4.3 Basic Plan

4.3.1 Road Plan

Based upon the topographic map and the result of the site reconnaissance, the construction of the study routes will be categorized by the work shown in Table 4-3.

Table 4-3 Work Category of the Study Routes

Route No.	Bridge name	Length (km)	Bridge length (m)	Approach road (km)	Road rehabilitation (km)
Route 357	Odzi Bridge	41.6	157.0	4.443	37.00
Route 956	Ungwe Bridge	37.8	49.5	0.247	37.50
Route 344	Devure I Bridge	86.9	107.0	1.843	79.08
	Sote Bridge		74.0	0.826	
	Pembezi Bridge		49.5	4.921	
Route 359	Devure II Bridge	16.0	173.0	1.327	14.50
Route 759	Nata Bridge	1.7	74.0	1.626	-
Total		184.0	684.0	15.233	168.08

Remark : The project length of Route 956 above equals the initial project length of 38.06 km determined during the site reconnaissance minus the existing Sanyati Bridge length.

The pavement design of the project road was carried out based on the pavement standard defined by DSR as tabulated below:

Table 4-4 Pavement Standard of the Studied Routes

Route Name	Pavement Standard
Route 357	0.3 M
Route 956	0.3 M
Route 344	0.3 M
Route 359	0.1 M
Route 759	0.1 M

Surfacing of the study routes will be carried out the 8 m full width with a "two coat surface treatment" of 19 mm tack coat and 7 mm seal coat. The pavement design was conducted based upon the "Manual:Part C:Planning" and "Standard Specifications", April 1989, DSR.

Regarding the alignment design, the following were the major considerations for the Project:

Horizontal alignment

1 The approach roads will connect the new bridges and existing roads under specified geometric conditions. The length of the approach roads will be designed to link the new bridges and existing roads in the shortest distance.

2 In the case that DSR has already finished the detailed design or carried out the alternative route study, the horizontal alignment design will be carried out following the DSR's plan as much as possible.

3 Location of the proposed bridges was finally determined by the site reconnaissance and several meetings with DSR, as follows:

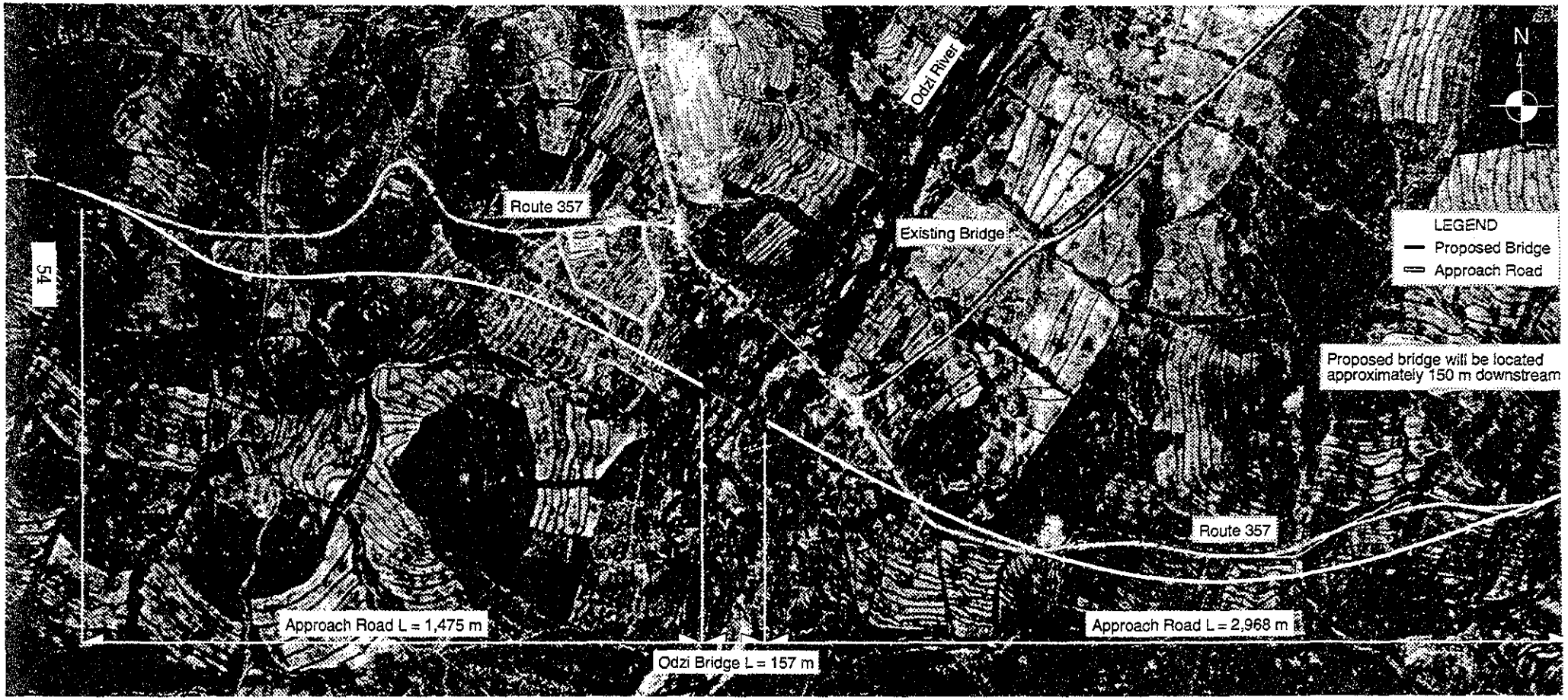
1	Odzi Bridge (Route 357)	: Follow DSR design. Proposed bridge will be located approximately 150 m downstream from the existing bridge
2	Ungwe Bridge (Route 956)	: Follow DSR design. Proposed bridge will be located on the existing alignment.
3	Devure I Bridge (Route 344)	: 30 m downstream from the existing structure referring to the route study by DSR
4	Sote Bridge (Route 344)	: 30 m upstream from the existing structure referring to the route study by DSR
5	Pembezi Bridge (Route 344)	: Approximately 400 m downstream from the existing structure referring to the route study by DSR
6	Devure II Bridge (Route 359)	: 15 m upstream from the existing structure
7	Nata Bridge (Route 759)	: 30 m upstream from the existing structure

Vertical alignment

1 Vertical alignment of the approach roads will be designed based on the formation height of the new bridges to be determined by the Study Team after reviewing the design flood water level, in accordance with the specified geometric design criteria.

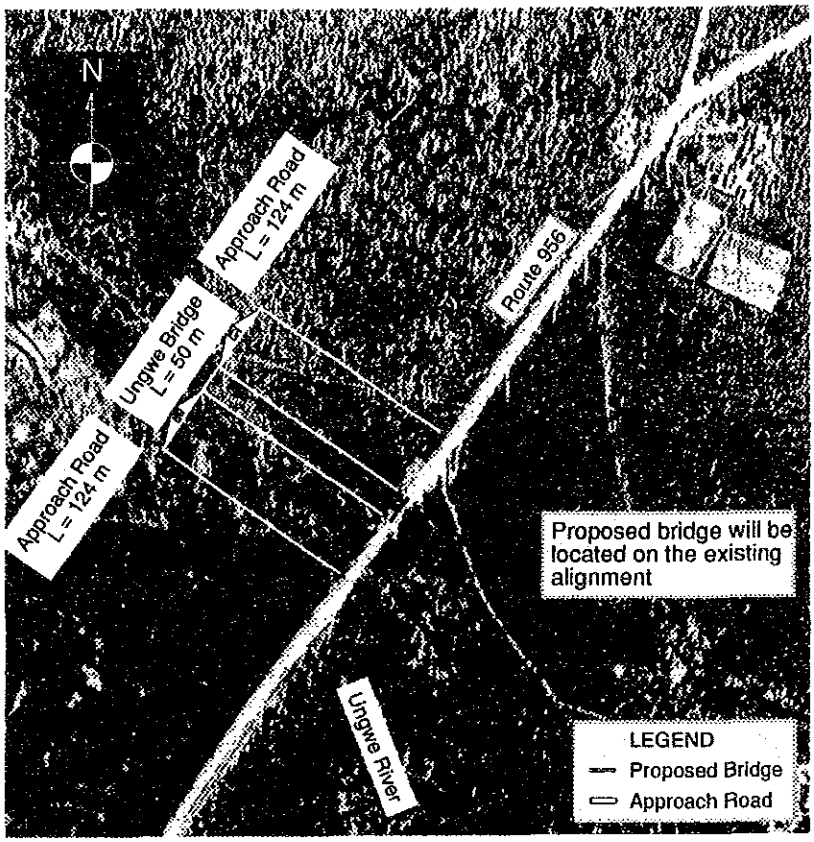
2 For the section of rehabilitation, the existing road surface will be scarified with the minimum thickness required for paving. Therefore, alignment design will be conducted to keep the required minimum height for the construction work. When the existing road condition is substandard or requires special attention for drainage facilities, design will be carried out to improve the existing conditions.

Figures 4-2 (1)~(6) show the proposed bridge location on aerial photograph.

