	1	4 WAY	30 m	0.5- 400	50 m
MURAMBINDA	1	4 WAY	30 m	0.5- 400	50 m

(3) Direct Buried Cable

Direct buried cables are installed inside BRA. Connection with the conduit cable is to be made in manhole at one end and on terminal blocks installed on either wall of buildings or poles at the other end for distribution of subscriber lines.
Work volume is estimated by the BRA demand in each exchange.

Exchange	Unit	Number of Cable Pairs						
		10	20	30	50	100	200	Total
NKAYI	(km)	-	-	2.5	0.5	1.0	-	4.0
GUTU	(km)	-	-	-	5.5	1.0	5.0	11.5
CHATSWORTH	(km)	-	-	1.0	-	0.5	0.2	1.7
KEZI	(km)	-	-	-	-	0.8	1.3	2.1
BEATRICE	(km)	-	-	2.0	2.0	1.0	1.0	6.0
MURAMBINDA	(km)	-	-	1.0	1.0	1.0	0.5	3.5
Total	(km)	-	-	6.5	9.0	5.3	8.0	28.8

(4) Aerial Cable

Aerial cables are applied for inside and outside BRA.
In the inside BRA, aerial cables are applied to the area where subscribers are sparsely scattered and distant from an exchange, and the cables are connected with direct buried cable/conduit cable from the exchange at one end and terminal block at the other end for subscriber distribution lines.

As for the outside BRA, all distribution cables apply the aerial cables considering economic aspects. The cables are installed for the section between the subscriber multiplexing terminal station to terminal block for subscriber distribution lines.
However, conductor gage of the cable is to be 0.5 mm for the inside BRA and 0.9 mm for the outside BRA respectively, considering the limitation of attenuation loss and loop resistance of cables.

For the study purposes, the work volume of aerial cables to be installed inside BRA of each exchange is estimated by the area demand and conditions.

In the outside BRA, the work volume is estimated by the specific cable size calculated by the area demand and a 6 km total to be installed at each terminal station.

Conductor Size		Number of Cable Pairs								
		0.9 mm			0.5 mm					
Exchange	Unit	10	20	30	10	20	30	50	100	Total
NKAYI	(km)	108	-	-	2	1	4	-	-	115
GUTU	(km)	42	42	-	-	-	4	10	2	100
CHATSWORTH	(km)	-	33	33	11	2	-	-	-	79
KEZI	(km)	102	-	-	-	-	5	6	-	113
BEATRICE	(km)	-	60	60	-	-	3	8	-	131
MURAMBINDA	(km)	66	66	-	6	8	2	3	-	151
Total	(km)	318	201	93	19	11	18	27	2	689

(5) Open-Wire

Open-wires are used outside BRA only in the case that the subscribers line loss exceeds the transmission loss limitation using cable with maximum conductor gauge, in principle.
The work volume of open wire assumes a 3 km total construction at each terminal station.

The material of open-wire shall be supplied by the project, but construction of open-wire facilities are to be implemented by PTC at its own responsibility, as such construction is a kind of drop-wire installation.

Exchange	Unit	Per Circuit
NKAYI	(km)	54
GUTU	(km)	42
CHATSWORTH	(km)	33
KEZI	(km)	54
BEATRICE	(km)	60
MURAMBINDA	(km)	66
Total	(km)	309

(6) PCM Cable for Subscriber Multiplexing System

Work volume of PCM cable installation is estimated by the distance along the road from exchange to subscriber multiplexing terminal station.

Exchange	No. of Sections	Length (km)
NKAYI	1	13
GUTU	6	70 *
CHATSWORTH	3	45 *
KEZI	-	-
BEATRICE	5	80
MURAMBINDA	-	-
Total	15	208

Note: Figure with * mark indicates total cable section length including one cable PCM section between exchange and repeater required for MARS.

8.4 Power Supply Systems

Primary power sources for telecommunications system are of three kinds. They are commercial power, engine-generator and solar power.

At present, commercial power supply is available at limited locations in rural areas in Zimbabwe although an electrification program is being implemented, hence, the undermentioned 2 types of power supply systems are recommended for the rural telecommunications networks considering easy operation and maintenance.

Power Supply Systems for Rural Telecommunications Network

Facilities	Primary Power	Standby Power
Exchange/Base St.	Commercial Power	E/G+Battery
MARS Repeater	Solar Power	Battery
MARS Terminal	Solar Power	Battery
Terminal St. for Cable PCM	Solar Power	Battery
Radio Repeater on Trunk	Solar Power	Battery

E/G : Engine-Generator

Provision of portable type of engine-generator is required in each exchange area for maintaining the stations where solar power system is employed, since most of test equipment operate with AC power.

Installation plan applied for power supply facilities are as under.

(1) For power supply facilities of exchange/base station, new power supply system, i.e., the battery full-floating system with engine-generator as a standby unit is to be provided under the current plan at Maphisa and Murambinda exchanges where commercial power is available.

The existing facilities or the facilities to be prepared by PTC are to be utilized at other exchanges/base stations. However, provision of rectifier and battery is to be made under the current plan for the rural telecommunication system at the 4 stations listed below:

- Beatrice, Nkayi, Gutu and Chatsworth terminal exchanges

(2) For the stations for subscriber multiplexing system (cable PCM and MARS) and trunk transmission system, solar power supply system is to be newly installed under the current plan. The solar power system is to be designed referring to the solar radiation intensity data. Shown below is the data taken at Bulawayo area.

Average Solar Radiation Intensity in Langlay

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Radiation	548	512	540	497	445	396	423	491	540	562	540	501	500

When tilt angle of 20 degrees is considered for solar panel installation, average sunshine intensity becomes at approx. 535 in langlay ($cal/cm^2/day$).

Autonomy of the battery is to be 5 days or more taking the initial cost and life-span of the battery. 7 days of autonomy is to be considered for the power supply system of MARS, and 10 days, for trunk transmission system.

(3) For the repeater stations of MARS at Chatsworth and Gutu where trunk transmission systems are installed, power supply system provided for trunk transmission system is to be used for MARS.

Power supply system to be introduced is summarized in Table 8.2.

Table 8.2 Power Supply System to be introduced in Each Exchange Area

Power Supply System	No. of Stations						
	NKI	GTU	CHT	KEZ	BTR	MRB	Total
(Solar Power System)							
MARS	19	9	10	17	15	21	91
Cable PCM Sys.	1	5	2	-	5	-	13
Trunk Transmission Sys.	-	-	-	2	-	3	5
(Full Floating System with Stand-by E/G)							
Exchange/Base Station E/G, Rec. & Batt.	-	-	-	1	-	1	2
Rec. & Batt.	1	1	1	-	1	-	4

(Note) E/G : Engine-Generator

8.5 Antenna and Antenna Mast

8.5.1 Antenna

For antenna to be adopted in MARS, omni-directional antenna and directional antenna, Yagi/horn/grid parabolic antenna are to be used at the base station and the subscriber terminal station, in principle.

However, the grid type parabolic antenna is to be adopted for the section where high gain is required to meet the circuit requirement, while the grid type of antenna is to be used for trunk transmission circuit.

To determine the required antenna height, the prerequisite is to know the atmosphere refraction index inclination that exerts a great influence on radio propagation characteristics. However, detailed data is not available for these areas. Therefore, the following requirements are to be considered for determining the antenna height:

For MARS system, clearance factor (U) is to be 0.6 or more under effective earth radius factor (K) of 4/3.

While, for trunk transmission system, U is to be 0.3 or more under K=2/3, which is to be considered in addition to the above requirement, and whichever is the higher is to be adopted as the antenna height.

In consideration of arboreal growth on the propagation path and buildings in the neighborhood of the proposed site, the antenna height is to be at least higher than given below.

- In the case of site located in city area : 20 m
- In the case of site located in town/village and on flat land: 15 m

8.5.2 Antenna Mast

For antenna mast, the top requirement is to endure the maximum wind load of 130 km/hour which is applied for antenna mast designing in PTC. Furthermore, to facilitate the erection work and to reduce the erection work cost, the tower of lightest possible weight and lowest possible price is to be introduced.

A self-supporting tower is to be used for both MARS and trunk transmission system, in principle. However, in case antenna mast height is 25 m or less, steel pole is to be adopted for subscriber terminal station of MARS system, and a guyed type of antenna mast is to be considered for MARS repeater/terminal stations where considerably high mast is needed to give the necessary path clearance.

All towers to be newly constructed must be provided with lightning conductor and grounding. Antenna mast with height of 45 m or more must be provided air-craft warning light and painting.

The antenna mast height and type, determined according to the foregoing basic design, appear in Table 8.3 for each exchange area. The antenna height for each radio hop is given in path profile map attached in separate book, "DATA FILE".

Table 8.3 Type of Antenna Mast and Height in Each Exchange Area

Antenna Mast		No. of Antenna Masts						
Type	Height	NKI	GTU	CHT	KEZ	BTR	MRB	Total
Pole	15m	6	3	5	1	4	9	28
Pole	20m	4	2	-	3	-	3	12
Pole	25m	1	1	1	3	5	1	12
Self	20m	-	1	-	-	-	1	2
Self	25m	-	-	1	2*	-	4	7
Self	30m	2	2	1	2	1	2*	10
Self	35m	4	-	-	4	2	2*	12
Self	40m	1	-	1	4	2	2	10
Self	45m	1	-	-	-	1	1	3

* : One antenna mast required for trunk transmission system is included in each figure.

Antenna mast constructed for trunk transmission system is to be used for MARS at Gutu and Chatsworth repeaters, where MARS and trunk transmission system are installed.

8.6 Building Facilities

Building facilities required in the current plan are as under.

(1) Building for the stations of subscriber multiplexing system (MARS and cable PCM) and new radio repeaters on the trunk route - prefabricated shelter/cabinet is to be provided to install transmission equipment as well as battery.
However, transmission equipment for both terminal and repeater stations is installed in the waterproof case.

(2) For terminal exchange and existing radio repeater stations on trunk route, existing buildings are to be utilized, except at Maphisa where new exchange building is to be constructed by PTC before commencement of construction work for the project.

(3) Shelter or cabinet to be newly constructed under the current plan is to be the prefabricated type that can be constructed easily and in a short period. Air-ventilation facilities are to be provided for these shelter or cabinet.

(4) Prefabricated type shelter/cabinet is to be as small as possible and be the kind that can be assembled at the field.

The following are size of the shelter/cabinet required for each category of the station.

Stations	Shelter/Cabinet Size
(Subscriber Multiplexing System) - For repeater/terminal station (Power supply equipment)	2m x 2m
(Trunk Transmission System) - For repeater station (Radio equipment) (power supply equipment)	2m x 2m 2.5m x 2m

The shelter/cabinet necessary for the project appear in Table 8.4, and the typical site layout plan for the MARS stations and trunk transmission system is shown in Figure 8.8 (1/2-2/2).

Table 8.4 Shelter/Cabinet Constructed in Each Exchange Area

Shelter/Cabinet Size	No. of Shelters/Cabinets						
	NKI	GTU	CHT	KEZ	BTR	MRB	Total
(MARS) Power (2x2m)	19	9	10	17	15	21	91
(Cable PCM) Transmission (2x2m) Power (2x2m)	1 1	5 5	2 2	- -	5 5	- -	13 13
(Trunk Transmission Sys) Transmission (2x2m) Power (2x2.5m)	- -	- -	- -	2 2	- -	3 3	5 5

8.7 Terminal Facilities

Subscriber apparatus, telephone sets for both public and ordinary subscriber, facsimile terminal and necessary facilities for subscriber line connection, such as poles, drop-wire (open wire), protector against surge, are to be provided by PTC.

Based on the results of demand forecast, the number of subscriber apparatus to be provided at 1996, 2001 and 2006 are as follows.

Exchange	1996	2001	2006
NKAYI	130	130	100
GUTU	330	260	200
CHATSWORTH	90	150	150
KEZI	130	240	120
BEATRICE	300	170	290
MURAMBINDA	200	230	200
Total	1,180	1,180	1,060

