# TECHNICAL REPORT

# ROAD UPGRADING OPERATIONS

Contract No. AFR-0028-S-00-1093-00
Project No. 660-0028
Agricultural Marketing Development

Prepared for USAID Mission
Kinshasa, Zaire
by
Lloyd R. Crowther, Consulting Engineer
Wheaton, Maryland, USA

Final Cost of this Report is
$13,800

LLOYD CROWTHER, P.E.
10810 HORDE STREET
WHEATON, MARYLAND, 20902
Phone: 301-649-5905

October 16, 1981

Mr. H.L. Braddock
Design, Evaluation and
Capital Project Officer
USAID Mission
Boite Postale 8599
Kinshasa
Zaire

Dear Sir,

This report is a technical analysis of the road upgrading portion of Project 660-0028, Agricultural Marketing Development. The analysis was made during the six weeks between September 24, 1981 and October 16, 1981 under a contract for consulting services number AFR-0028-S-00-1093-00.

That contract called for a road inventory of the road between Kikwit and Idiofa and an evaluation of that inventory to assist in the preparation of project documentation for Project 028.

I wish to express my appreciation to the Zaire AID Mission for its cooperation in the preparation of this report.

Sincerely,

Lloyd R. Crowther

Lloyd R. Crowther

TABLE OF CONTENTS


| | | Page |
|---|---|---|
| Section 1: | Activities Narrative | 1 |
| Section 2: | Road Inventory | 2 |
| Section 3: | Construction by the Sideborrow Method | 5 |
| Section 4: | Widening Existing Alignment | 8 |
| Section 5: | Road Surfacing Operation | 9 |
| Section 6: | Calculations for Project Paper | 11 |
| Section 7: | Feeder Roads | 12 |
| Section 8: | Labor Intensive or Contract Construction Possibilities | 13 |
| Section 9: | Technical Assistance | 15 |
| Section10: | Training | 16 |
| Section11: | Construction Camps | 18 |
| Section12: | Maintenance | 18 |
| Section13: | An Alternate Alignment to Idiofa | 21 |

Section 1: Activities Narrative

I left Washington D.C. on 9/4 and, after an unscheduled delay of 13 hours waiting for the flight from Lisbon, arrived in Kinshasa on the evening of 9/6. On 9/8 I flew from Kinshasa to Ilebo, the farthest most point of the proposed project road where I met L. Eldridge, an engineer from REDSO/WA, and L. Waskin, USAID Kinshasa, who had traveled the road from Kikwit. The afternoon was spent in discussing their observations of the road. The next morning Mr. Eldridge flew back to Kinshasa and Mr. Waskin and I began the trip back over the proposed project route. Unfortunately the vehicle had no odometer so all observations were general in nature, identifiable only as being between ferrys or the few villages that had names.

The trip to Kikwit took 3 days. Both nights were spent in Idiofa. The last portion of the road between Idiofa and the last (or first) ferry were observed on the second day because we were unable to complete the whole section before dark. The third day we viewed the section between Idiofa and Kikwit.

Two nights were spent in Kikwit. We were unable to meet any of the expatriates stationed in Kikwit but observed the Office des Routes (OR) facilities there. We received a list of all equipment in the Bandundu region. We discussed the current operating procedures of the Idiofa Brigade which had been working on the project road and collected information about local costs and pay scales. The next day, 9/13, we returned to Kinshasa.

The period between 9/14 and 9/26 was spent assisting in the preparation of the project documentation. This activity included the collection of current equipment prices, several meetings with USAID project personnel and with Mr. Penfentenyo of OR (9/15, 9/19, 9/21, 9/22), to discuss road design, equipment requirements, project staffing, and local costs. The maintenance, construction options and training aspects of the project were investigated and the productivity of the equipment was evaluated. During this time major decisions made by USAID personnel included:

a) the reduction of the project scope to 150 km of main road upgrading and 50 km of feeder road construction,

b) the relocation of the route from the current trench section to an elevated 8 meter platform in plateau areas using side borrow to reduce the drainage problems,

c) the inclusion of 12 trucks for brigade use,

d) a construction period of 36 months, and

e) the use of only two technical advisors.

The period from 9/28 thru 9/30 was spent studying air photos of project area and marking the route on selected photos to review in the field. On 10/1 A. Williams, USAID, Kinshasa, and I left to make an inventory of the project road between the end of the pavement west of Kikwit and Idiofa. The inventory took 4 days (10/2 - 10/5). On 10/6 we investigated another proposed alignment between Idiofa and Kimbanda. This alignment had been proposed by OR as a possible substitute for the subject project since a paved road is being constructed from Kikwit thru the Kimbanda area. The trip was 82.3 km each way. We arrived back in Kinshasa on the afternoon of 10/8.

The evaluation of the inventory required 3 days (10/9 - 10/11). The remaining time in country 10/12 - 10/16 was spent preparing this report. The report presents the problem first (the inventory) followed by the proposed solutions, however in fact the major evaluations had to be prepared for the project documents before the inventory was made so most assumptions in the backup calculations are based on 150 km of primary road construction rather than the 131.0 km derived from the inventory.

Section 2: Road Inventory

The road inventory was made in a Chevrolet pick-up truck with 4 wheel drive. Fuel for the entire trip was carried in drums in the bed of the truck.

The odometer was calibrated on the paved road between Kinshasa and Kikwit. Readings were taken at kilometer marker 277, the first of the markers set on the road, and km. markers 287, 327, 377, 427 and 523, which is located on the outskirts of Kikwit. The odometer correction was calculated to be 0.992, i.e. the odometer read more than the actual distance. This correction was applied to each day's inventory readings.

The inventory was made going towards Idiofa. The first day 49.6 km were inventoried. On succeeding days 34.8 km, 26.8 km and 19.8 km were inventoried. In addition, on the second day when we moved our base of operations from Kikwit to Idiofa, the entire length of the inventoried road was measured. The measurement was used as a check against the summation of the daily inventories.

The inventory was recorded in a standard engineer's hard cover bound Field Book. The readings were noted from the bottom of the page upwards so that the left side of the page represented the left side of the road. The distances, including the correction factor, were computed by day, and cumulatively. Those calculations are also included in the field book. A photocopy of that raw inventory data was left in Kinshasa.

The inventory began at the end of the paved road east of Kikwit

slightly beyond kilometer marker 531. It ended at an arbitrarily selected intersection in Idiofa called the Circle de la Revolution. This is a chanelized intersection with a monument in the middle. The route to Ilebo continues directly ahead. The new road will pass in front of the OR compound and by most of the major governmental buildings.

While the raw inventory data are not included with this report, a summation of the information is attached as Annex A in the form of Table A-1, Villages; Table A-2, Water Crossings and Culverts; Table A-3, Road Intersections; Table A-4, Burial Sites; Table A-5, Vegetation; and Table A-6, Topography.

Interpretation of this data indicates that different construction methodology must be followed in different areas. At present all of the route is in form of one continuous trench or canal. Water is diverted by means of miter trenches. On side hill locations these trenches are daylighted to the down hill sideslope. In some rolling terrain these miters lead to sump holes where the water seeps into the sandy soil which predominates throughout the area. In many locations the water merely evaporates or is absorbed by the slightly plastic sandy soil which forms the road. There is little effort made to crown the road sections. The evaporation/absorption drainage solution seems to be less successful in the forested areas of the project.

Since maintenance consists of hand shoveling the loose sand out of the roadway trench, many of the miter drains are above the existing roadbed. When the road bed in the plateau areas becomes too deep to shovel from, and consequently very narrow, a new alignment is prepared. Presently this alignment is partially stripped by a grader to a width of 10 to 16 meters and traffic proceeds to form its own series of ruts within the stripped area. Previous alignments were developed on much narrower widths and consequently had a shorter life span.

Table 1, Construction Methodology, was developed from the road inventory to try to correct these problems. The basic road section in table 1 is a crowned 6 meter wide traveled way with a one meter shoulder on each side, or basically an 8 meter platform. On each side a one meter long 2:1 side slope leads to the invert of a drainage ditch which is 0.5 meters below the edge of the road. In cut sections, noted in table 1 as "widen the existing road" areas, the ditch back slope will be the natural angle of repose of the existing soil. In plateau areas table 1 is based on the assumption that economics dictates realignment of the existing roadway to a slightly elevated roadway using side borrow ditches 10 meters in width which will allow for evaporation/absorption without resorting to miter trenches in most cases. In forested areas, which are all in the "widen present road" category, all trees should be cut within 15 meters of the centerline of the widened areas to enhance the drying of the road surface. The underbrush and tree roots in these areas should not be removed to prevent erosion and/or unstability at the top of the slope.

Table 2, Excavation Quantities, is a summation of the locations, lengths, and excavation quantities in Bank Cubic Meters of each of the different construction activities listed in Table 1.

Table 1:

CONSTRUCTION METHODOLOGY

| | |
|---|---|
| 0.0 - 16.0 | Widen existing road, cut trees back |
| 16.0 - 17.7 | Major problem area, extensive drainage required, road width may have to be substandard. Do not cut trees on extremely steep side slopes to prevent slides. |
| 17.7 - 37.9 | New side-borrow alignment |
| 37.9 - 39.4 | Major problem area, try to build new side hill section if another route not available from Imbongo |
| 39.4 - 40.6 | Two side hill alignments available, put traffic on one while widening the other |
| 40.6 - 40.8 | Must stay on existing ridge |
| 40.8 - 42.8 | New side-borrow alignment |
| 42.8 - 45.7 | Two side hill alignment available, put traffic on one while widening the other |
| 45.7 - 54.0 | Widen existing road,cut trees back to km 52 |
| 54.0 - 80.4 | New side-borrow alignment |
| 80.4 - 80.9 | Widen existing road |
| 80.9 - 82.2 | Try new side-borrow alignment, if not possible put traffic on alternate side hill alignment and widen existing alignment |
| 82.8 - 87.9 | New side-borrow alignment if soil from ditch areas is suitable, otherwise must use pit material for embarkment. This is a troublesome ridge line area, new alignment must be close to existing road |
| 89.7 - 94.4 | New side-borrow alignment |
| 94.4 - 96.6 | Widen existing road |
| 96.6 -114.7 | New side-borrow alignment |
| 114.7-114.8 | Rebuild road so culvert functions properly |
| 114.8-116.1 | Try new side-borrow alignment, if sideslope too steep widen existing road |
| 116.1-116.8 | New side-borrow alignment |
| 116.8-117.5 | Widen existing road, major excavation required but roadway already 7 m wide. Horizontal alignment will be substandard |
| 117.5-121.0 | New side-borrow alignment |
| 121.0-121.5 | New side-borrow alignment between bridges |
| 121.5-127.0 | New side-borrow alignment |
| 127.0-129.2 | Widen existing side hill alignment, use alternate alignment for detour if practical |
| 129.2-130.2 | Improve existing road to 8 m platform thru Idiofa |
| 130.2-131.0 | Trees in middle of road way, may have to select one side to widen to save trees. |