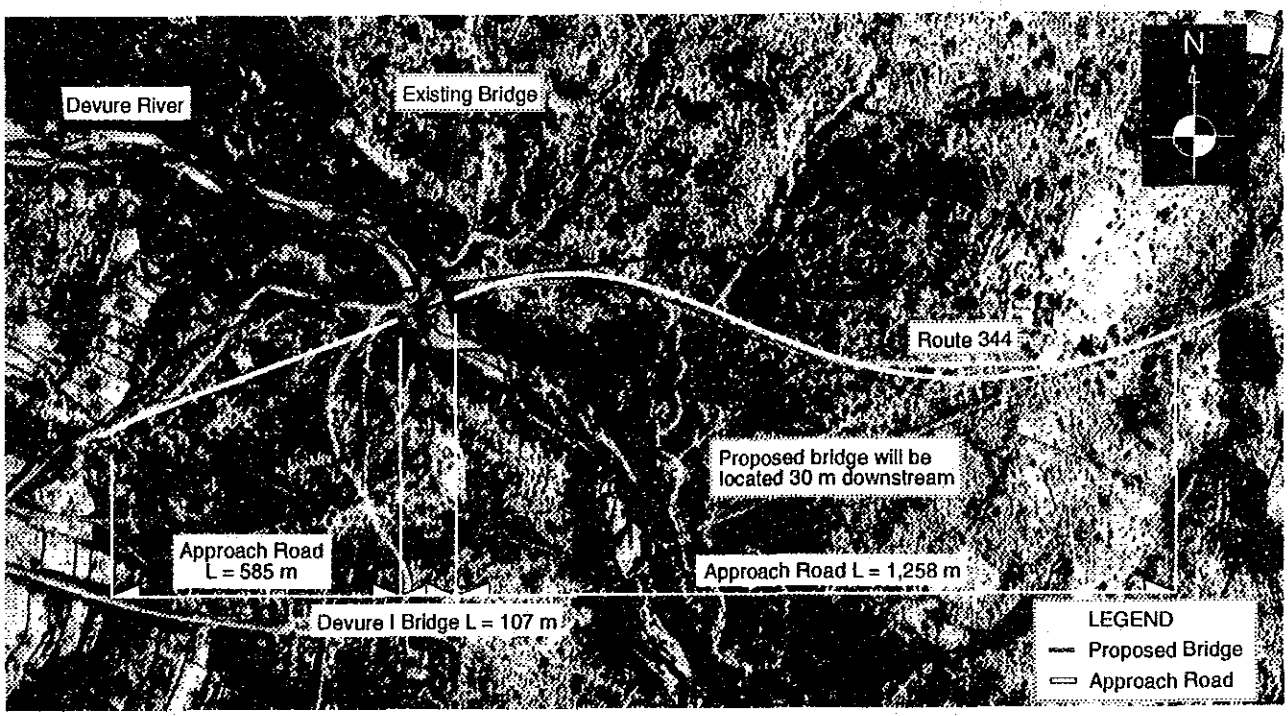


(a) Odzi Bridge

Fig. 4-2 (1) Location Plan of Bridges

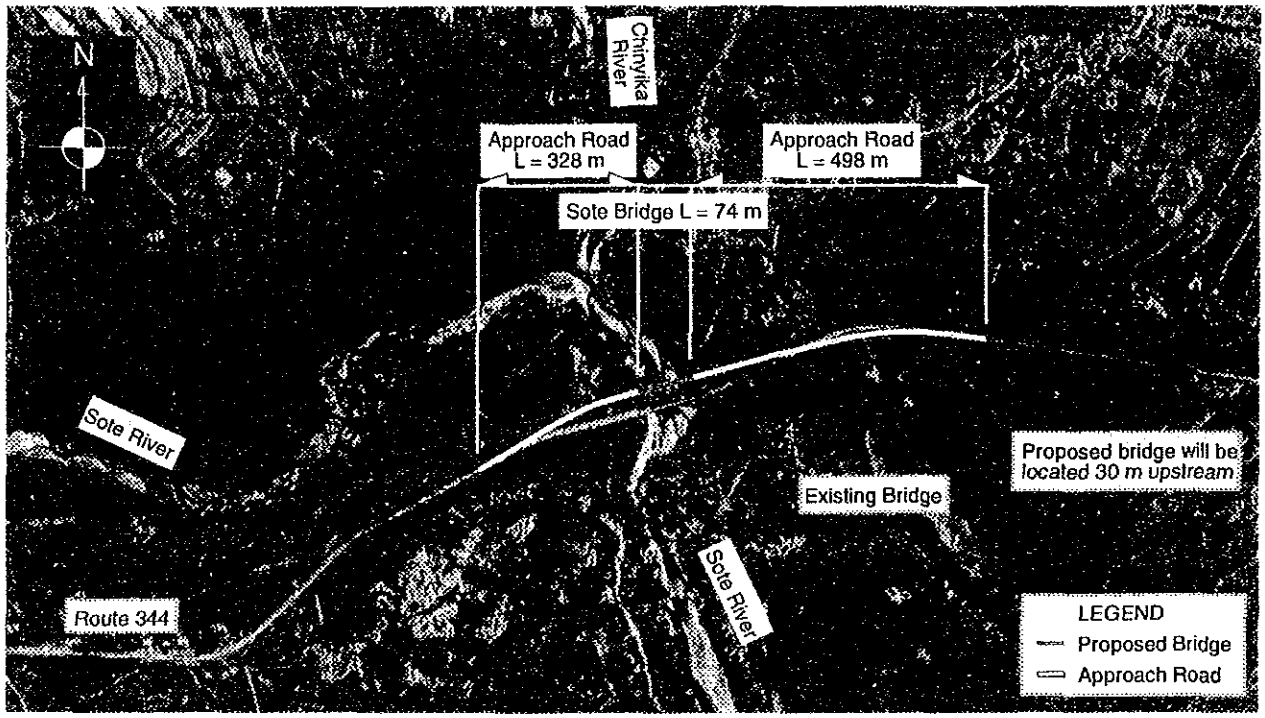


(b) Ungwe Bridge



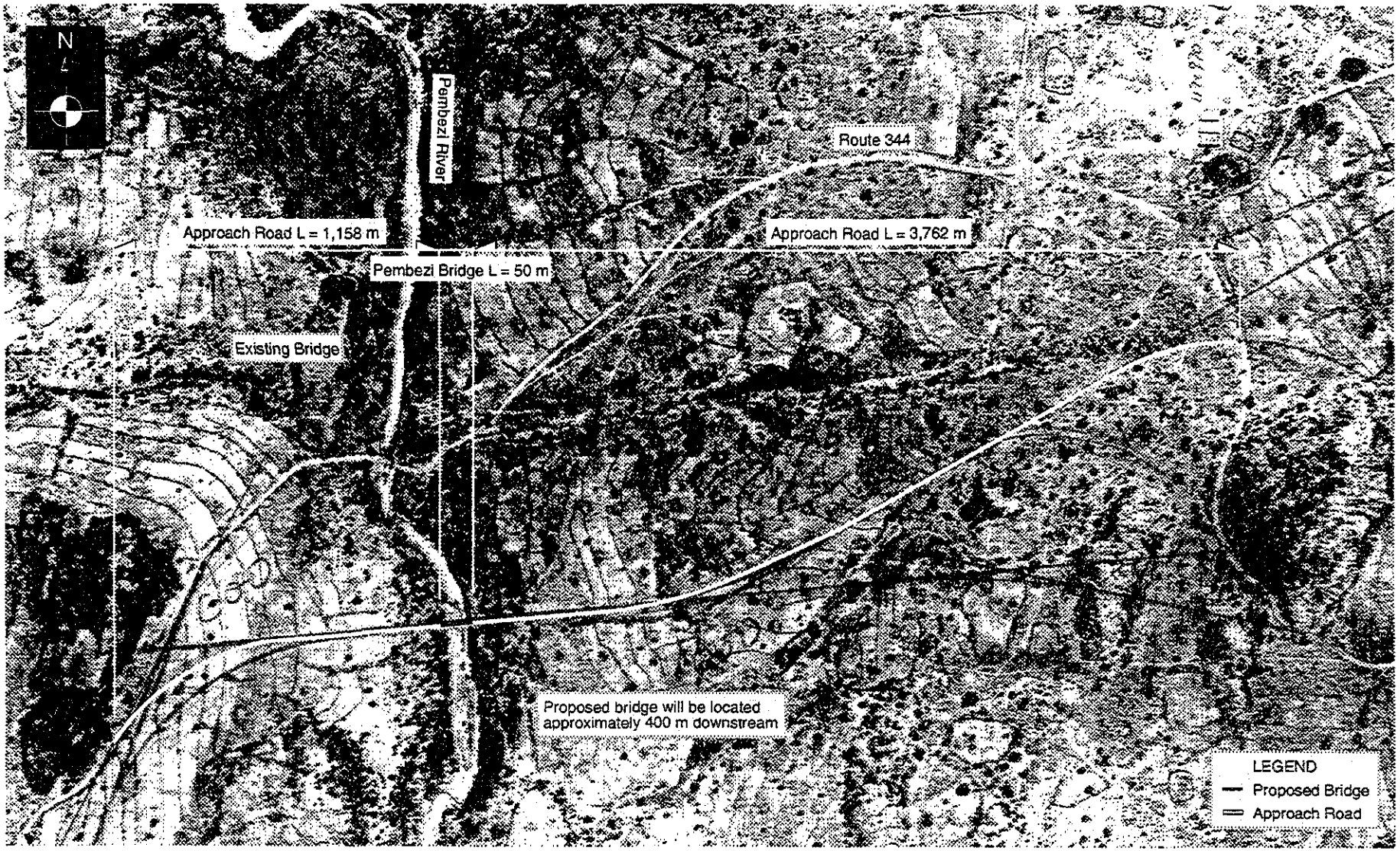
(c) Devure I Bridge

Fig. 4-2 (2) Location Plan of Bridges



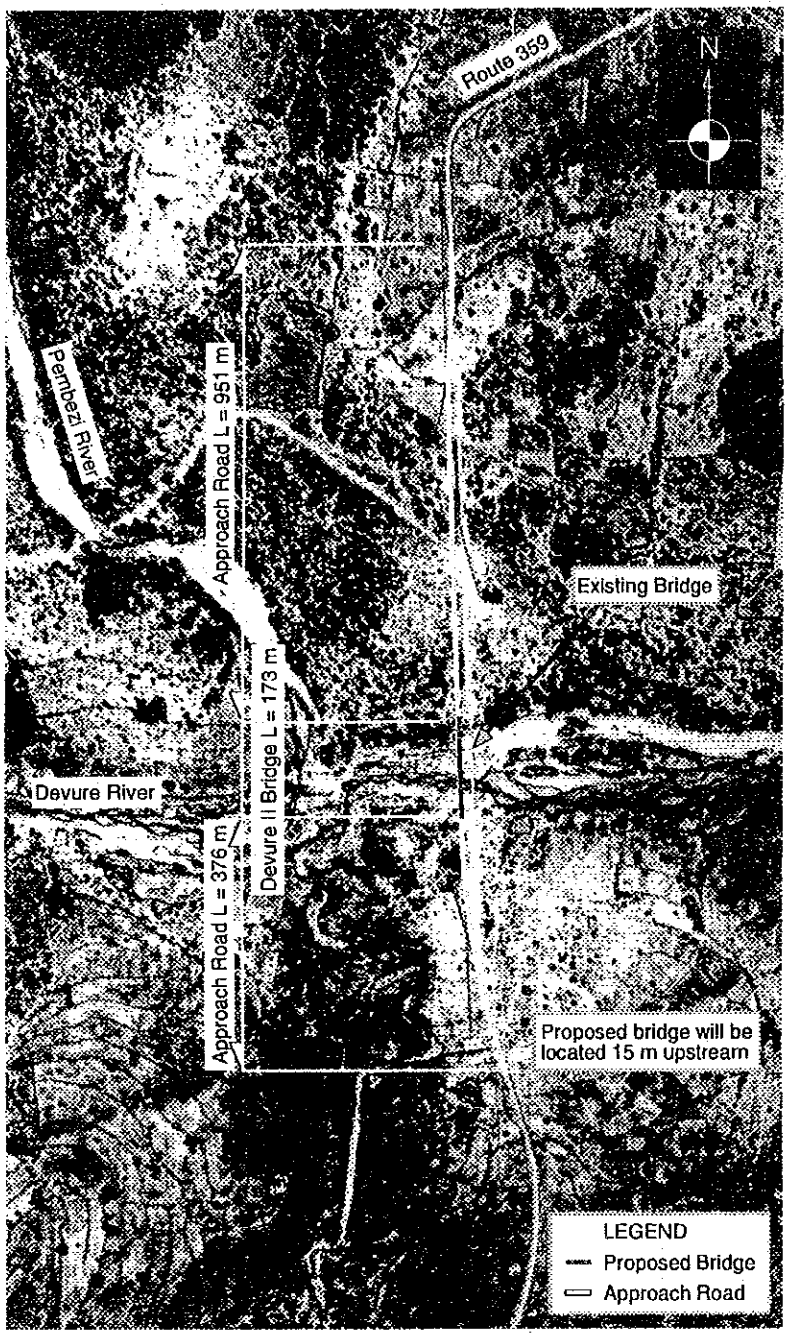
(d) Sote Bridge

Fig. 4-2 (3) Location Plan of Bridges



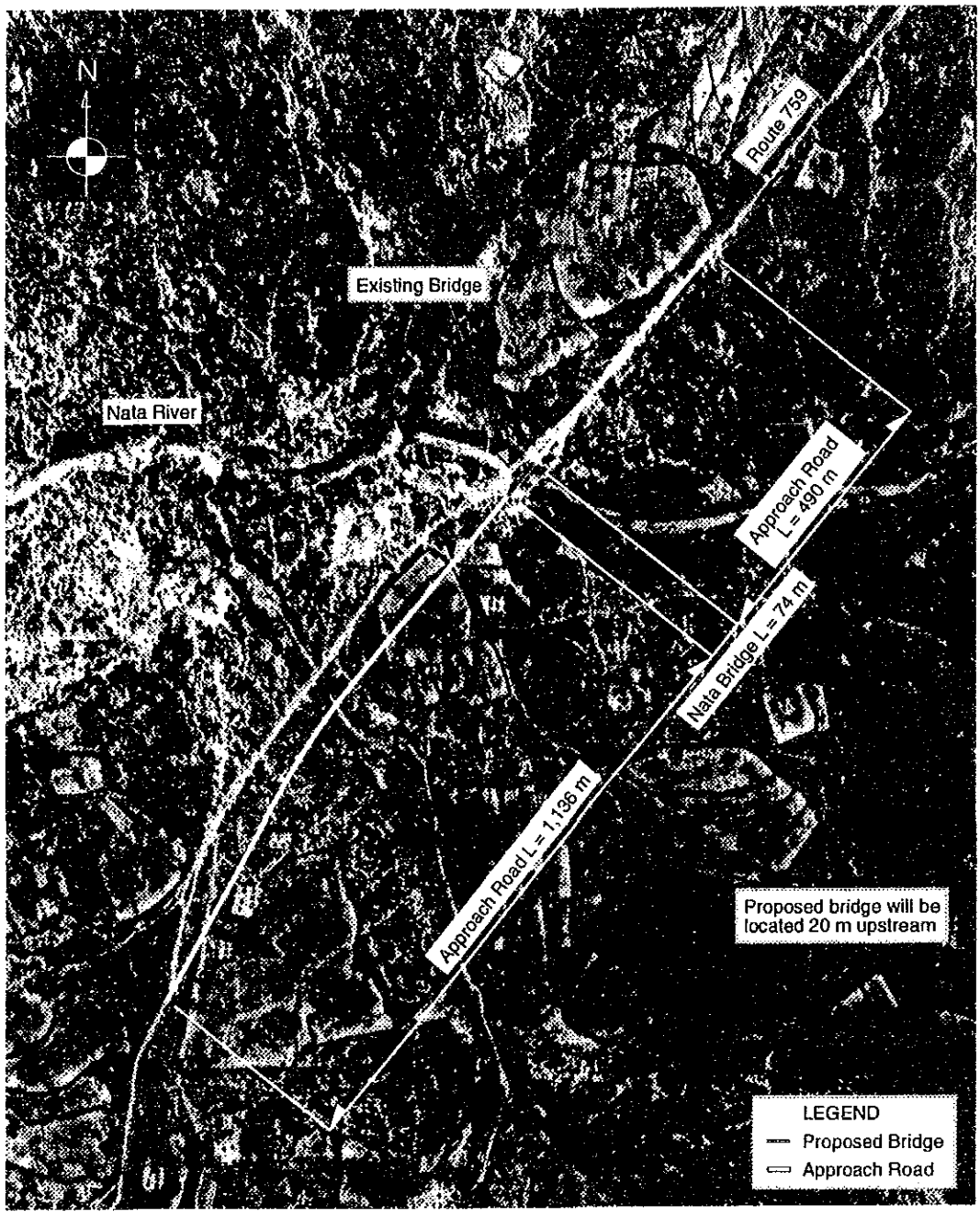
(e) Pembezi Bridge

Fig. 4-2 (4) Location Plan of Bridges



(f) Devure II Bridge

Fig. 4-2 (5) Location Plan of Bridges



(g) Nata Bridge

Fig. 4-2 (6) Location Plan of Bridges

4.3.2 Bridge Plan

(1) Determination of Bridge Length, Span, and Height

Bridge length and height are to be determined to secure an adequate bridge opening to accommodate the design flood discharge. The blocking of river flow or erosion around the bridge foundations by river flow due to an insufficient opening should be avoided. In addition, it is planned that the minimum revetment work along river banks and the protection of riverbeds around piers will be carried out.

The formation height of the bridges were determined from the design flood level, an appropriate free board, and the required girder height, as listed in Table 4-5. The design flood volume and design flood level were estimated based on the Manual Part C, and surveyed river cross sections, respectively.

Under the above mentioned conditions, total bridge length was designed based on the standard bridge length stipulated in the Manual, the results of the topographic/ geotechnical investigation and site reconnaissance.

Table 4-5 Conditions for Bridge Design

Bridge Name	Catchment Area (km^2)	Flood Discharge (m^3/s)	Design flood level (m) *	Free Board (m)	Proposed Total Bridge Length (m)	Block Ratio of River (%)
Odzi	2, 450	1, 148	798.2	1.0	157.0	4.6
Ungwe	172	270	2, 900.4	0.8	49.5	2.4
Devure I	686	700	2, 999.0	1.0	107.0	4.5
Sote	344	613	1, 113.0	1.0	74.0	3.2
Pembezi	122	240	2, 997.5	0.8	49.5	2.4
Devure II	3496	1, 375	813.0	1.0	173.0	4.2
Nata	1, 292	800	2,998.9	1.0	74.0	3.2

Notes: * : Elevation is based on the topographic map

(2) Design of the Superstructure

Post-tensioning prestressed concrete girder type bridges was adopted for the Project, as described in the section 4.2.2 (5). By applying the Japanese Standard Design for post-tensioning PC girder, the standard bridge of the Project with a 24 m span length and four main girders was designed. The girder height was 1.35 m and 9 PC cables were scheduled to prestress the girder. The end spans of some bridges were designed as a 16 m span length with 1.0 m girder height.

(3) Design of the Substructure

The design of the substructure was proposed after deliberations on the type of superstructure, geotechnical and topographic conditions, river condition, and construction method. It was not always necessary to apply deep embedding because of the low possibility of scoring and good soil conditions. However the riverbed protection shall be applied to the disturbed portion by excavation work during the substructure construction. The pier was designed as a wall type having circular end at up and

downstream sides to secure smooth flow. The type of abutment was planned as the inverted T type for the height less than or equal to 10 m, and the buttress type for the height more than 10 m.

4.3.3 Basic Design Drawing

The basic design drawings for the Study were prepared for the purpose of estimating the construction period and cost, and determination of the scope of works in Japan's Grant Aid. Figures A-1 to A-9 annexed in the Report show the general views of the proposed bridges and structural drawings of superstructure. Figures A-10 to A-21 show the profile of the approach roads. Among the approach roads for seven bridges, roads for the Odzi and Ungwe Bridges were designed to follow DSR's design except for the revision of the bridge formation height.

4.3.4 Approximate Work Quantities

Quantities for the construction cost estimates were calculated based on the following conditions:

(1) Superstructure (L=24 m)

- Concrete volume, Form area, PC cable, etc. were derived from the standard drawings of PC Bridges, Japan.
- Reinforcement bar weight was estimated to equivalent local square twisted steel weight, converted from D13 and D16 which were applied in the said standard drawings.

(2) Superstructure (L=16 m)

- Concrete volume, Form area, PC cable, etc. were calculated from the design drawings of the Project.
- Quantities of reinforcement bar were estimated referring the Japanese standard design PC girder of 20 m span, since the shape of main girder was similar. Then the weight was calculated converting to the equivalent local square twisted steel.

(3) Excavation and Backfill

- Excavation was classified into common excavation and rock excavation. Under-water excavation was not applied, because the work was intended to execute in the dry season as much as possible, and to provide the coffer to secure the safety during the construction. Cut slope of 1:1 for common and 1:0.3 for rock excavation were applied.