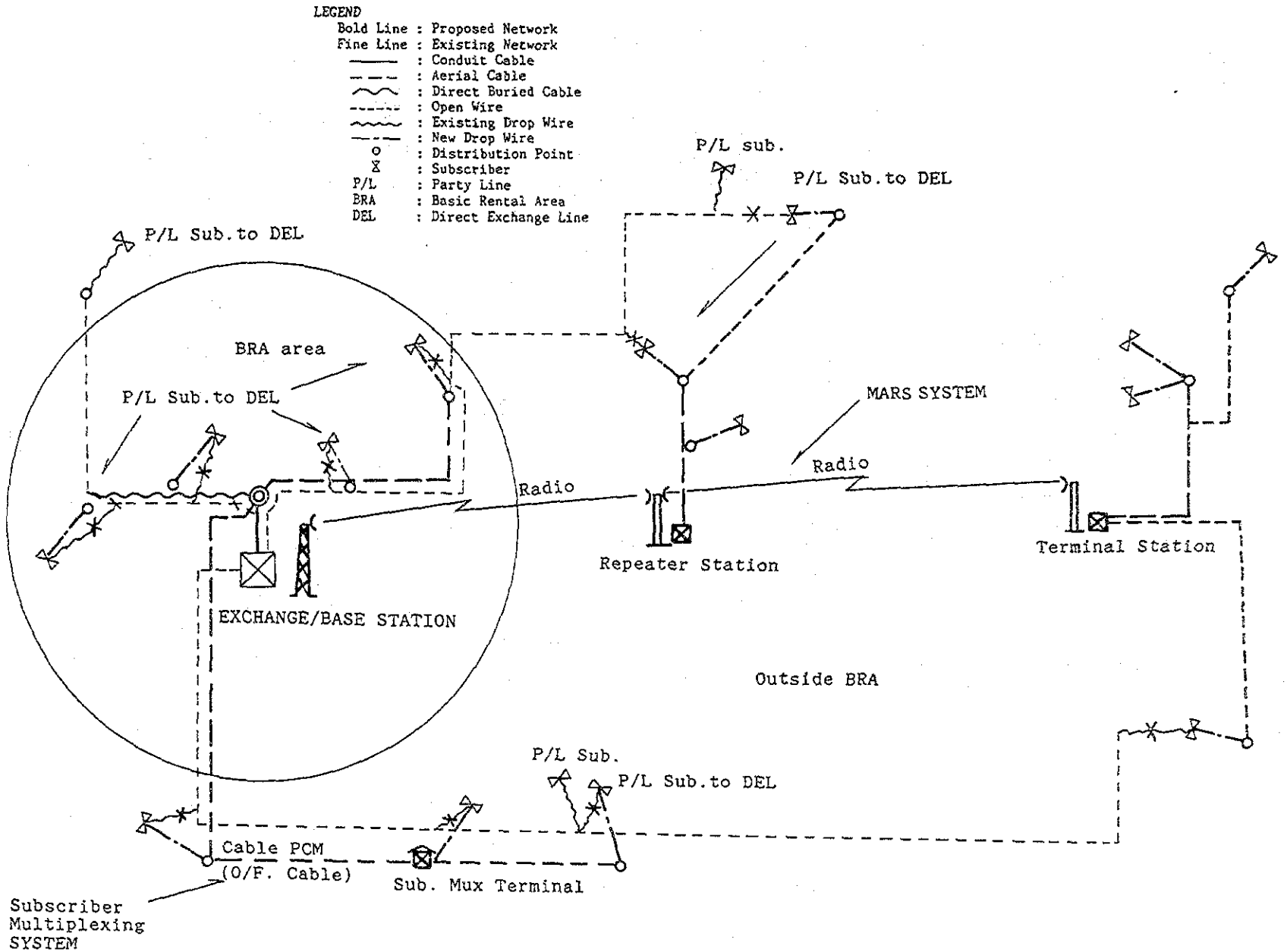
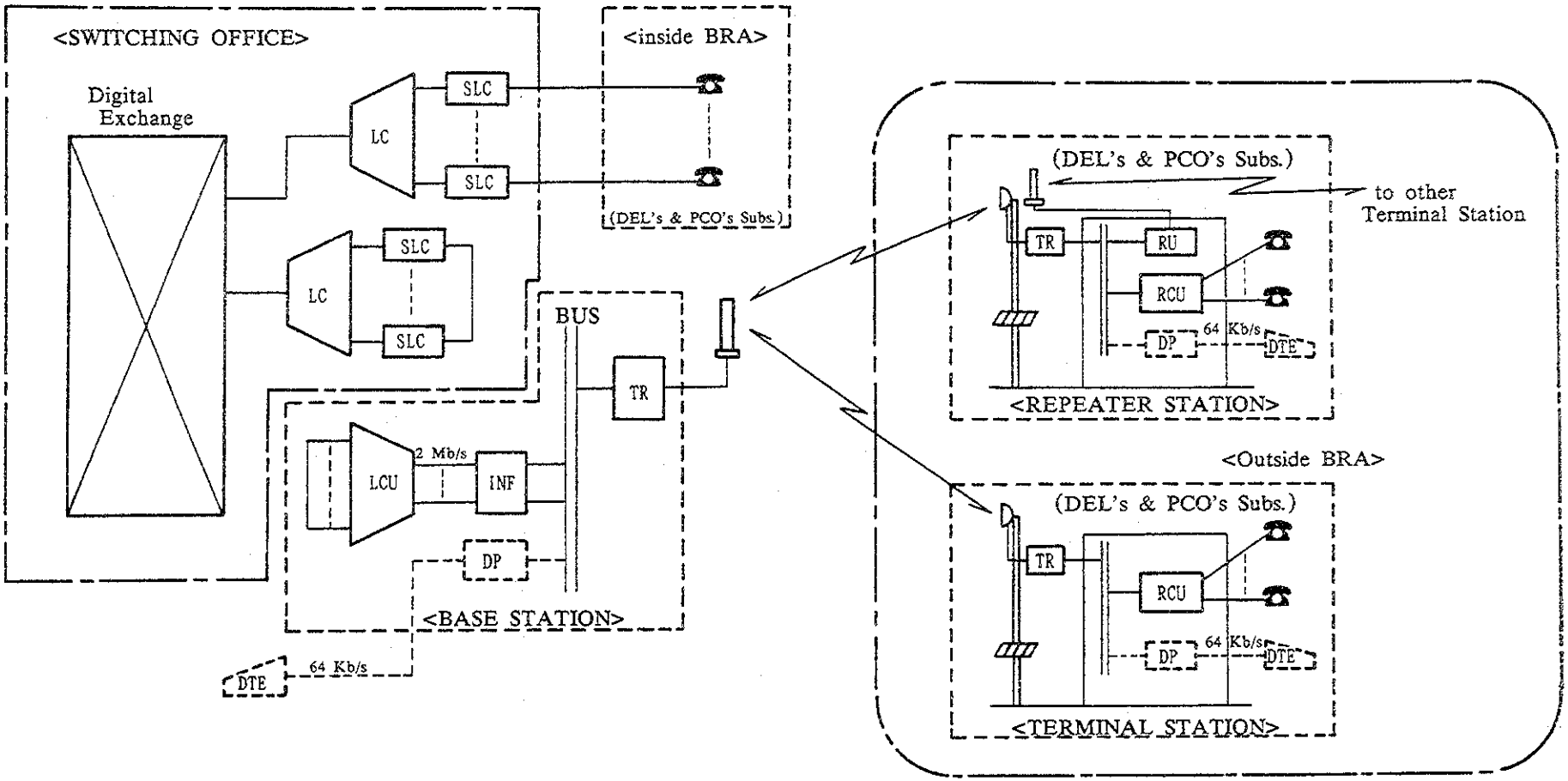


Figure 8.1 Network configuration Plan



LEGEND:

	:	Omni-directional Antenna	TR	:	Transmitter-Receiver
	:	Directional Antenna	INF	:	Interface
	:	Subscriber	LC	:	Line Concentrator
RCU	:	Radio Concentrator Unit	SLC	:	Subscriber line Circuit
RU	:	Repeater Unit	DP	:	Data Port Module
LCU	:	Line Concentrator Unit	DTE	:	Data Terminal Equipment