Table 2: EXCAVATION QUANTITIES

A. New Sideborrow Alignment

| | | |
|---|---|---|
| Km 17.7 - 37.9 = 20.2 km | | |
| 40.8 - 42.8 = 2.0 | | |
| 54.0 - 80.4 = 26.4 | | |
| 80.9 - 94.4 = 13.5 | | |
| 96.6 -114.7 = 18.1 | | |
| 114.8 -116.8 = 2.0 | | |
| 117.5 -127.0 = 9.5 | | |
| Total | 91.7 km at 3400 BCM/km = | 311,800 $m^3$ |

B. Widen Existing Road Under Traffic

| | | |
|---|---|---|
| 0.0 - 16.0 = | 16.0 @ 117,000 | |
| 37.9 - 39.4 = | 1.5 @ 39,400 | |
| 40.6 - 40.8 = | 0.2 @ 1,600 | |
| 45.7 - 54.0 = | 8.3 @ 62,200 | |
| 80.4 - 80.9 = | 0.5 @ 7,200 | |
| 94.4 - 96.6 = | 2.2 @ 30,700 | |
| 116.8 -117.5 = | 0.7 @ 6,700 | |
| Total | 29.4 km | 264,800 $m^3$ |

C. Widen Existing Road Using Detours

| | | |
|---|---|---|
| 39.4 - 40.6 = | 1.2 @ 19,800 | |
| 42.8 - 45.7 = | 2.9 @ 44,900 | |
| 127.0 -129.2 = | 2.2 @ 9,900 | |
| Total | 6.3 km | 74,600 $m^3$ |
| Subtotal embarkment Excavation | | 651,200 $m^3$ |

D. Excavate Surfacing Material from Pits

| | |
|---|---|
| 131.0 x 2250 BCM/km = | 294,800 $m^3$ |
| Total Excavation | 946,000 $m^3$ |

Section 3: Construction by the Sibe-borrow Method

The ROW is to be cleared for a 30 meter width. The following assumptions have been made:

a. Weight of material to be stripped, loan at 1543 kg/BCM or 1246 kg/loose cubic meter. Thickness 0.2 m in place, firm earth underneath, traction factor = 0.9. Shrubs will present no problems. ROW will be cleared from center to each side.

The clearing will take place using a D6D tractor or equivalent. At a weight of 13.8 ton the tractor can push up to 12.4 tons of material. The weight of the material on ½ the ROW at a blade width of 3.8 m is 15 x 3.8 x 0.2 x 1543 = 17.6 ton, therefore two passes will be required to clear each blade width. The number of passes required to strip a 300 length of road (9000 $m^2$) is (300 x 4) ÷ 3.8 = 316. The following operating assumptions have been made.

b. Speed D6D, 2nd gear pushing 9 ton = 2.8 km/hr
Reverse speed 2nd gear (standard transmission) = 4.5 km/hr
Shifting time 0.10 minutes

The time for one pass becomes forward (60 x 15) ÷ 2800 = 0.32 min, reverse (60 x 15) ÷ 4500 = 0.20 min, plus shifting time = 0.62 min per pass. The total maximum passes per day is (8 x 60) ÷ 0.62 = 774. However the following correction factors must be applied: average operator at 0.75, dead soil at 0.80 and 50 minute hour at 0.84. The actual number of passes/day therefore becomes 774 x 0.75 x 0.80 x 0.84 = 390. Therefore the time required to clear 300 meters of road becomes 316 ÷ 390 or 6.5 hours per day.

The side-borrow material has to be moved to the road platform. The following assumptions have been made:

c. Weight of material to be moved, Damp Sand of 1899 kg/BCM, 1691 kg/LCM. Table 3: Determination of material quantities, new alignment, indicates that a loose volume of 3.8 LCM is required per meter of roadway.

A Clark 75 B front end loader or equivalent has a bucket fill factor for uniform aggregates up to 3 mm of 95%. The heaped capacity of the bucket 2.1 $m^3$ x .95 means that one bucket load equals 2.0 LCM, or that two bucket loads (one on each side) is required per meter of road. This becomes 600 bucket loads per day. The following assumptions have been made:

d. Cycle time to load, dump and maneuver is 0.42 minutes. Haul time plus return for 10 meters is 0.15 minutes. Total time is therefore 0.57 min.

The total maximum bucket loads per day becomes (8 x 60) ÷ 0.57 = 842. Using an efficiency factor of .8 the actual number of buckets per day becomes 673 and the time required becomes 600 ÷ 673 = 7.1 hours. If this capacity cannot be met because of the difficulty in digging the bulldozer will have sufficient time to loosen (scarify) the material to a depth of 0.2 meters after the stripping operation.

The material must be compacted in lifts once it is on roadway. The depth of each lift will be approximately .30 meters loose which is more than is commonly used but acceptable when using a vibratory roller on sandy material. After the material from one side of the borrow area is placed it

must be shaped by heaviest of the two graders and then rolled before the other side of the borrow area is placed. Therefore an evaluation of the roller capacity is in order. The following is assumed:

e. Bottom lift is 10 m. wide, second lift is 9 m. wide, and cap material is 8 m. wide. Drum width is 1.93 m. First lift requires 6 roller width per pass, second and third (cap) lifts require 5 roller widths per pass. Roller speed 6 km/hr.

The time to travel 350 m. at 6 km/hr is 3.5 minutes, stopping and starting require 0.5 minutes, therefore one roller width requires 4.0 minutes. The first pass requires 6 widths or 24 minutes. The second and third passes require 20 minutes each therefore the roller can roll all three lifts, one pass each, in 64 minutes. However, the 80% efficiency factor increases this to 80 minutes - (60 x 8) ÷ 80 = 6 passes per lift per day as a practical roller capacity. The rule of thumb for roller passes per lift is 4 to 6 with 6 being used on material with less than ideal moisture content. However, vibratory rollers on sandy soil require less passes to obtain satisfactory results.

The use of the above methodology would indicate that the equipment is suitable to meet the production requirements.

Table 3: DETERMINATION OF MATERIAL QAUNTITIES, NEW ALIGNMENT

Step 1. Strip loam 8" depth, (0.2 m), for a width of 30 meters.
Step 2. Construct embarkment

a. Breakpoint at shoulder to be 0.5 meters above stripped surface, cross slope 5% on platform surface, crown point 0.2 meters above breakpoint.

b. Compacted volume per meter

$(0.5 + 0.7) \times \frac{1}{2} \times 4 \times 2 = 4.8\ m^3$
$(0.5 \times 1.0) \times \frac{1}{2} \times 2 = 0.5\ m^3$
$5.3\ m^3$

Deduct 0.25 m surfacing material from above

$0.25 \times 8 = 2.0\ m^3$
$0.25 \times 0.5 \times \frac{1}{2} \times 2 = 0.1\ m^3$
$- 2.1\ m^3$

Compacted volume of side borrow = $3.2\ m^3$/meter

c. Loose volume of side borrow

$3.2 \times 1.20 = 3.8\ m^3$/meter

d. Bank volume of side borrow

$3.8 \div 1.12 = 3.4\ m^3$/meter

e. Additional depth to get side borrow
3.4 ÷ (2 x 10) = 0.17 say 0.2 meters

f. Depth of 10 meter drainage swale below shoulder
0.5 + 0.2 = 0.7 meters

Section 4: WIDENING EXISTING ALIGNMENT

Under these conditions the only stripping required is that width which is to be excavated. Tree cutting, I am informed, will be done by the local residents in return for the wood. In the past, I am also told, if the local inhabitants were reluctant to cut the trees the army was sent to supervise the cutting.

The material cut from the side of the road must be used to build up the road bed which will reduce the depth of the cut area, in some cases significantly. Two restrictions apply however. First the material must be spread and shaped to the proper depth and each lift properly compacted. Second the finished surface of the completed roadway on steep side hill cuts must be below the berm of natural soil that currently exists in order to control the runoff, to prevent part of the road from sliding down the hill side, and to provide at least a visual barrier to prevent the local drivers, who are used to driving in trenched sections, from driving over the side. Any additional excavated material must be wasted.

Concrete drainage ditches must be provided on the uphill side of long or steep areas to provide for erosion control. Culverts must be used as needed to discharge the water for these concrete ditches into the existing miters thru the earth berm.

The production rates are difficult to predict since the road widths vary as does the height of the cut face. However, if the average production rate in the 36 kilometers which must be widen drops below 120 meters per day it is unlikely that the road will be completed on schedule. To approach the problem in a different way, the excavation in these areas must average approximately 1200 BCM* per day to meet the production schedule while the normal capacity of a single front end loader of the type provided for this project is about 850 BCM per day. This confirms the assumption that as much of the excavated material as possible must be bulldozed onto the existing roadway and

---

* This figure does not take into account any savings in excavation to be realized from using as much of the excavated material as possible to build up the existing roadway. The excavation quantities presented in Section 2, Table 2 are in that sense very conservative since they are taken to the top of the berm where berms exist and make no allowance for topsoil to be stripped or for any reduction in cut depth due to filling the existing road.

compacted since there will be a considerable excess of roller capacity during the period when the production rates are reduced. Furthermore, since there is no requirement that pit material be hauled every day, it may be wise to stop that operation at least every other day and use the equipment to assist in the road widening process.

Section 5: ROAD SURFACING OPERATION

The road surface will consist of a granular material taken from borrow pits. It will be spread to a 0.3 meter depth and compacted to 0.25 meters. Gravel is available at the beginning of the project but most of the surface will be a fine sand with some binder.

OR reports that pits have been located at the following places (these locations are not comparable to the project km. in the inventory since they are OR locations from some unknown point in or near Kikwit): km 4, 14, 18, 18.3, 28, 38, 48, 58, 68, 81, 83, 90, 100.5, 107, and 117. The depth to suitable material near Idiofa is approximately 5 meters.

These pits have been investigated by the OR soils department but the analysis is not complete. Provision has been made to include a soils specialist and helper in the brigade to further analyze these pits, locate other pits, and control the compaction operation. The equipment for this activity has been included in the camp costs.