- As for the backfill materials for piers, boulders or cobblestone were applied for the riverbed protection.
- Backfill slope of 1.1 for cut portion and 1:4 for fill portion were applied.

- Approach cushion slab was designed following the standard drawings of Zimbabwe. Slab thickness or the required reinforcement bar will be reviewed in the detailed design stage.

(4) Substructure

- Reinforcement bar weight of substructures were estimated referring the design drawings of DSR. Once a drawing of substructure, 9 m in height (this height was also applied in the project design), was selected as a typical one, and the unit weight of reinforcement bar per wall, footing were estimated. Then the weight of reinforcement bar of each substructure of the Project were calculated, proportional to the concrete volume.

(5) Others

- Bearing and expansion joint were assumed to be imported from Japan. Newel posts, drain pipes, guard rails, and name plate were estimated based upon the Zimbabwean standard.

Major work quantities estimated from basic design drawings are tabulated below.

Table 4-6 Bridge Construction—Major Quantities

	Bridge Name	Route Number	Bridge		Abutment (nos.)	Pier (nos.)
			Length (m)	Surface area (m^2)		
1	Odzi	(357)	157.0	1,382	2	6
2	Ungwe	(956)	49.5	436	2	1
3	Devure I	(344)	107.0	942	2	4
4	Sote	(344)	74.0	651	2	2
5	Pembezi	(344)	49.5	436	2	1
6	Devure II	(359)	173.0	1,522	2	6
7	Nata	(759)	74.0	651	2	2
	Total		684.0	6,020	14	22

Table 4-7 Bridge Construction—Major Materials

	Bridge Name	Route Number	PC Girder (nos.)		PC Cable (t)		Concrete (m^3)		Reinforcement bar (t)	
			24 m	16 m	24 m	16 m	Superstructure	Substructure	Superstructure	Substructure
1	Odzi	(357)	20	8	18.2	4.0	652	1,239	86	112
2	Ungwe	(956)	8	-	7.3	-	210	433	28	41
3	Devure I	(344)	12	8	10.9	4.0	443	937	59	106
4	Sote	(344)	12	-	10.9	-	314	648	41	62
5	Pembezi	(344)	8	-	7.3	-	210	571	28	56
6	Devure II	(359)	28	-	25.4	-	732	1,537	96	146
7	Nata	(759)	12	-	11.0	-	315	581	41	55
	Total		100	16	91.0	8.0	2,876	5,946	379	578

Table 4-8 Approach Road Construction—Major Quantities

Bridge Name	Route Number	Length (m)	Earth work (m^3)		Pavement (m^3)	Surfacing (m^2)	Culvert (m)
			Excavation	Fill			
1 Odzi	(357)	4,443	96,400	68,700	19,600	35,500	195
2 Ungwe	(956)	247	6,100	6,400	1,300	2,000	20
3 Devure I	(344)	1,843	19,900	24,800	8,100	14,800	0
4 Sote	(344)	826	3,300	7,900	3,600	6,600	0
5 Pembezi	(344)	4,920	17,300	11,100	21,700	39,700	0
6 Devure II	(359)	1,327	19,700	9,300	5,800	10,600	30
7 Nata	(759)	1,626	3,700	14,900	7,200	13,000	30
Total		15,232	166,400	143,100	67,100	122,200	275

4.3.5 Equipment and Materials Plan

The scope of works to be carried out by the Zimbabwean side covers the rehabilitation, in the form of an asphalt surfacing, of the existing roads totaling 168 km and the improvement of related drainage structures.

The major works will include:

- surfacing after scarifying and leveling the existing metal road, or surfacing after construction of the base layers and/or subgrade for non metalling roads or newly constructed roads.
- raising of the grade and construction of drainage for the sections proven to inundate in the rainy season.
- improvement of the road alignment with new embankments and pavements.

The above works will be carried out by two construction units to be selected from seven construction units. Construction units No. 2 and No. 5 are expected to be allotted the works.

(1) Required Equipment to be supplied by GOJ

The equipment required to complete the rehabilitation of the roads, of 168 km, within the most economical construction period, was examined considering the following conditions:

a) Construction period

The construction period will be determined taking into account the urgency of the project, the site condition, the construction ability, and the economical viewpoint. In this basic design study, the construction period was assessed based on the economical viewpoint considering the construction capability by utilising the construction equipment, and the economical operation life of the construction equipment.

The economical operation life of the construction equipment was judged as 5 to 6 years. The equipment can be used over 5 or 6 years, but the maintenance cost,

generally, shows a rapid increase, and some equipment need to be replaced. In this study, the construction period more than 6 years was rejected for it was judged as uneconomical. Since the "Guideline for the Construction Estimates", Ministry of Construction of Japan, specifies the equipment life of backhoe or dump truck as 5 years, it was recommended to complete the Project within 5 years.

On the other hand, the construction speed of the road rehabilitation, similar scale to this project, by one construction unit of DSR was 18 km/year, based on the past experience. Therefore the required construction period of 168 km road rehabilitation by one construction unit was estimated as 9.3 years, as shown below.