Figure 8.2 Configuration of MARS Network

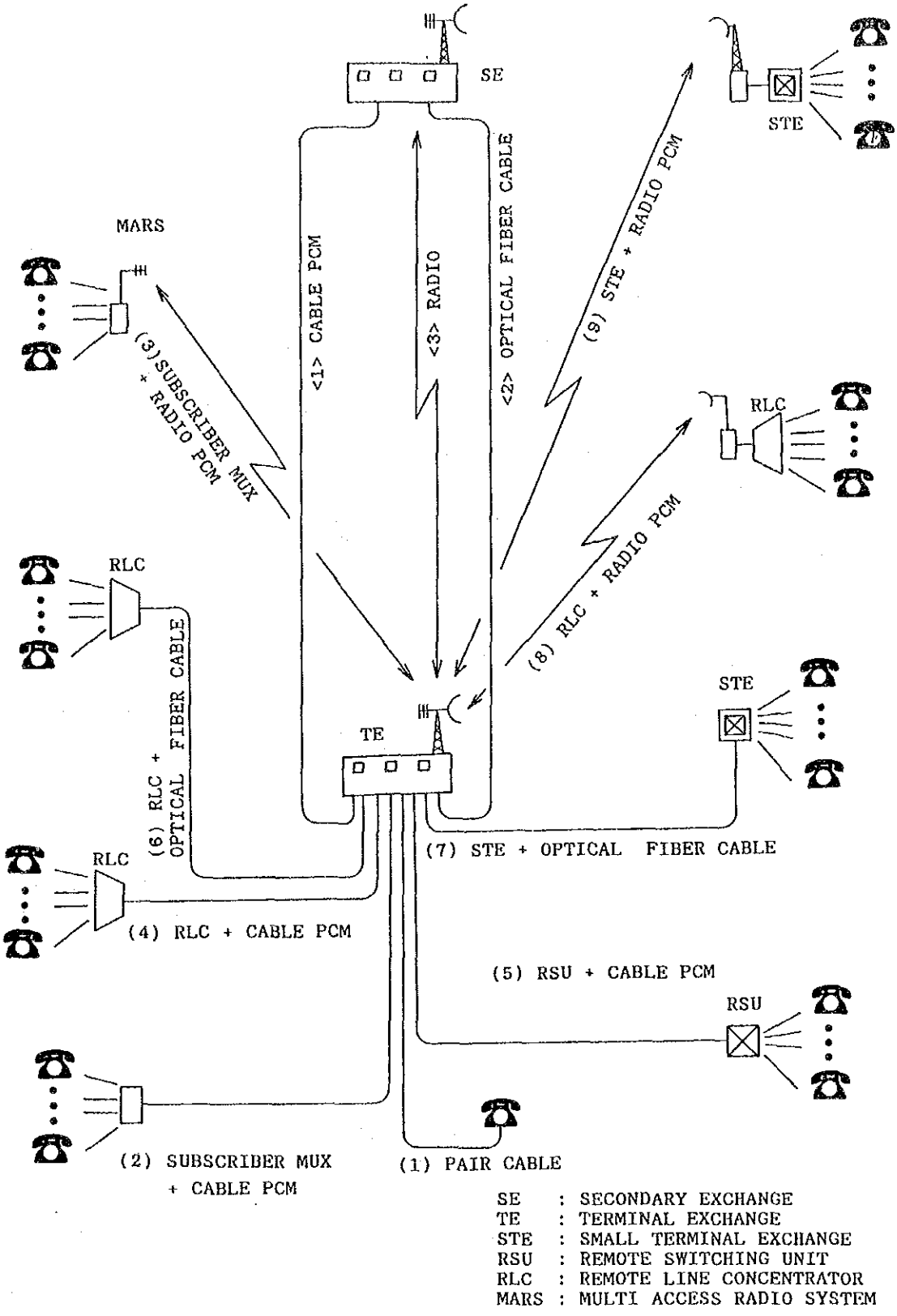


Figure 8.3 (1/3) Rural Telecommunication Network Pattern

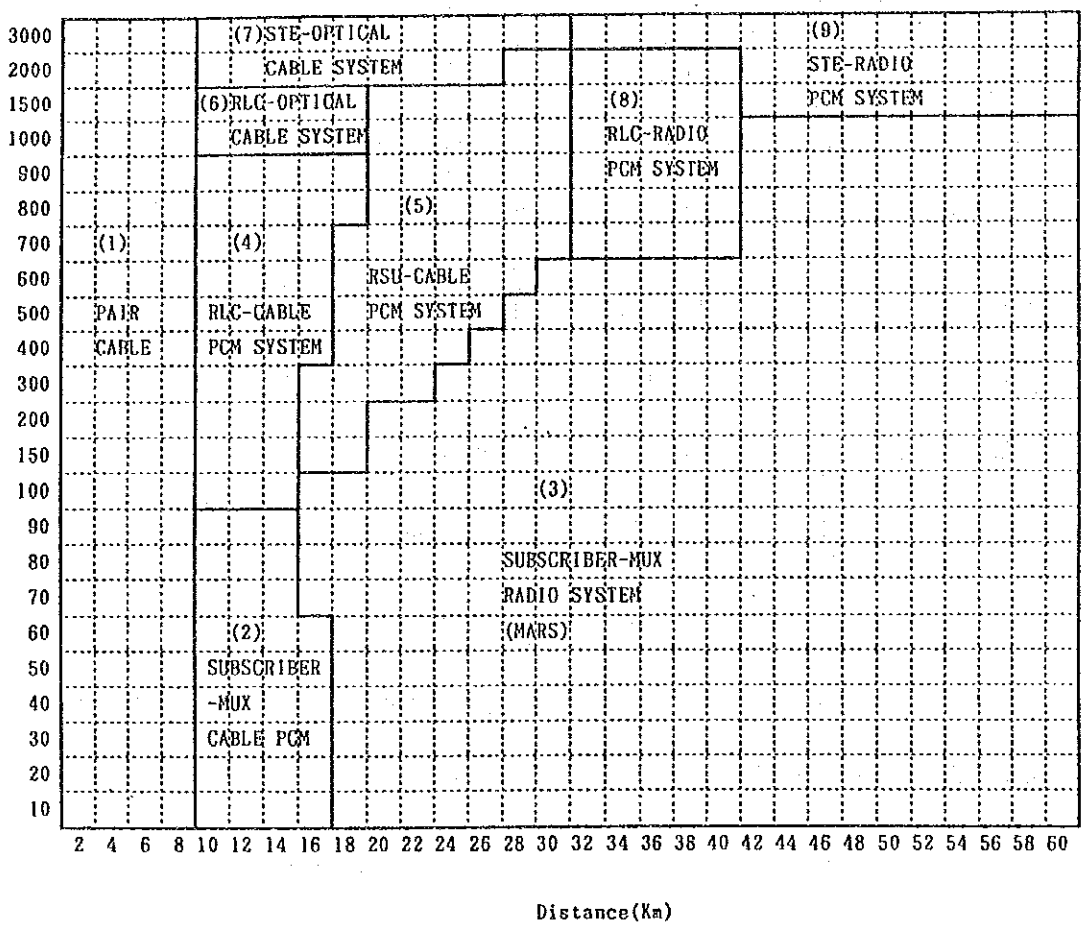


Figure 8.3 (2/3) System Selection Diagram for Rural Telecommunication Network

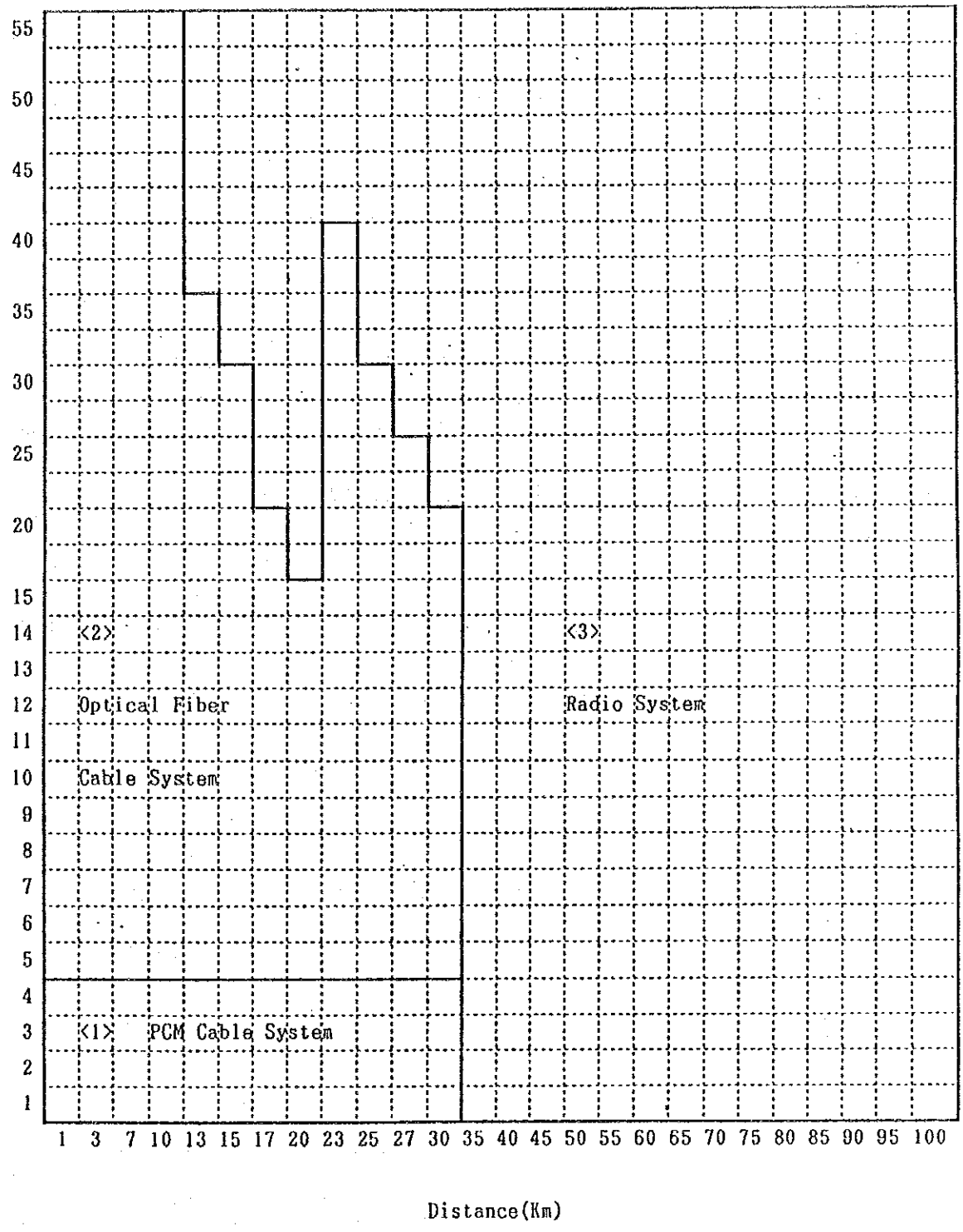


Figure 8.3 (3/3) System Selection Diagram for Transmission Network

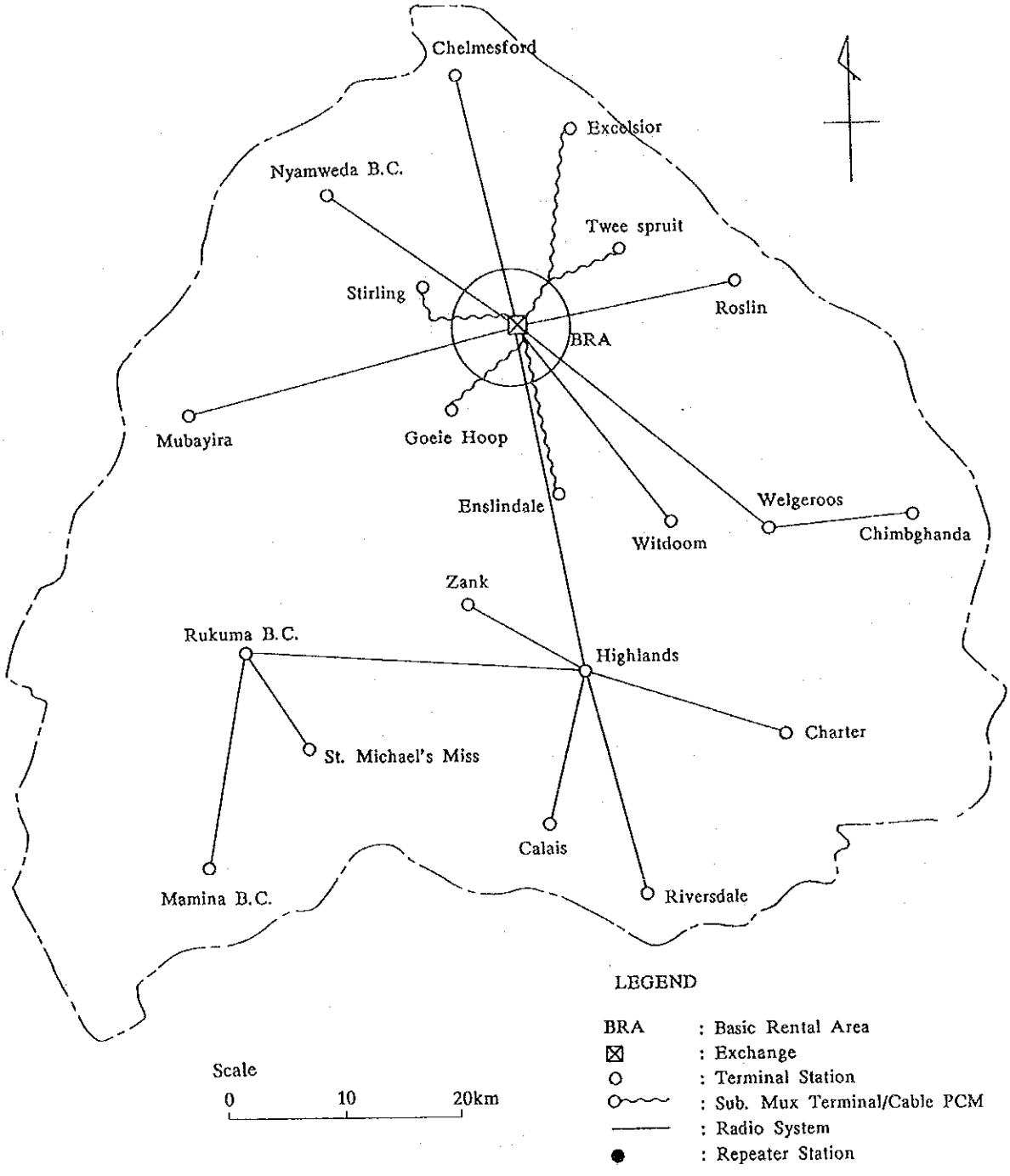


Figure 8.4 (1/6) Transmission Route Plan for Rural Exchange (Beatrice)

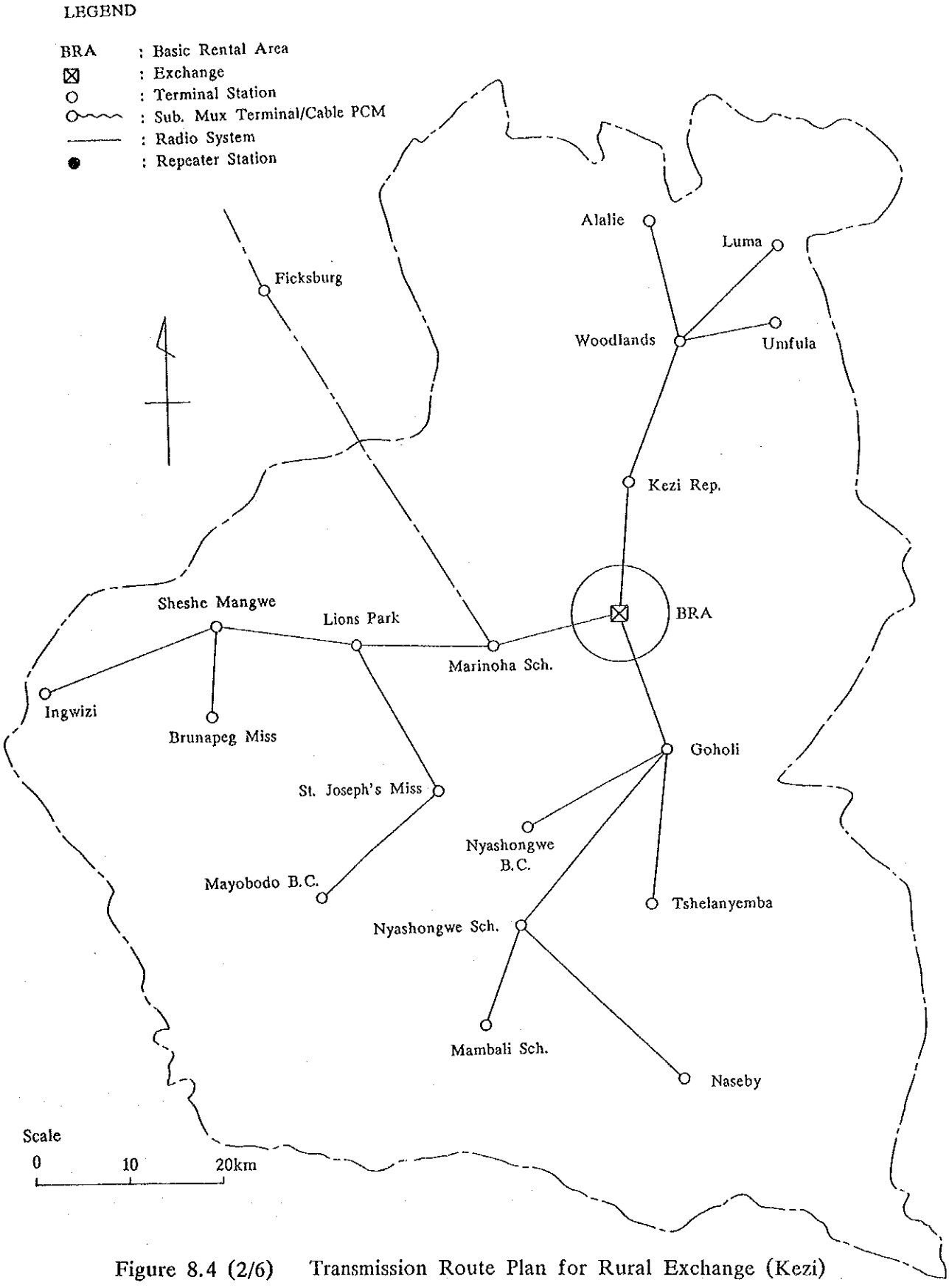


Figure 8.4 (2/6) Transmission Route Plan for Rural Exchange (Kezi)

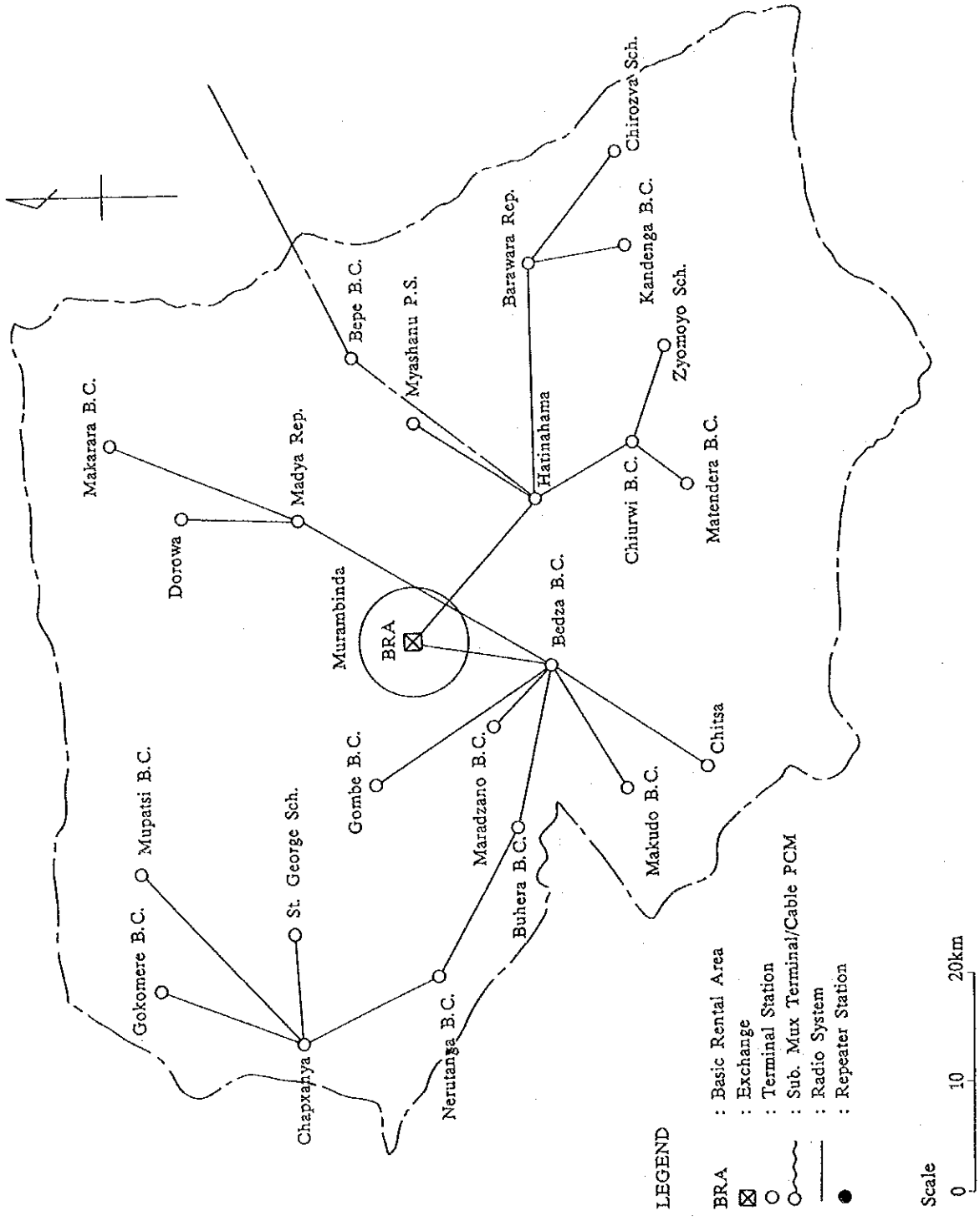


Figure 8.4 (3/6) Transmission Route Plan for Rural Exchange (Murambinda)