Table 3, Section 3, indicates that the compacted volume of surfacing is 2.1 $m^3$/meter. This equates to 2.5 LCM. The average distance between known pits is reported as 10 km, therefore the maximum haul distance on the road will be 5 km and the average haul distance, including the pit access road is assumed to be 3 km.

As indicated in Section 3, a Clark 75 B loader or equivalent can handle 2 LCM. If the loose material weighs 1700 kg/meter one bucket load will weigh 3400 kg. The loaded bucket capacity is 4100 kg. so the loader is properly sized for the pit operation. The F 700 trucks have a 4 $m^3$ box. Therefore two bucket loads will fill a truck. This is the proper ratio of truck to loader capacity. The truck rating indicates a design payload of 7000 kg. Since two bucket loads is 6800 kg, the truck will not be overloaded during the surfacing operations. The following assumptions have been made:

a. Load cycle time is 0.4 minutes per bucket. Truck travel time loaded is 16 KPH, empty is 40 KPH.

Dump time and turn around is 2 minutes. The time for loading one truck is 2 x 0.4 or 0.8 min. However, applying an 80% efficiency factor this becomes 0.8 ÷ 0.8 = 1 minute. Therefore the loader can load one truck per minute or 60 x 4 = 120 LCM per hour at 80% efficiency.

Since the surfacing requirement is 2,5 LCM per meter x 300 miters = 750 LCM per day and the loader can load 120 LCM/hr - the total loading time is 750 ÷ 120 = 6,25 hours. The remaining 1,75 hours is available for the loader to work on the face of the pit.

Truck travel time is (3 ÷ 16) + (3 ÷ 40) or 0.2625 hour which is 15.75 minutes. Dumping adds 2 minutes and loading requires one minute so the total round trip becomes 18.75 minutes. Assuming 80% efficiency increases this time to 23.4 minutes, or 24 minutes for ease in calculation. One truck can therefore make (8 x 60) ÷ 24 = 20 round trips per day and move 20 x 4 = 80 LCM per day. Number of trucks becomes 750 ÷ 80 = 9.4 or 10 trucks per day. Ideal spacing would indicate one truck would arrive at the pit every 2.4 minutes. Since the loader can load a truck in one minute the truck fleet controls the production and placing of surfacing material.

To evaluate the POL costs for the truck fleet the projected consumption of a truck hauling surfacing material can be assumed to be usage of the entire fleet of 12 trucks. Each truck makes 20 trips of 6 km or 120 km/day. At the rate of 100 km/30 liters consumption is 36 liters per day or 4.5 liters/hour. However, the truck engines will be running during the time that was added for the 80% efficiency of the operation but not at the same rate of consumption. Using a factor of 75% consumption for this inefficient time increases the fuel consumption to 5.3 liters/hr. The total fleet of 12 trucks will therefore consume 63.6 liters per hour.

The total time to surface the 131 km of road will be 131 ÷ 0.3 = 434 days which indicates that 166 days or 28% of the project time the truck fleet and pit loader will be available for other work.

Optimum moisture for the compaction of both the surfacing and subase material can only be evaluated in the laboratory, the amount of water required to reach optimum moisture will also change because the actual moisture content varies due to weather and other causes. However the optimum moisture for fine grain soils should be thoroughly damp but not wet and sticky. Assuming this point to be half way between the damp sand as excavated and wet sand, 64 liters of water would have to be added to each loose cubic meter.

The total quantity on a 300 meter section of sideborrow construction is 750 LCM of pit material and 1140 LCM of side borrow. This will require (750 + 1140) x 64 = 121,000 liters. Each water truck holds 1500 gal. x 3.785 = 5678 liters. Therefore the water requirements is 121,000 ÷ 5678 - 21 truck loads per day. To simplify calculations assume 20 truck loads per day which is 10 loads per truck. If a truck takes 10 minutes to load and 10 minutes to discharge its load, those operations will consume 20 x 10 = 200 min. or 3.3 hours. This leaves 280 minutes for travel time. Assuming the truck travels 25 KPH full and 50 KPH empty since the load weighs less than the dump trucks are carrying and the water trucks are not getting in each other's way, the truck will average 37.5 KPH or 625 meters per minute. However,

since it has to go both ways the actual distance traveled to and from the water supply is 310 m/min. 10 trips per day reduces this travel to 31 m/min and the greatest distance from a water source that the truck can operate is 280 x 31 = 8.7 km.

In areas where the distance between water supplies are located less than 8.7 x 2 = 17.4 km two trucks will be sufficient. However, in the areas from km 14.9 to km 39.0 and from km 58.3 to 66.9 additional water sources must be found.

Section 6: Calculations for Project Paper

Several tables appear in the project paper that I helped develop. The original calculations are included in Annex B of this report although they may be redundent. Figure 1 in Annex B is a sketch of the project road. Table B-1: Heavy Equipment, FOB, USA, indicates the type of equipment chosen for the cost estimate in the project paper. Each piece of equipment designated by a model number (i.e. D6D) is a specific model and the FOB price is the current US price as quoted by a local dealership. In many cases this equipment was selected from several quotations as the best available for the price. The Equipment Brochures where left in Kinshasa. Some of the prices (specifically Caterpillar) are due for an increase in November so I would urge early procurement to insure that the prices quoted are valid. All prices are for 1982 model equipment.

Table B-2 shows the computation of the equipment depreciation costs. The heavy equipment was depreciated over 8 years assuming the 80% efficiency factor. This figure was chosen because heavy equipment is depreciated in accordance with the clock hours that show on the instrument panel and idle time is not recorded even if the equipment is running. All other equipment was depreciated over 5 years.

This information was developed to prepare Table B-3: Average Cost of Road Improvements. This is the total cost of the project less the value left in the equipment. The costs were developed assuming 150 km of primary road upgrading and are therefore lower than the actual costs per kilometer for the actual 131 km of primary road. That correction increases the cost per km to AID - 12.790, GOZ - 13.762, Total - 26.552. These costs per km prices are unrealistic since the feeder roads will be much less expensive than the primary roads, however, the total overall costs remain the same.

Table B-4 was developed to determine the actual costs for importing the equipment and transporting it to Kinshasa. The import tax charged OR is based on the CIF value and the railroad freight from the port to Kinshasa is based on the shipping weights. However, OR later indicated that their experience with recently imported Saudia Arabian supplied equipment indicated that the cost delivered on site was approximately 10% of the CIF cost so that figure was used.

Table B-5, POL Evaluation, was prepared using Caterpillar consumption rates for heavy equipment and other assumptions listed in the table. OR compared these figures with actual brigade costs. This estimate was slightly higher (0.3%) probably because the loss (theft) factor (10%) included in this estimate was unduly pessimistic.

Table B-6, Local Personnel in Brigade, was calculated directly from OR supplied data. The original estimate included 78 men while OR anticipates 80 local personnel. OR includes extra equipment operators but assumes if a truck driver is unavailable one of the mechanics can fill in. OR also included drivers for each of the pickups. Since this table represents a standard brigade (except for the soils personnel) configuration and is paid for by the GOZ it was accepted as presented.

Table B-7: Expatriate costs, and Table B-8: Camp costs, were both worked out jointly by myself and the OR representative.

Table B-9: Estimate Drainage Materials Cost, was developed using Corrugated Metal Pipe for culverts because there is a local CMP distributor in Kinshasa. The pipe costs were taken from his current price list. OR later informed me that the distributor demands payment in hard currency and at this time OR does not have the means to purchase CMP. They indicated that this may change before the project started. OR worked out their own, much more detailed cost estimate for the drainage costs of the project using actual current costs for concrete structures but substituting site produced concrete pipe for the CMP. Since I feel very strongly that in situations where culverts are placed directly below the road surface CMP is far more durable than unreinforced job site manufactured concrete pipe, OR agreed that since the total cost of each estimate was substantially the same they would accept my estimate in the project paper even through they did not anticipate the use of CMP.

Table B-10 represents an attempt to modify Table 4: Estimated Expenditure Over the Life of the Project, of the project paper to include the local costs of the road construction segment of the loan agreement. It is included here to show my rational in determining these costs.

Section 7: <u>Feeder Roads</u>

I was informed that OR and/or other GOZ agencies will participate in the selection of the location of the 50 km of feeder roads for this project. Since feeder roads usually carry vehicles that are measured by the week instead of the day (10 to 20 a week is a common value) a feeder road can have a minimum width in the order of 3.5 meters.

This type of road can be completely constructed with a grader. The accepted method is to remove the top soil and then cut the ditches by grader, using the material from the ditches to build up the roadbed so that it is above the existing ground. The width can be increased beyond the minimum with very little extra grader effort in flat terrain.

I would anticipate that the feeder roads can be constructed while the brigade is involved in areas requiring considerable earthmoving activity since there should be spare grader capacity at that time. The feeder roads can be compacted when the brigade reaches the junction of the feeder road with the main road since if the main road is on a new location a new intersection must be built at that time. Early opening of the basic feeder road should increase the impact of the project on the local economy while a later light grading and rolling will permit any deficiencies in the original construction such as inadequate ditching to be corrected.

Section 8: Labor Intensive or Contract Construction Possibilities

During the field phase of this contract data were gathered to evaluate the possibility of executing some or all of the construction and/or maintenance of the project roads by labor intensive methods or by private contract. The availability of village unskilled labor, the wage structure, and community and private contractor capabilities were all evaluated to the extent possible within the time available.

Presently OR contracts much of the maintenance on the existing road. The maintenance contracts are with individual day laborers, with village headmen and with merchants who maintain sections of roads when it is to their advantage to do so. I was not able to determine how much, if anything, OR pays the private merchants for their maintenance activities, however, interviews with laborers working on the road indicate that the monthly wage paid to both OR and village employed casual road labor was Z 40. The OR casual employees had not been paid for several months but the village casual employees had been paid regularly. Language difficulties prohibited any evaluation of additional benefits which may also have been paid, but so many interviews indicated the same Z 40 rate that one is prone to accept that figure.

A permanent OR laborer receives a monthly salary of Z 340 (see cost of brigade calculations). This pay includes many allowances which a casual laborer would not enjoy. The casual laborer receives very little supervision by OR personnel. The documentation for Project 026 indicates that these day laborers actually work for about 2½ hours although they are paid for a full day.

The apparent availability of contractors in the area is very small. A contractor had just finished the approaches to a new bridge to be built to replace the 1st ferry beyond Idiofa on the road to Ilebo. The road was 9 meters wide and had been constructed with a bulldozer. No compaction was included other than by the bulldozer. The road, which was as yet unused had begun to experience side slope erosion due to the lack of compaction. The contractor's supervisor indicated that no provision had been made for compaction in the future.