Required construction period by one construction unit = 168 ÷ 18 = 9.3 years

According to DSR, two construction units out of 7 can be mobilised to the Project. In This case, the road rehabilitation of the Project will be completed within 5 years. Therefore, 5 years construction period was determined for the works to be carried out by the Zimbabwean side.

b) Type and quantity of the equipment

Based upon the "Guideline for the Construction Estimates", Ministry of Construction of Japan, required type and quantity of the construction equipment for the road rehabilitation of 168 km was estimated. The assumption of the estimates was as follows:

Construction period : 5 years
Workable days : 200 days/year
Workable hours : 6.5 hours/day

Summary of the required types and mathematically estimated quantities of the construction equipment, and the breakdown of estimation are shown in Tables 4-9 and 4-10 respectively.

Table 4-9 List of Required Types and Quantities of Equipment (1/2)

Equipment Type	Quantity	Remarks
1) Bulldozer, 21 t class	1.9 nos.	for clearing at the borrow pit, excavation of hard ground and rocks
2) Bulldozer, 15 t class	1.4 nos.	for excavation at the borrow pit and fill work (except for miscellaneous works)
3) Backhoe, 0.7 m^3 class	1.9 nos.	for loading at the borrow pit and drainage construction
4) Wheel loader, 1.9 m^3 class	0.9 no.	for loading at the borrow pit and aggregate stock pile
5) Dump truck, 8~11 t class	12.4 nos.	for a hauling distance of 5 km
6) Motor grader, 130 PS class	3.9 nos.	for scarifying the existing road, and pavement works.

contd.....

Table 4-9 List of Required Types and Quantities of Equipment (2/2)

Equipment Type	Quantity	Remarks
7) Water tanker, 8 m^3 class	3.1 nos.	in the dry season, 1.5 times of the estimated quantities will be required for fill works. Water supply for the concrete works will be also required.
8) Tyred roller, 8~20 t class	1.6 nos.	for compaction.
9) Road roller, 10/12 t class	1.6 nos.	for compaction.
10) Vibration roller, 6.5 t class	1.7 nos.	for compaction.
11) Disc harrow, tandem	0.4 no.	for the cement stabilization of the base layer.
12) Wheel tractor, 100 PS class	0.4 no.	for towing the disc harrow. Towing work for other equipment was not counted.
13) Chip spreader (for 8 t dump truck)	0.1 no.	for spreading aggregate for road surfacing.
14) Asphalt distributor, 6 m^3 class	0.2 no.	for the road surfacing.
15) Water pump (80 mm)	2.4 nos.	for the drainage during the construction such as the culvert work. In the dry season, also used for water supply to a water tanker.
16) Concrete mixer (0.25 m^3)	1.2 nos.	for the concrete structure such as concrete culverts, or catch basin, etc.

Remarks : Regarding the asphalt distributor, one unit will be enough when two construction units execute the works contiguously. However, it was recommended to provide one unit per one construction unit, taking into account the case of equipment breakdown or the construction sites locate in the distance each other.

c) Recommended quantity of the equipment

Considering the results of the above examination on the major equipment, it was recommended by the basic design study to provide the equipment listed in Table 4-11 to the Zimbabwean side.

Some of the DSR's equipment such as the motor grader, tyred roller, water tanker (towed type), etc. may be required to support the Project at peak times.

(2) Required Materials to be supplied by GOJ

The following materials are to be used for the 168 km road rehabilitation:

- Cement for stabilizing the base layer, and aggregates and asphalt for surfacing.
- Reinforced concrete pipes, galvanized corrugated steel pipes, and aggregate and cement for construction of the drainage structures.

The material estimates for the 168 km road rehabilitation are as follows:

- Portland cement for stabilization : Approx. 14, 000 ton
  ($252,000\ m^3 \times 3\% \times 3.0\ t/m^3 \times 60\%$)
  $252,000\ m^3$: Estimated quantities of Base 1
- Aggregates for surfacing : Approx. 35, 000 m^3
  ($1,344,000\ m^2 \times 0.026\ m$)
  $168\ km \times 8\ m = 1,344,000\ m^2$

Table 4-10 Breakdown of Estimation—Work Quantities and Required Equipment

Equipment		Existing Roadbed	Preparation of Roadbed (New construction)			Pavement (2 layers)	Pavement (1 layer)	Surfacing	Total operation hours (hrs)	Required number for 5 years construction (see note)	Recommended number of equipment	Required number
		Leveling	Clearing	Common Excavation/Fill	Rock Excavation							
		716,000 m2	500,000 m2	90%=915,000m3	10%=102,000m3	416,000 m3 2,773,000 m2	252,000 m3 1,680,000 m2	1,348,000 m2 (40,000 m3)				
1 Bulldozer	21 t		8 hr/ha 400 hrs	91.8 m3/h 65 % 6,500 hrs	51.6 m3/h 2,000 hrs	91.8 m3/h 50 % 2,300 hrs	91.8 m3/h 50 % 1,400 hrs		12,600	1.9 no.	1 no. per construction unit	1 no.x 2 = 2 nos.
2 Bulldozer	15 t			56.5 m3/h 20 % 3,200 hrs		56.5 m3/h 50 % 3,700 hrs	56.5 m3/h 50 % 2,200 hrs		9,100	1.4 no.	1 no. per construction unit. This class of bulldozer is very useful for civil work. Therefore it was expected to be utilised more frequent than the estimated numbers.	1 no.x 2 = 2 nos.
3 Backhoe	0.7 m3			46.0 m3/h 10 % 2,000 hrs	22.2 m3/h 40 % 1,800 hrs	46.0 m3/h 60 % 5,400 hrs	46.0 m3/h 60 % 3,300 hrs		12,500	1.9 no.	1 no. per construction unit	1 no.x 2 = 2 nos.
4 Wheel loader	1.9 m3		75,000 m3 60.3 m3/h 1,200 hrs	117 m3/h 5 % 1,900 hrs	60.3 m3/h 10 % 200 hrs	117 m3/h 40 % 1,400 hrs	117 m3/h 40 % 900 hrs	117 m3/h×0.6 700 hrs	6,300	0.9 no.	This equipment is used, mainly, for loading aggregate or fill materials. Though the required number was estimated small, it will be utilised in many aspects of construction as shown in this table. Therefore the study judged that 1 nos., at least, should be provided per construction unit.	1 no.x 2 = 2 nos.
5 Dump truck	8 t			11.3 m3/h÷2 10 % 4,000 hrs	9.3 m3/h÷2 10 % 500 hrs	7.9 m3/h 42,100 hrs	7.9 m3/h 31,000 hrs	11.3 m3/h 3,500 hrs	81,100	12.4 nos.	6 nos. per construction unit	6 nos.x 2 = 12 nos.
6 Motor grader	130 PS	380 m2 1,900 hrs		1,220,000 m2 910 m2 1,300 hrs		160 m2/h 17,300 hrs	320 m2/h 5,300 hrs	910 m2/h 1,500 hrs	25,400	3.9 nos.	2 nos. per construction unit	2 nos.x 2 = 4 nos.
7 Tyred roller	8~20 t			300 m2/h 30 % 900 hrs		300 m2/h÷2 30 % 5,500 hrs	300 m2/h 30 % 1,700 hrs	300 m2/h÷2 30 % 2,700 hrs	10,800	1.7 no.	1 no. per construction unit	1 no.x 2 = 2 nos.
8 Road roller	10/12 t			300 m2/h 30 % 900 hrs		300 m2/h÷2 30 % 5,500 hrs	300 m2/h 30 % 1,700 hrs	300 m2/h÷2 30 % 2,700 hrs	10,800	1.7 no.	1 no. per construction unit	1 no.x 2 = 2 nos.
9 Vibration roller	6.5 t			450 m2/h 40 % 800 hrs		450 m2/h÷2 40 % 4,900 hrs	450 m2/h 40 % 2,500 hrs	450 m2/h÷2 40 % 2,400 hrs	10,600	1.6 no.	1 no. per construction unit	1 no.x 2 = 2 nos.
10 Water tanker	8 m3			910 m2/h In the dry season 2,000 hrs (1,300 hrs)		480 m2/h÷2 In the dry season 17,400 hrs (11,600 hrs)	480 m2/h÷2 In the dry season 10,500 hrs (7,000 hrs)		In the dry season 29,900 hrs (19,900 hrs)	4.6 nos. (3.1 nos.)	Required number of 2.3 nos. per construction unit was estimated for fill work in the dry season. The study recommends to provide 3 nos. per construction unit, taking into account the water supply to the concrete work (approximately 3,000 hrs per 5 years.)	3 nos.x 2 = 6 nos.
11 Wheel tractor	100 PS						740 m2/h 2,300 hrs		2,300	0.4 no.	The required number was estimated to tow the disc harrow described below. However it was anticipated to tow other equipment such as tyred roller, grid roller or grader of DSR (500 hrs/year x 5 year = 2,500 hrs.) in addition, it will be utilised to tow a water tanker, fuel bowser or trailer in a daily basis. Therefore the study recommends to provide 2 nos. per construction unit.	2 nos.x 2 = 4 nos.
12 Disk harrow	Tandem						740 m2/h 2,300 hrs		2,300	0.4 no.	This equipment is used for cement stabilisation of the pavement layer. Though the required number was estimated small, it was judged that at least 1 no. should be provided to a construction unit.	1 no.x 2 = 2 nos.
13 Chip spreader	8 t							1,600 m2 800 hrs	800	0.1 no.	This equipment is used to spread aggregate for road surfacing. Though the required number was estimated small, it is necessary to provide 1 no. per construction unit.	1 no.x 2 = 2 nos.
14 Asphalt distributor	6 m3							860 m2 1,600 hrs	1,600	0.2 no.	Though the required number for surfacing work itself was small, it should be considered the required time for hauling the material around 100 ~300 km. It was judged as necessary to provide 1 no. per construction unit.	1 no.x 2 = 2 nos.
15 Water pump	80 mm			Culvert : 54 locations 2 nos./location/month in average					45 months (Exclude the rainy season from Dec. to Feb.)	54×2÷45 = 2.4 nos.	Though estimated as 2.4 nos., it was judged that 5 to 7 nos. in total will be required, taking into account the number of construction sites (2~3 locations) which will be executed simultaneously, and required period per construction site. In the study, 5 nos. + 1 no. for a spare, 6 nos. in total were recommended.	3 nos.x 2 = 6 nos.
16 Concrete mixer	0.25 m3			Culvert : 54 locations 1 no./location/month in average					45 months (Exclude the rainy season from Dec. to Feb.)	54÷45 = 1.2 no.	As explained in the above column, 3 to 4 nos. will be required, taking into account the number of construction sites (2~3 locations) which will be executed simultaneously. The study recommends to supply, at least, 4 nos. since other miscellaneous works, such as small scale drainage, catch basin, ditches, etc. also need the equipment.	2 nos.x 2 = 4 nos.

Note : Workable hours within 5 years was estimated as 6,500 hours. (6.5 hrs/day x 200 days/year x 5 years = 6,500 hours)

- Straight asphalt : 3, 650 m3
  ($1{,}344{,}000\ m^2 \times 0.0272\ m^3/m^2$)
  $0.0272\ m^3/m^2$: Standard application rate for two coat surface treatment in Zimbabwe

- G. Corrugated Steel Pipes : 98 ton
  $(0.076\ t/m \times 12\ m \times 2\ nos. \times \frac{8\ locations}{25\ km} \times 168\ km)$

Among the above materials, the corrugated steel pipes and straight asphalt are the materials requested by the Zimbabwean side and these are listed in Table 4-11.