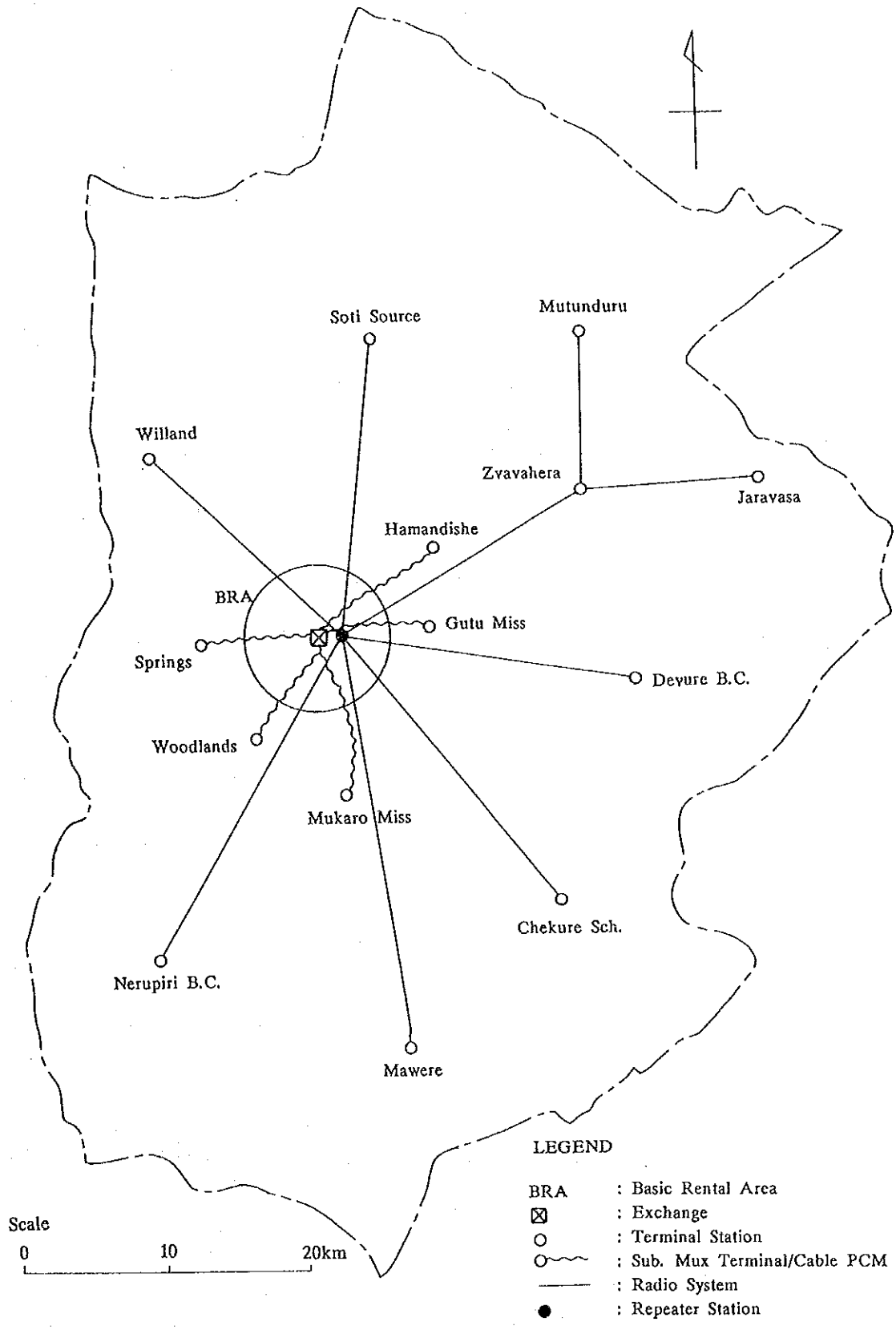


Figure 8.4 (4/6) Transmission Route Plan for Rural Exchange (Gutu)

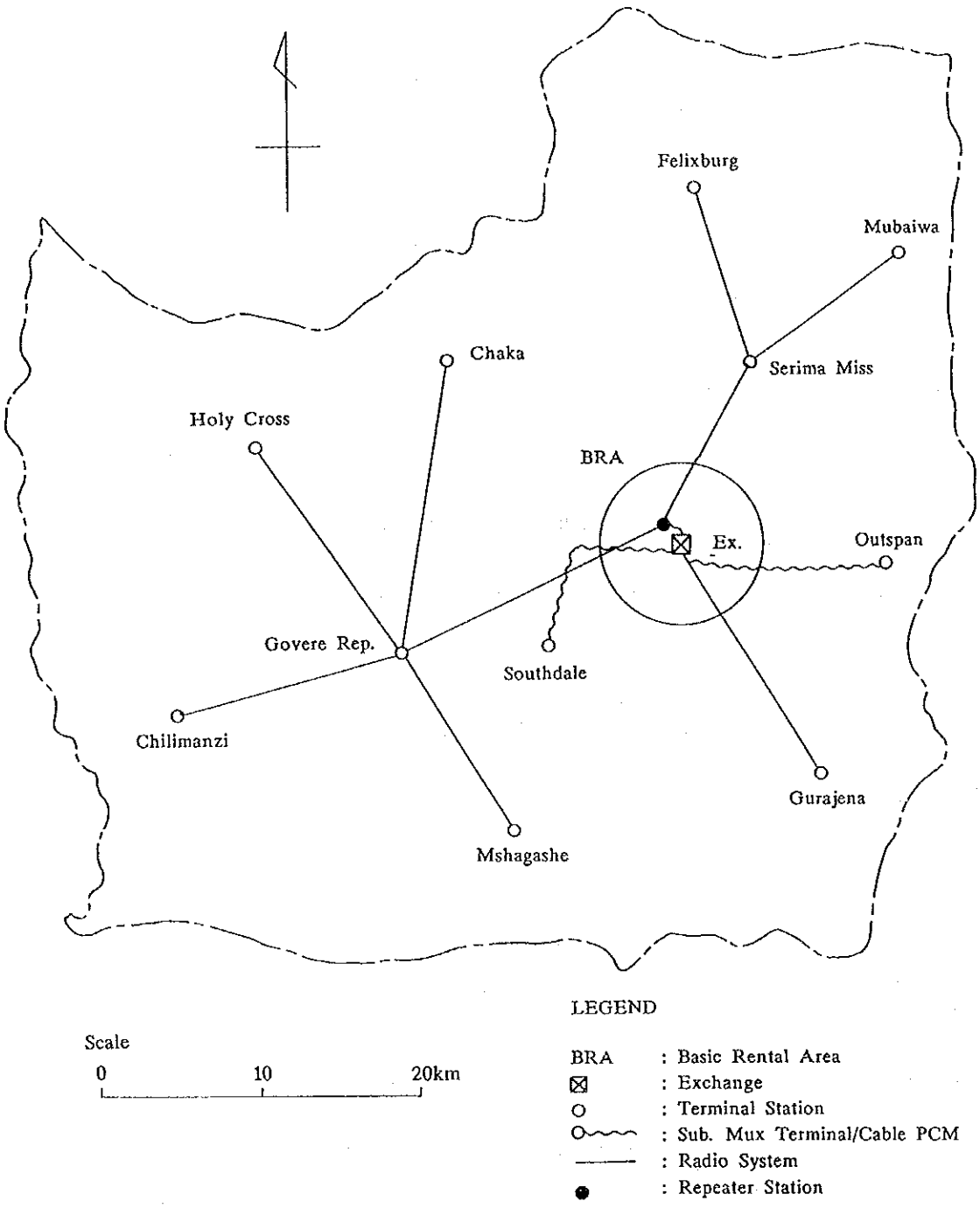


Figure 8.4 (5/6) Transmission Route Plan for Rural Exchange (Chatsworth)

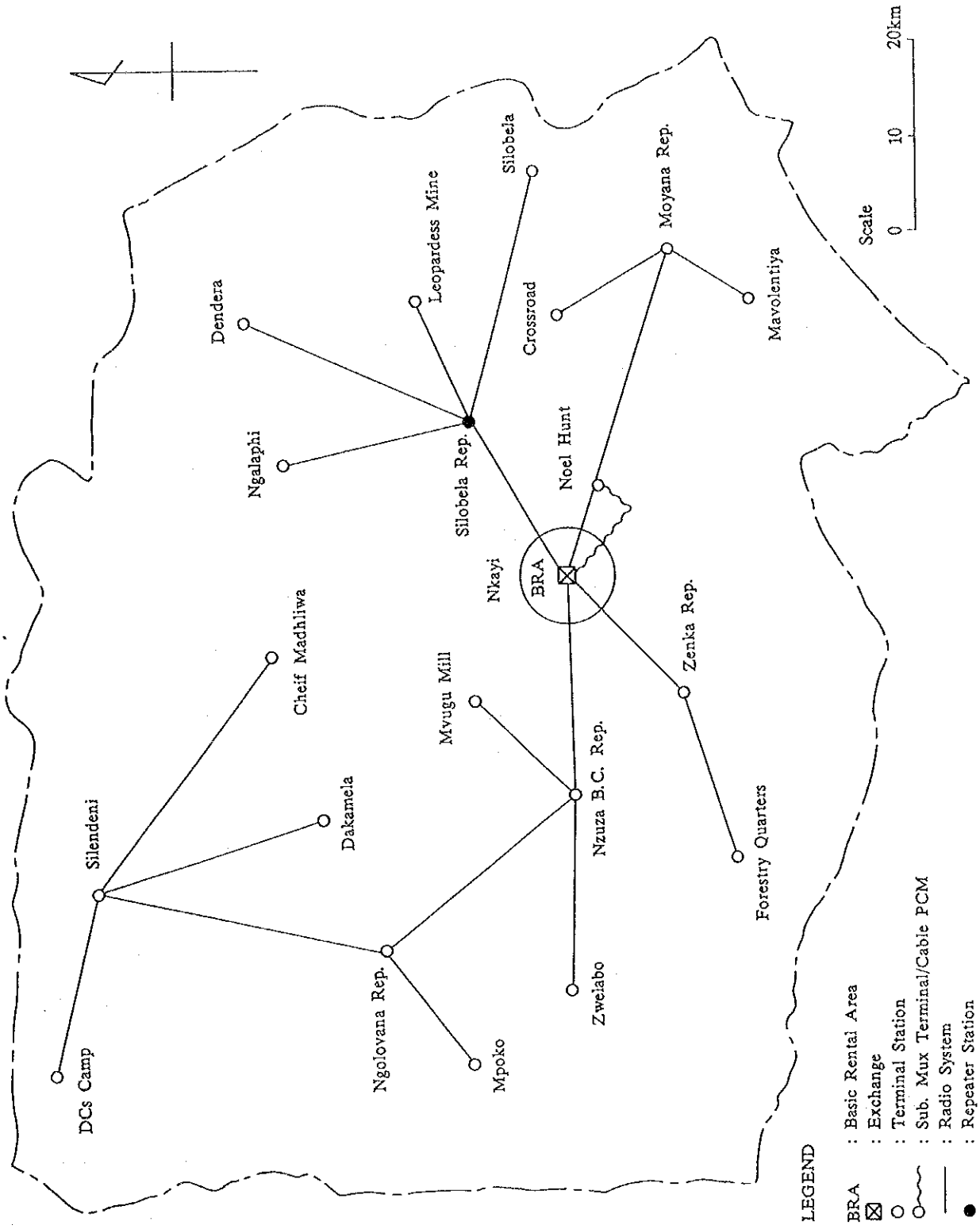


Figure 8.4 (6/6) Transmission Route Plan for Rural Exchange (Nkayi)