Since the men living in the villages along the road do not farm

because society has determined that farming is a woman's task, a labor pool would seem to be readily available to work on the road. World Bank studies indicate that any area in which the daily pay in 1976 dollars is less than $ 1.00 is a prime candidate for labor intensive construction or maintenance. Even at 16 work days a month (the figure used to determine project productivity) the 1981 daily wage is only $ 0.45, therefore the project area would seem ideal for a labor intensive or highly labor oriented approach. However, an equally important consideration is the availability of resources, i.e. a large enough pool of manpower living within an hour's walk of the work site. The vast open unpopulated areas along several sections of the project make such a labor pool unlikely.

A third factor in the evaluation of labor intensive construction is the governmental attitude towards that type of activity. This can take the form of a social taboo, i.e., the type of work is socially degrading, or a disinterest or lack of capability for developing the large administrative force necessary to make labor intensive work cost effective. Another, unmentioned factor in most labor intensive analyses, is the government's present commitment to capital intensive construction. As a practical measure, no government that is in the process of building up a pool of new equipment is going to abandon that equipment for any social reasons presented to encourage labor intensive construction. Since several donors (Saudi Arabia, World Bank, Japan, USA) are now helping the local government to renew its road building equipment fleet, it is impractical to suggest that a labor intensive or even a labor oriented approach be introduced into the construction phase of this project.

Labor intensive maintenance activities are suitable only on very low-volume roads (in the range of 10-20 vehicles per week). In all probability the feeder roads built by this project will fall into that category. Therefore the feeder roads could be maintained by labor intensive methods if OR can develop a suitable administrative capability to control and verify the labor expenditure.

Normally one laborer can maintain an average of 1.5 km of road after being properly trained in maintenance procedures. In LDC areas where labor intensive maintenance is practiced, the maintenance personnel learn by working as part of the labor intensive construction teams. Since the project roads will be constructed with equipment, this type of training will not be available.

The efforts of training and administrating the 33 laborers required to maintain 50 km of feeder roads must be balanced against the cost of a single yearly grading of the roads with equipment which will consume approximately 20 to 25 hours of grader effort. This balance in turn must be evaluated against the reduced user costs that will accrue from an earth road that is constantly maintained by labor over an earth road that is graded yearly. The user costs will vary more on an equipment maintained earth road. If the road is graded prior to the time of heaviest usage during harvest

season the user costs will be minimized. Therefore proper timing becomes another factor to be considered when deciding the type of maintenance to be used.

The primary road upgraded by this project will carry too much traffic to be maintained by labor intensive methods.

Section 9: Technical Assistance

The original concept for the make-up of the new brigade to be assembled for the upgrading/construction phase of this project called for three foreign specialists. Funding limits reduced the number of technical advisors to two, an Engineer/Construction Superintendent and a Master Mechanic.

These two people will determine the success or failure of the project. USAID usually specifies two requirements for the team leader that, in my opinion, are questionable. The first requirement is that the "engineer" have an engineering degree from an accepted college. While I do not question the benefits that accrue from such an education, I feel that there are a good many well qualified hands-on construction superintendents with a long record of successful construction projects who could supervise this rather straight forward construction activity very well. Engineers who graduated in the 1950's tended not to become construction superintendents because the need for engineers at that time diverted them to straight forward engineering activities. Yet it is the maturity of that generation of road builders that is needed to make this project a success. To limit the rather small pool of "right" people even further by insisting on an engineering degree will make the recruitment for that position extremely difficult.

The second questionable requirement applies to both positions. This requirement is for a certain number of years of construction experience in an LDC. While I recommend the loosening of the first requirement, I feel this requirement should be more closely defined. As presently stated, the technical assistants can qualify even if they have only worked for American or other constractors in places like Saudi Arabia where the entire crew is made up of foreign nationals. In this type of operation, superintendents and mechanics work only with their fellow countrymen and have little or no meaningful interaction with third world workers other than laborers. They work under conditions where everyone is highly motivated to produce at a profit. In a sense, this type of operation is like moving a little bit of the U.S. to the LDC.

People who have only worked overseas under these conditions rapidly become frustrated by the lackadaisical approach of local government employees who work under a welfare type of civil service that does not stress productiveness or efficiency.

On the other hand,people who have successfully worked directly

with LDC equipment operators, etc. already realize that these people respond to encouragement and strong supervision because, like everyone else, they want to be successful if they are properly motivated. I feel that the proper personnel for technical assistants should have had some experience working directly with LDC road organizations rather than just a physical presence in an LDC.

I had a third concern about the technical advisors when I first arrived in Zaire. Were they to be advisors whose advice was to be accepted or rejected by the local chief of brigade or would they be in effective charge of the operation. I therefore questioned all of the foreign advisors I met about this subject. OR is in fact run under the technical advisor system. I have been informed that in some areas, specifically up near the equator, the technical advisors have great difficulty exercising any real authority. However, in the Kikwit - Idiofa region the OR employees tend to respect and benefit from foreign technical assistance so it would appear that in fact, if not in theory, the technical advisors on this project will be in operational control.

Section 10: Training

The original draft of the project paper called for the technical assistants to set up and implement a formal training program for the local GOZ workers recruited for this new brigade.

Training is the teaching of work methods, techniques and skills necessary for the satisfactory performance of specific work assignments. Training should be limited to the subject matter needed to perform particular jobs. It should take place immediately before the trainee is to do that specific task. Unnecessary material will impair the effectiveness of a training program. Education, on the other hand, is the process of developing the general knowledge, mind, and character of a person through the study of histories, theories, and principles. Training is aimed at teaching the mechanic the proper direction in which to mount a grader tire rather than at explaining why the tire is more effective when correctly mounted.

The three most common approaches to formal training are (1) training centers, (2) training production units, and (3) decentralized training.

Training centers are fixed facilities that have classrooms, offices, shops, garages, sleeping quarters, and dining facilities. The staff is comprised of professional trainers. The trainees are transported to the training center where they participate in classroom discussion and in operational exercises where they perform simulated work. Training centers usually offer the most intensive programs, which, in turn, reduce training time.

Training production units are located in an area where work is

required. They are temporary or permanent camps that have additional classroom facilities. The staff is a cadre of professional trainers. The trainees are responsible for the construction or maintenance of a portion of an actual road network reserved for exclusive use by the TPU. The trainees are shipped to the camp where they undergo classroom discussions and do actual work on the road system assigned to the TPU. Usually, the training period is longer at a TPU than at a training center, and the number of trainees and types of training are less flexible. However, trainees must face actual work problems, and their work output offsets some of the training costs.

The brigade created to do the upgrading work for this project can not be considered a training production unit. The foreign advisors will not be qualified profession trainers nor does the proposed staffing schedule include a sufficient number of local qualified trainers to cover the many different activities the brigade will be undertaking. Furthermore, the work scheduled to be completed in the contract's three year active construction period precludes the use of a training production unit.

Decentralized training takes place at the trainee's regular work location; therefore, separate training facilities are not required. The training material is prepared by training specialists, but the actual training is done by the trainee's supervisor. This places the control, timing and amount of the training in the hands of the person who is responsible for the trainee's work. Decentralized training requires intensive preparation of complete and self-contained training programs by professional trainers and additional training for the supervisor-instructors. However, (a) the number of trainees is unlimited, (b) the training activity is completely flexible (allowing for minimal interruption to the trainee's work schedule), (c) the cost per trainee is nominal, and (d) trainees tend to pay strict attention to the training given by their supervisors.

This type of training can only be carried out in the brigade being developed for this project if OR has already properly developed the necessary training material and is able to prepare the supervisor-instructors for the brigade within the 9 months before actual construction activities are scheduled to begin.

Training's major objective is to teach each employee to do each work activity in the same, accepted way. Usually, a new training program is targeted at regular highway employees in order to standardize ongoing work methods. Once this immediate objective is obtained and the training methods have been perfected, the training program can be expanded to provide basic training for new employees and to prepare regular employees for advancement.

If the OR existing training facilities have not yet advanced to the stage where they are producing fully trained new employees this brigade must be formed from experienced OR employees. Otherwise it will not maintain the funded work schedule.

The technical advisors should be required to implement any and all training activities that have been properly developed by the OR training program. However, to expect two technical advisors to independently develop and execute a training program at the same time they are trying to maintain rather difficult production schedule is unrealistic and will undoubtly fail to achieve either objective. The advisors should be expected to give ad hoc individual instruction to improve and encourage proper work performance but this instruction cannot be considered a formal training program.

Section 11: Construction Camps

The original concept for this project was to build a series of construction camps along the road as the worked progressed. OR did not accept the concept and instead proposed a single facility be built in Kikwit to house the administrators, spare parts, materials etc. and to provide room for the mechanics to do all but the most major repair work on the project equipment. They proposed this separate facility so that the project spare parts would be used on project equipment and not lost in the regular OR warehouse and so that the Master Mechanic Advisor would not be diverted to making major repairs on other OR equipment in the existing compound.

When I questioned the housing of the employees I was informed that they would live in the villages along the road and that their pay included extra money for such lodgings. The guards included with the brigade would stay with the equipment at night so it would not have to be moved back and forth.

Since I was still concerned with the possibility that the workers might travel to and from the nearest village during work time thereby reducing the productivity of the brigade I further questioned the OR foreign technical advisors about this subject on my last trip to Kikwit. I was told that this is the accepted method and that the construction superintendent merely had to notify the workers of the specific time when one truck would leave the village each morning to get them to the work area before the workday began. The same truck would leave the project after the workday ended to return the workers to the village.

The concept of a single brigade facility in Kikwit seems to be viable and a routine solution for the brigade's requirements.

Section 12: Maintenance

No matter how well the roads are improved or constructed during this project they will begin to deteriorate as soon as they are finished. Even if they are never placed under traffic, the environment immediately begins to cause deterioration. On very low volume roads, such as some of

the projected feeder roads, the environment alone determines the amount of necessary maintenance.

An analysis of the maintenance requirements for this project is presented below. The following assumptions are made:

a. One grader can do 1.5 km of heavy grading a day or 2.5 km of light grading a day. One heavy grading is required per 6000 vehicles, one light grading is required per 4000 vehicles. The graders will work 200 days per year but the traffic will run 7 days a week. This is the concept from which average daily traffic is derived rather than from taking spot counts.