Table 4-11 List of Recommended Equipment and Materials

Equipment/Materials		Quantity	Power/Capacity/ Specifications
A	Earth equipment		
	Motor grader	4 nos.	130 kW
	Bulldozer	2 nos.	21 t class
	Bulldozer	2 nos.	15 t class
	Hyd. backhoe	2 nos.	0.7 m^3 class
	Dump truck	12 nos.	8 t class
	Wheel loader	2 nos.	1.9 m^3 class
B	Compaction equipment		
	Self prop. tyred roller	2 nos.	8~20 t class
	Road roller	2 nos.	10/12 t class
	Vibration roller	2 nos.	6.5 t class
C	Ancillary equipment		
	Water tanker	6 nos.	8 m^3 class
	Wheel tractor	4 nos.	100 PS class
	Disc harrow	2 nos.	Tandem, towed
	Water pump	6 nos.	80 mm dia. class
D	Paving equipment		
	Asphalt distributor	2 nos.	6 m^3 class
	Chip spreader	2 nos.	2.5 m for dump truck
E	Miscellaneous equipment		
	Concrete mixer	4 nos.	0.25 m^3 class
	Spare parts (35 % of equipment quotation)		
F	Construction materials		
	Galvanized corrugated steel pipes	98 t	
	Asphalt	3, 650 m^3	

(3) Construction period

It is planned that the rehabilitation works of the related roads will be completed within 5 years considering the construction speed of the construction units and the available number of construction units.

4.4 Implementation Plan

4.4.1 Implementation Principles

(1) Construction conditions

The most important factor to be considered in scheduling the construction period is the effect of the rainy season from November to March. During this period, construction of the roads and bridges is limited and progress of the superstructure work is usually slow, especially for erection of the girders. Taking into account this factor, the following basic principles were established to shorten the construction period to complete the Project within the earliest possible time:

- It is planned that construction of the substructures and fabrication & erection of the P.C. girders will be carried out simultaneously. Even in the rainy season, fabrication and erection of the girders will be carried out.
- Two construction crews shall be organized for construction of the seven project bridges: one for the Odzi, Devure II, and Nata Bridges and the other for the Ungwe, Devure I, Sote, and Pembezi Bridges.

(2) Construction period

Considering the above basic principles, it should take 28 months to complete the Project as shown in Figure 4-3. The sections to be implemented by GOJ and GOZ which were configured by this basic design study are illustrated in Figures 4-4 (1)~(4).

(3) Necessity of experts

Fabrication and erection of PC girders require well trained experts. Since the project sites locate in the distance from Harare, the capital of Zimbabwe, ranging from 250 km east to 350 km west, the basic design study recommends to dispatch the experts such as a operator of special equipment or PC bridge expert from Japan at the time required.

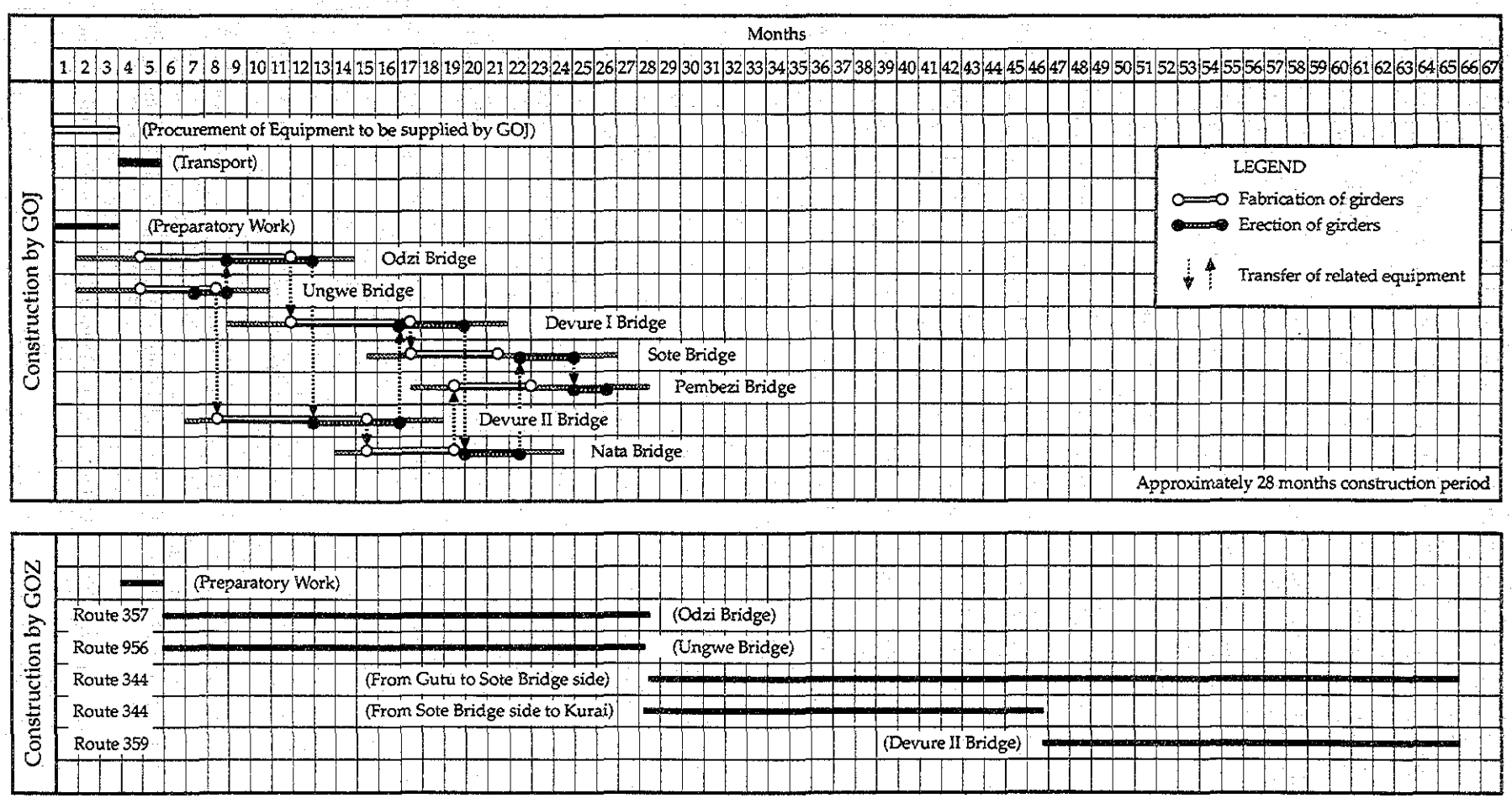


Fig. 4-3 Tentative Construction Schedule

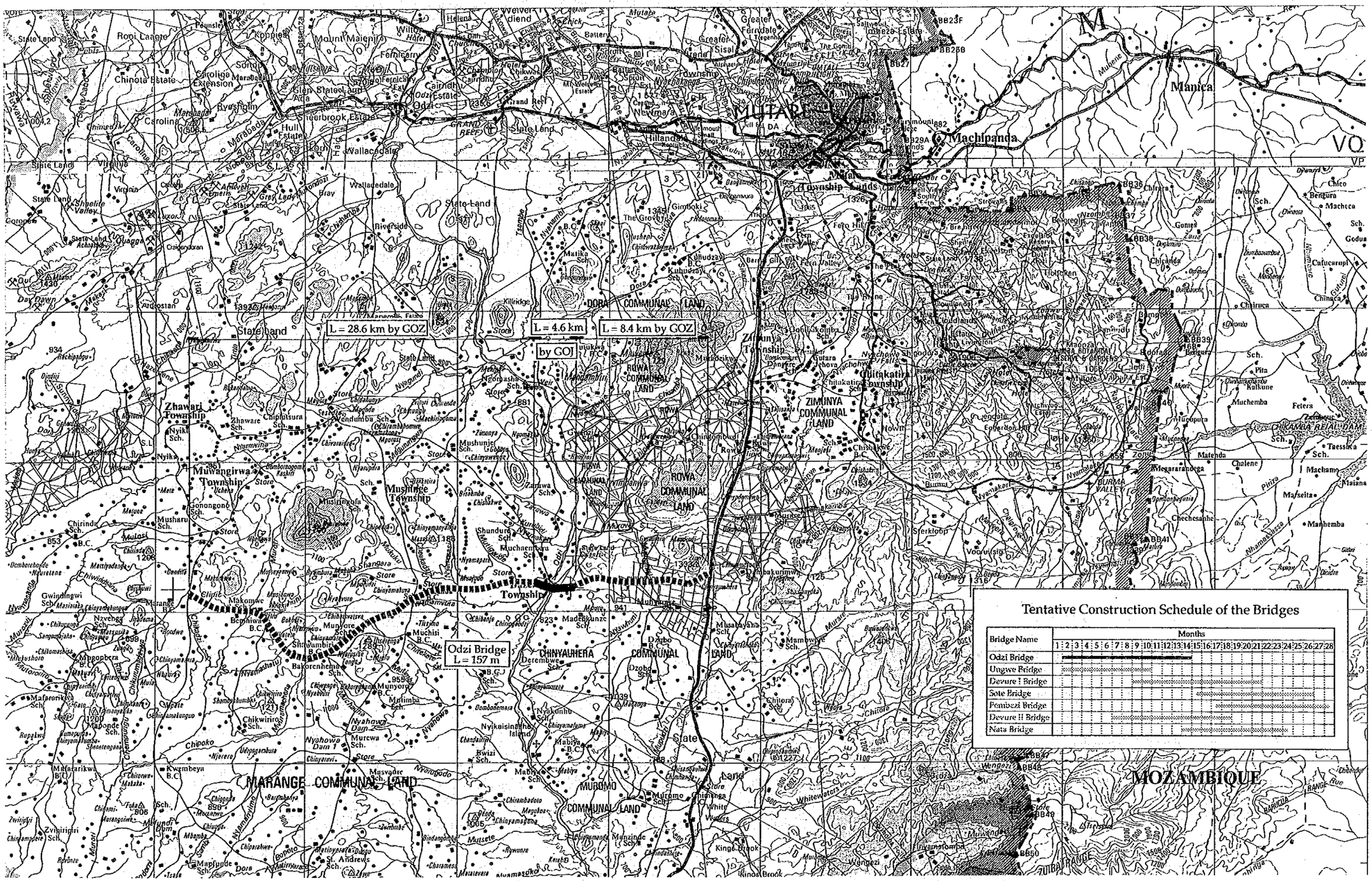
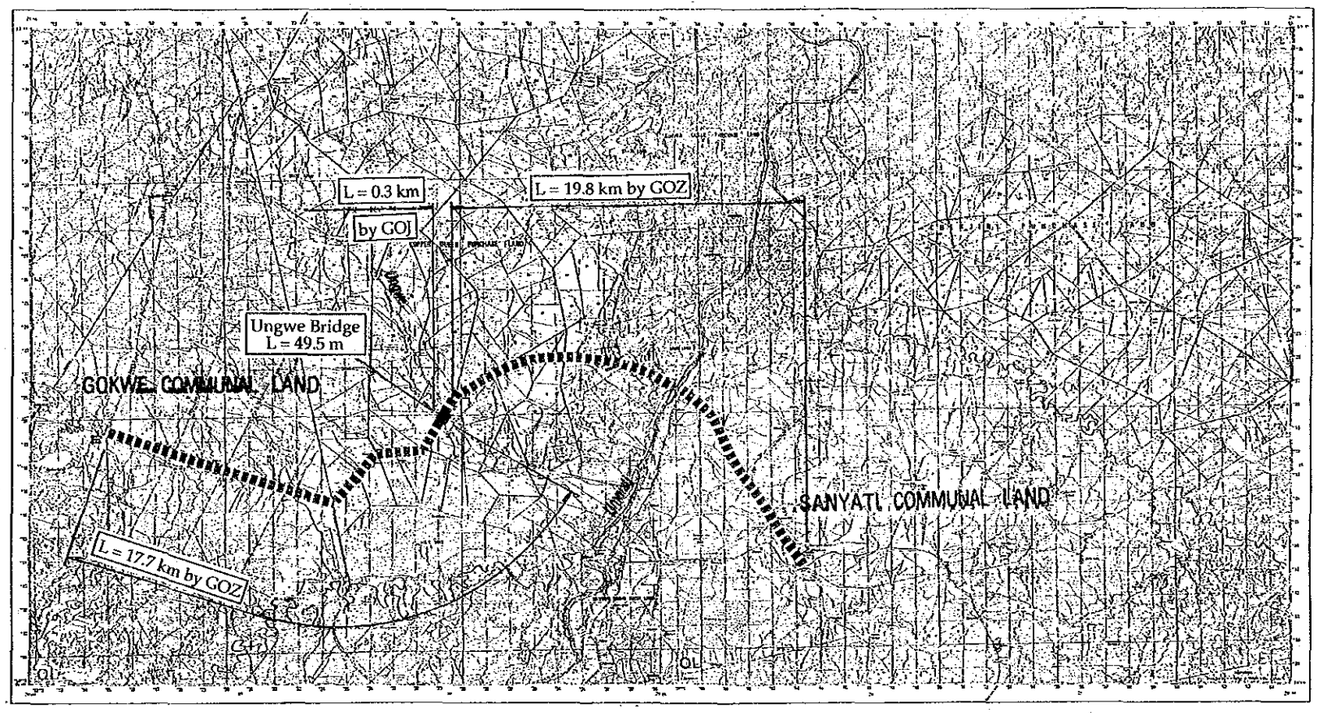