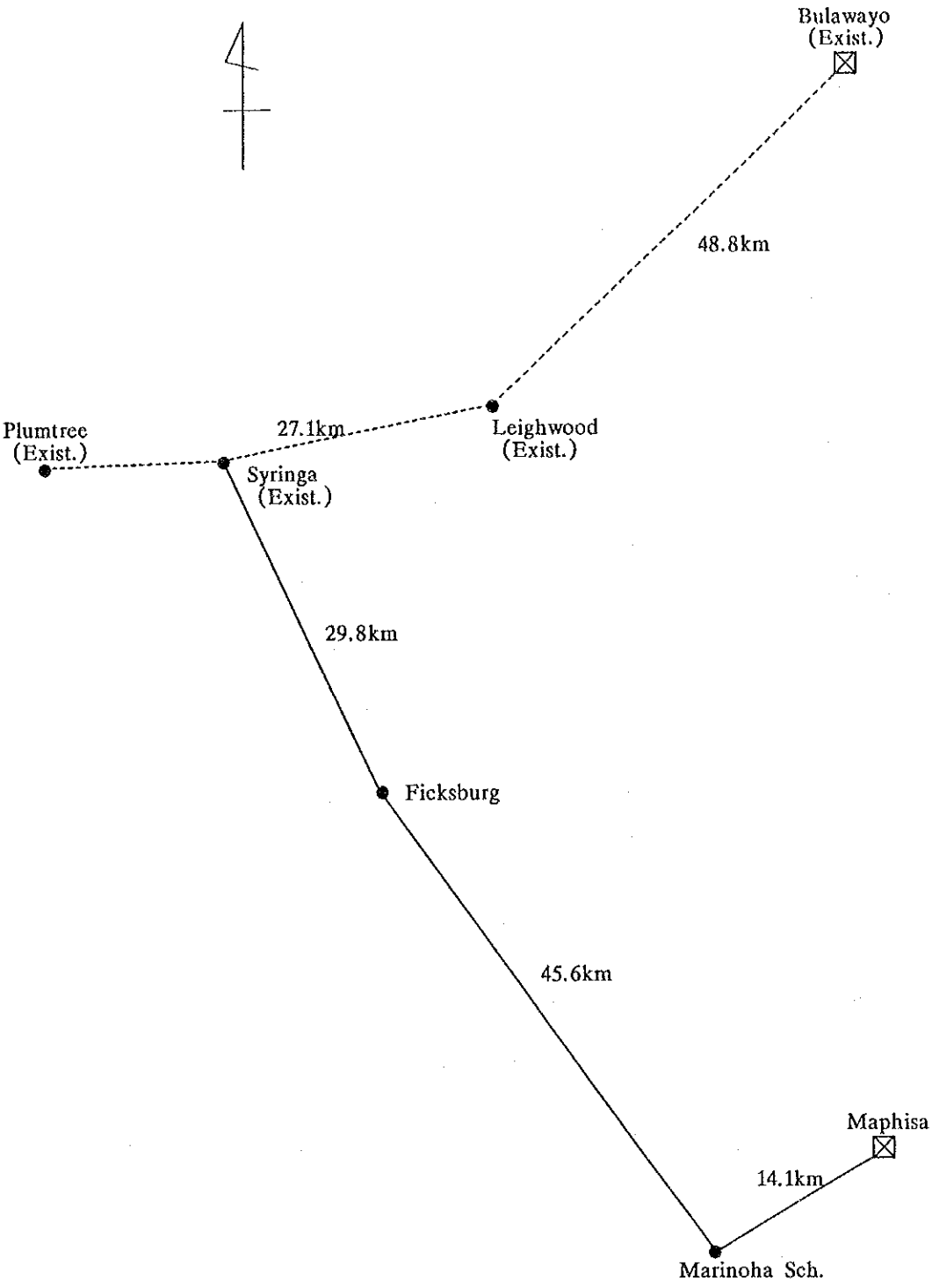


Figure 8.5 (1/2) Transmission Route Plan for Maphisa - Bulawayo Trunk Route

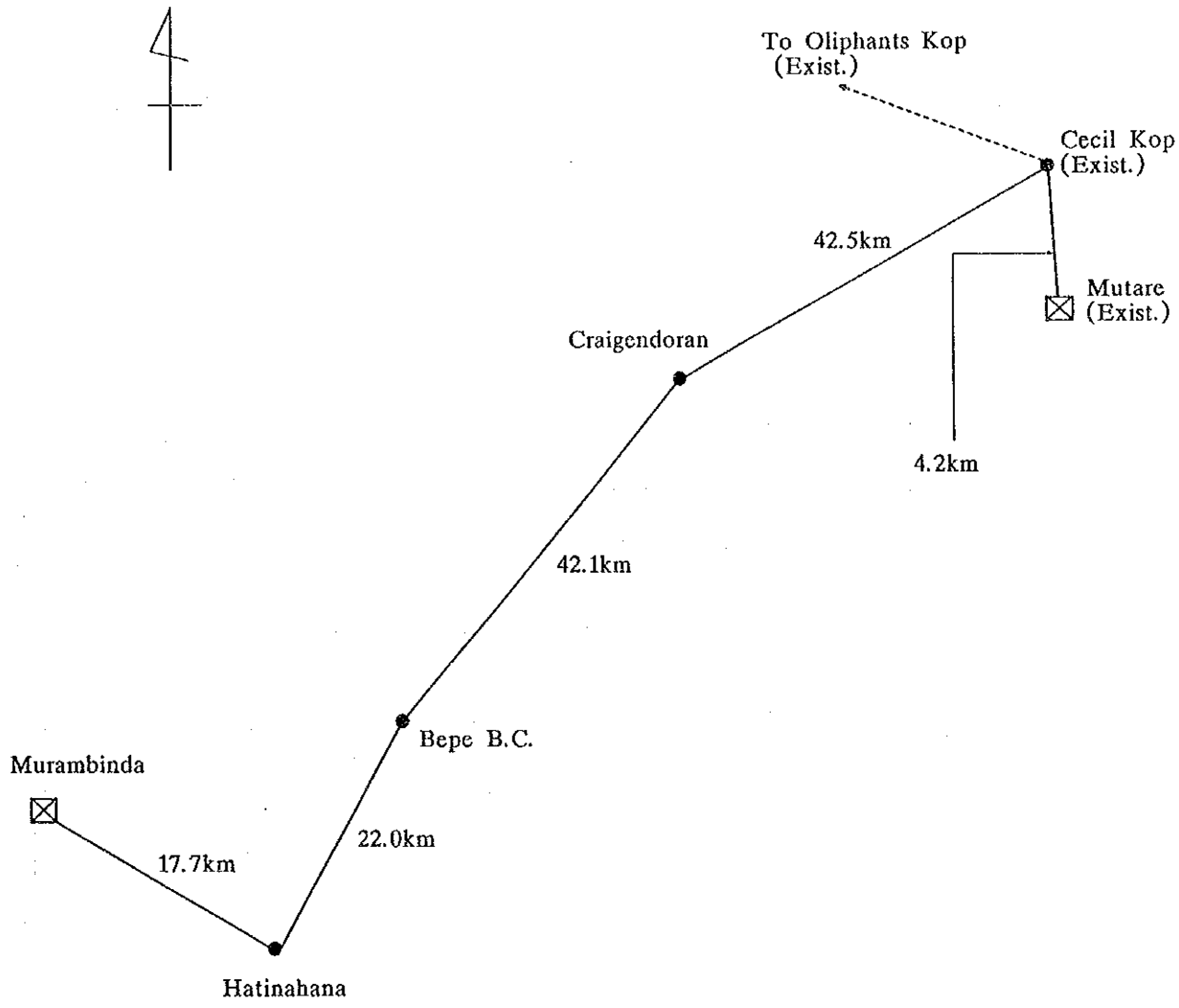
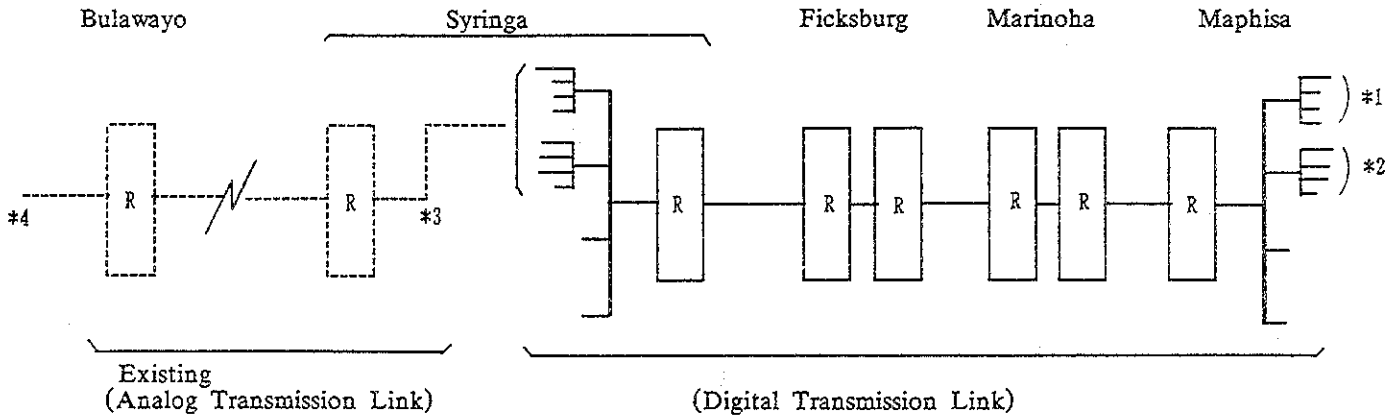


Figure 8.5 (2/2) Transmission Route Plan for Murambinda - Mutare Trunk Route



*1: Allocated for non-voice circuits, such as Telex, data.
*2: Digital Interface on 2 Mbit/s basis with digital exchange at Maphisa.
(Three 2 Mbit/s lines are required at initial stage (1996), and one additional 2 Mbit/s line becomes necessary in the future.)
*3: Interface on channel basis with the existing analog transmission System.
*4: Interface with exchange is made at 2 Mbit/s basis by providing digital multiplexing equipment at the Initial stage.

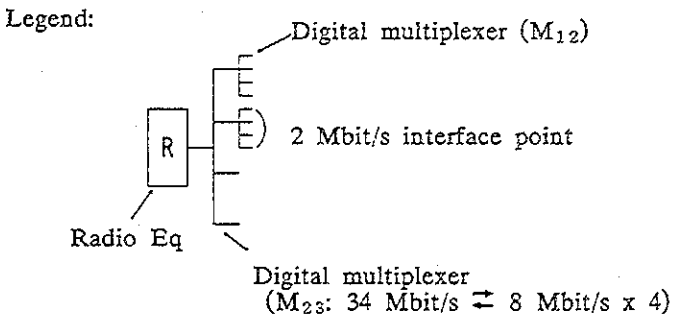
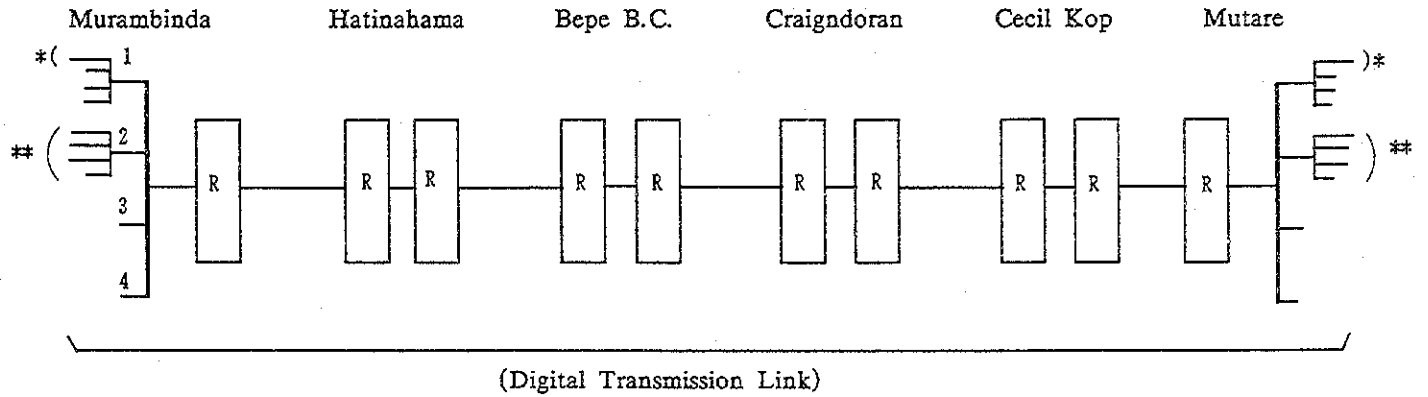


Figure 8.6 (1/2) Channel Accommodation Plan for Maphisa - Bulawayo Trunk Route



*: Allocated for non-voice cricuits, such as Telex, data.
**: Digital interface on 2 Mbit/s basis with digital exchange at both exchanges