Under these assumptions Table 2, below was developed. Table 2 was developed before the actual length of the road was known and therefore is based on 150 km of roadway. However, there are so many variables involved that the conclusions probably are as right or wrong for either distance.

One grader can do 1.5 x 200 = 300 km (year) heavy grading
One grader can do 2.5 x 200 = 500 km (year) light grading

Heavy grading - one grader can do road twice a year
Light grading - one grader can do road $3\frac{1}{3}$ times a year

Heavy grading @ 6000 vehicles per pass ÷ 365 = 16.4 vpd
One grader can handle traffic up to 33 vpd
Light grading @ 4000 vehicles per pass ÷ 365 = 11 vpd
One grader can handle traffic up to 37 vpd

TABLE 2

| No. of Graders | Heavy Grading VPD | Heavy Grading Passes/year | Heavy Grading Rate | Light Grading VPD | Light Grading Passes/year | Light Grading Rate |
|---|---|---|---|---|---|---|
| 1 | 33 | 2 | 6 months | 37 | $3\frac{1}{3}$ | $3\frac{2}{3}$ months |
| 2 | 66 | 4 | 3 " | 73 | $6\frac{2}{3}$ | $7\frac{3}{4}$ wks |
| 3 | 99 | 6 | 2 " | 110 | 10 | 5¼ wks |
| 4 | 132 | 8 | 6 weeks | 146 | $13\frac{1}{3}$ | 4 wks |
| 5 | 164 | 10 | 5 " | 183 | $16\frac{2}{3}$ | 3 wks |
| 6 | 197 | 12 | 1 month | 219 | 20 | 2½ wks |
| 7 | 230 | 14 | $3\frac{3}{4}$ wks | 256 | $23\frac{1}{3}$ | 2¼ wks |
| 8 | 263 | 16 | 3¼ wks | | | |

A surface treatment should be considered when the traffic reaches the range of 250 vpd. The actual traffic volume that economically justifies an asphaltic seal is dependent on the cost of the seal verses the savings in maintenance costs.

Traffic volume at present is assumed as 40 trucks per day. Other

vehicles (autos, etc.) do not significantly effect maintenance requirements at this level of traffic. Since the project does not begin for a year assume 10% increase before start. Assume an additional 50% increase due to completion of road. Since some of this increase will be due to better transportation and some will be expanded planting, assume additional increase will not be completed until a year after the road is completed. The increases due to the road construction, based on the length completed each year, is therefore assumed to be 7.5%, 15%, 22.5%, and 5%. Normal traffic growth will continue at 10% during the construction and after the impact of the new road is completed. The traffic volumes used to predict the required maintenance effort are as follows:

| | | | | |
|---|---|---|---|---|
| end of Year 1: | 40 x 1.10 | = | 44 | Begin construction |
| Year 2: | 44 x 1.175 | = | 52 | Under construction, 50 km done |
| Year 3: | 52 x 1.25 | = | 65 | Under construction, 100 km done |
| Year 4: | 65 x 1.325 | = | 86 | Road completed, 150 km |
| Year 5: | 86 x 1.15 | = | 98 | Road life, 1 year |
| Year 6: | 98 x 1.10 | = | 108 | Road life, 2 years |
| Year 7: | 100 x 1.10 | = | 119 | Road life, 3 years |
| Year 8: | 119 x 1.10 | = | 131 | Road life, 4 years |
| Year 9: | 131 x 1.10 | = | 144 | Road life, 5 years |

At the end of the first year of construction 50 km will require maintenance. The projected traffic is 52 VPD. Since the maintenance is only one third of final project only one grader is required for maintenance on a part time basis.

At the end of the second year 65 VPD are assumed to be using the road. 100 km are completed. If the light grading concept is adopted, the grading rate per grader will be 5 passes per year, but the road will require 6 passes per year so one grader will be required full time and one grader will be required on an occasional basis.

At the end of the project period 3 graders will be required for light grading. At the beginning of the third year after completion, the grader requirement increases to four. These four graders will be working full time, grading each section of the road every four weeks, by the end of the fifth year.

These graders should be stationed at villages along road and a foreman, mechanic and several laborers should be located in the same village so that each grader becomes the nucleus of a separate maintenance unit responsible for a given road section.

Another rule of thumb benchmark is the requirement for resurfacing the road. It is a common but unproven assumption that a gravel road will loose one inch of gravel per year. The surfacing material on this project is sand rather than gravel so that even this very loose assumption may well be incorrect. However, the 25 cm surface would have a lifetime of nine years if the above rule were to hold true. A normal 6 inch (15 cm) gravel road surface will last 5 to 6 years between regravellings.

Road surface material is lost for two reasons, traffic which causes a loss of fines as dust, and rainfall which washes away the fines and erodes the granular material. The granular material (sand) which is pushed to the side of the road, or formed into corrugations by traffic is brought back to its proper location by routine grading. When the correct cross slopes are maintained, also by routine grading, the material lost to water run off is reduced.

While the surface material loss on this project is unpredicable it can be lessen by re-rolling the reshaped road during the rainy season when the surface is near optimum moisture. The roller controls the rate of production but since the main objective is to firm up the surface rather than compact a substantial depth of loose material only one pass is required. The common practice is to use two or three graders with a single roller. A water truck used in the same operation improves the results of this team of equipment if the rainfall is not prolonged. During intermittant rains the natural moisture near the surface evaporates rapidly when the sun shines between rainfalls. This method of reducing road surface loss has not been acceptably measured as yet but indications are in the range of a 50% increase in time between regravellings with some materials.

Section 13: An alternate Alignment to Idiofa

During discussions with the OR representative in Kinshasa the subject of a new paved road presently being built from Kikwit to the east came up. This road will pass near the village of Kimbanda in four or five years if the funding continues. It was suggested that perhaps the brigade could improve the connection to this future road instead of improving the existing Kikwit-Idiofa road because the brigade would have less distance to go. I was asked to travel the existing roads to Kimbanda to see if this would be a more suitable route.

The distance to Kimbanda was 82.3 x 0.992 or 81.6 km. The first 51.5 km followed the roads shown on the maps we had to Yasa-Lokwa. From there on the mapped road none existant and we followed grass tracks and local directions to Matanda and Kimbanda. The terrain had the same characteristics as that near Idiofa on the project route except that the 7 valleys we crossed were smaller. We crossed a continuation of the same ridge area with white sandy soil that was encountered between km 82.8 and 87.9. However, this route traveled 10.3 km over that particular geological formation rather than the 5.1 km on the project road. The existing roads were mostly 2.5 to 3 meters wide. There were 6 water crossings including one CMP culvert, one very impressive double arch stone bridge, one log crossing and three poor timber decked bridges.

The alternate route lacked the violent terrain found near Kikwit, because the proposed paved road will traverse that mountainous area.

A road following the alignment we took can certainly be built. The conditions are about the same as the project road near Idiofa except that the valleys are smaller and the descents and ascents steeper, but shorter. However, any benefit gained by building a shorter route would probably be lost by the logistical problems inherent in starting any road construction from Idiofa and trying to supply it over the existing Kikwit-Idiofa road. In my opinion a major factor in the possibility of finishing the project road on schedule is the fact that the supply line to the construction site will always be the already improved road.

I cannot speculate on the engineering or funding problems the GOZ may encounter before they get the paved road to Kimbanda however I would be willing to guess that the project road will begin to impact the Idiofa area long before the alternate alignment becomes a viable solution and that even if such a connection were made the project road will still carry a substantial amount of traffic.

ANNEX A

Table A-1

VILLAGES

Kilometers from - to

| Left | Right | Comments |
|---|---|---|
| 0.0 - 0.3 | -- | |
| 3.4 - 3.9 | 3.6 | OR brigade headquarters on right |
| - | 9.3 - 9.7 | |
| - | 10.2 - 10.3 | |
| - | 12.4 - 12.5 | |
| 13.6 - 14.2 | 13.6 - 14.2 | Kimputu |
| - | 15.2 - 15.3 | |
| 18.0 - 18.8 | 18.6 - 18.8 | |
| | 25.1 | Large village ½ km to right, not on this road |
| - | 29.2 - 30.5 | Kipini |
| - | 32.8 - 33.9 | Mulungu |
| 36.7 - 37.7 | 37.6 - 37.9 | Imbongo |
| - | 42.6 - 42.7 | |
| 45.7 | - | Few houses where old alognment joins new. |
| 46.4 - 47.6 | 46.4 - 47.6 | Scattered dwellings intensifying near Idjim River |
| 47.9 - 49.6 | 47.9 - 49.6 | Scattered dwellings between Idjim and Luano Rivers |
| 49.7 - 49.8 | 49.7 - 49.8 | Pomongo Post, probably name back to 46.4 |
| 50.7 - 50.8 | 50.7 - 50.8 | Coffee growing here |
| 55.0 - 55.5 | 55.0 - 55.5 | Pomongo Village, microwave tower |
| 57.1 - 57.3 | 57.1 - 57.3 | |
| 74.1 - 77.5 | 73.2 - 77.0 | Kimpata-Eku, concentrated on right, more scattered left. Mpumu River here. |
| 92.0 - 92.8 | 92.0 - 92.8 | Bwalenge |
| 101.3 - 102.0 | 100.9 - 101.3 | Bitshambele Mbele, Labwi River here |
| 104.9 | 103.3 - 104.8 | Bitshambele Ibamda |
| 106.1 - 107.0 | - | Luse |
| 111.2 - 111.3 | - | Tomote |
| | 117.0 - 119.9 | Lungu I |
| | 119.7 - 119.9 | also Lungu I |
| 121.1 - 121.4 | 121.2 - 121.7 | also Lungu I, Pio Pio river here |
| 129.2 - end | 129.1 - end | Idiofa |

Table A-2

WATER CROSSINGS & CULVERTS

| Km | Flow | Comments |
|---|---|---|
| 6.2 | right | Yomsi river,twin CMP 1.5 meter pipes being installed (incorrectly) |
| 47.7 | left | Idjim river, one lane wood deck, 5 m. |
| 49.6 | left | Luano river, one lane wood deck, 13 m. |
| 75.6 | left | Mpumu river, one lane wood deck, 5 m. |
| 79.1 | left | Lubwe river, one lane wood deck, 22 m. |
| 85.3 | left | This section of road is on difficult soil so an attempt has been made to raise the road above the existing road and drainage dirches have been installed. A 1.0 meter CMP 4 m. in length was installed, however the road on the left side has collapsed blocking the outlet. |
| 94.3 | left | Kamtsha river, one lane wood deck, 8 m. |
| 101.6 | left | Labui river, one lane wood deck, 8 m. |
| 114.8 | right | CMP culvert,silted in except for top 15 cm which is flowing full. Size unknown but must be removed and reinstalled. |
| 116.8 | left | Matende river, one lane wood deck, 5 m. |
| 121.1 | left | Mbabo river, one lane wood deck, 2.5 m. |
| 121.4 | left | Pio Pio river, one lane wood deck, 8 m. |
| 127.1 | left | Mosanga river, one lane wood deck, 8 m. |