Fig. 4-4 (1) Demarcation of the Project Implementation (Route 357)



Tentative Construction Schedule of the Bridges

Bridge Name	Months (1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28)
Odzi Bridge	
Ungwe Bridge	
Devure I Bridge	
Sote Bridge	
Pembezi Bridge	
Devure II Bridge	
Nata Bridge	

Fig. 4-4 (2) Demarcation of the Project Implementation (Route 956)

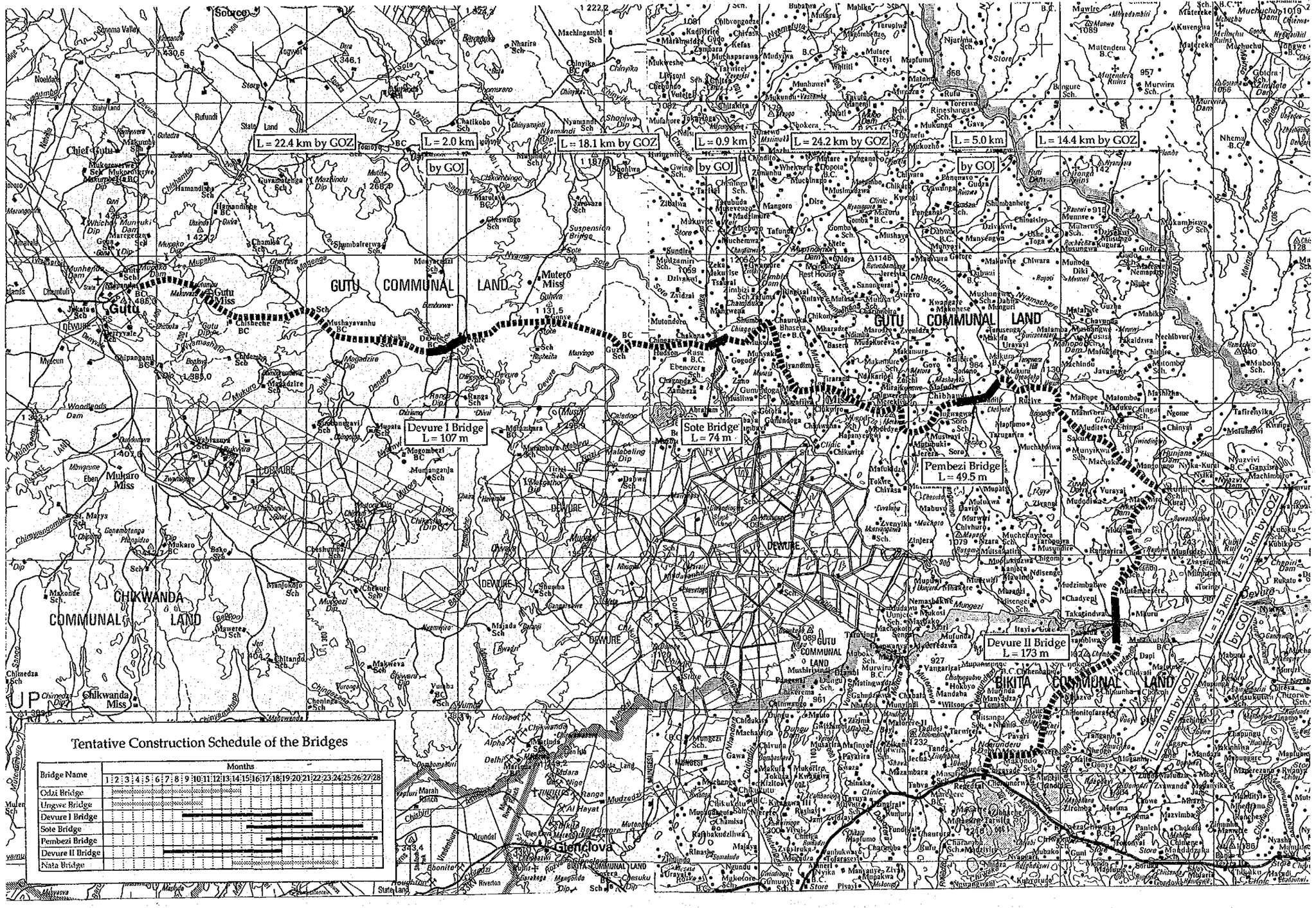


Fig. 4-4 (3) Demarcation of the Project Implementation (Route 344 and Route 359)

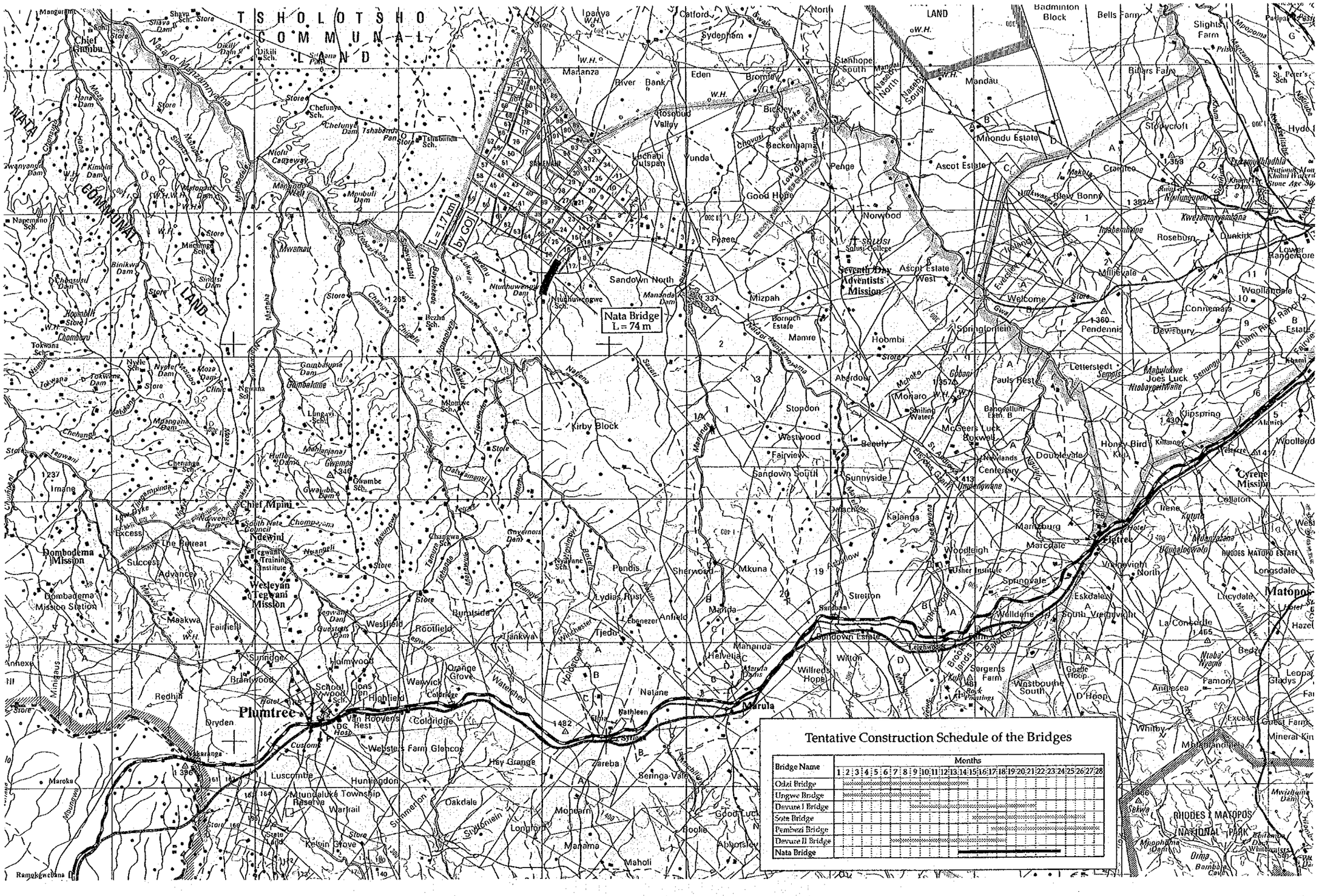


Fig. 4-4 (4) Demarcation of the Project Implementation (Route 759)

4.4.2 Special Considerations in the Construction Plan and Scheduling

For the construction of the 7 bridges including their approach roads and the rehabilitation of the existing roads, the following shall be taken into account, in respect of workability, accessibility, and procurement of the construction equipment and materials:

(1) The dry and rainy seasons are clearly divided in Zimbabwe. So the construction of the substructure shall be concentrated in the dry season.

(2) The duration of the rainy season in Zimbabwe is generally from November to March. Therefore it would be desirable to initiate the substructure work from April.

(3) Out of the seven bridges, the Ungwe Bridge requires a detour during the period of construction. Although the detour will run through the riverbed, it is presumed that this detour will not cause any traffic problems because of the dry river conditions in the dry season. However, special attention shall be paid to traffic safety, in case the work is carried out beyond the dry season.

(4) Most of the works for Routes 357, 956, 344 and 359 are rehabilitation of the existing roads except for a few stretches of realignment. It is therefore necessary to consider traffic control in formulating the construction plan.

(5) Road and bridge construction work requires a large amount of water. Since there are several job sites where water is not available during the dry season, it is important to prepare a water distribution plan for the construction.

(6) Before commencement of the work, GOZ must settle the undertakings specified in the Inception Report, especially regarding security of the land required for the construction camp and erection and construction yards.