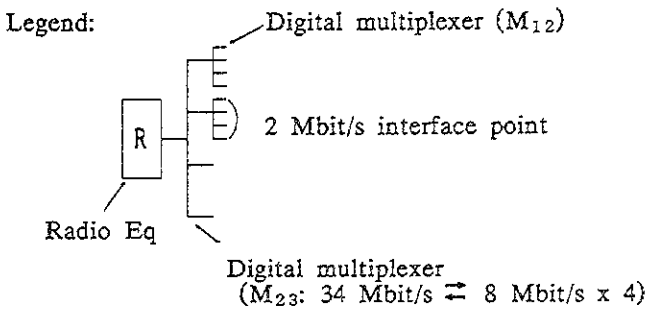


Figure 8.6 (2/2) Channel Accommodation Plan for Murambinda - Mutare Trunk Route

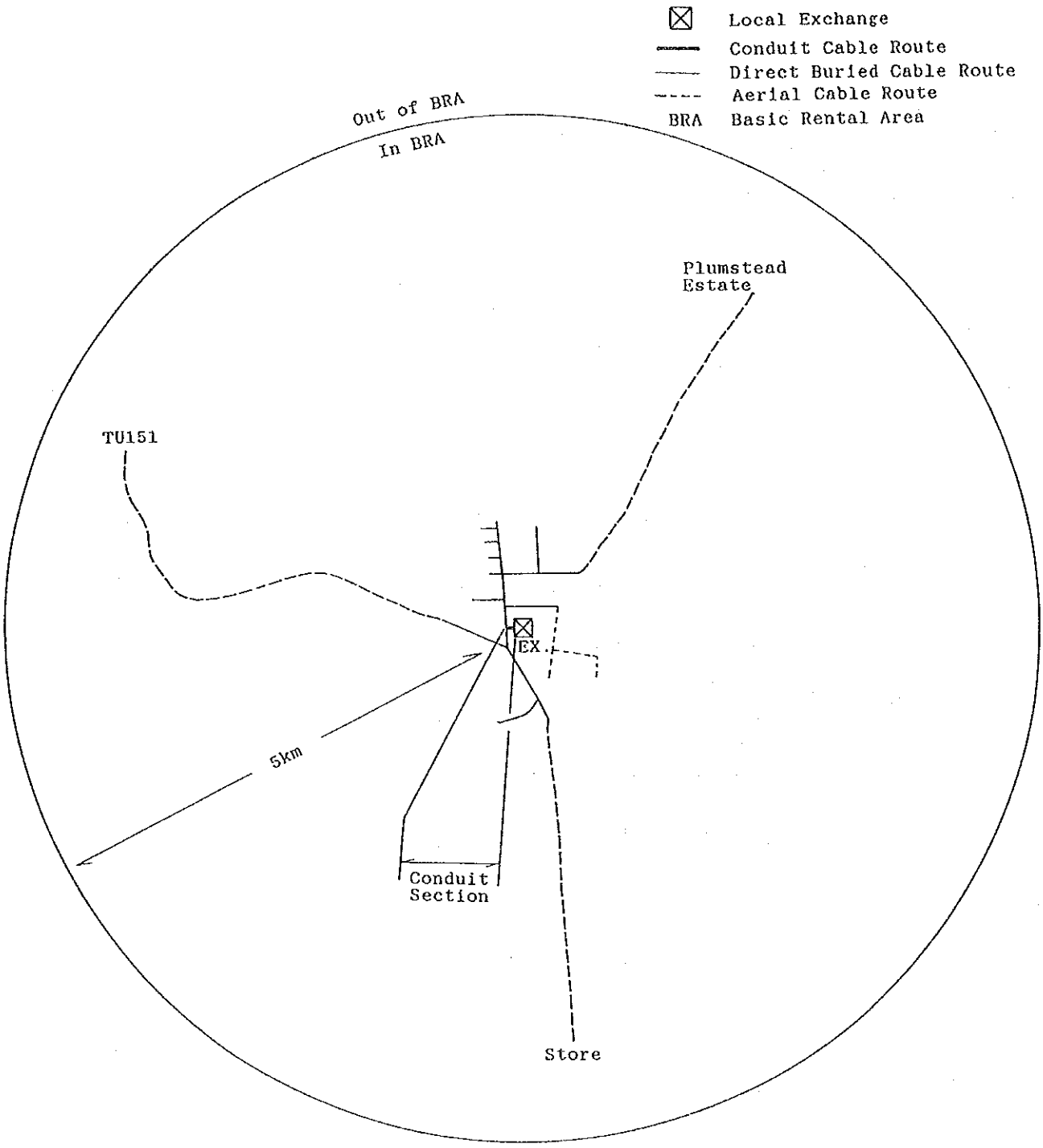


Figure 8.7 (1/6) Local Cable Distribution Plan in BRA (Beatrice Exchange)

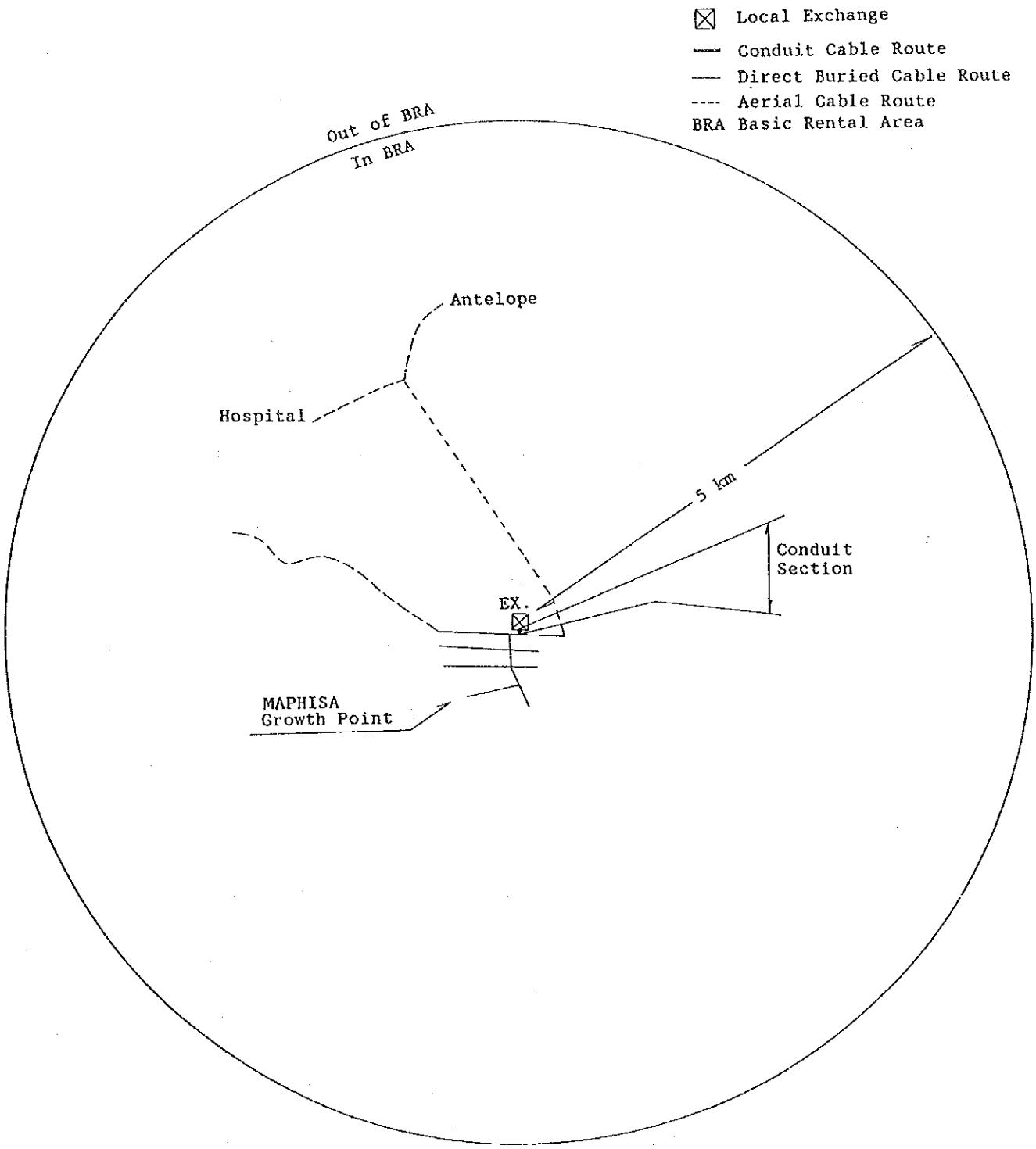


Figure 8.7 (2/6) Local Cable Distribution Plan in BRA (Kezi Exchange)

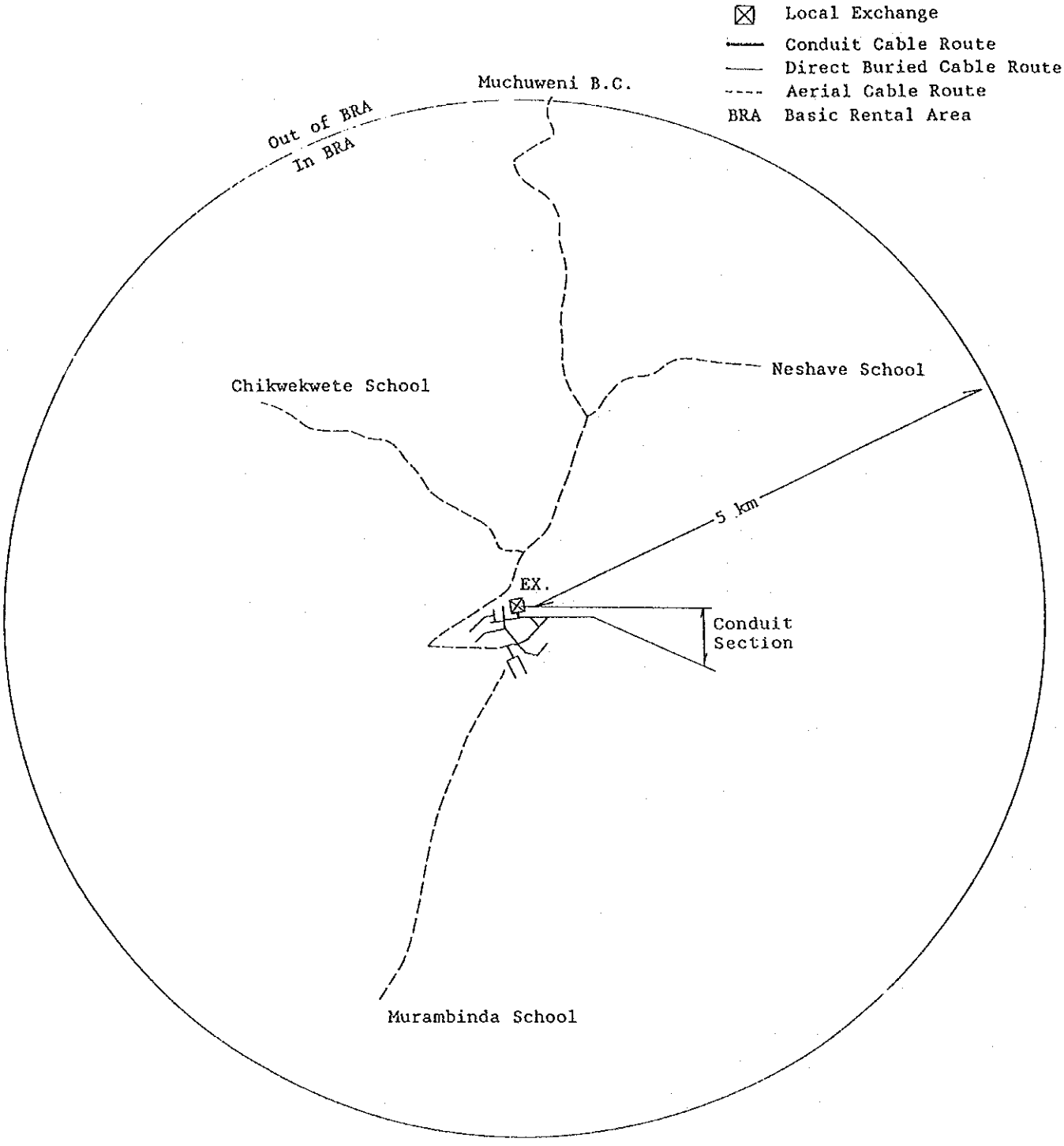


Figure 8.7 (3/6) Local Cable Distribution Plan in BRA (Murambinda Exchange)

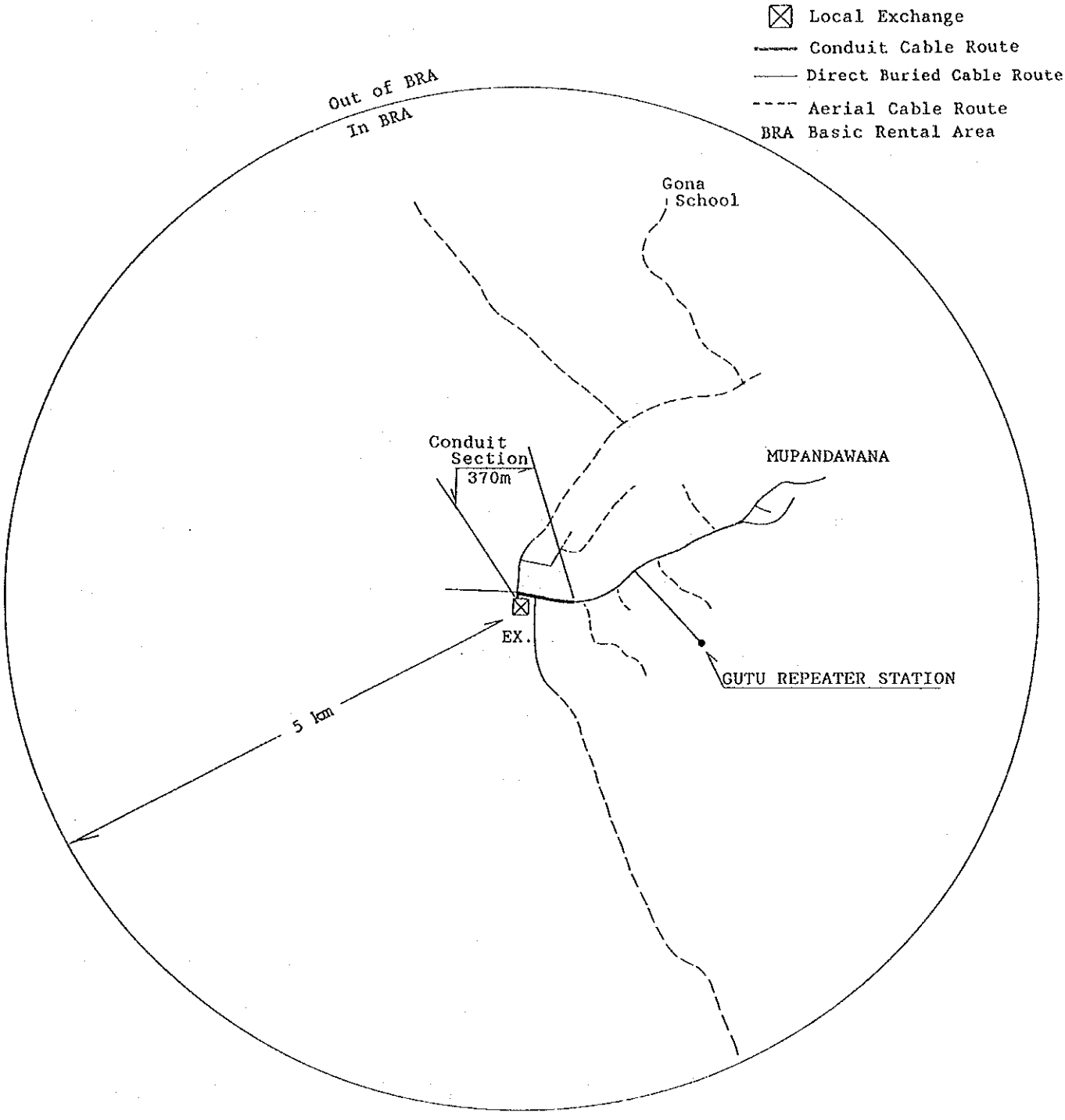


Figure 8.7 (4/6) Local Cable Distribution Plan in BRA (Gutu Exchange)