Table A-3

ROAD INTERSECTIONS

| Kilometer Left | Kilometer Right | Remarks |
|---|---|---|
| 2.1 | 2.1 | |
| | (3.5) | Gravel pit entrance |
| 4.1 | | |
| 5.0 | | Two roads at same location |
| 5.7 | | |
| 6.0 | | Entrance to building complex |
| | 6.8 | |
| 8.6 | | |
| | 11.1 | |
| | 12.3 | |
| | 13.1 | |
| | 13.8 | Intersection in village of Kimputu |
| | 14.9 | PLZ company road, most roads to here for palm oil |
| 15.6 | | |
| (20.6) | (20.6) | Old alignment crossing |
| | 28.9 | Intersection just before village of Kipini |
| | 37.7 | Road sign: to Collectivite d'Imbongo |
| | 39.0 | |
| | (39.4) | Junction with old alignment |
| | (40.6) | Old alignment returns |
| | 40.8 | |
| (41.8) | | Old alignment rejoins |
| (42.8) | | Junction with old alignment |
| (44.7) | (44.7) | Old alignment crosses |
| (44.8) | | Old alignment leaves |
| (45.7) | | Old alignment rejoins |
| (54.9) | | Old alignment begins |
| (55.0) | | Entrance to microwave tower |
| (55.8) | (55.8) | Old alignment crosses |
| 57.3 | 57.3 | Two roads on left, one on right |
| | 59.0 | |
| | (60.8) | Tie to alternate alignment |
| (62.2) | (62.2) | Old alignment crosses |
| | (62.4) | Second alternate alignment starts |
| (64.0) | | Alternate alignment joins |

Table A-3 (continued)

| Kilometer Left | Kilometer Right | Remarks |
|---|---|---|
| (64.5) | (64.5) | Old alignment crosses |
| (66.3) | (66.3) | Old alignment crosses |
| (66.7) | (66.7) | Old alignment crosses |
| | (72.4) | Old alignment joins |
| (72.9) | | Old alignment joins (sign: Idiofa 64 km) |
| 73.3 | | Sign: Nanzonzi - 3 km, Kanga - 10 km |
| (78.0) | | Old alignment leaves |
| | (78.2) | Another old alignment leaves |
| (79.2) | | Pit entrance |
| | 80.9 | |
| (82.2) | (82.2) | Old alignment crosses |
| (82.7) | (82.7) | Old alignments begin both sides |
| (84.4) | | Pit entrance |
| | 85.4 | Sign: Kilembe, Tshikapa, Yasa-Lokwa - 20 km |
| | (87.9) | Begin old alignment |
| | (88.0) | Begin second old alignment |
| 92.4 | | Goes back to Pomango village & Madai, palm oil factory 15 km |
| (95.7) | | Pit entrance |
| | (96.6) | Old alignment to right |
| | (96.7) | Second old alignment to right |
| (97.3) | (97.3) | Old alignment crossing |
| (98.9) | | Connection to old alignment |
| (100.9) | | Old alignment joins |
| | (104.9) | Old alignment joins |
| 105.7 | | Intersection to Mikulukau |
| (106.0) | | Old alignment begins |
| | (106.1) | Old alignment joins |
| (107.2) | | Old alignment joins |
| (110.2) | | Old alignment begins |
| (110.9) | | Old alignment joins |
| 111.2 | | Sign: Mamgai, Panu |
| (114.9) | | Pit entrance |
| 115.3 | | |
| 116.4 | | Sign: Kalamganda, Sedzo - 154 km Panu- 190 km, Mateko - 187 km |
| 119.7 | | Pit entrance & road to Mabanga |
| | (119.9) | Track marking new re-alignment |
| | (120.8) | 15 m stripped for new alignment back to 119.9 |
| | (121.0) | Pit entrance |

Table A-3 (continued)

| Kilometer | | |
|---|---|---|
| Left | Right | Remarks |
| 121.5 | | Road to DPP farm |
| (121.6) | | Old alignment begins |
| | 126.4 | |
| 126.5 | 126.5 | Road to villages both ways |
| (126.6) | | Old alignment returns |
| (127.2) | | Old alignment begins |
| | 129.2 | Sign: Banda - 75 km, Kilembe - 141 km<br>Mitumbi - 172 km, Tshikapa - 293 km |
| 129.8 | | Local roads in Kikwit |
| 129.8 | | " " " " |
| 130.0 | 130.0 | " " " " |
| 130.2 | 130.2 | " " " " |
| 130.3 | | " " " " |
| 131.0 | 131.0 | Circle de la Revolution,<br>cross roads w/monument. |

Table A-4

BURIAL SITES

| | |
|---|---|
| 74.2 | On right, in Kimpata - Eku |
| 75.9 | On left, in Kimpata - Eku |
| 93.5 | Both sites, beyond Bwalenge |
| 106.4 | On right, opposite Luse |
| 115.4 | On left, near road intersection, no houses nearby. |

Table A-5

VEGETATION

Beginning Km. - Type of Growth

| Left | | Right | |
|---|---|---|---|
| 0.0 | Palms | 0.0 | Palms and forest |
| | | 2.1 | Palms |
| | | 5.4 | Palms and forest |
| 6.5 | Forest | 6.5 | Palms |
| 7.1 | Palms and forest | | |
| 9.3 | Forest | | |
| | | 9.9 | Forest |
| 10.5 | Palms | 10.5 | Palms |
| 15.4 | Forest | | |
| | | 16.0 | Forest |
| 16.7 | Savannah/shrubs | 16.7 | Savannah/shrubs |
| 19.2 | Savannah | 19.2 | Savannah |
| 36.3 | Palms | | |
| 37.5 | Savannah | | |
| | | 38.5 | Forest |
| 39.4 | Forest | 39.4 | Savannah/shrubs |
| 39.6 | Savannah/shrubs | | |
| 45.4 | Forest | 45.4 | Forest |
| 45.9 | Palms | 45.9 | Palms |
| 47.0 | Forest | 47.0 | Forest |
| 47.7 | Savannah/shrubs | 47.7 | Savannah/shrubs |
| 48.1 | Forest | 48.1 | Forest |
| 48.4 | Palms | 48.4 | Palms |
| 51.8 | Forest | 51.8 | Forest |
| | | 51.9 | Savannah/shrubs |
| 52.2 | Savannah/shrubs | | |
| 58.2 | Savannah | 58.2 | Savannah |
| 65.2 | Savannah/shrubs | 65.2 | Savannah/shrubs |
| 65.6 | Savannah | 65.6 | Savannah |
| 73.5 | Palms | 73.5 | Palms |
| 74.7 | Savannah | 74.7 | Savannah |
| | | 75.4 | Savannah/shrubs |
| | | 75.9 | Savannah |
| 76.5 | Savannah/shrubs | | |
| | | 77.0 | Savannah/shrubs |
| 77.5 | Savannah | 77.5 | Savannah |
| 79.2 | Savannah/shrubs | 79.2 | Savannah/shrubs |

Table A-5 (continued)

| | | | |
|---|---|---|---|
| 81.1 - | Savannah | 81.1 - | Savannah |
| 92.0 - | Palms | 92.0 - | Palms |
| 93.0 - | Savannah | 93.0 - | Savannah |
| 94.6 - | Savannah/shrubs | 94.6 - | Savannah/shrubs |
| 95.6 - | Savannah | 95.6 - | Savannah |
| 100.0- | Savannah/shrubs | 100.0- | Savannah/shrubs |
| | | 103.1- | Savannah |
| 103.3- | Savannah | | |
| | | 106.4- | Savannah/shrubs |
| 107.0- | Savannah/shrubs | | |
| 114.4- | Palms | | |
| | | 114.8- | Palms |
| 115.1- | Savannah/shrubs | 115.1- | Savannah/shrubs |
| 117.7- | Palms | | |
| 117.9- | Savannah/shrubs | 117.9- | Palms |
| | | 118.3- | Savannah/shrubs |
| 119.3- | Palms | 119.3- | Palms |
| 119.5- | Forest | 119.5- | Forest |
| 119.7- | Savannah/shrubs | 119.7- | Savannah/shrubs |
| 119.9- | Palms | | |
| 120.2- | Savannah/shrubs | | |
| 123.2- | Savannah | 123.2- | Savannah |
| 127.0- | Savannah/shrubs | 127.0- | Savannah/shrubs |
| | | 128.7- | Palms |
| 129.2- | Idiofa City scattered palms | 129.2- | Idiofa City scattered palms |