4.4.3 Detailed Design and Construction Supervision

Immediately after the Exchange of Notes (E/N), the contract for Consulting Services will be signed. The Services will cover the preparation of the design drawings and contract documents, tendering, and construction supervision. The required Japanese staff and their responsibilities concerning the Services will be as follows:

1) Team Leader

Responsible for all the aspects of the Consulting Services

2) Road Engineer

Responsible for the detailed design of the roads, and supervision of road construction

3) Superstructure Engineer

Responsible for the detailed design of the superstructure, and supervision of superstructure construction

4) Substructure Engineer

Responsible for the detailed design of the substructure, and supervision of substructure construction

5) Construction Planner/Cost Estimator

Responsible for the preparation of the detailed implementation schedule and project cost estimates during the detailed design stage

6) Contract Specialist

Responsible for the preparation of tender and contract documents during the detailed design stage

7) Resident Engineer

Resides in Zimbabwe and supervises construction

8) Material Engineer

Responsible for the control/advise of specified material quality and strength for road and structure work during construction

4.4.4 Procurement Plan

(1) Labour

Most of the skilled labourers experienced in bridge and road construction are employed by the local contractors, and it may be difficult for the Japanese contractor to recruit skilled labourers by himself. It is probable that he should use local contractors as his subcontractors and thus obtain the required skilled labourers, including operators and mechanics. Since the Zimbabwean labourers have experience of R.C. bridge construction but none have experience of PC bridge construction, it will be necessary to train the labourers.

Unskilled labourers are available because the Project area is a fairly densely populated area. The opportunity for employment will be increased in the construction period.

(2) Construction Materials and Equipment

A survey was conducted on the construction materials and equipment available in the local markets. Most construction materials are available in the local markets as described below:

a) Construction Materials

i) Cement

Both the Circle Cement Company and Unisem Company manufacture cement in Zimbabwe. The production outputs are 420,000 ton/year and 800,000 ton/year, respectively. The Unisem Company also produces a high early strength cement but the production output is small. Therefore, there may be a shortage of the high early strength cement in construction of the PC beams if the other projects need the cement.

The price of cement is almost the same between these two companies. The Circle Cement Company supplies Harare city and the northern area, while the Unisem Company supplies Bulawayo city and the southern area.

ii) Reinforcement Bars

Reinforcement bars are manufactured by the ZISCO Company and twist bars by Steel Force according to British Standards. A small quantity of round steel bars will be imported from Japan.

iii) Crushed Stone and Sand

There are various types of crushed stone supplier in Zimbabwe. But the project sites are 40~230 km from the crushing plant (average 140 km). Supply will not be a problem and it will be economical to transport from the plant to the sites because the required amount is small.

iv) Timber

There are some timber yards in Harare, Bulawayo, and other middle sized cities. Desirable plywood with a water-proof treatment for concrete forms is not available but watertight wood can be used in the concrete works. Timber and others are available and can be transported from both Harare and Bulawayo cities.

v) Other Steel Materials

Light gauge section steel for the temporary works is available, but H-section steel beams should be imported from Japan.

vi) Embankment and Base Course Materials

Embankment and base course materials will be supplied from the borrow pits. The average hauling distance is estimated to be within 5 km.

vii) Asphalt Material

Straight asphalt for the road surfacing works will be imported and supplied by the National Oil Company in Zimbabwe. The price of straight asphalt is fixed in each region.

viii) Oil and Lubricant

the price of oil and lubricant are regulated by the Government and their prices are constant in Zimbabwe. Oil suppliers can transport them to the site if the demand is large enough.

ix) Other Construction Materials

PC tendons, PC anchors, concrete admixture, and expansion joints will be imported from Japan.

b) Construction Equipment

Most of the construction equipment available in Zimbabwe is old and it is difficult to obtain spare parts quickly in the case of breakdown. Equipment can be rented from the big construction companies when it is not in use, but there is no assurance that it is always available. It is judged that construction of the 7 bridges and 15.2 km of approach roads within 3 years will be difficult. Therefore, it was decided that equipment should be brought in from Japan, except equipment which will be used at peak times and for the preparatory works.

c) Regulations

Zimbabwe was a socialist country until several years ago, so there are rather strict laws to protect labour , and labour unions have a lot of power. Employers should register, in several forms, labor recruiting.

The minimum wage of labourers, which is a labour regulation, is Z$ 296.05/Month in the construction industry. The working hours are 7:00~16:30, with 30 minutes for lunch. the overtime wage is 1.5 times and 2 times for Sundays and holidays.

d) Technology of Local Contractors

There are three contractors: the Gulliver Company which specializes in roads, dams, and railways; the Costain Company which specializes in concrete structures (main structures are buildings); and the Bitcon Company which specializes in road pavement. But, these companies will not be the general contractors. Consequently, the main contractor, which will obtain the Project, will sublet to the other contractors.

Only the Fort Concrete Company has experience in constructing pre-tensioned beams approximately one hundred, so it is considered that the technology for PC bridge construction is not available.

4.4.5 Implementation Schedule

The implementation schedule, after conclusion of E/N up to the completion of construction of the 7 bridges and their approach roads by the Japanese side is depicted in Figure 4-5. The total implementation period is broadly divided into three stages as described below.

(1) Contract with the Consultant and the Detailed Design

After signing the contract with a Japanese consultant, the detailed design will be carried out by the consultant to prepare the tender document including drawings.

(2) Tendering and Contract with the Contractor

After discussion with and approval from JICA with regard to evaluation of the items for pre-qualification (P/Q) of tenderers for the construction work, the P/Q will be carried out in Japan by the Consultant on behalf of GOZ to select the qualified tenderers and the P/Q document will be verified by JICA.

In the tendering, the principle of general competitive biding will be applied to select a prospective Japanese contractor for the construction work. Evaluation of the tenders and selection of the prospective contractor will be carried out in Japan by the representatives of GOZ and the Consultant in the presence of JICA's official. Negotiation and signing of the contract with the selected contractor will be also be done in Japan. The direct contract system will be applied to the consulting service and construction, i.e. signing of the contract between GOZ and the Japanese consultant or contractor/supplier.

Parallel to the signing of the contract, GOZ will conclude a banking arrangement with an authorized foreign exchange bank in Japan to open a special account for the purpose of receiving the funds granted by GOJ, and making the payment to the Japanese company. This banking arrangement will serve as the basis for GOZ to issue the Authorization to Pay (A/P) that, in turn, is indispensable for the Japanese contracting company to obtain export licences for the products as well as receive payments as stipulated in the contract terms. The banking arrangement is usually concluded within one month after the signing of E/N

The next step is verification to be conducted by GOJ. Verification means to examine whether the contents of contracts conform to the provisions of E/N, which is requisite for the contract to be effective.

In short, the Japanese company will carry out its contract responsibility only after receiving the verified contract and A/P

(3) Construction Works

The construction works will consist of mobilization, road works, foundation and substructure works, fabrication and erection of beams, bridge surfacing work, river protection work, and ancillary work. The construction is estimated to take 28 months to complete all the works.

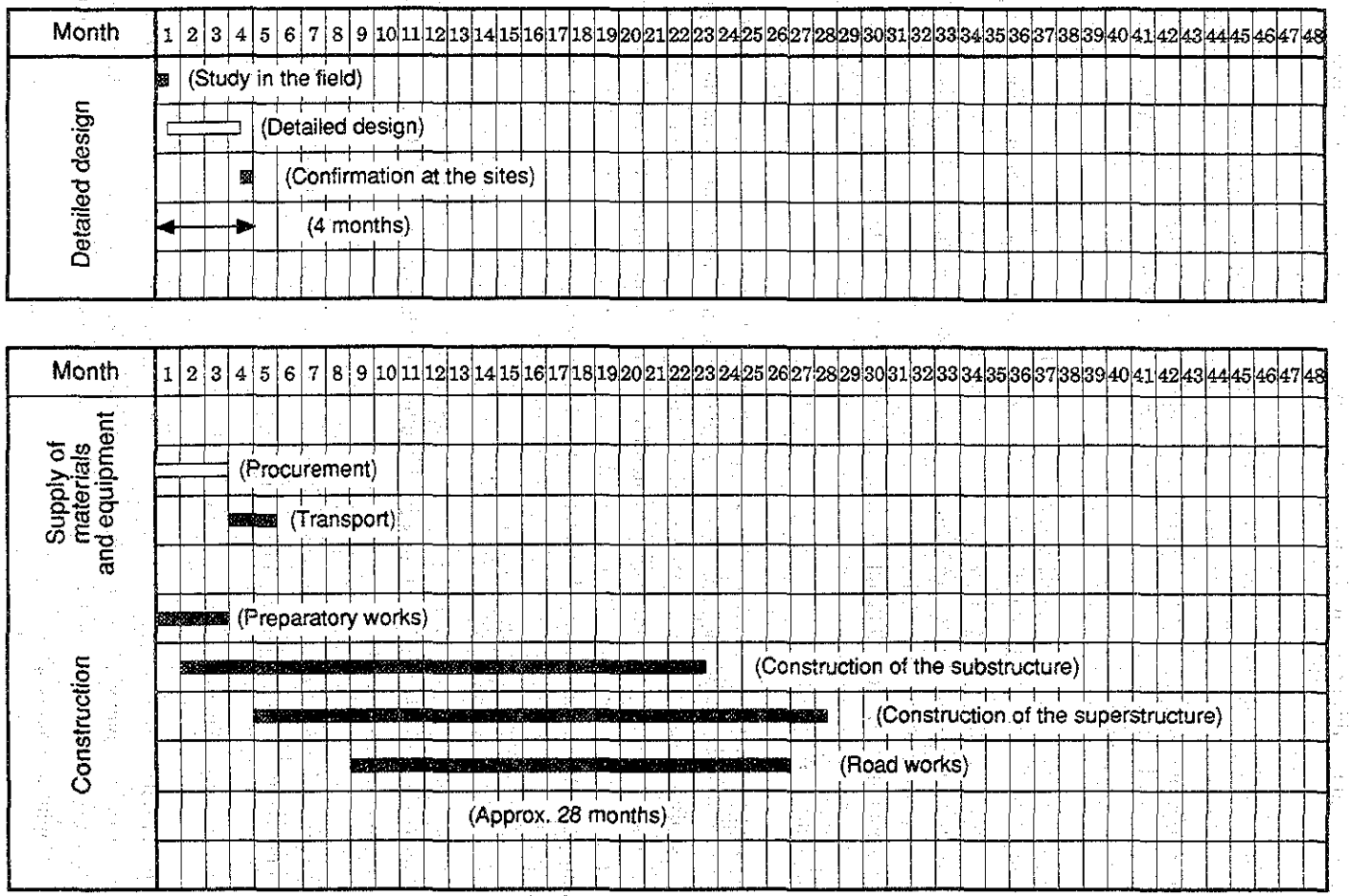


Fig. 4-5 Tentative Implementation Schedule

4.4.6 Scope of Works

The works to be executed by the Japanese side and the Zimbabwean side are summarized below (for details refer to Section 3.3.3), together with the required undertakings by GOZ.

- Scope of Works to be executed by the Japanese Side
  - Construction of the Odzi Bridge, Ungwe Bridge, Devure I Bridge, Sote Bridge, Pembezi Bridge, Devure II Bridge, and Nata Bridge.
  - Construction of the approach roads for the above 7 bridges.
  - Provision of construction equipment and materials for road rehabilitation to be implemented by GOZ.
- Scope of Works to be executed by the Zimbabwean Side
  - Road rehabilitation of Routes 357, 956, 344 and 359 using the construction equipment and materials to be provided by Japan's Grant Aid.
- Undertakings by GOZ
  - Provision of necessary land for construction of bridges and approach roads to be implemented by GOJ.
  - Demolition of impediments within the above mentioned land.
  - Tax exemption on the construction equipment and materials provided by the Japanese Grand Aid.