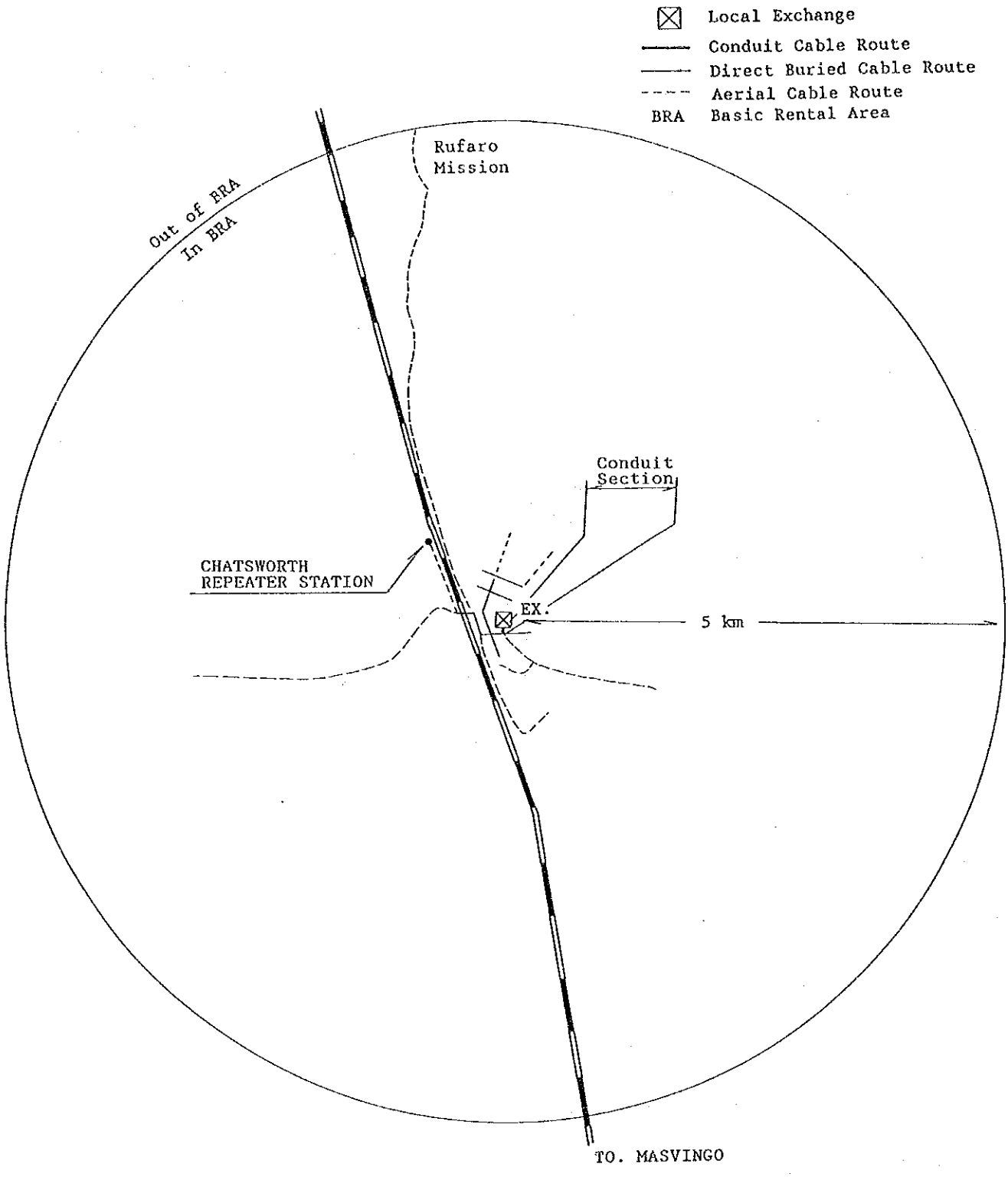


Figure 8.7 (5/6) Local Cable Distribution Plan in BRA
(Chatsworth Exchange)

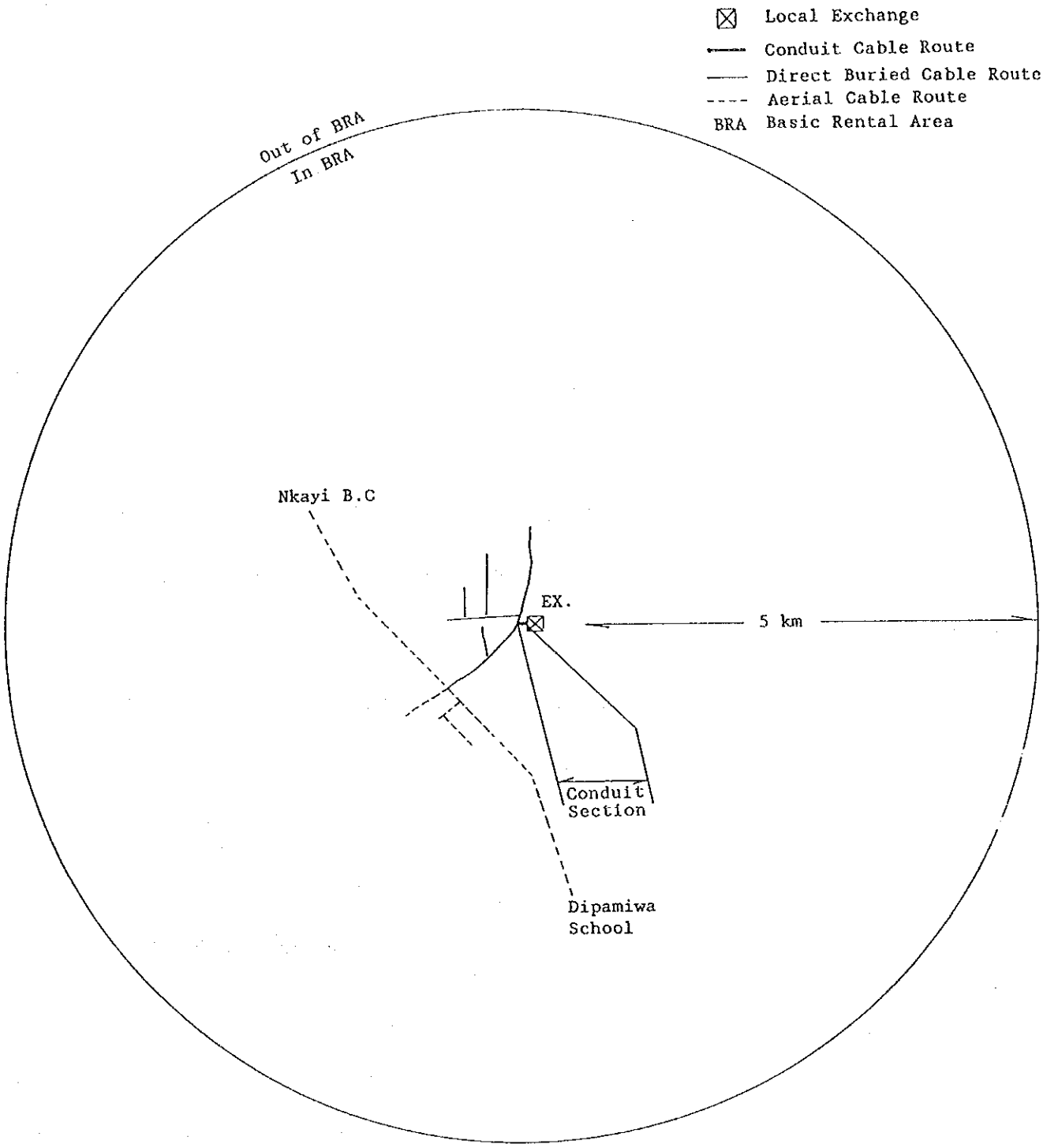
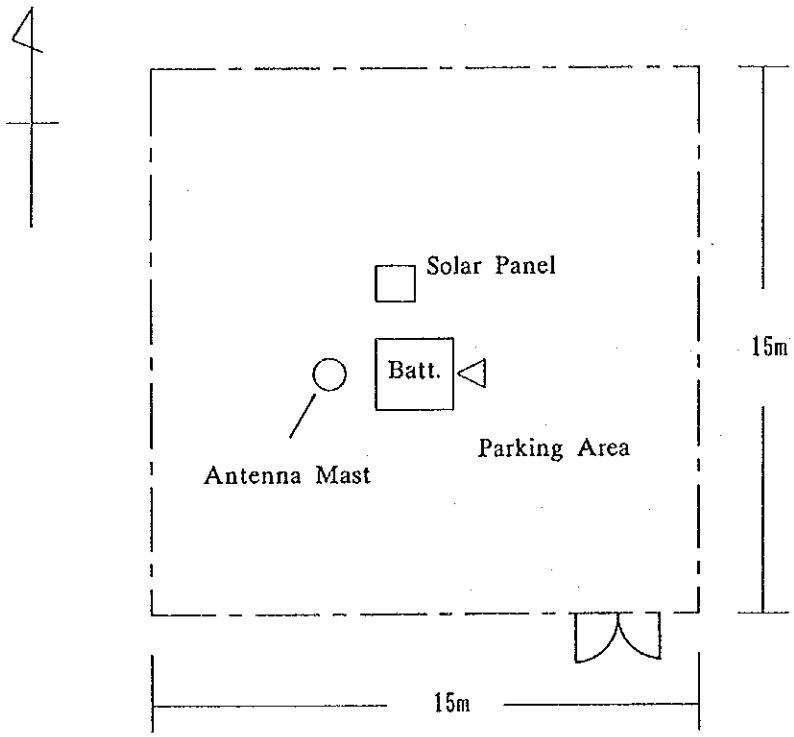


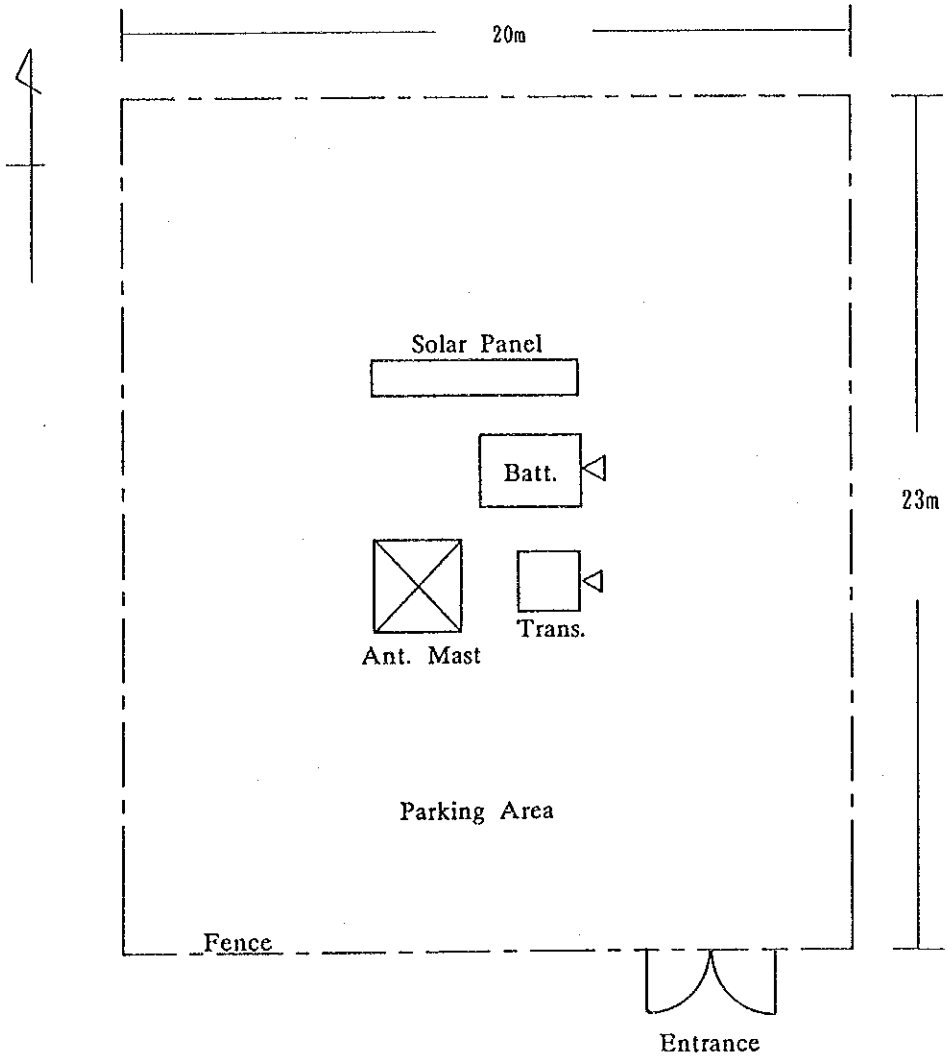
Figure 8.7 (6/6) Local Cable Distribution Plan in BRA (Nkayi Exchange)



Solar Panel is to be installed away from fence to ensure exposure of the panel to sun rays without obstruction of possible shades and to guard against vandalism.