Table A-6

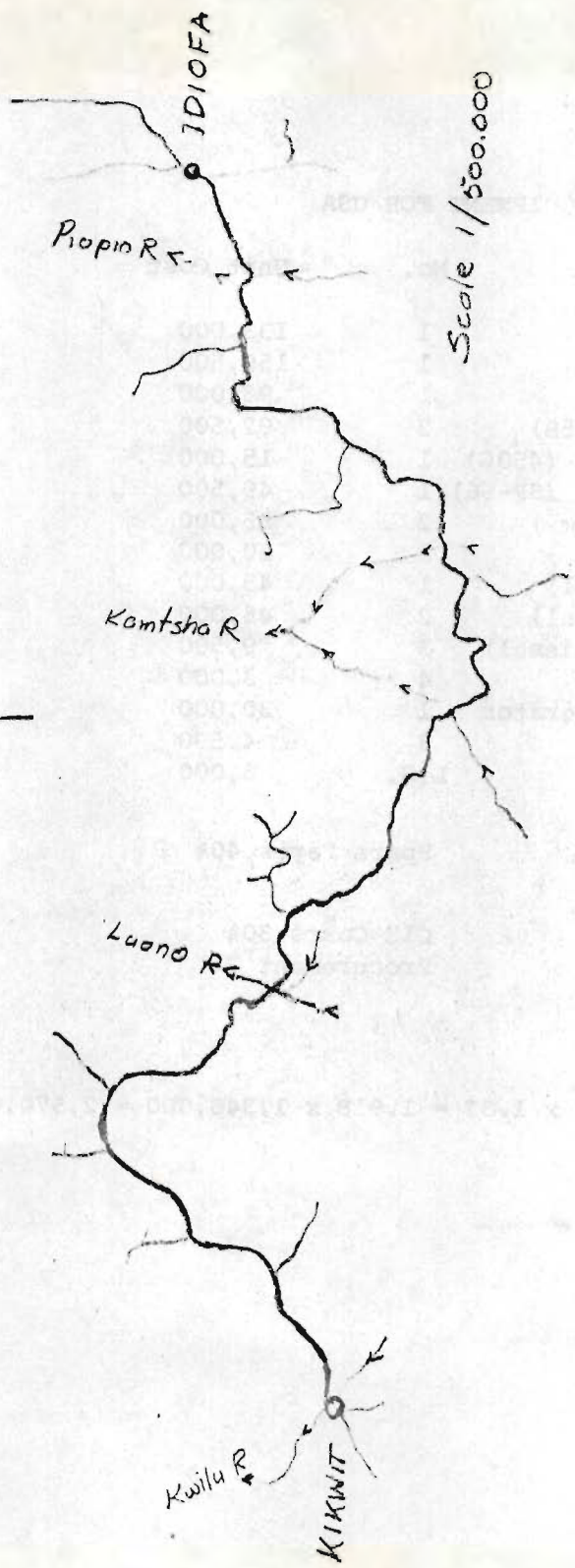
TOPOGRAPHY

| Kilometers | |
|---|---|
| 0.0 - 0.8 | Side hill, drain to right |
| 0.8 - 3.4 | On ridge, drain both sides |
| 3.4 - 3.9 | Up hill |
| 3.9 - 4.9 | Side hill, drain to left |
| 4.9 - 6.2 | Down hill, drain to left |
| 6.2 - 8.6 | Up on side hill, drain to left |
| 8.6 - 10.3 | Sinous alignment, road basicly level |
| 10.3 - 12.3 | Down on side hill, drain to left |
| 12.3 - 16.0 | Side hill, drain left |
| 16.0 - 16.5 | Up on side hill, switch back, some clay, erosion, drain right, major problem area |
| 16.5 - 17.7 | Up on side hill, switch back, drain left, problem area |
| 17.7 - 19.0 | Not yet at top of hill but realignment possible this area, road less steep |
| 19.0 - 22.4 | Road begins up again, drains right, old alignments visible |
| 22.4 - 29.7 | Rolling topography, on plateau, drains right |
| 29.7 - 37.9 | Rolling topography, on plateau, drains left |
| 37.9 - 39.0 | Down on side hill, begin problem area, side hill very steep, drainage left, 2.5 m width. Cut face on right 5 m. high. Possibility of old alignment further back up hill beginning at Imbongo (km 37.7) |
| 39.0 - 39.4 | Section between two roads, second of which is definitely an alternate alignment. 2.5 m. width, road undulating with 3 m. cut face on right side. |
| 39.4 - 40.6 | Parallel old alignment to right in this area, road climbing. Embarkment face 2 m., width 2.5 m. |
| 40.6 - 40.8 | On ridge, road level, trench 0.5 m., width 3.0 m alternate alignment begins on right |
| 40.8 - 42.8 | Rolling terrain, drain to left |
| 42.8 - 44.8 | Down side hill, switch back, drain right width ave. 3 m. embarkment face ave. 2.5 m. alternate alignment available |
| 44.8 - 45.7 | Down side hill, drain right alternate alignment higher up hill |
| 45.7 - 46.9 | Down hill, drain right, width 6 m. |
| 46.9 - 47.7 | Down hill, drain right, width 3.5 m. |
| 47.7 - 51.4 | Sinous, rolling alignment on side hill of river valley, drain right |
| 51.4 - 52.3 | Up side hill, switch back, drain right. Width 6 m, stone quarry on left |

Table A-6 (continued)

| | |
|---|---|
| 52.3 - 53.2 | Up side hill, drain right. Varying widths |
| 53.2 - 54.0 | Up side hill but less steep, width 4 m. |
| 54.0 - 72.2 | Plateau area, alternate alignment visible, road on recent alignment width 12 m, depth ½ m. or less |
| 72.2 - 75.6 | Down hill, width varies 3 - 7 m. depth ave. 1.5 m. |
| 75.6 - 79.5 | Sinuous rolling alignment in valley. Other alignments visible |
| 79.5 - 80.4 | Up side hill but back to valley, drain right |
| 80.4 - 80.9 | Up side hill, drain right. Embarkment face 2.5 m. |
| 80.9 - 82.7 | Up side hill, drain right, face 1 m. alt. align. visible |
| 82.7 - 87.9 | On plateu, poor material, road on level of old ground, covered with material from pit. Formal drainage ditches. Alignment follows ridge line but is flat. Room for new alignment next to existing |
| 87.9 - 91.4 | On plateau, several alignments visible |
| 91.4 - 93.5 | Down hill to valley, road narrows but alignment remains good. New alignment possible |
| 93.5 - 94.4 | Valley floor, road at ground level |
| 94.4 - 95.9 | Up on side hill, drain right. Ave. width 3-4 m. Embarkment face ave. 2.5 m. |
| 95.9 - 96.6 | Switch back, continue up, width 4 m. face 2 m. drain right |
| 96.6 - 98.9 | On plateau, several alignments visible |
| 98.9 - 100.9 | Down to river crossing, other alignments visible |
| 100.9 - 101.7 | Valley bottom, road 7 m. trench less than 1 m. |
| 101.7 - 102.7 | Up to plateau, other alignments visible, drain right |
| 102.7 - 111.9 | On plateau, several alignments visible |
| 111.9 - 113.5 | On ridge, but still room for another align. drain right |
| 113.5 - 114.4 | Down side hill, drain left, width 6 m. trench 1 m. |
| 114.4 - 114.8 | Valley bottom, rolling profile, another align. possible except at culvert |
| 114.8 - 116.4 | On side hill, road level, drain right, width 5 m. embarkment face up to 2 m. |
| 116.4 - 116.8 | Bridge approach at ground level |
| 116.8 - 117.5 | Up side hill, problem area, width 5-7 m. Embarkment face up to 5 m. Drain right |
| 117.5 - 119.9 | Flat, new alignment possible. Drain right, width 3 m. |
| 119.9 - 120.8 | Difficult side hill alignment down, drain left, erosion. However new alignment has been cleared straight down hill to by pass this area |
| 120.8 - 121.6 | Valley bottom, sinuous alignment, rolling profile |
| 121.6 - 123.6 | Uphill, roadside erosion, alternate alignment visible |
| 123.6 - 125.6 | Straight level road on plateau |
| 125.6 - 126.6 | Down hill, sinuous alignment, alternate alignment joins road at 126.6 |
| 126.6 - 127.1 | Valley bottom, road at ground level |
| 127.1 - 129.2 | Up side hill alignment, drainage left. Two alternate alignments to left, one on each side of draw |
| 129.2 - 131.0 | In Idiofa, on plateau. |

ANNEX B


IDIOFA
Scale 1/500.000
Piopio R
Kamtsha R
N
Luano R
Kwilu R
KIKWIT

ANNEX B

Table B-1

HEAVY EQUIPMENT FOB USA

| Unit | No. | Unit Cost | Total Dollars |
|---|---|---|---|
| Bulldozer (D6D) | 1 | 133,000 | 133,000 |
| Grader (12 G) | 1 | 159,500 | 159,500 |
| Grader (120 G) | 1 | 93,000 | 93,000 |
| Front End Loader (75B) | 2 | 92,500 | 185,000 |
| Back Hoe Attachment (450G) | 1 | 15,000 | 15,000 |
| Vibratory Compactor (SP-56) | 1 | 49,500 | 49,500 |
| Dump Trucks (F700/4m$^3$) | 12 | 35,000 | 420,000 |
| Lubrication Truck | 1 | 60,000 | 60,000 |
| Fuel Truck (2000 gal) | 1 | 45,000 | 45,000 |
| Water truck (1500 gal) | 2 | 45,000 | 90,000 |
| Pickup (F 150 4x4 diesel) | 3 | 9,500 | 28,500 |
| Water pumps | 4 | 3,000 | 12,000 |
| House Trailer w/generator | 1 | 30,000 | 30,000 |
| Radio | 3 | 4,500 | 13,500 |
| Tools | L.S. | 6,000 | 6,000 |
| | | | 1,340,000 |
| | Spare Parts 40% | | 536,000 |
| | | | 1,876,000 |
| | CIF Costs 30% | | 563,000 |
| | Procurement 7% | | 131,000 |
| | | | 2,570,000 |

Check added % 1.40 x 1.37 = 1.918 x 1,340,000 = 2,570,000

Table B-2

EQUIPMENT DEPRECIATION - TIRES NOT CONSIDERED SEPARATELY

Heavy equipment life = 10,000 hours operation
at 8 x 0.8 hours/day = 6.4 hours x 200 day = 1280 hrs/year
10,000 ÷ 1280 = 7.8 years, say 8 years

Trucks and other equipment to be depreciated in 5 years

| Heavy equipment costs | | Other costs | |
|---|---|---|---|
| D6D | 133,000 | F 700 | 420,000 |
| 12G | 159,500 | Lub | 60,000 |
| 120G | 93,000 | Fuel | 45,000 |
| 75B | 185,000 | Water | 90,000 |
| 450G | 15,000 | P.U. | 28,500 |
| SP-56 | 49,500 | Pumps | 12,000 |
| | 635,000 | Trailer | 30,000 |
| + 37% | 235,000 CIF | radio | 13,500 |
| | 870,000 x $\frac{3}{8}$ = 326,000 | tools | 6,000 |
| | | | 705,000 |
| | | + 37% | 261,000 CIF |
| | | | 966,000 x $\frac{3}{5}$ = 580,000 |

Total depreciated value of equipment

| | |
|---|---|
| Heavy | 326,000 |
| Other | 580,000 |
| | $ 906,000 |

Cost of Spare parts

536,000 x 1.37 = $ 734,000

Table B-3

AVERAGE COST OF ROAD IMPROVEMENTS

150 km of primary road upgraded, 50 km of feeder road built

| Item | | AID | (000) GOZ | TOTAL |
|---|---|---|---|---|
| Equipment Depreciation | | 906 | - | 906 |
| Spare parts | | 734 | - | 734 |
| Handling Equipment in country | | - | 244 | 244 |
| POL | | - | 631 | 631 |
| Labor | Local | - | 366 | 366 |
| | U.S. T/A | 675 | 165 | 840 |
| Drainage | CMP Culverts | - | 290 | 290 |
| | Concrete | - | 482 | 482 |
| | Reinforcing bars | - | 95 | 95 |
| Camp facilities | | | 218 | 218 |
| | TOTALS | $ 2,315, | $2,491 | $4,806 |
| Cost per kilometer | | $ 11.575 | $12.455 | $24.030 |