The expenditure to be borne by GOZ in connection with the implementation of the Project is estimated as shown below:

1.	Construction Cost	52.8 million Z $
2.	Management Cost of DSR	4.4 million Z $
Total		57.2 million Z $

Chapter 5 Project Evaluation and Conclusion

Chapter 5 Project Evaluation and Conclusion

5.1 Project Effect

Based on the results of the technical assessment and the social, economic and transport studies executed by the basic design study team, the impact of the Project on the economy and society are summarized below:

Present Condition and Problems	Counterplans in the Project	Project Effect and the Extent of Improvement
• The communal lands where living conditions are poor, are mostly situated in the rural areas of Zimbabwe. These areas are expected to be upgraded environmentally. • Equal ownership of agricultural lands has been a national policy of Zimbabwe since independence in 1980. In order to realise this policy, the Government put special emphasis on the resettlement programme and rural development, and has promoted the rehabilitation of roads and bridges in rural areas as one of the most effective measures. However, the implementation of these rehabilitation programmes is impeded mainly by financial problems.	• Three routes passing through the communal lands will be rehabilitated with construction equipment and materials provided under the Japanese Grant Aid. • Replacement of 7 bridges on the above routes will provide all weather roads i.e. no traffic interruptions due to flooding. These works will be carried out by the Japanese side under the Grant Aid System. • Prestressed concrete (PC) bridges by the post-tension system which have not been built in Zimbabwe before will be introduced to improve bridges.	• Upgrading of basic human needs in the communal lands. • Due to the improvement of transport facilities, lower transport costs and easier accessibility to adjacent major cities, activation of the regional economy will be accelerated. • Increasing job opportunities in the rural areas will contribute to the improvement of living standards in the communal lands. In addition, excessive population flow to the Capital will be prevented. • Construction of PC post-tensioned bridges will create new technology transfer to the Republic of Zimbabwe. • Contribution to equal distribution of agricultural land due to promotion of the rural development plan and the resettlement programme.

5.2 Conclusion

As mentioned in the previous section, it is expected that the Project will contribute to an upgrading in the living standards of people in the project area and will generate a considerable effect on the basic national policy of GOZ. In view of the above considerations, it would be most appropriate to implement the rehabilitation of Route 357, Route 956, Route 344 and Route 359, and the construction of related bridges under the Japan's Grant Aid Program. However, it was finally judged that, compared with other bridges, the

construction of Nata Bridge would not give the expected effect as the Japan's Grant Aid Program, to the project area.

It is recommended to implement the Project in accordance with the priority as early as possible. It is hoped that the supplied construction equipment from GOJ will enforce the construcytion capacity of DSR.

Appendices

JICA BASIC DESIGN STUDY TEAM
MEMBER LIST

1 First Field Survey Mission (February~March, 1993)

Chief of Consultant	Mr. Kazumasa TADA	Nippon Koei Co., Ltd.
Highway Engineer	Mr. Eiichi YOKOTA	Nippon Koei Co., Ltd.
Geotechnical Engineer	Mr. Toshio AIDA	Nippon Koei Co., Ltd.

2 Second Field Survey Mission (May~June, 1993)

Team Leader	Mr. Takeo KAI	Transport and Land Development Specialist, Institute for International Cooperation, JICA
Bridge Planner	Mr. Yoshitaka KISHIMOTO	Project Leader, Honshu-Shikoku Bridge Authority
Coordinator	Mr. Toshiyuki IWAMA	Second Basic Design Study Division, Grant Aid Study & Design Department, JICA
Chief of Consultant	Mr. Kazumasa TADA	Nippon Koei Co., Ltd.
Highway Engineer	Mr. Eiichi YOKOTA	Nippon Koei Co., Ltd.
Transport Engineer	Mr. Akio TATSUNO	Nippon Koei Co., Ltd.
Geotechnical Engineer	Mr. Toshio AIDA	Nippon Koei Co., Ltd.
Bridge Engineer	Mr. Masami TAKAHASHI	Nippon Koei Co., Ltd.
Construction Planning/ Cost Estimator	Mr. Atsuya SAISHO	Nippon Koei Co., Ltd.

3 Draft Report Mission (September, 1993)

Team Leader	Mr. Takeo KAI	Civil Engineering Development Specialist, Institute for International Cooperation, JICA
Bridge Planner	Mr. Yoshitaka KISHIMOTO	Superintendent Engineer, Honshu-Shikoku Bridge Authority
Chief of Consultant	Mr. Kazumasa TADA	Nippon Koei Co., Ltd.
Highway Engineer	Mr. Eiichi YOKOTA	Nippon Koei Co., Ltd.

ACTIVITIES OF JICA BASIC DESIGN STUDY TEAM IN ZIMBABWE

1 First Field Survey Mission

Order of Date	Month/Day		Field Survey Activities
1	2/26	(Fri)	Left Narita
2	2/27	(Sat)	Left Amsterdam
3	2/28	(Sun)	Arrived at Harare
4	3/01	(Mon)	Courtesy call to Embassy of Japan
			Courtesy call and meeting with DSR regarding Inception Report and Questionnaire
5	3/02	(Tue)	Internal meeting regarding site reconnaissance
6	3/03	(Wed)	Hearing from local contractors of topographic survey, and geological survey
7	3/04	(Thu)	Site reconnaissance of Route 759 and proposed Nata Bridge site
8	3/05	(Fri)	Site reconnaissance of Bulawayo city for materials and equipment
9	3/06	(Sat)	Site reconnaissance of Route 956 and proposed Ungwe Bridge site
10	3/07	(Sun)	Site reconnaissance of Kadoma city for materials and equipment
11	3/08	(Mon)	Site reconnaissance of Route 344 & 359, and proposed Devure I, Sote, Pembezi and Devure II Bridge sites
12	3/09	(Tue)	Site reconnaissance of Route 357 and proposed Ozdi Bridge site
13	3/10	(Wed)	Site reconnaissance of on-going road rehabilitation project near Mutare city
14	3/11	(Thu)	Meeting with local contractors of topographic survey, and geological survey
			Courtesy call to Embassy of Japan
15	3/12	(Fri)	Inspection of private pre-cast concrete factory
16	3/13	(Sat)	Study on road/bridge design criteria
17	3/14	(Sun)	Compilation of collected data
18	3/15	(Mon)	Site reconnaissance of road construction by contractors (Route 131)
19	3/16	(Tue)	Meeting with DSR regarding study policy
20	3/17	(Wed)	Courtesy call to Embassy of Japan
			Left Harare
21	3/18	(Thu)	Arrived at Frankfurt
22	3/19	(Fri)	Left Frankfurt
23	3/20	(Sat)	Arrived at Narita

2 Second Field Survey Mission

Order of Date	Month/Day		Field Survey Activities
1	5/21	(Fri)	Left Narita
2	5/22	(Sat)	Left Frankfurt
3	5/23	(Sun)	Arrived at Harare
4	5/24	(Mon)	Courtesy call to Embassy of Japan
			Courtesy call and meeting with DSR
			Preparation of tender documents for topo/geological survey
5	5/25	(Tue)	Site reconnaissance of Route 759 and proposed Nata Bridge site
			Preparation of tender documents for topo/geological survey
6	5/26	(Wed)	Site reconnaissance of Route 956 and proposed Ungwe Bridge site
			Pre-bid meeting for topo/geological survey
7	5/27	(Thu)	Meeting with DSR regarding design policy
8	5/28	(Fri)	Meeting with DSR regarding design policy
			Tender for topographic/geological survey
9	5/29	(Sat)	Site reconnaissance of Route 357 and proposed Odzi Bridge site
10	5/30	(Sun)	Site reconnaissance of Route 344 & 359, and proposed Devure I, Sote, Pembezi and Devure II Bridge sites
11	5/31	(Mon)	Signing of Minutes of Discussion
			Contract of topographic/geological survey
12	6/01	(Tue)	Design data collection and compilation
13	6/02	(Wed)	Internal meeting. Preparation for field investigation
14	6/03	(Thu)	Meeting with DSR regarding bridge design and data collection
15	6/04	(Fri)	Meeting with DSR regarding road/bridge design and data collection
16	6/05	(Sat)	Field investigation of Route 956 and proposed Ungwe Bridge site
17	6/06	(Sun)	Market research of Bulawayo city
18	6/07	(Mon)	Field investigation of Route 759 and proposed Nata Bridge site
19	6/08	(Tue)	Field investigation of Route 357 and proposed Odzi Bridge site
20	6/09	(Wed)	Field investigation of Route 344 & 359, and proposed Devure I, Sote, Pembezi and Devure II Bridge sites
21	6/10	(Thu)	Meeting with DSR regarding road/bridge design
			Meeting with contractors regarding work schedule and current progress of field investigation
22	6/11	(Fri)	Meeting with DSR regarding road/bridge design
			Data collection and compilation on materials and equipment
23	6/12	(Sat)	Internal meeting on road/bridge design, traffic analysis and implementation schedule
24	6/13	(Sun)	Compilation of collected data

Order of Date	Month/Day		Field Survey Activities
25	6/14	(Mon)	Meeting with DSR regarding design policy and further study schedule
			Internal meeting on road/bridge design, traffic analysis and implementation schedule
26	6/15	(Tue)	Courtesy call to Embassy of Japan
			Compilation of collected data
			Left Harare
27	6/16	(Wed)	Arrived at London
28	6/17	(Thu)	Left London
29	6/18	(Fri)	Arrived at Narita

3 Draft Report Mission

Order of Date	Month/Day		Field Survey Activities
1	9/17	(Fri)	Left Narita
2	9/18	(Sat)	Left London
3	9/19	(Sun)	Arrived at Harare
4	9/20	(Mon)	Courtesy call to Embassy of Japan
			Courtesy call to DSR, and discussions on the Draft Report
5	9/21	(Tue)	Internal meeting
6	9/22	(Wed)	Signing of Minutes of Discussions at Ministry of Finance
7	9/23	(Thu)	Supplemental data collection
8	9/24	(Fri)	Payment settlement of topographic/geological survey
9	9/25	(Sat)	Supplemental data collection and compilation
10	9/26	(Sun)	Compilation of collected data
11	9/27	(Mon)	Courtesy call to Embassy of Japan
			Left Harare
12	9/28	(Tue)	Arrived at Amsterdam
13	9/29	(Wed)	Left Amsterdam
14	9/30	(Thu)	Arrived at Narita

List of People met in Zimbabwe

Ministry of Finance

Mr. Matshalaga	Under Secretary
Ms. A. Guwauza	Assistant Secretary

Ministry of Transport and Energy (MOTE)

Mrs. T. Zinanga	*Assistant Secretary, Central Planning Unit*
Mr. R. Mekuwatine	Costing Officer, MOTE, Headquarters

Department of State Road (DSR)

Mr. R. H. J. Mitchell	Director
Mr. S. Murimba	Acting Chief Engineer, Planning Div.
Mr. B. Mugabe	Deputy Director, Design Div.
Mr. N. Kudenga	Deputy Director, Operation Div.
Mr. S. Jaya	Deputy Chief Engineer, Design Div.
Mr. Musharo	Chief Engineer, Maintenance Div.
Mr. C. Emmaner	Deputy Chief Engineer, Design Div.

Provincial Road Engineer Office

Mr. J. Moya	Provincial Road Engineer, Matabeleland South Province
Mr. M. Zemarian	Provincial Road Engineer, Masvingo Province
Mr. J. A. Njunga	Provincial Road Engineer, Manicaland Province
Mr. I. Cannel	Provincial Road Engineer, Midlands Province
Mr. P. T. Mzarabani	Sr. Improvement Officer, Masvingo PRE Office

Central Mechanical Equipment Department

Mr. S. Museyazviriyo	Chief Officer, Masvingo, CMED

National Economic Planning Commission (NEPC)

Ms. E. M. Hlazo	Senior Planner

Rural District Council

Mr. J. K. Mubako	Assistant Administration Officer, Gutu Rural District Council

Embassy of Japan

Mr. Mitsuo IIJIMA	Ambassador Extraordinary and Plenipotentiary
Mr. Masaki KONISHI	Ambassador Extraordinary and Plenipotentiary
Mr. Haruo OKAMOTO	Minister
Mr. Takumi OHASHI	Councilor
Mr. Toshiaki SAITOH	First Secretary