Transmission equipment for MARS is to be installed in a cabinet which can be mounted on antenna mast.

Figure 8.8 (1/2) Typical Site Layout Plan for MARS Terminal Station



Solar Panel is to be installed away from fence to ensure exposure of the panel to sun rays without obstruction of possible shades and to guard against vandalism.

Note: Antenna Mast is not required at terminal station for subscriber multiplexing system on Cable PCM.

FIGURE 8.8 (2/2)

Typical Site Layout Plan for Repeater Station on Trunk Transmission Route and Terminal Station for Subscriber Multiplexing System on Cable PCM

SECTION 9 OPERATION AND MAINTENANCE

SECTION 9 OPERATION AND MAINTENANCE

The operation and maintenance work aims at maintaining proper functions and performance of the system introduced for improving services in the areas concerned. Items to be taken up in the maintenance works are determined in full consideration of the efficiency and quality of the telecommunications system concerned.

9.1 Present Situation of the Operation and Maintenance

9.1.1 Number of Staffs

The number of staff classified by the level for the operation and maintenance in each region is stated below.

Table 9.1 Number of Staff

Region	S/M	CTT	TT	TM	TW	SUB.T	GW	EO	Other	Total
MASHONALAND	15	61	328	124	494	1022	235	4	73	1334
MATABELELAND	8	20	67	52	260	407	106	4	73	590
MANICALAND	4	12	41	30	193	280	47	1	23	351
MASVINGO	3	10	20	26	157	216	49	0	12	277
MIDLANDS	6	9	31	10	71	127	42	2	21	192
EARTH STATION	1	3	12	0	0	16	6	1	2	25
Total	37 (36)	115 (112)	499 (487)	242 (242)	1175 (1175)	2068 (2052)	485 (479)	12 (11)	204 (202)	2769 (2744)

Figure in the paren theses shows total number of staff excluding the staff working in the earth station.

S/M: Section Manager is authorized to control all staff in an authorized section.

CTT: Chief Telecoms Technician is classified as a skilled technician working as a single working unit whether with staff or without any staff.

TT: Telecoms Technician is classified as a skilled technician working under CTT with assistance of TW.

TM: Telecoms Mechanic, Same as TT's responsibility.

TW: Telecoms worker is a semi-trained assistant to technician and trained to carry out work assisted by upper level technician and/or to provide supportive activities with manual skills.

GW: General worker is an untrained worker to assist in labor work of other technician.

The number of staff per 1,000 subscribers in each region as of 1991 is stated Table below, and whole PTC's rate becomes 23.6 including non-technical staff, administrative staff and general workers, and 17.6 excluding non-technical staff.

According to the "TELECOMMUNICATION DEVELOPMENT PLAN, 1986-2005" issued by ITU and the report "ESTABLISHMENTS : TELECOM OPERATIONS. REVISION OF STAFFING REQUIREMENTS FOR ALL TELECOM REGIONS" issued by PTC, the target number of staff per 1,000 subscribers in whole PTC is 10.1 without non-technical staff.

Table 9.2 Operation/Maintenance Staff per Region (1991)

Region	MAIN/LINES (1)	O/M STAFF (2)	TECH.STAFF (3)	Rate (2)/(1)	Rate (3)/(1)
MASHONALAND	64,530	1,334	1,022	20.7	15.8
MATABELELAND	28,800	590	407	20.5	14.1
MANICALAND	8,407	351	280	41.8	33.3
MASVINGO	5,358	277	216	51.7	40.3
MIDLANDS	9,294	192	127	20.7	13.7
Total	116,389	2,744	2,052	23.6	17.6

(2) Fault Rate and Repair

Telephone faults and repaired (cleared) reported numerically on the 1st quarter 1991/92 in each region are stated in table below,

Table 9.3 Telephone Faults and Repaired (1st Quarter 1991/92)

Items	MASHONA	MATABEL	MANICA	MID	MASVING	Total
No.of Faults	59567	10871	5453	3008	3379	82278
(Reports duplicated)	(11244)	(3710)	(28)	(295)	(66)	(15343)
Ave. Faults/100 Main Lines/month	21.6	12.5	21.1	10.8	21.1	21.6
Total No. Cleared	54235	10400	5313	3001	3358	76339
% Fault Clearance						
Under 24 hrs	35.7	58.1	74.4	75.6	77.4	44.1
Under 48 hrs	59.8	77.5	89.4	92.4	91.7	66.4
Under 7 days	78.2	91.0	96.0	99.6	98.7	82.6
Under 30 days	91.2	95.7	97.4	99.8	99.4	92.8

Note: Meaning of fault clearance is a duration to clear one fault. And the faults classified by occurrence location are shown in Table below, within the same period (1st quarter

1991/92).

Table 9.4 Fault Classification (%)

Facility	Region					
	MASHONA	MATABELE	MANICA	MID	MASVINGO	Total
SUB.PREMISES	23.77	13.88	18.06	14.30	27.87	20.85
O/HEAD LINE	13.40	3.68	11.41	6.65	7.60	10.68
U/G LINE	4.95	4.16	3.48	6.90	8.72	4.97
EXCHANGE	15.43	10.54	11.39	10.46	13.07	13.83
PAIR GAIN	2.73	1.89	0.40	0.00	0.46	2.09
RIGHT WHEN TESTED	7.41	30.43	25.31	28.23	25.35	15.34
OTHERS	32.31	35.42	29.95	33.46	16.93	32.25

According to PTC's targets for maintenance;
the rate of faults per 100 main lines per month is to be reduced to 8.3 and the percentage of faults clearance target is that 70 % of faults should be cleared within 24 hours, 80 % of faults should be cleared within 48 hours, 98 % of faults should be cleared within 7 days, 100 % of faults should be cleared within 30 days.

(3) Training

Training of technical staff is being carried out in PTC Training College located in Harare, in order to secure the scale of personnel to be required for maintenance and operation of telecommunication system.
The training being provided by PTC Training College normally consists of the Technician training, Graduate engineer training, In-service training and Commercial personnel training.

a) The technician training course is to provide both theoretical lectures and practical laboratory work for trainee telecom technicians.
b) The graduate engineer training course is to provide knowledge in the discipline of each sub-system, such as external plant, transmission, switching, data and telegraphy for graduate at university/college engineers employed by the PTC.
c) The In-service training course may be held after consideration by PTC's H/Q when further training is required for new technologies being brought into the PTC, to qualified telecom mechanics, technicians and engineers.

9.2 Operation and Maintenance for the Study Areas

Operation and Maintenance for the existing telecommunications facilities in the study areas is performed by the regional centre for trunk transmission system and staff at the respective exchanges take the same functions for the switch and external plant network. And this constitution is considered to continue in future.

9.2.1 Operation and Maintenance Staff's Activities

O/M staff's activities expected for each sub-system after the completion of the network construction for the study area are as follow.

(1) Switching Sub-system

A lot of operation and maintenance works can be simplified by the introduction of digitalized switching system, and by means of the Centralized Operation and Maintenance Control system (COMC) introduced in future, compared with the switching system presently being used. Therefore, only a limited number of sufficiently trained staff is required at each exchanged. However, O/M staff for CHATSWORTH exchange is not required, since introduction of RLC (with stand alone function) system is planned, which works with the control by the host exchange installed at GUTU.

Main activities are:

a) Routine maintenance and Periodical inspection of system,
b) Monitoring of subscriber lines conditions, by the visual display unit for supervision and monitoring.
c) Management by subscriber lines, e.g., connection work for new subscribers, transfer, removal and change of subscriber number,
d) Trouble-shooting and repairing of major fault with the assistance from the maintenance staff stationed in parent exchange,
e) To take care of charging magnetic tape,
f) To take care of measuring equipments and spare parts.

(2) Transmission Sub-system

Centralized supervisory system is introduced for subscriber multiplexing system, and remote supervision and control system is introduced for trunk transmission system.

For MARS, the centralized supervisory system installed at each exchange is to monitor the operating status of terminal stations.

An additional trained technician to be stationed in each exchange is required for operating and maintaining the system, since no technician for this system is deployed to the exchanges at present. As for trunk transmission system, the remote supervision and control system is installed at the parent exchange and takes care of operation and maintenance of trunk circuits to be connected to respective exchanges. In this regard, the main activities of the technician stationed at each exchange would be the routine maintenance of the MARS system, while the periodical corrective maintenance would be carried out by staff at the parent exchange assisted by the station technician. Main activities are listed hereunder.

Main activities at each exchange are:

a) Routine maintenance of subscriber multiplexing system through the centralized supervisory system, installed at terminal exchange.
b) Maintenance itineration of repeater stations and subscriber stations of MARS.
c) Remedy work for any obstacles caused in MARS (Mainly, by changing faulty panel/unit with spares),
d) Periodical inspection (Mainly, meter reading),
e) To assist with periodical corrective maintenance to be carried out for MARS by maintenance staff stationed in parent exchange,
f) To take care of spares for equipments.

Main activities at parent exchange are:

a) Supervision of trunk transmission system with the remote supervisory and control system installed for trunk transmission system.
b) Maintenance itineration of respective radio terminals.
c) Remedy work for any obstacles,
d) Periodical inspection (Mainly, meter reading),

e) To take care of measuring equipments and keeping sufficient maintenance spares, and distribution thereof where necessary.

(3) External Plants Sub-system

External plants are not changed significantly in terms of maintenance work, with exception of increment of facilities volume. And also subscriber line monitoring function to be equipped to the proposed switching system will ease the work. Therefore, no additional technician is required for O/M in consideration of the work volume.

Main activities are:

a) Maintenance itineration in an exchange area
b) Periodical inspection of facilities (Including PCO)
c) Installation of new subscriber apparatus, transfer and removal
d) Remedy work for any obstacles
e) To take care of measuring equipments/tools and spare materials.

9.2.2 Required Staff Number

According to "The Manpower plan of July 1989 - June 1995" prepared by PTC, the number of staff for the operation and maintenance is expected to increase as shown in the following Table within the years up to 1995. Then, engineers and trained telecoms technicians of operation and maintenance staff are significantly increased to cope with the complicated network which requires more efficient O/M, and on the other hand, telecoms workers are decreased.

Table 9.5 Increment of Staff

Categories	Present	1995	Magnification
ENGINEER & S/M	37	96	2.59
CHIEF TELECOMS TECHNICIAN (CTT)	115	130	1.13
T.TECHNICIAN (TT)	499	739	1.48
T.MECHANIC (TM)	242	242	1.00
T.WORKER (TW)	1,175	1,027	0.87
OTHERS	701	701	1.00
Total	2,769	2,935	1.06

For each study area, the additional O/M staff are not required except the staff for MARS mentioned above in the item 9.2.1 (2), when sufficient recruitment has been completed by PTC as per target staffing for the year 1995.

Proper type of vehicles shall be provided to this additional staff to maintain MARS system installed in the vast exchange area, therefore, each study area should have the following establishment for the operation and maintenance staff after 1995.

Item	Sub-System			
	SWITCHING	TRANSMISSION	EXTERNAL	Total
TT TW GW	1 - 1	1 1 1	*a 2 -	2 3 2
Total	2	3	2	7
VEHICLE	-	1	*b	1

TT: Telecoms Technician, TW: Telecoms Workers, GW: General Worker
*a: The duties of TT for External Sub-system will be undertaken by TT for Transmission Sub-system.
*b: Existing vehicle is to be used.

In addition to the above establishment, one vehicle for O/M staff of trunk route should be provided at each parent exchange i.e., five vehicles in total. The parent exchanges are listed below,

Study Exchanges	Parent Exchanges
NKAYI	KWEKWE
GUTU, CHATSWORTH	MASVINGO
KEZI	BULAWAYO
BEATRICE	HARARE
MURAMBINDA	MUTARE

9.3 Training

Training is divided into three categories, i.e., training at PTC Training College, at Facilities Manufacturer's Factory and On-the-job Training.

9.3.1 Training at PTC Training College

Present situation of the training being conducted at PTC Training College is mentioned in the item 9.1 (3), and the courses given by the college are recognized as essential training not only for the field of operation and maintenance but also for every personnel related to the telecommunication organization.

It is recommended that the model system of MARS which is the same type to be installed in the project should be introduced to PTC Technical College in order to obtain more effective training to the staff of operation and maintenance for the MARS system and also considering system expansion to the other exchange areas in future.

9.3.2 Training at Facilities Manufacturer's Factory

This training is intended to acquaint the outline of facilities to be constructed to the staff and to give knowledge for operation and maintenance.

O/M staff who have completed this training are preferable to work as instructors in the subsequent training series or as responsible persons for management of the whole operation and maintenance work. Therefore, the trainees should rather be selected from among instructors of PTC Technical College or senior engineers with a certain degree of field experience, e.g., the personnel scheduled to be assigned to maintain MARS system in the study exchanges.

The number of trainees and their training period is to be two personnel (one each for switch and transmission system) and at least for two monthly period.

9.3.3 On-the-Job Training

All the qualified operation and maintenance staff are to take a part in the construction work, so as to acquire the necessary knowledge for the subsequent O/maintenance work, such as the method of testing and of handling the measuring equipments.