(not prorated between primary roads and feeder roads)

Table B-4

COSTS OF SHIPPING EQUIPMENT TO KIKWIT - GOZ COSTS

Rates: By OR figures 10% of CIF will unload ship, pay taxes and get material to Kikwit.

| | | Total cost | Shipping weights, tons |
|---|---|---|---|
| | Bulldozer (D6D) | 133,000 | 57.2 |
| | Grader (12 G) | 159,500 | 13.4 |
| | Grader (120 G) | 93,000 | 11.5 |
| 2 | Front End Loader (75 B) | 185,000 | 26.4 |
| | Back Hoe Attachment (450G) | 15,000 | 1.0 |
| | Compactor (SP 56) | 49,500 | 8.8 |
| 12 | Dump Trucks (F 700/4 $m^3$) | 420,000 | 66.0 |
| | Lub. Truck | 60,000 | 6.5 |
| | Fuel Truck | 45,000 | 6.0 |
| | Water Truck | 90,000 | 6.0 |
| 3 | Pick up (F 150) | 28,500 | 6.0 |
| 4 | Water Pumps | 12,000 | 0.5 |
| | House Trailer | 30,000 | 5.0 |
| | Radio | 13,500 | - |
| | Tools | 6,000 | 1.0 |
| | Spare Parts | 536,000 | 21.7 |
| | | 1,876,000 | 237.0 |

$ 1,876,000 x 1.30 x 0.1 = $ 243,900, say $ 244,000

GOK costs 244,000 x 5.5 = Z 1,342,000

Table B-5

POL EVALUATION

| Item | HP | Fuel |
|---|---|---|
| Bulldozer D6D | 140 | 23.1 |
| Grader 12G | 135 | 18.1 |
| Grader 120G | 125 | 16.7 |
| Front End Loader 75B | 140 | 17.4 |
| Front End Loader 75B | 140 | 17.4 |
| Compactor SP 56 | 86 | 14.8 |
| Dump Truck F 700 | 165 | 63.6 |
| Lub Truck | 165 | 3.4 |
| Fuel Truck | 165 | 3.4 |
| Water Trucks 2/ | 165 | 13.6 |
| Pickup 1/ | - | 3.8 |
| Pickup | - | 3.8 |
| Pickup | - | 3.8 |
| Water Pumps | - | 0.5 |
| Trailer Generator | - | 0.5 |
| | TOTAL | 204.0 liter/hr x 2.8 x 1.15 3/ = 657 Z/hr POL |

Daily cost 657 x 8 x 1.1 4/ = 5782 ÷ 5.5 = $ 1050
Monthly cost 657 x 8 x 200 x 1.1 ÷ 12 = 96,400 ÷ 5.5 = $ 17,530
Yearly cost 657 x 8 x 200 x 1.1 = 1,156,000 ÷ 5.5 = $ 210,200
Project cost 657 x 8 x 200 x 3 x 1.1 = 3,469,000 ÷ 5.5 = $ 631,000

---

1/ Assume 12 mpg or 5 km/liter of 100 km/day = 12.5 km/hr and add 50%

2/ Two trucks , haul 20 loads/day, ave. dist. 15 km = 300 km or 90 liter ÷ 8 = 11.3 liters for hauling x 1.2 to account for distribution = 13.6 liters

3/ Heavy equipment evaluation using Caterpillar performance handbook and prices for engine oil, hydraulic oils, filters and grease indicate that these additional costs are 12% of the cost of the heavy equipment fleet above. Use 15% for this estimate.

4/ Assume 10% losses in hauling, storage, etc.

Table B-6

LOCAL PERSONNEL IN BRIGADE*

| Classification | No | Monthly salary | Total Monthly Salary |
|---|---|---|---|
| Brigade Chief | 1 | 2340 | 2340 |
| Chief Assistant | 1 | 1690 | 1690 |
| Admin. Supervisor | 4 | 1390 | 5560 |
| " Helper | 2 | 660 | 1320 |
| " " | 1 | 530 | 530 |
| Tech. Studies Supervisor | 2 | 1390 | 2780 |
| Topo & Lab. Personnel | 4 | 1150 | 4600 |
| " " Helper | 3 | 530 | 1590 |
| Chief Mechanic | 1 | 1690 | 1690 |
| Mechanic | 9 | 660 | 5940 |
| Work Supervisor | 3 | 1390 | 4170 |
| Equipment Operator | 9 | 660 | 5940 |
| Truck Driver | 16 | 530 | 8480 |
| Pick up Driver | 3 | 530 | 1590 |
| Masons | 6 | 430 | 2580 |
| Laborers | 10 | 340 | 3400 |
| Guards | 5 | 340 | 1700 |
| TOTALS | 80 | | 55,900 |

55,900 x 12 = 670,800 x 3 = 2,012,400 ÷ 5.5 = $ 366,000

Salary per month includes: Basic salary
Housing and Furniture Allowance
Efficiency Bonus
End of Year Bonus
Holiday Bonus
Taxes
Medical Charges

* These figures supplied by OR.

Table B-7

EXPATRIATE COSTS

1 Construction Advisor

1 Master Mechanic

The following costs are given by OR

| | | |
|---|---|---|
| Equipment for 2 houses, air conditioner, refrigerator, furniture | | Z 300,000 |
| Rent for querters in Kikwit 3000x12x3x2 | | Z 216,000 |
| | Housing costs | Z 516,000 |
| Local currency salary costs | | |
| Construction Advisor 5,000 x 12 x 3 | | Z 180,000 |
| Master Mechanic 4,000 x 12 x 3 | | Z 144,000 |
| | | Z 325,000 |
| International Travel 2000 x 6 x 5.5 | | Z 66,000 |
| | Total Z Cost | Z 907,000 |

Conversion for Project Paper

| | |
|---|---|
| Housing costs 516,000 ÷ 5.5 = | $ 94,000 |
| Local allowances 325,000÷ 5.5 = | $ 59,000 |
| International Travel 66,000÷ 5.5= | $ 12,000 |
| | $165,000 |
| U.S. AID COSTS (Per AID officials) | $675,000 |
| Total expatriate cost | $840,000/project ($280,000/year) |

Table B-8

CAMP COSTS

Construction of a separate facility near Kikwit to house administrative personnel, a soils laboratory, a repair shop for routine equipment maintenance and a storehouse for supplies.

| | |
|---|---|
| Construction of camp | 800,000 |
| Office & Lab. Equipment and operating expenses (3years) | 400,000 |
| | 1,200,000 |

U.S. Dollar Equivalent $ 218,000

Table B-9

ESTIMATE DRAINAGE MATERIALS COST

Culverts

Assume 50% at 0.8 m. dia & 50% at 1.0 m. dia Cost/m becomes
(754.54 + 945.65) ÷ 2 = Z 850/lineal meter
Assume 150 culverts at 10 m each

| | | |
|---|---|---|
| 1500 x 850 | = | 1,275,000 |
| add 25% for transportation | = | 319,000 |
| CMP Culvert total | = | 1,594,000 |

Concrete

Concrete cost per $m^3$

| | | |
|---|---|---|
| Cement in Kikwit Z 108/sack x 7 | = | 756 |
| Aggregate per ton Z60x1.12 ton/$m^3$ | = | 67.2 |
| Transport Agg. @ 1.5/km/tonx550kmx1.12 | = | 924 |
| Total cost / $m^3$ | = | 1750 |

From discussions at Kikwit 1 sack makes 9 sections of concrete ditch, each .25 m long 1 sack makes 2.25 m., 7 sacks (1 $m^3$) makes 15.75 m of ditch or 4$m^3$ = 63 meters of ditch at a cost of 4 x 1750 = 7000

Assume 6 areas of 3 km each requiring ditch. Cost for concrete ditch becomes 18,000 x 7000/63 = 2,000,000

Assume 300 headwalls at 1 meter per wall. Cost for concrete in headwalls is 300 x 1750 = 525,000

Assume 80 kg of reinforcing steel per $m^3$ of headwalls. 80 kg x 300 = 24 ton. Cost in Kinshasa 20,000/ton. Transportation is 3/ton/km x 550 km = 1650. Transported ton cost 21,650. Cost for reinforcing steel becomes 24 x 21,650 = 520,000

Drainage Cost Evaluation (add 5% to concrete for waste)

| | | | | |
|---|---|---|---|---|
| Culverts | 1,594,000 | ÷ 5.5 | = | $ 290,000 |
| Concrete | 2,651,000 | ÷ 5.5 | = | 482,000 |
| Reinforcing | 520,000 | ÷ 5.5 | = | 95,000 |
| Total | 4,765,000 | ÷ 5.5 | = | $ 866,000 |

Table B-10

INPUT LOCAL COSTS PRORATED OVER THE LIFE OF THE PROJECT

Add Z cost to Table 4: Estimated Expenditure over the Life of the Project (000)

(1) Do not charge any dollar costs
(2) Add prorated Z costs to Z costs for training center shown on table
(3) Job begins June 1, 1982, finishes May 31, 1985

| Inputs | Totals | 4/36 FY 82 | 12/36 FY 83 | 12/36 FY 84 | 8/36 FY 85 |
|---|---|---|---|---|---|
| Technical Assistance 1/ | 907 | 300<br>33<br>60<br>393 | 180 | 180 | 33<br>121<br>154 |
| National Personnel | 2,012 | 223 | 671 | 671 | 447 |
| Construction | - | | | | |
| Training Equipment | - | | | | |
| Eqip, Spares & Tools 2/ | 1,342 | 959<br>61<br>1020 | 115 | 153 | 54 (lead time) |
| Drainage 3/ | 4,765 | 1059 | 1588 | 1588 | 530 " |
| POL | 3,469 | 385 | 1157 | 1157 | 770 |
| Supplies and Utilities | | 1050 | | | |
| Construction Camp 4/ | 1,200 | 17<br>1067 | 50 | 50 | 33 |
| Cont & Inflation | | | | | |
| | 13,695 | | | | |

1/ 300 for house equipment and 66 for transportation

2/ All equipment and 16% spares in original, 30% spares next year, 40% next and only 14% last year because of lead time.

3/ Unbalanced by lead time to order cement, pipe and steel

4/ Camp construction 800, equipment 250, rest is supplies etc.